SCCWRP

2017 ANNUAL REPORT

Preparing for climate change

Science provides options for responding to aquatic ecosystem impacts

Southern California Coastal Water Research Project

A Public Agency for Environmental Research

Welcome to the interactive version of SCCWRP's 2017 Annual Report! Click on the links below to jump directly to specific areas of the report. To request a printed copy of this report, contact pubrequest@sccwrp.org.

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Field researchers gather data in Upper Newport Bay in Orange County for a project that will model how animals in Southern California's coastal wetland environments respond to changing environmental conditions, especially sea level rise. SCCWRP is working to expand knowledge about sea level rise's ecosystem impacts. **Page 13**

Southern California Coastal Water Research Project 2017 Annual Report

Editor
Stephen B. Weisberg, Ph.D.

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Cover Photo
Courtesy of Kirk Gilligan
High tides surround an endangered Ridgway's rail as it tends to its nest at the Seal Beach National Wildlife Refuge in Orange County. Rising sea levels threaten the unique coastal habitats where this bird and many other vulnerable animals live.

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Snapshot of Success

Steps taken by SCCWRP to improve aquatic science research and water-quality management in 2017

1 Scientific credibility

Goal: Establish and maintain credibility with colleagues in the aquatic science community

SCCWRP can more effectively transition science into application when the agency engenders credibility with scientific peers. SCCWRP uses two primary metrics to quantify success in this area:

» Publication rate

Publishing prolifically in scientific journals is an important measure of scientific success, as these articles go through a rigorous peer review process. A robust publication rate engenders credibility for SCCWRP in the broader scientific community.

Accomplishment

SCCWRP scientific staff published an average of **3.0** journal articles each per year over the past three years. This compares favorably with the **2** publications per year minimum that SCCWRP's partners at academic research institutions generally seek to achieve when being considered for promotion. **Page 31**

» Citation rate

Whereas the number of publications quantifies productivity, citation rate provides a measure of how widely read SCCWRP's work is and the degree to which it is influencing other scientists. SCCWRP's goal is for other scientists to reference SCCWRP's work when publishing their own.

Accomplishment

SCCWRP publications were cited **1,521** times in 2017, according to Web of Science statistics, which represents a **4.1%** increase in the number of citations compared to the previous year.

2 Scientific consensus-building

Goal: Promote consensus-building through scientific collaboration and leadership

The most expeditious path for the water-quality management community to incorporate scientific findings into decision-making is for scientists to achieve consensus. SCCWRP facilitates consensus-building through:

» Leadership

Attaining leadership roles with professional scientific organizations enhances SCCWRP's opportunities for interactions and consensus-building in the aquatic sciences.

Accomplishment

SCCWRP scientific staff held **107** leadership roles with professional societies, advisory committees, and scientific journals in 2017. **Page 65**

» Collaboration

External interactions, especially in leadership capacities, often translate to collaborative scientific publications. The number of external organizations with which SCCWRP coauthors scientific publications is a reflection of SCCWRP's success building consensus.

Accomplishment

SCCWRP published scientific articles and reports with **78** different institutions in 2017. **Page 31**

What SCCWRP seeks to achieve

- Translate aquatic science research into management applications
- Optimally position the water-quality management community to benefit from scientific research
- Positively influence how aquatic systems are managed in Southern California and beyond

3 Management influence

Goal: Positively influence decision-making and actions by the end-user water-quality management community

Scientific credibility and consensus-building are important waypoints along SCCWRP's journey to produce science that positively influences management. The feature articles in this report chornicle SCCWRP's efforts to help the region's water-quality management community respond to the ecological impacts of climate change.

» Characterizing the issue

SCCWRP is tracking environmental change across the region by facilitating collection of high-quality data and forecasting how conditions will change over time.

» Developing tools and technology

SCCWRP is developing next-generation management strategies and tools to maximize the effectiveness of management responses.

» Assessing effectiveness of management actions

SCCWRP is using modeling and other analytical techniques to gauge the effectiveness of potential management actions and to inform next steps.

Accomplishment

To help managers establish flow patterns that protect aquatic ecosystems, SCCWRP is helping to implement a standardized, consistent approach to protecting environmental flows statewide. **Page 7**

Accomplishment

To guide long-term planning and priority setting for Southern California's low-lying coastal wetlands, SCCWRP and its partners have completed a study evaluating long-term vulnerability to rising sea levels. **Page 13**

Accomplishment

To help managers understand the impacts of land-based discharges on West Coast ocean acidification, SCCWRP is helping to build a set of models that will illuminate if, where and when these discharges are having adverse ecosystem impacts. **Page 25**

4 Long-term support

Goal: Provide technical support and expertise to SCCWRP's 14 member agencies to maximize their adoption and use of science

While influencing management decision-making is a signature SCCWRP accomplishment, SCCWRP maximizes the effectiveness of this influence by providing long-term guidance and assistance to its 14 member agencies.

» Training

SCCWRP develops user-friendly instruction materials and conducts hands-on training to ensure managers are properly educated about new tools and technologies.

» Intercalibration

SCCWRP facilitates intercalibration and quality-assurance exercises to ensure managers can demonstrate proficiency using new tools and technologies.

» Vetting

SCCWRP facilitates case studies and expert advisory committees to fully vet new tools and technologies.

» Outreach

SCCWRP conducts outreach activities to ensure managers and stakeholders buy into and fully embrace new approaches and technologies.

SCCWRP prides itself on the long-term support it provides to member agencies through programs like Bight regional monitoring.

Accomplishment

SCCWRP staff spent more than **6,000** person-hours in 2017 providing implementation support to member agencies.

Director's Message

Is climate change real?

SCCWRP's mission is to ensure that our member agencies have the most recent, relevant and robust science as they develop management and policy decisions. From this perspective, I have watched with curiosity and concern how national political debate on climate change has usurped science. I believe the debate is a consequence of not adequately segregating where scientific knowledge ends and policy discussions begin. I hope to disentangle science and policy by addressing three questions I am frequently asked.

Is carbon dioxide in the atmosphere increasing? This is purely a science question, and one that is easily answered. Scientists are able to directly measure atmospheric carbon concentration. Moreover, we measure carbon dioxide levels in environments that integrate over time – including ice cores, trees trunks and ocean waters – to verify our atmospheric chemistry observations. These measurements all lead to the same conclusion: Carbon dioxide levels are rising at a rate never before experienced in the earth's history, and it corresponds temporally with human use of fossil fuels.

Are we seeing any effects of increasing atmospheric carbon dioxide, and how large will the effects be in the future? This is also a science question, and again, scientists are in agreement: The effects are real, are already beginning to happen, and have the potential to be biologically significant. The challenge here is the word "potential," as scientists estimate future effects based largely on extrapolation from modeling and laboratory experimentation. There are several steps in these predictions, including determining how rapidly carbon dioxide will rise in the future, how this rise will manifest in changing temperature and weather systems, and what the consequences will be for biota (including humans). Although scientists expect the effects will be large, these conclusions ultimately are predictions, and predictions contain uncertainty. Scientists responsibly quantify this uncertainty, which some skeptics use to incorrectly dismiss the findings by stating that scientists are uncertain. Don't be fooled. Scientists are in firm agreement that weather patterns will change, sea levels will rise, and the ocean will become more acidic – and that biota will be affected by these changes. What scientists are still working to refine is only a matter of scale – that is, how long it will take for those effects to fully manifest, and where the effects will fall in a range from undesirable to catastrophic.

What we should do about climate change? This is where we transition from science to public policy. Some folks believe that humans can weather the storm (literally, as we saw recently during Hurricanes Katrina and Harvey) or lessen the effects through engineering solutions such as building seawalls to protect coastlines. However, others believe the effects will be too substantial to endure without intervention, and the only logical approach is to fix the problem at its source (i.e., lower carbon dioxide inputs to the atmosphere). In reality, both sides are probably right. The effects of unchecked carbon dioxide emissions on our present trajectory are likely to be so severe that we shouldn't want to chance the consequences. There are also things we can do to lessen effects of changes we already expect. Our political leaders will need to decide our relative investment in these two potentially complementary strategies.

Scientists have a responsibility to continually inform this policy debate by developing the best answers to what changes will take place, how long they will take to manifest, and the likely effectiveness of various management strategies. SCCWRP is pleased to be part of the scientific contingent that is informing public discussions about climate change, particularly regarding effects on aquatic environments. Our research focuses on four main areas: environmental flows, sea level rise, shifts in aquatic species distributions, and ocean acidification. This Annual Report provides perspective on what we already know in these fields and how we're working to improve that knowledge.

We invite our member agencies and others involved in climate change policymaking to reach out to us when you seek unbiased information that will help inform your decision-making processes.

Stephen B. Weisberg, Ph.D.
Executive Director

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PREPARING FOR CLIMATE CHANGE

SCCWRP is working to understand the ecosystem impacts of a changing environment – and how the water-quality management community can effectively respond

The scientific 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 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.

But these insights focus on the physical environment.

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 the changing physical environment. Just as

Courtesy of Kirk Gilligan

Courtesy of Ryan Peek, University of California, Davis

Southern California's environmental management community has invested heavily in protecting and restoring coastal wetlands, such as this dredging effort in Los Peñasquitos Lagoon in San Diego to maintain flow patterns. Rising sea levels threaten the long-term viability of many low-lying, ecologically important coastal areas.

importantly, managers need to know which strategies, tools and approaches are viable, cost-effective and optimized to help mitigate and offset ecosystem impacts.

SCCWRP's climate change research is focused on connecting rapidly growing knowledge about the physical manifestations of climate change with assessments and predictions about how aquatic ecosystems respond.

Specifically, SCCWRP is seeking to document how aquatic organisms respond to four types of physical changes triggered by rising greenhouse gas emissions:

- Altered stream flow patterns
- Sea level rise
- Warming waters
- Rising ocean acidity

SCCWRP is invested 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.

In laying this scientific foundation, SCCWRP is positioned to answer managerially relevant questions about how these changes adversely impact priorities and goals for environmental management, and how to design and activate strategies optimized for Southern California's ecosystems.

"We recognize that environmental managers cannot act on cutting-edge climate science that gets published in peer-reviewed journals – it needs to be translated into insights and options relevant to their thought processes and decision-making authorities," said Dr. Stephen Weisberg, SCCWRP's Executive Director. "That's where SCCWRP's niche lies. We are helping to fill this critically important role at the nexus of climate science and management of the aquatic environment."

The four articles that follow in this Annual Report detail SCCWRP's progress to date in documenting how aquatic ecosystems will be impacted by changing environmental conditions, and how California's water-quality management community can respond to optimally protect and restore these ecosystems in the coming decades.

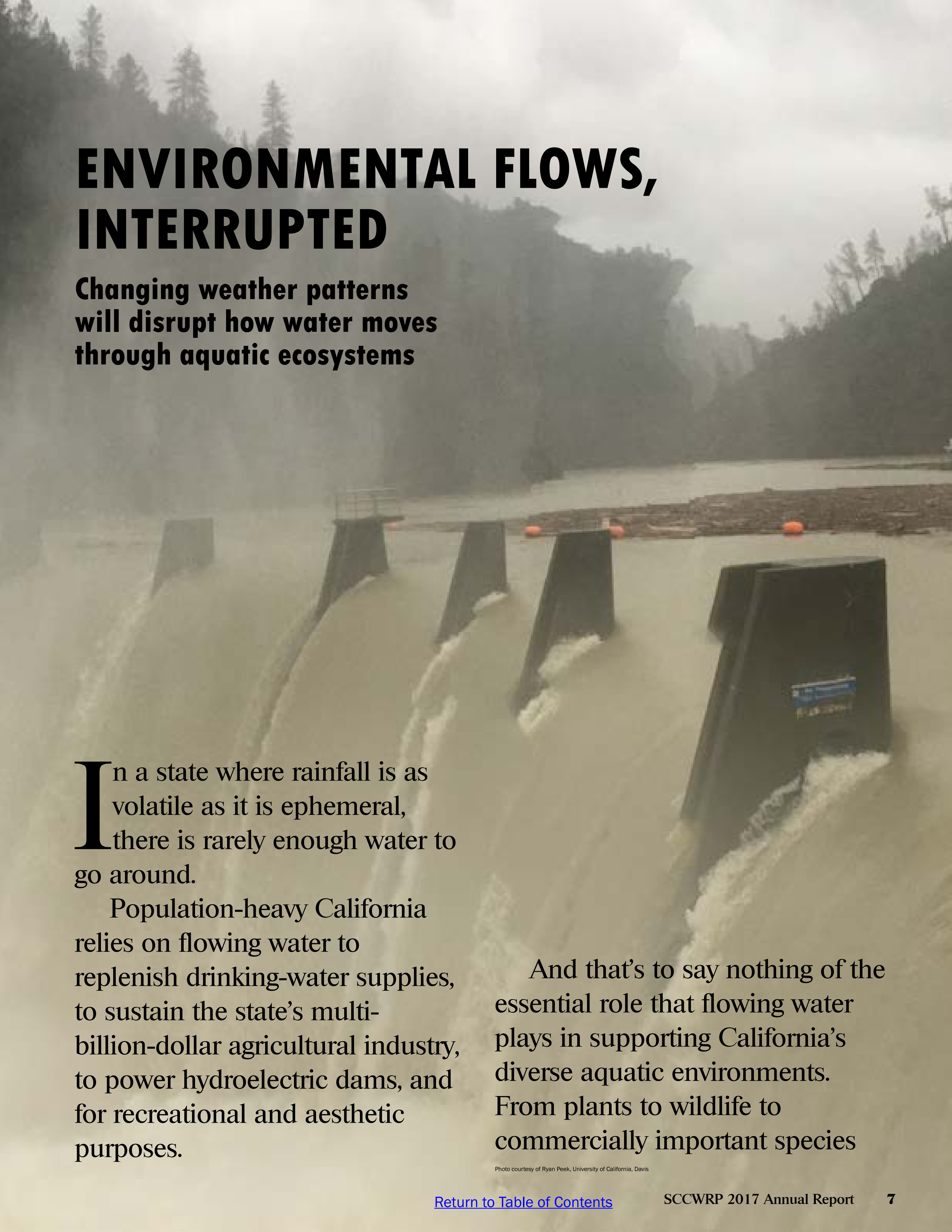
» In **Environmental flows, interrupted**, SCCWRP explores how changing rainfall and runoff patterns will impact California's efforts to optimally protect the environmental flows that sustain aquatic ecosystems, and how the state's water resources management community can improve and better coordinate its approaches to protecting these flows. **Page 7**

» In **Rising seas, vulnerable wetlands**, SCCWRP explores 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 to preserve these ecological resources. **Page 13**

» In **Warming waters, new ecological threats**, SCCWRP examines how nuisance species, particularly cyanobacterial blooms, are threatening both public and ecosystem health, and how a long-term management strategy and next-generation monitoring programs can mitigate ecosystem damage and protect human health. **Page 19**

» In **Intensifying ocean acidification**, SCCWRP examines how corrosive coastal ocean conditions are threatening the health of marine food webs, and how computer modeling is answering key questions about the degree to which human activities are exacerbating coastal acidification. **Page 25**

A field crew from the Southern California Bight Regional Monitoring Program lowers instruments into the coastal ocean to track the speed and intensity of ocean acidification in Southern California.



ENVIRONMENTAL FLOWS, INTERRUPTED

Changing weather patterns will disrupt how water moves through aquatic ecosystems

In a state where rainfall is as volatile as it is ephemeral, there is rarely enough water to go around.

Population-heavy California relies on flowing water to replenish drinking-water supplies, to sustain the state's multi-billion-dollar agricultural industry, to power hydroelectric dams, and for recreational and aesthetic purposes.

And that's to say nothing of the essential role that flowing water plays in supporting California's diverse aquatic environments. From plants to wildlife to commercially important species

Photo courtesy of Ryan Peek, University of California, Davis like salmon, flows are a lifeblood in many ecologically sensitive systems.

California is highly adept at stretching limited water resources to maintain flows across the state, but this balancing act is never easy – and it's expected to get even tougher in the decades to come.

Changing weather patterns triggered by global climate change will fundamentally alter how water flows across the landscape.

Some waterways in California will be inundated with more rain, while other waterways accustomed to receiving certain baseline flows will get drier. Meanwhile, warming atmospheric temperatures will cause snow to melt faster and earlier in the year, altering traditional trajectories for the timing, magnitude and duration of these flows.

In response, the local, state and federal agencies responsible for managing flows across California will be called on to develop next-generation strategies and tools to minimize and mitigate the ecological impacts of these flow-related disruptions.

The new approaches, which researchers already are starting to develop, are intended to clarify the relationships between flow patterns and the health of aquatic ecosystems. Water resources managers will gain key insights into how to best sustain and protect California's aquatic ecosystems over the long term, even in the face of global climate change.

"Climate change will bring huge challenges for environmental flow management in California, but it also provides us with a tremendous opportunity to rethink our entire approach to how we manage flows," said Dr. Eric Stein, Principal Scientist for SCCWRP's Biology Department. "Science can inform how we promote the long-term resiliency of all of California's aquatic ecosystems, so we can optimize the chances of preserving and hopefully even improving the ecological outcomes of environmental flows."

Urban waterways in California are highly managed systems, a consequence of the need to extract more utility out of flowing water. Above, the San Diego River flows through the community of Mission Valley.

Managing within highly managed systems

Prior to development, water flowed naturally across California's varied landscapes, supporting vibrant plant and animal communities.

But over time, Californians have placed tremendous demands on these natural flows. In their effort to extract more utility out of flowing water, humans have diverted it, redirected it and impounded it behind dams, levees and other infrastructure.

Within this tightly controlled, highly managed system, California's water resources management community is tasked with optimally protecting environmental flows to sustain aquatic ecosystems.

The challenge never gets easier, especially as Californians continue to put pressures on status-quo flow patterns to serve societal needs.

Every time that homes and businesses are constructed on previously undeveloped land, for example, developers need permission to alter the way that rain water runs off the landscape.

Meanwhile, as part of standard operations, some industries routinely discharge wastewater into nearby waterways.

Even recent efforts to recycle more treated wastewater effluent in rainfall-starved Southern California are adding new complexity to the management of environmental flows. Reusing effluent instead of discharging it into waterways can help meet intense urban demands, but this

Courtesy of U.S. Fish and Wildlife Service

The arroyo chub, left, and the endangered Santa Ana sucker, right, are among the freshwater species in California sensitive to changes in flow patterns. Stream flows, for example, help flush out the gravel-filled habitats where the Santa Ana sucker lays its eggs.

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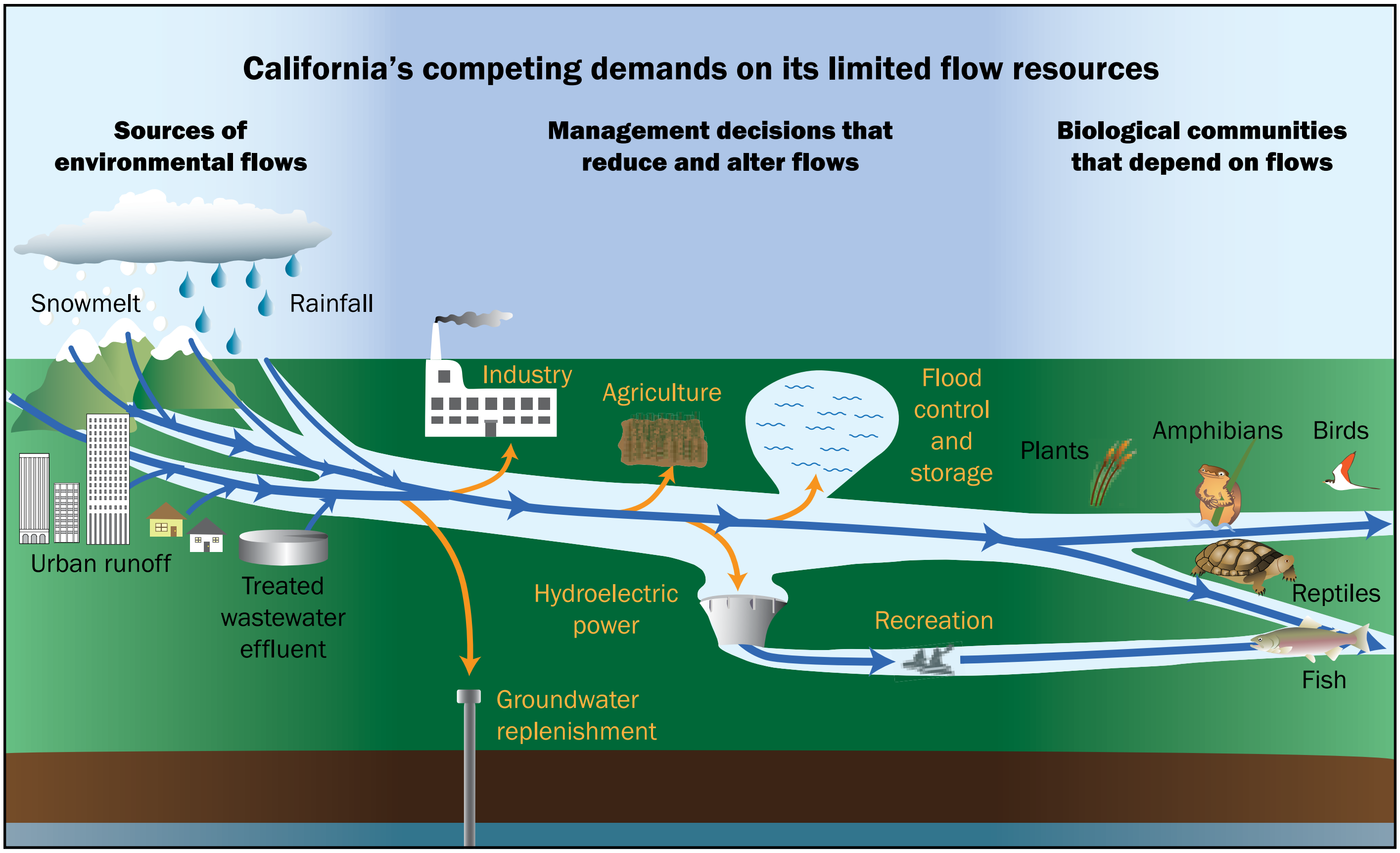

effluent often is the major source of flows in these waterways. Consequently, aquatic ecosystems over the decades have become inextricably dependent on year-round, effluent-dominated flows.

California's water-quality regulatory community is so concerned about the ecological implications of effluent flow diversions, in fact, that entities like wastewater treatment agencies are required to obtain a waiver under state Water Code Section 1211 before they can divert their flows for recycling. In the 1211 waiver application, the agency must explain, among other things, how it will protect ecosystem integrity once flows are reduced.

Even as water resources managers work through the day-to-day challenges of protecting and sustaining environmental flows, they also are looking ahead to potential ecosystem impacts from climate change.

Indeed, as flows are fundamentally altered by changing rainfall and runoff patterns, plant and animal communities already stressed by sub-optimal environmental flows in California could be impacted even more severely – an outcome that could mean the difference between life and death for vulnerable species.

"Even if we can figure out ways to keep our aquatic ecosystems functioning today, what happens if the habitat suddenly becomes much drier?" said Dr. Julie Zimmerman, Lead Freshwater Scientist for The Nature Conservancy. "Climate change is really going to test California's long-term ability to sustain our most vulnerable habitats."

Linking flows to ecosystem health

To protect environmental flows in California, water resources managers have historically set minimum base-level flows. If the flow at a given site drops below the target baseline, ecosystem health is

Sites like the Los Angeles River just downstream of the L.A.-Glendale Water Reclamation Plant are dominated by continuous discharges of treated wastewater effluent. Because ecosystems can become dependent on these year-round flows, wastewater treatment agencies must seek regulatory approval to divert these flows for water recycling purposes.

considered compromised.

But this approach is overly simplistic. Aquatic ecosystems don't depend on a static, unwavering flow regime to survive and thrive; biological systems are accustomed to seasonal and even hour-by-hour extremes in the way water flows, and they have adapted and evolved accordingly.

That's why researchers have begun developing next-generation strategies and tools for understanding the complex relationships between flows and the integrity of aquatic ecosystems. These approaches rely on sophisticated computer modeling of annual flow patterns and the way that biological communities respond to alterations to these flow patterns.

One important advantage of this modeling approach is that climate change considerations can be factored in – that is, how projected changes to rainfall and temperature patterns will impact flow patterns and, ultimately, ecosystem health.

In 2017, a group of researchers led by SCCWRP launched a two-year pilot study in Los Angeles and Ventura Counties examining how aquatic organisms will be impacted by climate change-induced alterations to environmental flows.

The study will model how flow patterns are expected to change across the region through 2100 in response to projected changes in Southern California rainfall and temperature patterns. Then, researchers will use species distribution models that estimate the likelihood that a handful of key flow-dependent species – from the arroyo toad to birds like the Least Bell's vireo – will be able to survive and thrive under these changing flow conditions.

The work, expected to be completed in 2019, will give the region's water resources managers a snapshot of when and where changing flow patterns are most likely to threaten the health of vulnerable species. By pinpointing these vulnerabilities, managers will be able to make better-informed decisions related to the future of flow management in Southern California.

"If we know that some areas are going to be less vulnerable than others, we want to ensure we're focusing our resources on restoring and protecting the areas we stand a realistic chance at protecting," Stein said. "We cannot stop climate change, but we

Courtesy of U.S. Geological Survey

The endangered Least Bell's vireo depends on specific flow patterns to support the riparian habitats where it builds its nests.

Courtesy of U.S. Fish and Wildlife Service

The endangered arroyo toad breeds at the edges of aquatic habitats, so even small changes in flow patterns can destroy its breeding grounds.

Can flows be restored to "natural" conditions?

As water resources managers work to protect environmental flows, one of their central dilemmas is how to restore flow patterns to more natural conditions. Although it is always a starting point, this goal is generally impractical and, in the end, an undesirable outcome.

Take the Los Angeles River, which was historically a sandy wash that ran dry for much of the year. Today, it's constantly flowing because of urban discharges, and ecosystems have grown dependent on these flows.

Thus, instead of trying to re-create historical flow patterns, L.A. River managers are focused on replicating ecologically important elements of the river's natural flow regime, such as by controlling the release of water or by limiting diversions from the river at certain times of year.

Courtesy of AECOM

This artist rendering of the Los Angeles River represents one vision for how the river could be reimagined through downtown. Flow patterns are unlikely to be restored to a natural, pre-development state.

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Courtesy of Ryan Peek, University of California, Davis

The 75-foot-high Our House Dam on the Yuba River in Northern California provides hydroelectric power, as well as facilitates diversion of part of the Yuba River's flows to another waterway about four miles away.

can optimize the survival for flow-dependent species."

Overlapping protection goals

In California's complex regulatory environment, multiple federal, state and local agencies have overlapping responsibilities and mandates to protect environmental flows.

Consequently, each agency has developed its own management strategies and tools that optimally position the agency to meet these requirements.

At the state level alone, the key agencies with responsibility for protecting environmental flows include:

» California Department of Fish and Wildlife, which is charged with managing flows in ways that will ensure protection of wildlife, from endangered species to commercially important fish communities

» State Water Board's Water Quality Division, which is charged with managing flows in ways that will protect water quality as measured by the health of bottom-dwelling stream invertebrates, algae and other sentinel organisms

» State Water Board's Water Rights Division, which is charged with balancing the right of landowners to receive stream flows for aesthetic and recreational purposes with the right of farmers and others to divert water for agricultural uses

» Groundwater management agencies, including the State Water Board and the California Department of Water Resources, which are required under the state's Sustainable Groundwater Management Act to develop groundwater management plans that, among other things, prevent the de-watering of surface-level flows

While this management paradigm has extended important protections to environmental flows across California, planning decisions tend to get made one reach or sub-basin site at a time.

Consequently, some areas of California have fully articulated, long-term flow management plans in place, while others lack even basic environmental-flow protections.

As climate change exerts an increasingly strong influence on environmental flow management in California, it will become more important than ever that flow management programs are coordinated, consistent and standardized statewide.

"If we're going to maintain in-stream flows for environmental purposes as weather patterns change, we need to get on the same page," said Karen Larsen, Deputy Director of the State Water Board's Division of Water Quality. "Agreeing on a common language and a common framework is our best bet for maximizing the effectiveness of management actions."

Designing a unified flow management framework

Bringing standardization to flow management planning in California is not an easy proposition.

To unify the water resources management community around a shared approach, the solution must integrate seamlessly with existing management paradigms and be flexible, rapid and cost-effective to implement statewide. A one-size-fits-all approach will not work.

In 2016, a group of environmental

flow researchers from across California, including at SCCWRP, began developing the technical underpinnings for a unified, integrated framework that can optimally protect environmental flows statewide. The California Water Quality Monitoring Council, which works to improve coordination of water-quality management programs across California, agreed in 2017 to sponsor the group's work and facilitate the framework's implementation over the next few years.

Under this environmental flows framework, water resources managers will be able to take one of two basic approaches to set environmental flow targets at a given site. Managers can either:

» Accept default flow targets, which will be available for every stream site in the state

» Conduct a more intensive, tailored flow analysis that takes site-specific ecological factors and priorities into consideration

While adopting the default targets will be the most expedient management option, these targets will be based on a coarse, screening-level analysis that does not incorporate data specific to the site of interest.

Courtesy of Ventura River Watershed Council

The Foster Park Subsurface Dam and Diversion in Ventura County is designed to slow the flow of water in Coyote Creek, enabling water to be extracted more readily and improving the efficiency of groundwater recharge. Californians have made numerous alterations to the way water flows across landscapes.

Consequently, site-level managers may determine the default targets are adequate. For example, if managers are trying to protect an endangered bird species during critical egg-laying periods, they may determine that the default targets are not sufficient to meet this site-specific ecological goal.

That's why site-level managers also will have the flexibility to conduct their own more tailored, intensive analysis.

The key advantage of this two-tiered approach is that the more intensive analysis will build off the default analysis, ensuring a consistent technical approach and making data more readily comparable statewide.

Furthermore, the environmental flows framework will enable managers to incorporate climate change into long-term flow planning decisions. Managers will be armed with a common set of flow modeling tools that help them move in lockstep to protect flow-dependent ecosystems over the long term.

"A lot of the motivation and sense of urgency we feel around protecting environmental flows is really driven by climate change and protecting the ecosystem," said Dr. Mas Dojiri, Assistant General Manager for the City of Los Angeles Bureau of Sanitation. "We are going to do everything we can to ensure we're not just protecting flows today, but also 50, 60, 70 years from now."

Protecting environmental flows using a two-tiered framework

Researchers are developing a two-tiered management framework to bring consistency to how water resources managers analyze flow patterns and set environmental flow targets that protect ecosystem health. Researchers created the two options in recognition of the fact that the same intensity of analysis cannot be conducted at every stream site in California.

	Option 1	Option 2
Use case	Default option; no analysis required	Customized analysis tailored to a particular site
Type of analysis	Coarse, screening-level analysis based on one of nine reference hydrographs	Use of a reference hydrograph, plus incorporation of site-specific factors
Data type	Reference data spanning multiple decades on ranges for daily flows	Custom-generated data on site-specific characteristics and conditions
Outcome	Broad ranges for flow targets	Narrow ranges for flow targets, with consideration for site-specific tradeoffs

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RISING SEAS, VULNERABLE WETLANDS

Low-lying coastal wetland ecosystems will be particularly vulnerable to sea level rise

Prior to passage of the federal Clean Water Act in 1971, the federal government treated coastal wetlands as wastelands, incentivizing their conversion to land for housing and other uses.

As a result, more than half of these habitats at the land-sea interface were lost across Southern California.

But in recent decades, government agencies and environmental groups have worked in earnest to protect what remains of these unique ecological resources, even acquiring swaths of the coastline to reverse some of the losses.

The intensive efforts are the result of widespread recognition that coastal wetlands play a vitally important ecological and societal role.


Courtesy of National Parks Service

Coastal wetland areas provide a key habitat where young leopard sharks learn to forage.

The nearly 100 major coastal wetland sites that remain in Southern California help buffer against flooding, recharge groundwater supplies, provide critical habitat for vulnerable plant and animal communities, and create opportunities for aesthetic and recreational enjoyment.

Unfortunately, much of the work that has gone into protecting and restoring these low-lying coastal areas is now in jeopardy because of rising sea levels.

As global climate change causes the ocean to warm and polar ice caps to melt, sea levels are projected to rise by anywhere from one to eight feet over the next century.

In the absence of management intervention, nearly half of Southern California's coastal wetland area is estimated to become completely submerged by 2100.

Like homes and other infrastructure that sit at or near sea level, coastal wetlands will need a long-term management plan that can guide efforts to optimally protect these natural resources.

Indeed, the courses of action that coastal resources managers take in the coming decades – or don't take – will have enormous ripple effects for wetlands' long-term viability.

» Should coastal managers raise the elevation of existing wetlands to keep pace with sea level rise?

» Should they create new wetlands on higher ground that can replace the ones being drowned out?

» Should they insulate wetlands from sea level rise by building protective barriers and infrastructure?

» Should managers accept some losses as inevitable, and help transition these areas to fully submerged habitats?

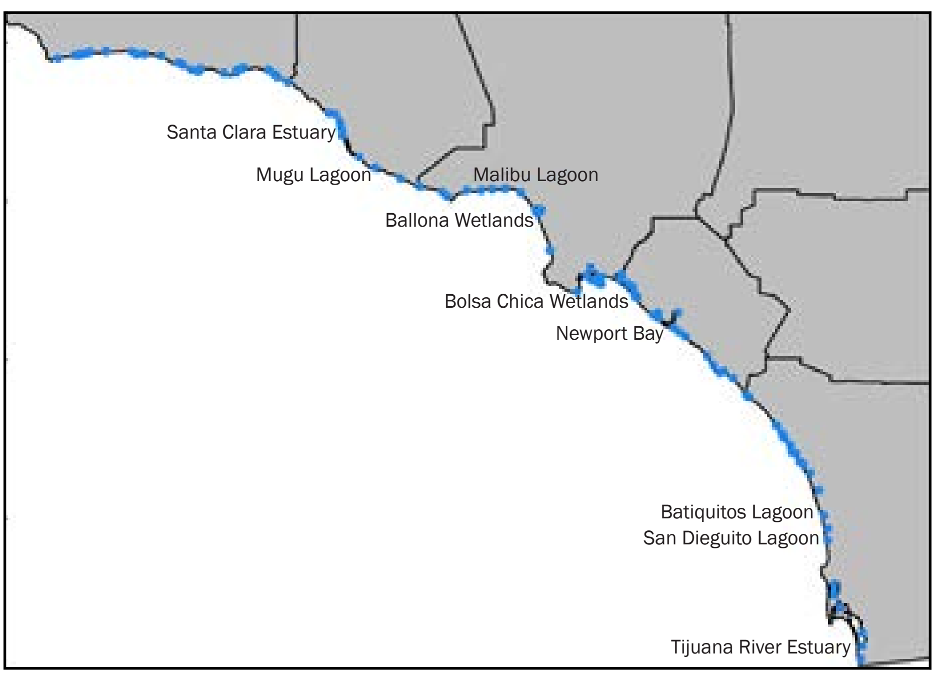
Most likely, long-term management strategies for Southern California's wetlands will come down to a combination of these solutions.

Researchers, including at SCCWRP, are working to help the region's wetland managers figure out which strategies make sense for which areas, and how to incorporate these solutions into long-term planning and management of wetlands.

"The State's investment in preserving and protecting coastal wetlands over the past few decades has been significant," said Megan Cooper, Deputy Regional Manager for the California State Coastal Conservancy's South Coast region. "If we are going to lose those wetlands to rising sea levels, we need solutions for preserving and expanding wetlands in other areas."


Courtesy of Roy Little

The endangered Ridgway's rail relies on tall cordgrass in wetland habitats to anchor its nest, which then can move up and down with the tides. Cordgrass habitats are threatened by rising sea levels.



Nearly 100 major coastal wetland areas dot the Southern California coastline. Researchers have evaluated the vulnerability of all of these low-lying areas to sea level rise.

Combatting projected impacts

Over the past 15 years, California has spent about $600 million to protect and

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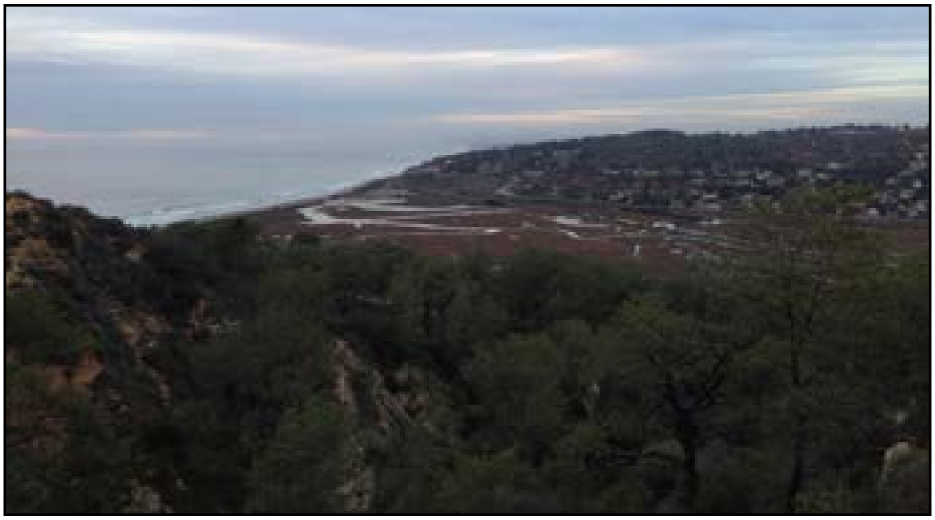

Coastal wetlands like Los Peñasquitos Lagoon in San Diego, above, that sit at or near sea level are in jeopardy of becoming completely submerged by 2100. Wetlands managers need a long-term management plan that enables them to intervene effectively as sea levels rise.

4 basic management options for wetlands vulnerable to sea level rise

1 Raise the elevation of existing wetlands to keep pace with sea level rise

- **Opportunity:** Could preserve status-quo wetland habitats over the long term
- **Challenge:** Would require importing sufficient levels of sediment at regular intervals over an indefinite period; also, not all wetlands will respond favorably to engineered accretion

2 Create new wetlands at higher elevations to replace areas that become submerged habitat

- **Opportunity:** Could minimize net loss of wetland habitats and, in some areas, lead to net gains
- **Challenge:** Would require re-designating land uses and potentially relocating public roadways, parking lots, roadways and even structures

3 Build protective infrastructure to insulate wetlands from rising sea levels

- **Opportunity:** Could preserve status-quo water levels through construction of levees, berms, etc.
- **Challenge:** Would cause wetlands to become geomorphically isolated islands that would lose much of their interconnected ecological functioning; also, not feasible to build protections for every wetland

4 Facilitate transition of existing wetlands to fully submerged habitat

- **Opportunity:** Would require the least amount of management resources and planning
- **Challenge:** Likely to be a politically and socially difficult decision to give up on wetlands

preserve wetlands, mostly by acquiring coastal property.

This financial investment has made wetlands' vulnerability to sea level rise a particularly difficult pill to swallow.

A 2017 vulnerability analysis by SCCWRP and its partners found that without management intervention, an estimated 48% of vegetated marsh and unvegetated flat areas in Southern California – the areas the public typically associates with wetlands – will become submerged by 2100. That's the equivalent of losing 4,000 acres of wetlands across the region.

But the news isn't all bad. The same analysis showed that with extensive interventions, including realigning levees, roads and other infrastructure, wetlands managers could create 7,700 to 8,800 acres of new wetland areas to replace the areas that will become submerged. This would represent a net gain of 3,700 to 4,800 acres.

To muster the political will and financial resources that will be necessary to initiate changes of this magnitude, Southern California's wetlands managers recognize that they will need to come to the table organized and coordinated, with optimized management strategies grounded in sound science.

SCCWRP is part of a group of wetlands researchers working to help managers understand how all of Southern California's major coastal wetlands will be impacted by sea level rise over the next century, and how to prioritize resources and make strategic decisions that will preserve maximum ecological functioning.

The wetlands researchers are compiling their insights and recommendations into a regional management strategy for the Southern California Wetlands Recovery Project, a consortium of the region's major wetland management agencies. This regional strategy, scheduled to be published in mid-2018, will guide the consortium's efforts to improve coordination of wetlands management programs across the region.

"We still have a couple of decades left before sea level rise starts to drown out our coastal wetlands, so this is our opportunity to inject more standardization into our approach to wetlands management," said Dr. Eric Stein, Principal Scientist for SCCWRP's Biology Department. "That's how we'll maximize the number of acres of wetlands we protect and preserve."

Considering regional perspective

Southern California's coastal wetlands tend to be managed as discrete, disconnected ecological resources.

Coastal resources managers at each site typically focus on optimizing how water flows through the area, determining the mix of plant and animal communities for the site, and controlling the discharge of land-based pollutants to the site.

While significant progress has been made under this site-specific management paradigm, sea level rise will challenge the effectiveness of such an approach going forward.

The reason is that coastal wetlands function best when they're managed as interconnected, interdependent entities. This is how they functioned prior to urban development, and this is the management approach that scientists believe will maximize their resiliency to sea level rise going forward.

Thus, to optimally protect and preserve wetlands across the region, the best-practices strategies and tools that are implemented at one site will need to optimally enhance ecological functioning for regional wetlands as a whole.

Adopting this more regionally focused perspective also will help inform tough conversations about the long-term viability of many wetland sites in the face of sea level rise.

Rather than try to protect every site – or protect selected sites at all costs – the regional perspective can help wetland managers make objective, science-informed decisions about which sites are realistic and cost-effective to protect and sustain over the long term.

"If we understand how each wetland site fits into a regional picture, our priority can shift to sustaining a healthy network of wetlands," Stein said.

"In other words, we may not be able to save every wetland, but we can aim to achieve a net benefit – ideally, a synergistic benefit that is greater than the sum of its parts."

Courtesy of Christine Whitcraft, California State University, Long Beach

Sediment is spread by a machine on top of a test area in the Seal Beach National Wildlife Refuge as part of a pilot effort to raise the wetlands' elevation to keep pace with sea level rise.

Assessing vulnerability to rising seas

Although sea levels are projected to rise globally, coastal wetlands won't all be impacted in the same manner.

The vulnerability of wetlands to sea level rise is strongly influenced by coastal topographical features, local tectonic activity, and patterns in how rivers and streams transport sediment to the site.

Meanwhile, factors like elevation, shape and configuration determine whether the site is protected from seawater influxes during ecologically critical times. Indeed, the way that seawater infiltrates a wetland can change dramatically based on the relative positioning of the estuary mouth and the presence and positioning of a protective outer berm.

To give managers a regional picture of

Courtesy of Roy Little

Kendall-Frost Marsh in San Diego at low tide, left, and during an unusually high tide, right. Although low-lying coastal wetlands are adapted to withstand temporary inundation during high tides, many of these areas across Southern California could become permanently submerged by 2100 in the absence of management intervention.

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Courtesy of Amanda Wagner, University of California, Los Angeles

A portion of the Seal Beach National Wildlife Refuge in Orange County is raised about a foot in elevation by spreading a layer of sediment across its surface. Although the sediment covers the vegetation, as shown above, researchers are examining whether the wetland habitat rebounds, which could make sediment spreading a viable, long-term strategy to help wetlands keep pace with sea level rise.

how sea level rise will play out in wetlands across Southern California, SCCWRP and its partners in 2017 completed a screening-level analysis of the relative vulnerability of all of Southern California's 96 major coastal wetland sites to sea level rise.

Researchers modeled the rate of sea level rise for each site across Southern California, as well as how biological communities will respond to these altered sea levels. Researchers then modeled how various possible courses of action – such as migrating wetlands to higher elevation or proactively raising the elevation of existing wetlands – could impact the trajectory of sea level rise's impacts on coastal ecosystems in the coming decades.

From the wetlands vulnerability analysis, researchers developed an initial set of recommendations that will inform the work of the Southern California Wetlands Recovery Project:

» Where feasible, managers should facilitate migration of wetlands to higher-elevation areas, enabling them to persist even as seas rise.

» In larger-scale systems, managers should pursue opportunities to proactively raise wetland elevation by incrementally adding layers of sediment to keep pace with rising sea levels.

» For smaller-scale systems constrained by urban development, managers should consider making a conscious decision to convert at least some of these areas to fully submerged environments.

The goal of these recommendations isn't to shape management plans for any particular wetlands site in Southern California, but rather to help shape development of strategies and priorities for the region as a whole.

"We're only at the beginning stages of using our regionally focused tools to drive wetlands management in Southern California going forward," Stein said. "This foundation we're building is exciting; it will guide all the work that's still to come."

Why a regional strategy?

Southern California's coastal management community is working to build a regional strategy that can bring more consistency to wetland protection and restoration efforts going forward. The strategy is regional – as opposed to statewide – because of the unique pressures and challenges faced by Southern California along its intensely urbanized coastline. The state's other major coastal population center – the San Francisco Bay Area – has developed its own wetlands management strategy centered around the San Francisco Bay Delta region.

Courtesy of Mary Gartung, Newport Bay Conservancy

Volunteers with the Newport Bay Conservancy remove invasive plants from Upper Newport Bay in Orange County. Rising sea levels threaten to undermine successful restoration and preservation efforts in Newport Bay and elsewhere in Southern California.

Courtesy of Richard Nye, Seal Beach National Wildlife Refuge

A man-made platform that travels up and down with the tides is one innovative way to provide nesting habitat for birds like the endangered Ridgway's rail as sea levels rise. The pair of poles, which keeps the platform from floating away, mimics the way that the Ridgway's rail attaches its floating nests to tall cordgrass.

A field researcher measures the elevation of bird nests in Upper Newport Bay in Orange County. The work is part of an effort to improve wetland management strategies for Southern California.

Developing site-specific strategy

Developing a regional wetlands management strategy and conducting screening-level vulnerability analyses are only the first steps that researchers and managers are taking in response to the looming threat of sea level rise.

To put in place viable, long-term management plans for various wetland sites, wetland managers also need to conduct much more extensive analysis on a site-by-site basis. This work involves detailed field measurements and site-specific modeling of both the physical changes that a site is predicted to undergo and the resulting changes to biological communities at the site.

Wetlands managers rely on these more intensive analyses to provide a higher degree of confidence that the courses of action they pursue will have intended – and optimal – effects.

Indeed, as wetlands managers look to develop next-generation wetlands management strategies for Southern California's diverse wetlands, the regionally focused mindset and tools pioneered by SCCWRP and its partners will serve as the foundation upon which to conduct subsequent analysis at the site-specific level.

In late 2017, SCCWRP began working with the University of California, Irvine on a four-year pilot study that will explore how to optimize wetlands management for Orange County's Upper Newport Bay and San Diego County's Tijuana River Estuary. Researchers at SCCWRP are working to build sophisticated models that explain how biological communities respond to inundation from sea level rise.

Then, they will model how various possible courses of action – such as spreading sediment on top of the wetland to incrementally raise its elevation – will influence the projected trajectory of impacts to biological communities at the site.

The goal is to show how managers can work through some of the key considerations, constraints and environmental factors that go into making optimized decisions for wetlands management.

"Sea level rise will represent a giant blow to wetland management efforts in Southern California, but that doesn't mean we toss in the towel and let all wetlands drown," said Dr. Jeff Crooks, Research Coordinator for the Tijuana River National Estuarine Research Reserve near the U.S.-Mexico border. "Thanks to science, we can and are findings ways to offset the ecological impacts and optimally preserve our wetlands."

Courtesy of Scripps Institution of Oceanography

A bulldozer carves a coastal outlet in Los Peñasquitos Lagoon in San Diego to help stagnant lagoon water drain to the ocean. Researchers are working to help coastal wetlands managers optimize the effectiveness of such interventions.

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WARMING WATERS, NEW ECOLOGICAL THREATS

Increasing water temperatures are fueling more toxic cyanobacterial blooms

On land, plant and animal communities are accustomed to dealing with dramatic swings in ambient temperatures; 30 or 40 degrees is common between day and night.

In aquatic environments, however, water has much more capacity to modulate and constrain temperature variability.

Consequently, the organisms that live in aquatic ecosystems tend to respond much more forcefully to relatively small shifts in water temperatures, including the modest temperature increases linked to global climate change.

These temperature shifts are fundamentally altering the ranges at which aquatic organisms – from single-celled bacteria to market squid – can survive and thrive.

Many of these species already have responded to warming waters by migrating, compressing into smaller geographic areas, or perishing.

A new crop of nuisance species, meanwhile, is thriving in warming aquatic environments. In coastal Southern California, the water-quality management community is concerned about pathogens like warm-water *Vibrio* bacteria that flourish in quiescent estuary environments, then get flushed into coastal waters and endanger the health of beachgoers.

Water-quality managers also may need to revisit how they quantitatively measure and score ecosystem health. Indeed, environmental scoring tools that have been built on static assumptions about species distribution patterns may require revisions and recalibrations to reflect changing environmental norms.

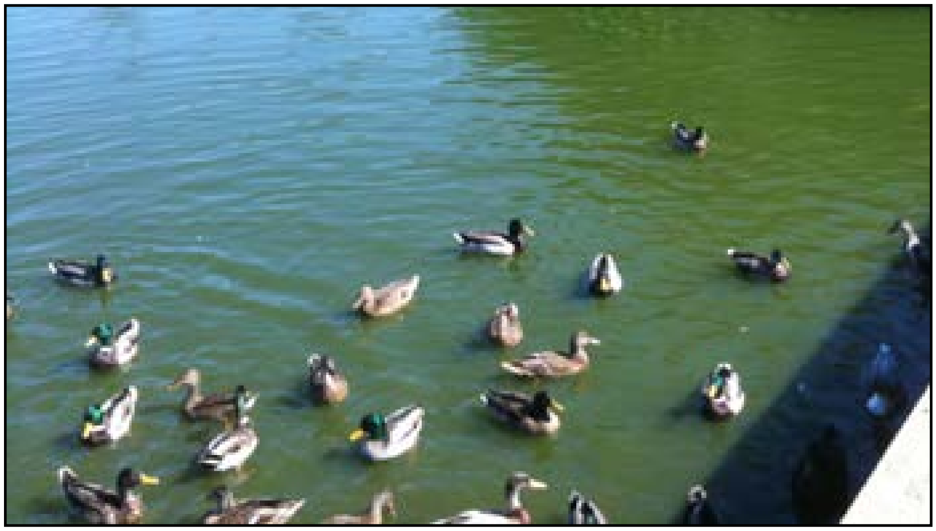
Even as these challenges loom large, an even more immediate problem stands out as the most prevalent and life-threatening consequence of warmer waters – toxin-producing cyanobacterial blooms.

Referred to as cyanobacterial harmful algal blooms, or cyanoHABs, these proliferations of toxic, brightly colored bacteria have been triggered with alarming frequency in recent years across California's freshwater and estuary environments.

The environmental impacts of cyanoHABs can be sudden, severe and lethal across all levels of aquatic and terrestrial food webs. Equally troubling, they can contaminate drinking water supplies, kill livestock and dogs, and sicken humans who swim in toxin-filled waters.

With cyanoHABs expected to become more and more severe in the coming decades in response to climate change, California's water-quality management community is mounting a multi-pronged response intended to mitigate ecosystem damage and better protect the health of humans and wildlife.

"CyanoHABs are becoming more frequent with warming temperatures, which means managing these bloom events is going to become more important than ever," said Dr. Meredith Howard, a SCCWRP Senior Scientist who runs the agency's HABs research programs. "We are creating a long-term strategy and management tools to help managers better protect public health and aquatic environments."



Ducks swim in a lake tainted green by a cyanobacterial bloom. When these blooms produce toxins, they can be lethal at all levels of aquatic and terrestrial food webs, from aquatic insects to birds.

Courtesy of Raphael Kudela, University of California, Santa Cruz

As waters warm, harmful algal blooms like this toxic cyanobacterial bloom in Pinto Lake in Santa Cruz County are becoming more severe, more geographically widespread and longer-lasting.

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How cyanoHABs threaten ecosystems

Originally classified as algae, cyanoHABs actually are a variety of bacteria that produce biological toxins as part of their normal lifecycle. These single-celled organisms can flourish for months at a time, tainting the color of water vibrant shades of blue and green.

Like multiple other types of harmful algal blooms, cyanoHABs disrupt aquatic ecosystems by proliferating suddenly and lowering dissolved oxygen levels. They also can interfere with other biological processes, including blocking sunlight from penetrating through water.

CyanoHABs are particularly concerning because cyanobacterial cells produce toxins that are released into aquatic environments as the cells break open and die – and sometimes even while the cells are still alive.

When humans swim in toxin-contaminated waters, they can develop acute poisoning symptoms, ranging from vomiting and diarrhea to liver damage to impaired motor functioning. In some cases, cyanotoxins can trigger respiratory paralysis that leads to death.

CyanoHABs also are concerning because they are spread easily through waterways, triggering bloom events in coastal estuaries and other downstream environments.

Although cyanoHABs cannot survive in the ocean, the toxins they produce can remain biologically active even after being washed into coastal marine environments. Indeed, cyanotoxins have been linked to deaths of endangered sea otters; they've

Courtesy of Susan Fricke, Karuk Tribe

The Klamath River in Northern California, tainted green by cyanoHABs, is among the waterways that are known to transport cyanobacteria and their toxins to downstream environments, including the coastal ocean.

Courtesy of Carey Nagoda

Cyanobacterial blooms aren't limited to freshwater systems; they also can proliferate in estuary environments, including San Diego County's San Elijo Lagoon, which experienced a massive bloom event in 2014.

Drinking water contamination

Cyanobacterial blooms aren't just disruptive to ecosystems; they also can contaminate drinking water supplies. About half a million residents of Ohio and Michigan were warned not to drink from their taps for three days in 2014. The culprit was a cyanobacterial bloom event in Lake Erie, which serves as the region's main drinking water source. The blooms introduced high levels of a toxin known as microcystin into the water.

Courtesy of Ohio Sea Grant and Stone Laboratory

A warning sign is posted in Lake Erie's Sandusky Bay during a 2014 cyanobacterial bloom event that contaminated drinking water supplies for nearly half a million residents.

also been shown to contaminate mussels and other shellfish consumed by humans.

"We're seeing cyanotoxins present at levels that exceed human health recreational and drinking water advisories," said Dr. Martha Sutula, Principal Scientist for SCCWRP's Biogeochemistry Department. "We are even detecting toxins within aquatic and terrestrial food webs, with impacts to insects, sea otters, birds and even domestic pets. It really underscores the importance of improved management strategies."

Why blooms are flourishing

Toxin-producing cyanobacteria have long been part of the makeup of freshwater and estuary environments, living alongside hundreds of thousands of other species of single-celled aquatic organisms, including non-toxic cyanobacteria.

But in recent years, harmful blooms of all kinds – including cyanoHABs – have become more severe, more geographically widespread and longer-lasting.

In freshwater and estuary environments, there are three main factors driving cyanoHABs events:

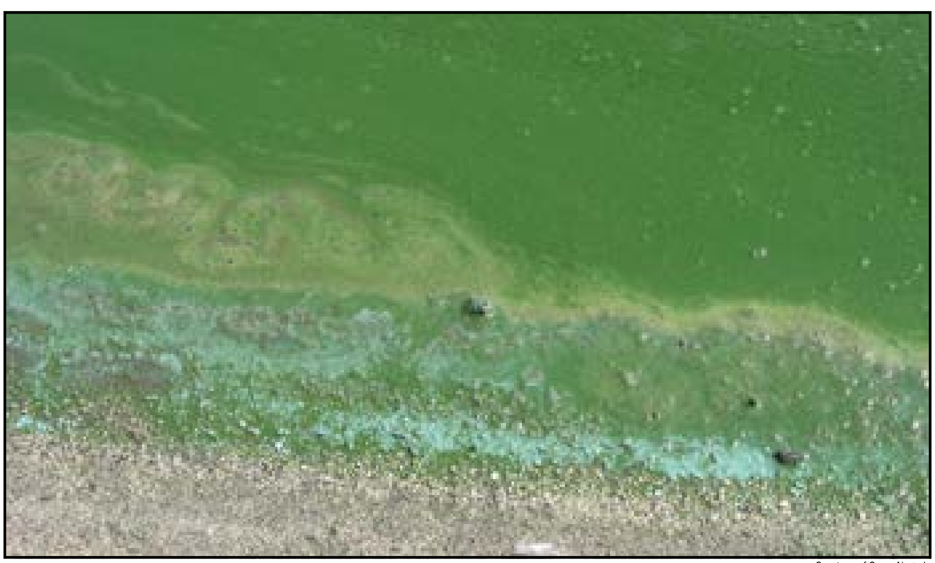
» Warming water temperatures, which enable cyanobacteria to grow and multiply much faster than in colder waters

» Dams, reservoirs and other human modifications, which slow the flow of water and promote cyanobacterial growth

» Readily available nutrient supplies, which provide an abundant food source fueling rapid growth

While water-quality managers cannot control water temperatures and are limited in their ability to alter flows, they can work to control excess nutrient inputs to vulnerable lakes, streams, estuaries and other water bodies.

Mussels cover a rock at low tide. Mussels are among the marine animals that can be contaminated by cyanotoxins, which are transported through waterways to the coastal ocean.



Courtesy of Carey Nagoda

Cyanobacterial blooms can flourish for months or even years at a time, tainting the color of water vibrant shades of blue and green.

Algal blooms in marine environments

While the cyanoHABs problem has been definitively linked to warming waters in freshwater and estuary environments, the reasons behind increased blooms in marine environments are just beginning to emerge. Many of these reasons are linked to climate change, including:

- Warmer ocean water temperatures
- Intensification of coastal upwelling
- Increased dissolved carbon dioxide levels
- Changes in salinity and rainfall patterns
- Sea level rise

A massive bloom event that spanned the North American West Coast in 2015, for example, was triggered by anomalously warm ocean water temperatures. The toxins produced by the bloom sickened marine mammals and led to closures of shellfish, crab and finfish fisheries.

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Courtesy of National Oceanic and Atmospheric Administration

Endangered sea otters have died in California as a result of cyanotoxin poisoning. CyanoHABs don't grow in marine environments, but their toxins can travel through rivers and streams to the coastal ocean.

Instituting better nutrient controls in California, however, is a not an easy task. In population-dense California, nutrients enter aquatic environments via agricultural runoff, rainfall runoff, wastewater effluent discharges, industrial discharges and other diffuse sources.

Once introduced to water bodies, these excess nutrients not only can immediately disrupt ecosystems, but also can accumulate in sediment, where they continue to fuel cyanobacterial growth decades after being originally deposited.

In recent years, California's water-quality managers have emphasized development of more prescriptive management programs and policies that define how much nutrients in a given water body is too much, and that offer articulated pathways for reducing the many potential sources of nutrient inputs to California water bodies.

"Controlling nutrient inputs really is the best sustainable strategy to prevent or reduce the intensity of cyanoHABs events," said Dr. David Caron, a Professor of Biological Sciences at the University of Southern California and a close SCCWRP collaborator on HABs research. "We've made progress on this front, but certainly climate change is a reminder that we still have our work cut out for us."

Protecting public health, wildlife

Once cyanoHABs events are triggered, there is little that water-quality managers can do to contain the problem.

Although some lake managers have turned to algicide treatments, this costly solution offers only a cosmetic Band-Aid, with blooms typically returning in a matter of weeks or months.

The most important role that water-quality managers can play during bloom events is to ensure public health is protected – by posting warning signs, closing contaminated water bodies and ramping up monitoring efforts to know if the problem is spreading.

In the marine environment, California has a standardized, articulated monitoring program in place to track coastal bloom events and protect seafood from contamination. By contrast, cyanoHABs monitoring in freshwater and estuary environments is still in its infancy.

SCCWRP is part of a group of researchers working to change that, conducting foundational studies to understand the extent of the cyanoHABs problem across California. Researchers' long-term goal is to develop best-practices strategies and guidance to help managers begin monitoring water bodies in a consistent, cost-effective manner.

As part of their initial exploratory work, SCCWRP and its partners are pursuing multiple technologies to track where toxic blooms are occurring and how they are moving through aquatic ecosystems:

» Researchers are helping environmental managers deploy passive sampling devices – resin-filled devices that resemble tea bags – to routinely monitor toxin concentrations in water.

» Researchers are studying the genetic material of cyanobacteria to assess how DNA sequencing could be used to detect toxin-producing species in water samples.

» Researchers are exploring whether small unmanned aerial systems – commonly known as drones – could fly cameras and multispectral imaging sensors over water bodies to capture early evidence of bloom events.

By characterizing the extent of toxic

Representatives from the Utah Department of Agriculture and Food receive training at SCCWRP on how to deploy a passive sampling technology known as Solid Phase Adsorption Toxin Tracking (SPATT) to monitor for biological toxins. Researchers are concerned that these toxins could be taken up by vegetables and other crops consumed by humans.

bloom events, researchers hope to improve understanding of what kinds of management strategies and planning are necessary to protect humans and wildlife.

From early-warning systems to best-practices treatment regimens for humans and wildlife sickened by cyanotoxins, managers will need multiple solutions to combat a threat that is expected to intensify in the coming decades.

"As climate change drives us toward the likelihood of more frequent and more impactful cyanoHAB events in California, we have to have ways to better understand, predict and intervene as water resource managers," said Greg Gearheart, Deputy Director of the California State Water Resources Control Board's Office of Information Management and Analysis. "The work we are doing with SCCWRP and other researchers to build capacity in these areas is absolutely vital to our mission to protect humans, their pets and wildlife from the harmful elements of these changing natural phenomena."

Courtesy of Raphael Kudela, University of California, Santa Cruz

Cyanotoxin levels can become so elevated in water bodies experiencing bloom events that humans can experience skin irritation and other health problems upon contact. Above, a researcher's latex glove is stained dark green by toxic cyanobacteria.

SCCWRP and its partners assess water quality in Riverside County's Lake Elsinore using multiple techniques – an underwater autonomous vehicle, left, a camera and multispectral imaging sensor mounted to a drone, foreground, and traditional water sampling by boat, background. Researchers are looking for rapid, cost-effective ways to track early signs of cyanobacterial blooms in water bodies across California.

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INTENSIFYING OCEAN ACIDIFICATION

Corrosive seawater is threatening the health of coastal ecosystems

As humans release carbon dioxide into the atmosphere, this gas doesn't merely act as an insulating blanket that warms the planet.

About a third of carbon dioxide emissions are being absorbed by the ocean, gradually moving seawater conditions toward a more acidic, corrosive state.

This change in water chemistry – known as ocean acidification – is making seawater a less habitable environment for organisms ranging from sea snails to crabs to fish.

Pteropods, or sea snails, are having difficulty forming and maintaining their protective outer shells as a result of ocean acidification. A healthy pteropod, top, contrasts with pteropods experiencing varying degrees of acidification-related stress, middle and bottom.

Courtesy of National Oceanic and Atmospheric Administration

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Courtesy of Occidental College Vantuna Research Group

Blacksmith fish swim through a Southern California reef habitat. Ocean acidification has been shown to affect fish's navigation abilities, making it harder for them to find food, distinguish predators from prey, and identify safe habitats.

Under these corrosive conditions, shell-forming organisms are having a tougher time building their shells, and fish are experiencing behavioral changes that make them more vulnerable to predation.

The ecological consequences of ocean acidification, however, will not be felt uniformly around the world. Unique ocean circulation patterns make the coastline of the North American West Coast among the most vulnerable ecosystems on earth.

Scientific experts who have extensively studied West Coast acidification say that the environmental management community has a critical role to play in reducing the severity and progression of this global phenomenon – beyond simply reducing greenhouse gas emissions.

Indeed, local coastal environmental managers have an opportunity – and a responsibility – both to lessen the exposure of vulnerable marine species to corrosive conditions, and to enhance the ability of marine communities to cope with acidifying seawater.

Researchers from across the West Coast, including at SCCWRP, are working with the coastal management community to evaluate the effectiveness of multiple proposed management solutions for mitigating the ecosystem impacts of coastal acidification and a related phenomenon known as hypoxia, or low dissolved oxygen levels.

Among the most high-profile efforts is the ongoing development of a set of powerful computer models that will illuminate if, where and when land-based pollutant discharges into coastal waters are exacerbating corrosive, hypoxic conditions. Researchers also are exploring the feasibility of drawing down carbon dioxide levels in coastal waters by tapping into the natural photosynthetic power of aquatic plants such as seagrass and kelp.

"Ocean acidification is already impacting our coastal ecosystems now, but we've really done a good job mobilizing both scientists and managers," said Dr. Richard Feely, a Senior Scientist for the National Oceanic and Atmospheric Administration. "Everyone on the West Coast is working together to better understand what strategies will be most effective and efficient from a cost-benefit standpoint for optimally protecting vulnerable coastal habitats."

Corrosive conditions already manifesting

The biological and economic damage from corrosive coastal conditions isn't years or decades into the future; it's already here.

Since 2007, Pacific Northwest shellfish hatcheries have repeatedly experienced mass die-offs of oyster larvae and other shellfish, decimating the seed stocks that sustain multi-billion-dollar commercial industries. The culprit is corrosive seawater that is so deficient in the dissolved mineral aragonite that larvae shells are dissolving faster than the larvae can build them.

Corrosive seawater conditions also are turning up in Southern California's coastal waters. The Southern California Bight 2013 Regional Monitoring Program documented corrosive conditions at average depths of just 80 meters along the continental shelf during the spring season, and at 120-meter depths the rest of the year.

These unfavorable conditions eventually are expected to reach the upper water column – home to abundant marine life, including tiny sea snails called pteropods that form the base of marine food webs.

The dominant force bringing corrosive conditions into shallow coastal waters is a natural phenomenon called upwelling.

Courtesy of Oregon State University

When oyster larvae are old enough to attach permanently to a surface, they are transferred from hatcheries to coastal farms. At this life stage, they are known as spat.

Courtesy of Oregon State University

Oyster spat attached to this hard surface at a Pacific Northwest oyster farm exhibit visible signs of stress as a result of corrosive seawater conditions.

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Triggered by seasonal winds off the coast of North America, upwelling forces water to the surface that has been trapped at the bottom of the Pacific Ocean for decades. These deep waters tend to be high in dissolved carbon dioxide and low in dissolved oxygen.

When winds are particularly strong – as is common during the spring months – West Coast upwelling can bring so much carbon dioxide-rich water to the surface that seawater pH can drop as much as 90%.

Although West Coast marine organisms have adapted to intermittent exposure to corrosive, hypoxic seawater, these conditions are expected to become more prevalent and pervasive in response to global climate change.

Indeed, changing weather patterns are expected to bring even stronger West Coast winds that trigger more intense upwelling events. And as humans emit more and more carbon dioxide into the atmosphere, the ocean will continue to absorb it.

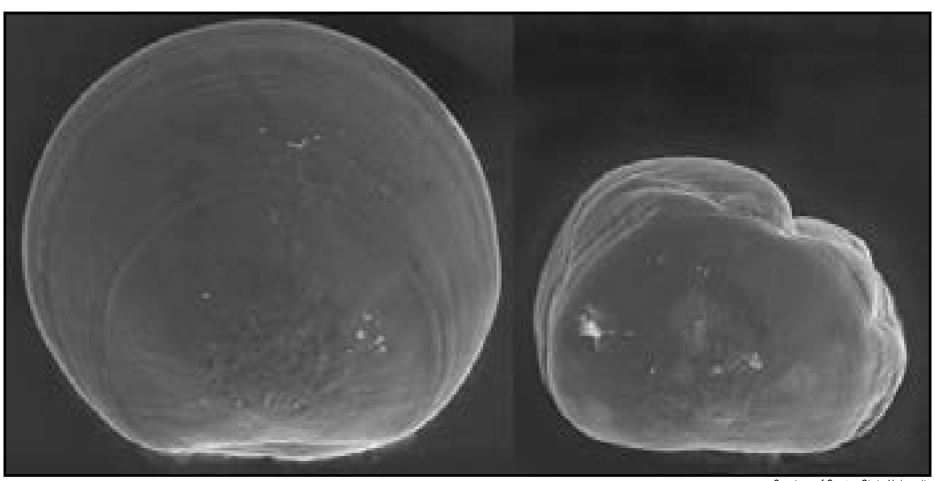
"We've got to figure out how to do everything we can to protect our coastal habitats, particularly in the nearshore areas of the Southern California Bight where we frequently encounter corrosive, hypoxic conditions," said Dr. Nina Bednarsek, a Scientist in SCCWRP's Biogeochemistry Department. "These are some of our most biologically productive areas, and yet they're also going to be among our most vulnerable."

Modeling impacts of land-based discharges

Like governments, nonprofits and ordinary citizens the world over, the West Coast environmental management community is pursuing strategies for reducing greenhouse gas emissions – the root cause of both climate change and ocean acidification.

Courtesy of Oregon State University

At oyster hatcheries in the Pacific Northwest, seawater from the ocean is pumped directly into tanks where larvae are growing. Hatcheries can experience mass die-offs of oyster larvae when seawater dips into corrosive territory,



Courtesy of Oregon State University

At just four days old, a healthy oyster larva, left, looks visibly different than a larva exposed to corrosive seawater conditions, right. Ocean acidification can mean the difference between life and death for oysters and other shell-forming organisms.

Using science to inform ocean management

California is a leader in incorporating knowledge about ocean acidification's ecosystem impacts into environmental planning and decision-making. To ensure managers operate with the most recent scientific information, California has convened two key science advisory bodies in recent years, both of which have included participation by SCCWRP:

» The 20-member **West Coast Ocean Acidification and Hypoxia Science Panel** brought together three West Coast states and British Columbia to develop a strategy for combatting the effects of acidification and hypoxia. In a comprehensive report published in 2016, the panel outlined a series of actions that West Coast managers should pursue; the California Ocean Protection Council already has begun implementing these recommendations.

» More recently, California established an eight-member **Ocean Acidification and Hypoxia Science Task Force** to review projects the state has funded in response to the panel's findings. The task force will ensure that project findings are appropriately communicated, and identify opportunities for California to continue to expand scientific knowledge.

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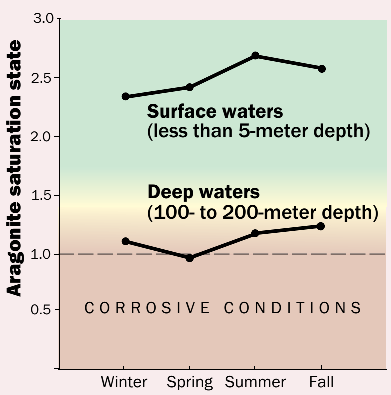
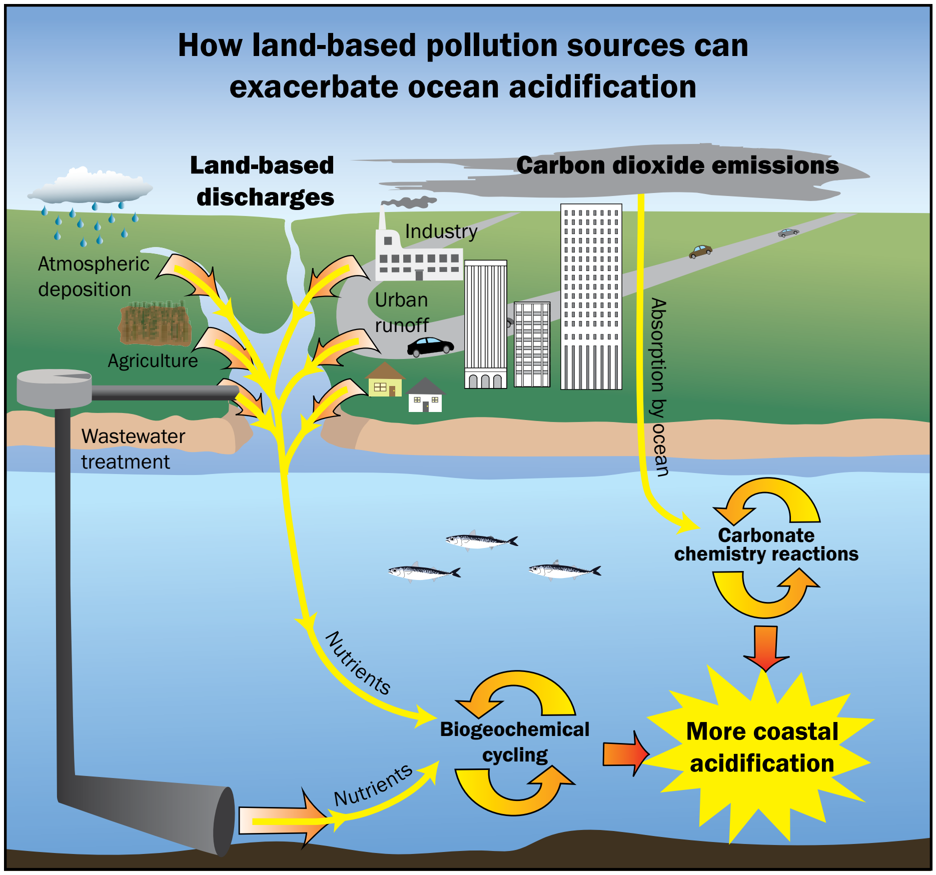
Tracking acidification in the Bight

The 2013 cycle of the Southern California Bight Regional Monitoring Program marked the first regional effort to track corrosive seawater conditions along the continental shelf of the Southern California Bight – the biologically productive region closest to shore. Bight '13 found that average aragonite saturation state – a way to express the concentration of a dissolved mineral called aragonite in seawater – drops below the critical 1.0 threshold in deep waters in the spring. Shells can dissolve spontaneously when aragonite saturation state drops below 1.0.



The next cycle of the program, Bight '18, will survey the continental shelf again to track whether conditions have changed five years later. Bight '18 also will examine whether larval fish and other species sensitive to ocean acidification are experiencing biological impacts from corrosive waters.



But West Coast environmental managers also are exploring more focused opportunities to make a difference in their own backyard.

One key avenue managers are pursuing is evaluating whether local, land-based discharges into coastal waters are directly exacerbating acidification of coastal waters and driving down dissolved oxygen levels.

For generations, coastal communities have released treated wastewater effluent, rainfall runoff and other discharges into coastal marine waters. These discharges typically contain high levels of nutrients – especially nitrogen and phosphorous – that can trigger complex biogeochemical cycling processes that raise dissolved carbon dioxide levels and lower dissolved oxygen levels.

Coastal environmental managers want to know if these nutrient discharges are making coastal waters more corrosive and hypoxic than they otherwise would be – and if so, when and where the ecological impacts are greatest.

SCCWRP is part of a consortium of West Coast researchers working to develop a set of integrated computer models for the North American West Coast that can estimate the influence of land-based discharges on coastal ecosystems.

The modeling effort, which builds off modeling work that dates back more than a decade, involves capturing the circulation and mixing patterns of coastal ocean water, as well as the biogeochemical cycling pathways that drive up dissolved carbon dioxide levels and drive down dissolved oxygen levels.

Modelers are focusing on major coastal population centers that are releasing continuous streams of nutrients into geographically compact areas of the North American coastline.

In California, for example, there are just eight major wastewater outfalls – four in the San Francisco area and four in Southern California – that discharge about 50% of all of the nitrogen that Californians are introducing to coastal waters via land-based discharges.

Courtesy of Sanitation Districts of Los Angeles County

A plume of treated wastewater effluent is discharged into the coastal ocean through an opening in an outfall pipe. Researchers are modeling whether these discharges, which are rich in nutrients, are among the land-based discharges that could be exacerbating ocean acidification and hypoxia conditions in Southern California coastal waters.

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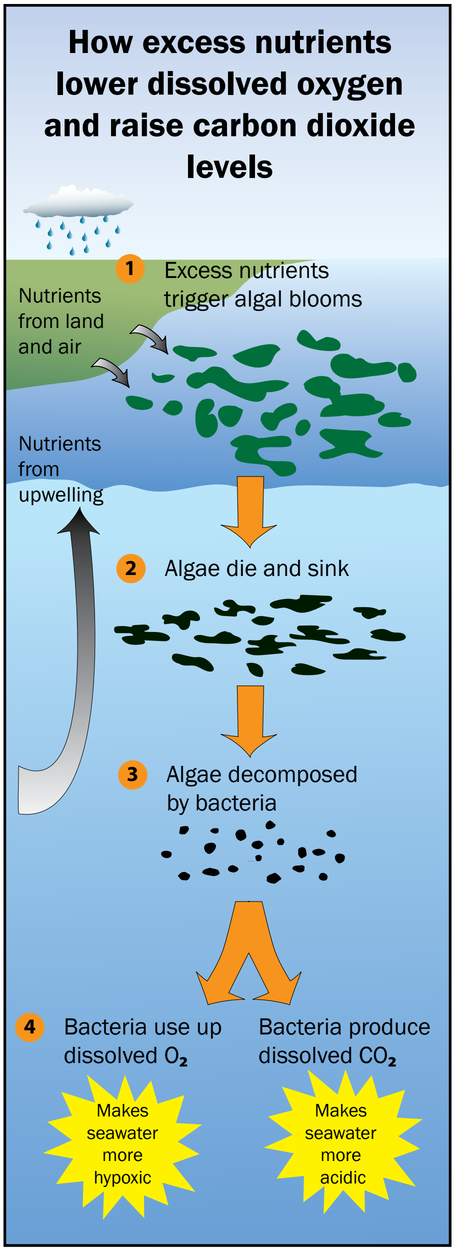

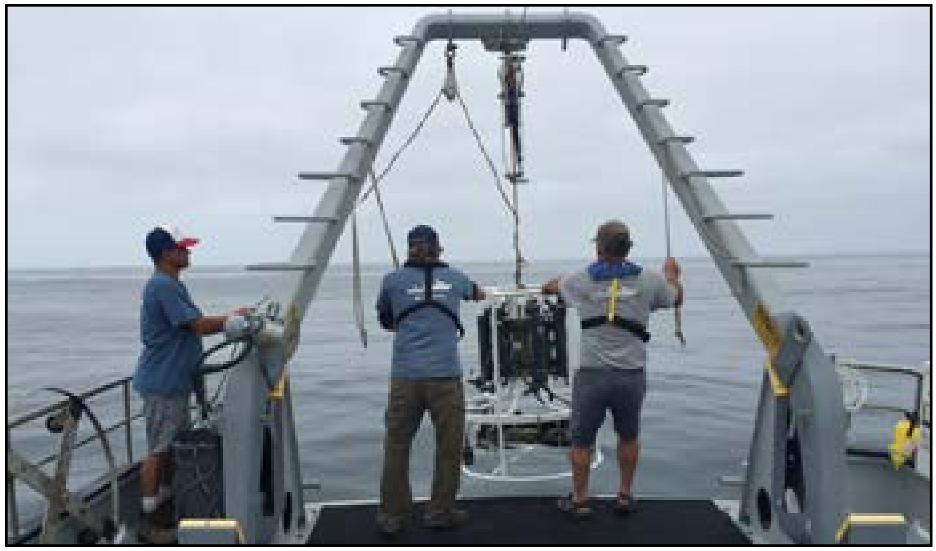

A field crew lowers a CTD (conductivity, temperature, depth) rosette into the ocean to take multiple measurements of seawater chemistry. Field measurements are taken throughout the year to assess the vulnerability of Southern California's coastal waters to ocean acidification.

"These outfalls are continuously discharging into our nearshore waters, and yet we don't know what the impacts on vulnerable species might be," said Dr. Raphael Kudela, a Professor of Ocean Sciences at the University of California, Santa Cruz. "Because there will be huge costs associated with reducing the nutrient content of our discharges, modeling is crucial to knowing if and where we have an opportunity to make a meaningful difference."

Understanding biological impacts

While the West Coast modeling effort will illuminate how seawater is being chemically altered by land-based discharges, it is the way that ecosystems respond to these chemical changes that is of ultimate management concern.

To that end, SCCWRP and its research partners have begun working to understand the relationship between chemical alterations to seawater and changes in the health and distribution of marine organisms. Researchers' goal is to develop tools that allow West Coast managers to assess the impacts of acidification and hypoxia by tracking the health of sentinel marine organisms.

Foundational to this work is developing agreed-upon thresholds at which sensitive marine species begin to experience specific impacts, ranging from shell dissolution to impaired reproduction to mortality.

SCCWRP and its partners began building this scientific foundation in fall 2017, convening an expert advisory panel to reach scientific consensus on biologically relevant acidification thresholds for pteropods, or sea snails.

Pteropods, which depend on minerals in seawater to form their highly soluble calcified shells, are among a handful of sentinel species that researchers intend to use as biological indicators of the pace and intensity with which acidification and hypoxia are impacting coastal ecosystems.

By combining data on biological impacts with chemistry-based field data and West Coast modeling projections, researchers will be able to produce "hotspot" maps that reveal which areas along the West Coast are particularly vulnerable to acidification and hypoxia.

These hotspot maps – when contextualized with information on the locations of nutrient-intensive discharges, designated fisheries zones and ecologically protected coastal areas – will help coastal managers determine the most effective courses of action to combat acidification and hypoxia.

For example, managers might decide that certain Marine Protected Areas (MPAs) in California are not well-suited

Pteropods as early-warning indicators

An advisory panel of scientific experts on pteropods, or sea snails, was convened by SCCWRP in fall 2017 to agree on what thresholds for aragonite saturation state are necessary to protect the health of these acidification-sensitive organisms. Environmental managers will be able to use the panel's recommendations to develop programs and policies that are based on an important early-warning indicator of how ocean acidification's impacts could ripple through marine food webs.

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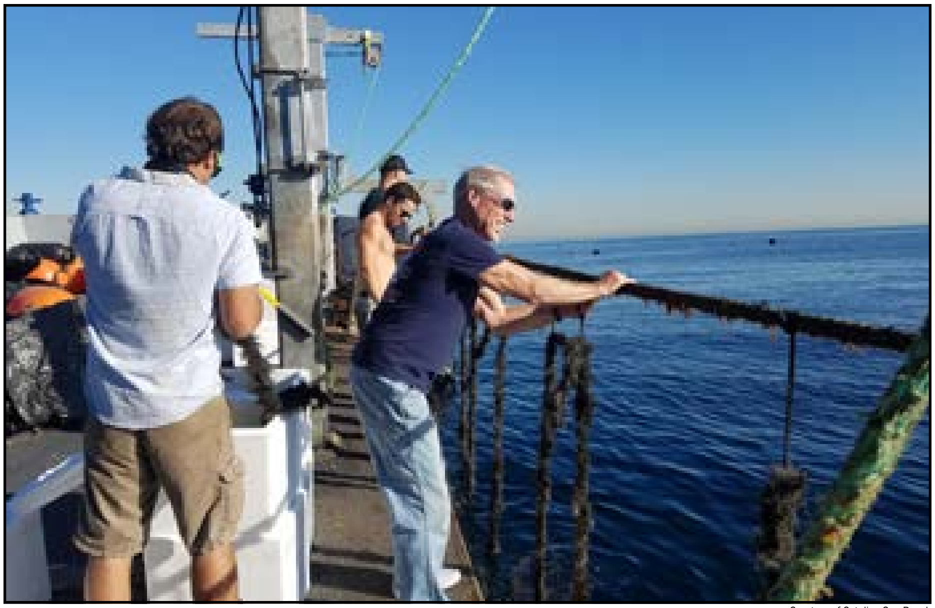

Courtesy of Catalina Sea Ranch

A field crew from Catalina Sea Ranch deploys kelp seedlings that will be grown on ropes suspended in the ocean off Catalina Island. Researchers are interested in evaluating the potential of aqua-farms to remove dissolved carbon dioxide from seawater via photosynthesis.

to serve as refuges for vulnerable marine communities as acidification intensifies. In response, they could put more focus and resources on protecting and enhancing quality of life in other MPAs that can effectively serve as refugia.

Similarly, if nutrient-heavy discharges are being released in areas that will be particularly vulnerable to intensifying acidification, managers might decide to redirect those discharges or reduce the nutrient concentrations of those discharges.

"We need to know what strategies are going to offer the biggest bang for the buck," said Jennifer Phillips, Climate Change Policy Lead for the California Ocean Protection Council. "Science helps us boil down a universe of possible actions into just a few that we have a high degree of confidence will be effective."

Other approaches to mitigating impacts

Understanding the impacts of land-based discharges on coastal waters is not the only approach that environmental managers and researchers are taking to understand how to alleviate the ecological impacts of ocean acidification.

Across the West Coast, researchers also are exploring how to tap into the natural ability of aquatic plants to remove dissolved carbon dioxide from water via photosynthesis. Like plants on land, aquatic plants take up carbon dioxide from water and release oxygen into water during photosynthetic processes. The carbon is fixed and stored in plant tissues.

As part of ongoing efforts to restore seagrass beds and cultivate kelp farms in shallow coastal environments, researchers are documenting how much carbon these underwater plants can remove from surrounding waters. The goal is to understand the environmental conditions and factors that will optimize the carbon sequestration potential of these plants.

In Southern California, SCCWRP is part of a four-year project led by the University of California, Irvine, examining how to optimally build underwater kelp farms suspended in the water column. While this study is focused on developing modeling systems that can optimize farm designs and environmental conditions for growing kelp in coastal waters off Catalina Island, researchers also are interested in examining whether kelp can meaningfully lower dissolved carbon dioxide levels.

Unlike natural kelp forests and seagrass beds that return much of their sequestered carbon to the water as they die and decompose, the harvested kelp – which can grow up to two feet a day – would be removed permanently from coastal waters, ensuring the sequestration process does not become a net-neutral proposition.

West Coast researchers hope that underwater kelp farms, in tandem with seagrass restoration efforts, hold promise to help buffer coastal waters from intensifying acidification.

"If we can show that solutions like this make a meaningful difference to improve seawater chemistry, we're going to be unlocking a whole arena of management options for mitigating coastal acidification," said Phil Cruver, CEO of Catalina Sea Ranch, an aquaculture company. "This is exactly the sort of out-of-the-box thinking we're going to need going forward."

Courtesy of National Oceanic and Atmospheric Administration

As part of efforts to restore seagrass beds in shallow coastal environments, researchers are examining whether this aquatic plant can remove dissolved carbon dioxide from seawater via natural photosynthetic processes.

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Accomplishments

SCCWRP is a national leader in aquatic sciences research, with a comprehensive research agenda that spans a diverse array of water-quality issues confronting the environmental management community.

SCCWRP mission

To enhance the scientific foundation for management of Southern California's ocean and coastal watershed resources

Research themes

SCCWRP research agenda is organized around nine major thematic areas

34 Number of peer-reviewed journal articles and book chapters co-authored by SCCWRP that appear in this Annual Report

22 Number of technical reports co-authored by SCCWRP that appear in this Annual Report

107 Number of leadership roles that SCCWRP scientists hold with professional societies, advisory committees and editorial boards of scientific journals **Page 65**

Information Technology and Visualization

With an ever-present need to improve the technology used to monitor and assess the health of aquatic ecosystems, SCCWRP is working to build next-generation tools that enhance environmental managers' ability to collect, store, standardize, share and visualize data.

Bioassessment

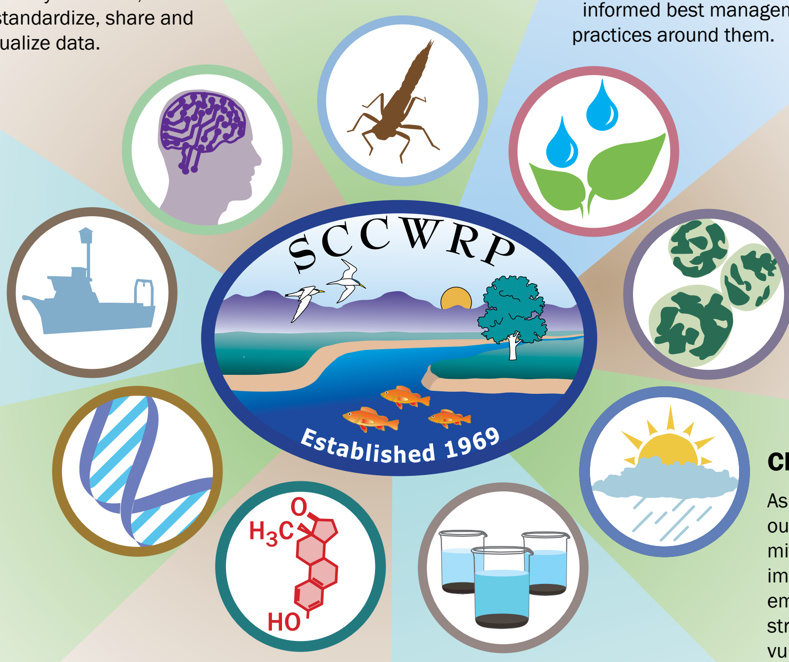
As environmental managers increasingly turn to measuring the health of aquatic systems through biological assessments – or bioassessment – SCCWRP is developing next-generation approaches that use benthic inverte-brates, algae and other organisms to evaluate ecological condition across a variety of environments, from streams to the coastal ocean.

Ecohydrology

As environmental managers work to protect aquatic systems and the biological communities they support from human-induced alterations to hydrological flow patterns, SCCWRP is working to better understand these ecohydrological relationships and how to develop science-informed best management practices around them.

Regional Monitoring

To give environmental managers comprehensive, big-picture snapshots of the condition of aquatic systems and how they are changing over time, SCCWRP facilitates the design and execution of multi-agency regional monitoring – notably, the Southern California Bight Regional Monitoring Program and the Southern California Stormwater Monitoring Coalition Regional Watershed Monitoring Program.



Eutrophication

With anthropogenic nutrient inputs a leading cause of eutrophication – or accelerated accumulation of organic matter from overgrowth of aquatic plants and algae – SCCWRP is working to help environmental managers understand the deleterious impacts of excessive nutrients and how they can more effectively manage nutrient loading to water bodies.

Microbial Water Quality

With runoff and discharge introducing potentially pathogenic waterborne microbes into coastal waters, especially at populated beaches, SCCWRP is working to more rapidly and effectively detect this microbial contamination, identify the source(s) of the contamination, and understand the risk of illness from water contact.

Climate Change

As environmental managers seek out next-generation solutions for mitigating and offsetting the local impacts of global carbon dioxide emissions, SCCWRP is developing strategies to optimally position vulnerable aquatic systems – and the biological communities they support – to cope with and adapt to climate change.

Contaminants of Emerging Concern

To help environmental managers identify which of the tens of thousands of largely unmonitored CECs in aquatic systems pose the greatest potential health risks to wildlife and humans, SCCWRP is developing novel approaches to rapidly and cost-effectively screen water bodies for CECs, connect screening-level monitoring data to higher-level biological responses, and understand exposure routes.

Sediment Quality

To help environmental managers extend greater protections to marine communities affected by contaminated seafloor sediment, SCCWRP is working to understand how this contamination enters food webs and bioaccumulates in fish and wildlife, and how to effectively clean up and remediate its toxic effects.

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Provisional algae-based stream scoring tool developed

SCCWRP and its partners have developed a provisional version of an assessment tool that scores the ecological health of California wadeable streams by analyzing the condition of in-stream algal communities.

The Algal Stream Condition Index (ASCI) is modeled after the California Stream Condition Index (CSCI), co-developed by SCCWRP and unveiled in 2015. While the CSCI uses bottom-dwelling macroinvertebrate communities as biological indicators of stream condition, the ASCI will use stream algal communities.

Multiple stream management agencies, including the Southern California Stormwater Monitoring Coalition, tested and evaluated the performance of the provisional ASCI in 2017. The final version of the tool, expected to be unveiled in summer 2018, will incorporate feedback from these end users.

The ASCI scoring tool will complement the CSCI by providing an additional line of evidence for conducting stream bioassessments. Algae are sensitive to different types of water-quality stressors than bottom-dwelling macroinvertebrate communities, underscoring the value of using both tools in tandem to evaluate stream health.

Algal matter covers the rocky bottom of the Santa Margarita River near Temecula. Researchers have developed a provisional tool for scoring the ecological health of California wadeable streams by analyzing the condition of in-stream algal communities.

Researchers have shown that the ASCI is highly responsive to changes in water chemistry, while the CSCI is responsive to changes in physical habitat.

The ASCI and CSCI will form the technical foundation for a proposed State Water Board wadeable stream biointegrity and biostimulatory policy intended to govern the health of wadeable streams statewide. The ASCI and CSCI will link biological impacts on aquatic life to nutrient enrichment.

Demonstration maps reveal extrapolation limits of stream condition scores

SCCWRP has generated a series of maps that reveal the geographical extent to which ecological condition scores calculated for stream sampling sites may be extrapolated to unsampled reaches upstream and downstream of the sites.

The maps, published in spring 2017, cover six demonstration watersheds across California. They enable stream managers to get a better sense of the areas where they already have sufficient data to estimate overall ecological condition, and the areas where they should consider more intensive sampling to improve confidence.

A stream bioassessment is typically conducted at only a few locations within a watershed, as stream managers don't have the resources to conduct bioassessment work along every stream reach in California.

The project involved application of a new statistical modeling technique known as spatial stream network (SSN) modeling, plus obtaining the consensus of an expert review panel.

Causal assessment approach for streams expands to embayments

SCCWRP and its partners have initiated an effort to determine potential causes of degraded ecological condition in Southern California embayments using an approach originally developed for wadeable streams.

The causal assessment framework, co-developed by SCCWRP for wadeable streams, is being tested on sediment-quality data from Marina del Rey in Los Angeles County. Researchers are using the framework to guide a multi-step data analysis intended to provide insights into the relative importance of various potential causes of stress on sediment-dwelling organisms.

Researchers hope to rank the relative importance of sediment toxics, physical disturbance, eutrophication and water quality in the harbor.

Through this work, researchers will enhance the set of standardized approaches used to interpret sediment-quality data from Southern California embayments; the data already are collected as part of routine monitoring programs.

A field crew collects sediment samples from Marina del Rey Harbor in Los Angeles County. Researchers are analyzing the harbor's sediment-quality data to assess potential causes of degraded ecological condition.

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Transferability of bioassessment indices among water body types and ecoregions: a California experiment in wetland assessment

Eric D. Stein, Jeffrey S. Brown, Raphael D. Mazor

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Abstract

Biological assessment of aquatic resources requires the availability of bioassessment tools that work in all waterbody types and regions of interest. Developing new assessment tools may require several years of data collection and substantial investment of resources, which may not be an option for some aquatic resource managers. Adapting tools developed for different regions or wetland types may be an attractive alternative to developing new indices, provided they work well in the novel setting. In this study, we explore the transferability of two bioassessment indices for application to depressional wetlands in California, which are wetland type of management concern but for which bioassessment tools don't currently exist. We tested the applicability of a depressional wetland invertebrate index of biotic integrity (IBI) developed in the San Francisco Bay region of northern California for application in the drier regions of southern California (i.e. geographic transferability), and the ability to apply a riverine benthic diatom IBI to benthic diatoms in depressional wetlands (i.e. water body type transferability). We evaluated the accuracy and responsiveness of the existing Indices for use in depressional wetlands and refined reference definitions and recalibrated thresholds relative to stressor gradients to maximize index performance. Performance of the adapted indices was compared to that of an existing habitat assessment tool (the California Rapid Assessment Method; CRAM) that has been developed for statewide application of depressional wetlands. Finally, we demonstrate application of the revised indices for ambient assessment of depressional wetland condition in southern California. Recalibrating both the macroinvertebrate and diatom indices to reference thresholds based on nutrient concentrations resulted in lower coefficient of variation among reference sites, greater differentiation between reference and non-reference and stronger relationship with stressors than when reference thresholds were based on landscape disturbance. Overall, the simple adjustment of the reference definition allowed us to transfer the indices with no structural changes to the metrics. This approach can facilitate future index adaptations that allow practitioners to include waterbody types for which there is no current index into routine biomonitoring programs.

Citation

Stein, E.D., J.S. Brown, R.D. Mazor. 2017. Transferability of bioassessment indices among water body types and ecoregions: a California experiment in wetland assessment. *Ecological Indicators* 81:65-73.

SCCWRP Journal Article #0988
Full text available by request: pubrequest@sccwrp.org

Anthropogenic threats to intermittent rivers and ephemeral streams

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Abstract

Intermittent rivers and ephemeral streams (IRES) occur worldwide and make important contributions to freshwater biodiversity and biogeochemical cycles at local, catchment, regional, and global scales (Chapters in Sections 1–4; Datry et al., 2014). IRES in all parts of the world are subject to many of the same human-induced threats as perennial rivers and streams. However, most IRES have far less legal protection than their perennial counterparts (Nikolaidis et al., 2013; Acuña et al., 2014; Chapter 5.3), reflecting the low value that society places on their ecological attributes and ecosystem services (Chapter 5.2). Given this lack of appreciation, IRES are probably under greater threat of degradation than perennial systems. They can serve as sites for the dumping of trash and dredging of sediment or as conduits for waste water disposal and road traffic (Fig. 5.1.1). Furthermore, the natural variability of their flow regimes and hydrological phases, which can result in extended and unpredictable periods of zero flow (Chapters 2.2 and 2.3), means that these activities, along with anthropogenic changes to their hydrology induced by artificial dewatering or augmented flows (Fig. 5.1.1), may be wrongly dismissed as unproblematic. Flow intermittence and the shifting aquatic-terrestrial habitat dynamics of IRES (Chapter 4.9) present challenges to both the aquatic and terrestrial biota inhabiting these systems. The biota must either withstand the episodic unfavorable conditions, such as dry habitat for aquatic biota or flooded habitat for terrestrial biota *in situ* (i.e., exhibit resistance), or escape them to return later when conditions again become favorable (i.e., exhibit resilience). Many taxa that inhabit IRES thus possess adaptive traits of resistance and/or resilience to flow extremes, including drying and flooding (e.g., Bêche et al., 2006; Leigh et al., 2016a; Chapter 4.8). However, anthropogenic activities that alter the natural flow regimes, geomorphology, and water quality of IRES, and even the composition of biotic communities (e.g., via introductions of alien species or clearing of vegetation) may push these ecosystems and biota beyond their adaptation thresholds. In this chapter, we review anthropogenic threats to IRES and their biota, broadly classified into the following (Fig. 5.1.2): hydrological alterations, including withdrawals or additions of water that change inundation durations and the dynamic interplay of aquatic vs terrestrial habitat (as well as altering other ecologically relevant aspects of the flow regime (Poff et al., 2010)); physical and

chemical alterations, including sedimentation, sediment mining, and water pollution that degrade aquatic and terrestrial habitats in IRES; and biological alterations, in particular the introduction or invasion of species that can threaten native communities. We discuss these threats and their individual and interactive effects on IRES, both those that undergo natural flow intermittence and those once-perennial rivers that now undergo anthropogenically induced intermittence and their adjacent ecosystems. Furthermore, we consider how climate change may interact with these threats or even induce hydrological, physical, chemical, and biological alterations directly (Box 5.1.1). Finally, we consider future needs and challenges for research and management to effectively prevent, reduce, or mitigate the impacts of anthropogenic alterations to IRES ecosystems.

CITATION

Chiu, M.-C., C. Leigh, R. Mazor, N. Cid, and V. Resh. 2017. Anthropogenic threats to intermittent rivers and ephemeral streams. in: T. Datry, N. Bonada, and A. Boulton, eds., *Intermittent Rivers and Ephemeral Streams: Ecology and Management*. Academic Press. London, UK.

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Full text available by request: pubrequest@sccwrp.org

Spatial statistical network models to estimate the spatial representativeness of bioassessment samples

Raphael Mazor[1], Peter R. Ode[2], Andrew C. Rehn[2], Eric D. Stein[1]

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[2]*Current address: Council for Watershed Health, Los Angeles, CA*
[3]*Current address: San Diego Regional Water Quality Control Board, San Diego, CA*

CITATION

Mazor, R., P.R. Ode, A.C. Rehn, E.D. Stein. 2017. Spatial statistical network models to estimate the spatial representativeness of bioassessment samples. Technical Report 979. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0979
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/979_SpatialStatisticalNetworkModel2017.pdf

Assessment of episodic streams in the San Diego Region

Raphael D. Mazor[1], Jeff Brown[1], Eric D. Stein[1], John R. Olson[2], Matthew D. Robinson[2], and Theresa Clark[2]

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[2]*California State University, Monterey Bay*

CITATION

Mazor, R.D., J. Brown, E.D. Stein, J.R. Olson, M.D. Robinson, T. Clark. 2017. Assessment of Episodic Streams in the San Diego Region. Technical Report 1011. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1011
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1011_BioIndicatorAssessCondSD_IRES.pdf

Mapping of non-perennial and ephemeral streams in the Santa Ana Region

Marcus Beck[1], Raphael D. Mazor[1], Eric D. Stein[1], Regan Maas[2], Danielle De Mello[2], Danielle Bram[2]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*Center for Geographical Studies, California State University, Northridge*

CITATION

Beck, M., R.D. Mazor, E.D. Stein, R. Maas, D. De Mello, D. Bram. 2017. Mapping of Non-Perennial and Ephemeral Streams in the Santa Ana Region. Technical Report 1012. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1012
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1012_MappingStreamsSantaAna.pdf

Assessment of the condition of San Francisco Bay Area depressional wetlands

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[2]*San Francisco Bay Regional Water Quality Control Board, San Francisco, CA*

CITATION

Stein, E.D., K.B. Lunde, J.S. Brown. 2017. Assessment of the condition of San Francisco Bay Area depressional wetlands. Technical Report 940. Surface Water Ambient Monitoring Program. Sacramento, CA.

SCCWRP Technical Report #940
Full text available online: www.sccwrp.org/documents

Project laying groundwork to develop flow-ecology tools

SCCWRP and its partners have begun laying the groundwork to develop a suite of assessment tools that illuminate how the ecological health of Southern California streams is impacted by alterations to hydrologic flow patterns.

The two-year project, which kicked off in summer 2017, will focus on improving understanding of the relationships between hydrologic flows and ecological condition, especially in light of shifting rainfall and temperature patterns triggered by climate change.

Researchers will explore using various modeling approaches and other assessment tools to help explain these flow-ecology relationships, and investigate the feasibility of developing flow-ecology bioindicators for fish, amphibians and riparian birds.

SCCWRP and its partners previously developed a flow-ecology assessment tool for Southern California streams based on the condition of bottom-dwelling macroinvertebrate communities.

A key priority for researchers when building this scientific foundation for the flow-ecology bioindicator development work is aligning it with an environmental flows statewide assessment framework being developed by a team of technical experts from across California, including SCCWRP. Researchers also are conducting a literature review.

Courtesy of U.S. Geological Survey

The endangered Least Bell's vireo is among the animals that could serve as flow-ecology bioindicator tools to assess the ecological health of streams. Researchers have begun laying the groundwork to develop these tools.

Environmental flows workgroup organizes under Water Quality Monitoring Council

A group of technical experts working to coordinate environmental flow management programs statewide has been recognized as a workgroup of the California Water Quality Monitoring Council.

The recognition, made official in fall 2017, gives the workgroup – which includes participation by SCCWRP – more visibility and accessibility to agency staff as it works to develop a more consistent approach to how watershed managers set ecologically optimal flow targets. The Water Quality Monitoring Council is made up of water-quality management agencies from across California; its goal is to improve coordination of water-quality monitoring and assessment programs statewide.

Environmental flow management has historically not been well-coordinated across California, resulting in fragmentation and inconsistencies among the multiple agencies responsible for setting flow targets.

A group of technical experts, including at SCCWRP, is working to inject more consistency and coordination into environmental flow management programs. Above, the San Diego River flows through Mission Valley.

The workgroup's goals include making environmental flow data more readily accessible and comparable across the state, and establishing a common approach to how various agencies use existing flow management tools and approaches to set flow targets.

Classification of California streams using combined deductive and inductive approaches: Setting the foundation for analysis of hydrologic alteration

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ABSTRACT

Regional classification of streams is an early step in the Ecological Limits of Hydrologic Alteration framework. Many stream classifications are based on an inductive approach using hydrologic data from minimally disturbed basins, but this approach may underrepresent streams from heavily disturbed basins or sparsely gaged arid regions. An alternative is a deductive approach, using watershed climate, land use, and geomorphology to classify streams, but this approach may miss important hydrological characteristics of streams. We classified all stream reaches in California using both approaches. First, we used Bayesian and hierarchical clustering to classify reaches according to watershed characteristics. Streams were clustered into several classes according to elevation, sedimentary rock, and winter precipitation. Permutation-based analysis of variance and random forest analyses were used to determine which hydrologic variables best separate streams into their respective classes. Stream typology (i.e, the class that a stream reach is assigned to) is shaped mainly by patterns of high and mean flow behavior within the stream's landscape context. Additionally, random forest was used to determine which hydrologic variables best separate minimally disturbed reference streams from non-reference streams in each of the seven classes. In contrast to stream typology, deviation from reference conditions is more difficult to detect and is largely defined by changes in low-flow variables, average daily flow, and duration of flow. Our combined deductive/inductive approach allows us to estimate flow under minimally disturbed conditions based on the deductive analysis and compare to measured flow based on the inductive analysis in order to estimate hydrologic change.

CITATION

Pyne, M.I., D.M. Carlisle, C.P. Conrad, E.D. Stein. 2017. Classification of California streams using combined deductive and inductive approaches: Setting the foundation for analysis of hydrologic alteration. *Ecohydrology* DOI:10.1002/eco.1802.

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Full text available by request: pubrequest@sccwrp.org

Application of regional flow-ecology relationships to inform watershed management decisions: Application of the ELOHA framework in the San Diego River Watershed, California, USA

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[2]University of Georgia, Athens, GA
[3]Colorado State University, Fort Collins, CO

ABSTRACT

Relationships between changes in streamflow and changes in biological condition are important considerations for water resources management decisions. The Ecological Limits of Hydrologic Alteration (ELOHA) framework offers a way to protect stream health by managing flow conditions. We demonstrate application of a regionally derived ELOHA framework to inform stakeholder-defined management challenges in the San Diego River Watershed in southern California, USA—a large semi-urbanized watershed that is undergoing land-use changes. Using previously defined flow-ecology relationships based on benthic invertebrate community composition, we: (1) assess how future land use changes will affect flow conditions and impact biological endpoints in the watershed; (2) demonstrate how flow–ecology relationships can be used to prioritize regions of the watershed into various flow management classes that can inform future planning decisions; and (3) evaluate how two future management decisions (specifically, modification of reservoir operations and implementation of low impact development strategies to reduce stormwater runoff) will affect in-stream flow conditions in the watershed. Our study shows a successful transition of regionally derived flow targets to inform local decisions at a catchment or watershed scale, thereby avoiding the need to develop local flow–ecology relationships for every stream of interest (as would be required by other instream flow methods). Case studies are a critical bridge between the science of flow-ecology and real-world implementation, and this work illuminates an example of how to navigate technical and management challenges and provide road maps for broader applications by including local stakeholders in defining, interpreting, and implementing products of flow-ecology analyses.

CITATION

Stein, E.D., A. Sengupta, R.D. Mazor, K. McCune, B.P. Bledsoe, S. Adams. 2017. Application of regional flow-ecology relationships to inform watershed management decisions: Application of the ELOHA framework in the San Diego River Watershed, California, USA. *Ecohydrology* 10:e1869.

SCCWRP Journal Article #0992
Full text available by request: pubrequest@sccwrp.org

Predicting hydromodification in streams using non-linear memory based algorithms: a southern California case study

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Abstract

Hydromodification is a serious management concern in semiarid regions and is expected to become worse with land use and climate change. Potential stream channel responses range from increased or decreased sediment loads, incision, and dramatic non-equilibrated channel enlargements. The prevalence of hydromodification, particularly in semiarid regions, creates a need for new predictive tools that can support decisions aimed at reducing or mitigating hydromodification effects in a large geographical region. Existing models to screen and predict hydromodification are limited in terms of performance and require time and data. This paper examines three nonlinear learning algorithms—support vector machines, artificial neural networks, and random forests—for predicting changes in stream channel morphology as an indicator of hydromodification. The authors explore the ability of each algorithm to rank the important variables that explain the degree of channel response for streams located in Southern California. Results suggest that variables pertaining to the stream bank morphology, such as bank angle, maximum bank height, and bottom widths, rank high in their ability to predict hydromodification. Among the three algorithms, random forest performance is robust compared to artificial neural networks and support vector machines, given its ability to accommodate small data sample sizes and minimal data preprocessing. The study shows that for complex responses, such as hydromodification of stream channels, preprocessing will continue to be a necessary step for nonlinear algorithms. With proper guidance, there is potential for using nonlinear algorithms to assess stream reaches vulnerable to hydromodification and inform management decisions to manage streamflow and runoff in southern California.

Citation

Sengupta, A., R.J. Hawley, and E.D. Stein. 2018. Predicting hydromodification in streams using non-linear memory based algorithms: a southern California case study. *Journal of Water Resources Planning and Management* DOI:10.1061/(ASCE)WR.1943-5452.0000853.

SCCWRP Journal Article #1006
Full text available by request: pubrequest@sccwrp.org

Development of recommended flow targets to support biological integrity based on regional flow-ecology relationships for benthic macroinvertebrates in Southern California Streams

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[5]California Department of Fish and Wildlife, Sacramento, CA

Citation

Stein, E.D., R.D. Mazor, A. Sengupta, K. McCune, B. Bledsoe, S. Adams, S. Eberhart, M. Pyne, P. Ode, and A. Rehn. 2017. Development of recommended flow targets to support biological integrity based on regional flow-ecology relationships for benthic macroinvertebrates in Southern California Streams. Technical Report 974. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0974
Full text available online: www.sccwrp.org/documents

Acidification model undergoes validation using field data

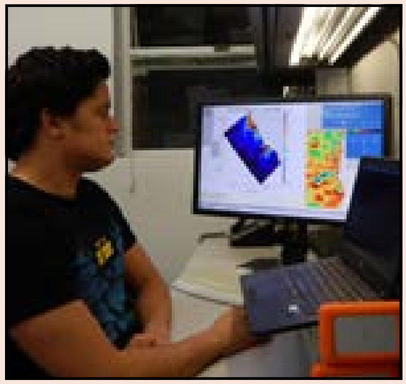
Researchers working to develop a West Coast computer model that predicts how land-based sources of nutrients influence ocean acidification and hypoxia in nearshore coastal waters have initiated a two-year effort to evaluate the accuracy of the model's predictions.

The model validation step, launched in spring 2017, involves using field data collected from the Southern California Bight to determine how accurately the computer model predicts acidification and hypoxia, or low dissolved-oxygen levels, across the Bight continental shelf.

Validating the model's performance with locally collected data will give managers increased confidence that the model's predictions can be used reliably for management decision-making.

The Bight validation data sets are made up of measurements of key biogeochemical cycling rates and processes, including primary production, respiration and nitrification.

SCCWRP's wastewater treatment member agencies collected the "process studies" data in the field and then reviewed and approved the data for use by the West Coast modelers.



Researchers are using field data collected from across the Southern California Bight to validate a West Coast ocean acidification computer model.

The West Coast acidification modeling effort, of which SCCWRP is a part, is a five-year initiative to help West Coast managers understand which marine habitats are most vulnerable to ocean acidification and to what extent local, land-based source of nutrients are exacerbating acidification conditions.

By feeding the biogeochemical cycling validation data into a downscaled Bight acidification model, researchers will be able to gauge how accurately it predicts how the ecosystem responds when nutrients are introduced to coastal waters.

Field data collection completed for Santa Margarita River nutrient management study

SCCWRP and its partners have completed field data collection for a three-year project seeking to establish scientifically defensible nutrient loading targets for reducing eutrophication and improving biological integrity in the Santa Margarita River watershed.

The data collection phase, which wrapped up in fall 2017, will enable researchers to develop an integrated toolkit of mechanistic computer models and empirical statistical models that water-quality managers can use to optimally protect biointegrity and human uses in the lower mainstem of the Santa Margarita River.

The tools and concepts being developed and applied to Santa Margarita are expected to influence how nutrient management is approached in eutrophic wadeable stream systems across California.

The Santa Margarita River watershed, which spans Riverside and San Diego Counties, has been grappling with excess nutrient inputs.

20 years of nutrient input data compiled for acidification model

SCCWRP and its partners have compiled a series of data sets reflecting the contributions of major sources of nutrients to the Southern California Bight over the past 20 years, part of a five-year effort to develop a computer model that explains how West Coast ecosystems respond to these nutrient inputs.

The work, completed in 2017, involved gathering data on a variety of local land-based and atmospheric discharges, including treated wastewater effluent, land-based runoff, atmospheric deposition and local atmospheric conditions. Researchers modeled the way that each source contributes nutrients to Bight coastal waters; SCCWRP member agencies helped compile much of the data.

The land-based runoff data included discharges of natural, point and non-point sources from coastal watersheds into rivers.

The data are being used to evaluate the performance of a computer model that predicts how land-based sources of nutrients influence West Coast acidification and hypoxia conditions.

Researchers are seeking to validate the model's ability to accurately reflect biogeochemical cycling patterns in the Bight that result from the introduction of human-created nutrient sources from air and land.

Courtesy of Sanitation Districts of Los Angeles County

A wastewater outfall discharges a plume of treated effluent into the Southern California Bight about two miles from shore. Data on major nutrient sources to coastal waters, including from wastewater outfalls, have been compiled for a modeling effort that will illuminate how ecosystems respond to these nutrient inputs.

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New insights into impacts of anthropogenic nutrients on urban ecosystem processes on the southern California coastal shelf: Introduction and synthesis

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ABSTRACT

Anthropogenic nutrients inputs are one of the most important factors contributing to eutrophication of coastal waters. Coastal upwelling regions are naturally highly variable, exhibiting faster flushing and lower retention times than estuarine systems. As such, these regions are considered more resilient to anthropogenic influences than other coastal waters. Recent studies have shown our perception of the sustainability of these systems may be flawed and that anthropogenic nutrients can have an impact at local and regional spatial scales within these larger upwelling ecosystems. Maintenance of an outfall pipe discharging wastewater effluent to the Southern California Bight (SCB) provided an opportunity to study effects of anthropogenic nutrients inputs on a near-shore coastal ecosystem. The diversion of wastewater effluent from a primary, offshore outfall to a secondary, near-shore outfall set up a large-scale, *in situ* experiment allowing researchers to track the fate of wastewater plumes as they were "turned off" in one area and "turned on" in another. In this introduction to a special issue, we synthesize results of one such wastewater diversion conducted by the Orange County Sanitation District (OCSD) during fall 2012. Anthropogenic nitrogen (N) from point-source discharges altered biogeochemical cycling and the community composition of bacteria and phytoplankton. Nitrification of ammonium to nitrate in wastewater effluent close to outfalls constituted a significant source of N utilized by the biological community that should be considered in quantifying "new" production. The microbial-loop component of the plankton community played a significant role, exemplified by a large response of heterotrophic bacteria to wastewater effluent that resulted in nutrient immobilization within the bacterial food web. This response, combined with the photosynthetic inhibition of phytoplankton due to disinfection byproducts, suppressed phytoplankton responses. Our findings have ramifications for future studies and regulatory monitoring, emphasizing the need to consider chemical and biological responses to wastewater effluent in assessing effects of anthropogenic nutrient inputs on urbanized coastal ecosystems.

CITATION

Howard, M.D.A., R.M. Kudela, K. McLaughlin. 2017. New insights into impacts of anthropogenic nutrients on urban ecosystem processes on the Southern California coastal shelf: Introduction and synthesis. *Estuarine, Coastal and Shelf Science* 186:163-170.

SCCWRP Journal Article #0964
Full text available by request: pubrequest@sccwrp.org

Evaluation of uptake kinetics during a wastewater diversion into nearshore coastal waters in southern California

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ABSTRACT

The global eutrophication of coastal ecosystems from anthropogenic nutrients is one of the most significant issues affecting changes to coastal oceans today. A three-week diversion of wastewater effluent from the normal offshore discharge pipe (7 km offshore, 56 m depth) to a shorter outfall located in 16 m water (2.2 km offshore) as part of the 2012 Orange County Sanitation District Diversion provided an opportunity to evaluate the impacts of anthropogenic nitrogen on phytoplankton community response. Nitrogen uptake kinetic parameters were used to evaluate the short-term physiological response of the phytoplankton community to the diverted wastewater and to determine if potential ammonium suppression of nitrate uptake was observed. Despite expectations, there was a muted response to the diversion in terms of biomass accumulation and ambient nutrients remained low. At ambient nitrogen concentrations, calculated uptake rates strongly favored ammonium. During the diversion based on the kinetic parameters determined during short-term experiments, the phytoplankton community was using all three N substrates at low concentrations, and had the capacity to use urea, then ammonium, and then nitrate at high concentrations. Ammonium suppression of nitrate uptake was evident throughout the experiment, with increasing suppression through time. Despite this interaction, there was evidence for simultaneous utilization of nitrate, ammonium, and urea during the experiment. The general lack of phytoplankton response as evidenced by low biomass during the diversion was therefore not obviously linked to changes in uptake rates, physiological capacity, or ammonium suppression of nitrate uptake.

CITATION

Kudela, R.M., M.D.A. Howard, K. Hayashi, C. Beck. 2017. Evaluation of uptake kinetics during a wastewater diversion into nearshore coastal waters in southern California. *Estuarine, Coastal and Shelf Science* 186:237-249.

SCCWRP Journal Article #0981
Full text available by request: pubrequest@sccwrp.org

Response of phytoplankton and bacterial biomass during a wastewater effluent diversion into nearshore coastal waters

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[5]*Monterey Bay Aquarium Research Institute, Moss Landing, CA*
[6]*Orange County Sanitation District, Fountain Valley, CA*

ABSTRACT

A 3-week diversion of the Orange County Sanitation District effluent discharge into nearshore waters off Newport Beach, CA constituted a considerable injection of secondarily-treated effluent into the coastal ecosystem. The location ≈1.6 km from shore, shallow water depth (≈16 m), volume and nutrient content of the discharge (≈5.3 x 108 L day^{-1} of effluent with inorganic nitrogen concentration >2 mM) during the diversion raised concerns regarding the potential for stimulating phytoplankton blooms and, in particular, blooms of toxic species. Remarkably, phytoplankton standing stocks during the event and shortly thereafter did not reach values associated even with minor blooms historically observed in the region (generally <5 µg 1^{-1}), although shifts in community composition were observed. Diatom abundances increased early during the diversion, dinoflagellates, phototrophic picoplanktonic eukaryotes and other algae increased mid-diversion, and cyanobacteria (Synechococcus, Prochlorococcus) increased near the end of the diversion. Concentrations of domoic acid (a phycotoxin commonly present in the area) remained near or below detection throughout the diversion, and abundances of potentially-harmful algal species were unresponsive. Bacterial biomass increased during the diversion, and equaled or exceeded total phytoplankton biomass in most samples. Abundances of microbial grazers were also elevated during the diversion. We speculate that nutrient uptake by the bacterial biomass, acting in concert with or a response to a negative effect of disinfection byproducts associated with chlorination on phytoplankton physiology, played a significant role in muting the response of the phytoplankton to nutrients released in the effluent.

CITATION

Caron, D.A., A.G. Gellene, J. Smith, E.L. Seubert, V. Campbell, G.S. Sukhatme, B. Seegers, B.H. Jones, A.Y. Lie, R. Terrado, M.D.A Howard, R.M. Kudela, K. Hayashi, J. Ryan, J. Birch, E. Demir-Hilton, K. Yamahara, C. SCholin, M. Mengel, G. Robertson. 2017. Classification of California streams using combined deductive and inductive approaches: Setting the foundation for analysis of hydrologic alteration. *Coastal and Shelf Science* 186:223-236.

SCCWRP Journal Article #0982
Full text available by request: pubrequest@sccwrp.org

Death from below: Investigation of inhibitory factors in bloom development during a wastewater effluent diversion

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ABSTRACT

Eutrophication of coastal waters is an urgent and globally increasing problem. A significant source of nutrients to Southern California coastal waters is direct discharge of secondarily treated wastewater effluent from regional Publicly Owned Treatment Works. The planned diversion of treated wastewater from the Orange County Sanitation District's main (5-mile) pipe to a shallow 1-mile pipe off Huntington Beach, CA in autumn 2012 provided an unprecedented opportunity to monitor the response of the coastal phytoplankton community to a major anthropogenic loading event. Despite the continuous release of approximately 11.07 x 10^6 m3 of effluent containing 1743 µM ammonium, there was virtually no detectable change in phytoplankton biomass, in striking contrast to the harmful algal bloom dominated community that quickly developed in response to a comparable diversion in Santa Monica Bay in 2006. Field and laboratory studies demonstrate that disinfection byproducts associated with enhanced dichlorination were present in the discharged water, and that these compounds had a strong inhibitory impact on phytoplankton photophysiology and growth, lasting 24 hours for photosynthetic performance and at least 3 days for growth, assessed as change in chlorophyll. Thus, the perhaps fortuitous unintended consequence of enhanced chlorination was the production of inhibitory compounds that suppressed the potential phytoplankton response over a large swath of the continental shelf during the diversion.

CITATION

Kudela, R.M., A.J. Lucas, K. Hayashi, M. Howard, K. McLaughlin. 2017. Death from below: Investigation of inhibitory factors in bloom development during a wastewater effluent diversion. *Estuarine, Coastal and Shelf Science* 186:209-222.

SCCWRP Journal Article #0980
Full text available by request: pubrequest@sccwrp.org

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Rapid nitrification of wastewater ammonium near coastal ocean outfalls, southern California, USA

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[2]*University of California, Santa Cruz, CA*
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Abstract

In the southern California Bight (SCB), there has been a longstanding hypothesis that anthropogenic nutrient loading is insignificant compared to the nutrient loading from upwelling. However, recent studies have demonstrated that, in the nearshore environment, nitrogen (N) flux from wastewater effluent is equivalent to the N flux from upwelling. The composition of the N pool and N:P ratios of wastewater and upwelled water are very different and the environmental effects of wastewater discharges on coastal systems are not well characterized. Capitalizing on routine maintenance of the Orange County Sanitation District's ocean outfall, wherein a wastewater point source was "turned off" in one area and "turned on" in another for 23 days, we were able to document changes in coastal N cycling, specifically nitrification, related to wastewater effluent. A "hotspot" of ammonium (NH_4^+) and nitrite (NO_2^-) occurred over the ocean outfall under normal operations and nitrification rates were significantly higher offshore when the deeper outfall pipe was operating. These rates were sufficiently high to transform all effluent NH_4^+ to nitrate (NO_3^-). The dual isotopic composition of dissolved NO_3^- ($\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$) indicated that N-assimilation and denitrification were low relative to nitrification, consistent with the relatively low chlorophyll and high dissolved oxygen levels in the region during the study. The isotopic composition of suspended particulate organic matter (POM) recorded low $\delta^{15}N_{PN}$ and $\delta^{13}C_{PN}$ values around the outfall under normal operations suggesting the incorporation of "nitrified" NO_3^- and wastewater dissolved organic carbon into POM. Our results demonstrate the critical role of nitrification in nitrogen cycling in the nearshore environment of urban oceans.

Citation

McLaughlin, K., N. Nezlin, M.D.A. Howard, C.D.A. Beck, R.M. Kudela, M.L. Mengel, G.L. Robertson. 2017. Rapid nitrification of wastewater ammonium near coastal ocean outfalls, Southern California, USA. *Estuarine, Coastal and Shelf Science* 186:263-275.

SCCWRP Journal Article #0952
Full text available by request: pubrequest@sccwrp.org

Multiple stressors at the land-sea interface: Cyanotoxins at the land-sea interface in the Southern California Bight

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[2]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[3]*San Diego Regional Water Quality Control Board, San Diego, CA*
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Abstract

Blooms of toxic cyanobacteria in freshwater ecosystems have received considerable attention in recent years, but their occurrence and potential importance at the land-sea interface has not been widely recognized. Here we present the results of a survey of discrete samples conducted in more than fifty brackish water sites along the coastline of southern California. Our objectives were to characterize cyanobacterial community composition and determine if specific groups of cyanotoxins (anatoxins, cylindrospermopsins, microcystins, nodularins, and saxitoxins) were present. We report the identification of numerous potentially harmful taxa and the co-occurrence of multiple toxins, previously undocumented, at several locations. Our findings reveal a potential health concern based on the range of organisms present and the widespread prevalence of recognized toxic compounds. Our results raise concerns for recreation, harvesting of finfish and shellfish, and wildlife and desalination operations, highlighting the need for assessments and implementation of monitoring programs. Such programs appear to be particularly necessary in regions susceptible to urban influence.

Citation

Tatters, A.O., M.D.A. Howard, C. Nagoda, L. Busse, A.G. Gellene, D.A. Caron. 2017. Multiple stressors at the land-sea interface: Cyanotoxins at the land-sea interface in the Southern California Bight. *Toxins* 9:95.

SCCWRP Journal Article #0989
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/989_MultipleStressorsCyanotoxinsSoCalBight.pdf

Microcystin prevalence throughout lentic waterbodies in southern California

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[1]Southern California Coastal Water Research Project, Costa Mesa, CA
[2]San Diego Regional Water Quality Control Board, San Diego, CA
[3]Department of Ocean Sciences, University of California, Santa Cruz, Santa Cruz, CA
[4]Department of Biological Sciences, University of Southern California, Los Angeles, CA
[5]German Federal Environmental Agency, Dessau, Germany

ABSTRACT

Toxin producing cyanobacterial blooms have increased globally in recent decades in both frequency and intensity. Despite the recognition of this growing risk, the extent and magnitude of cyanobacterial blooms and cyanotoxin prevalence is poorly characterized in the heavily populated region of southern California. Recent assessments of lentic waterbodies (depressional wetlands, lakes, reservoirs and coastal lagoons) determined the prevalence of microcystins and, in some cases, additional cyanotoxins. Microcystins were present in all waterbody types surveyed although toxin concentrations were generally low across most habitats, as only a small number of sites exceeded California's recreational health thresholds for acute toxicity. Results from passive samplers (Solid Phase Adsorption Toxin Tracking (SPATT)) indicated microcystins were prevalent throughout lentic waterbodies and that traditional discrete samples underestimated the presence of microcystins. Multiple cyanotoxins were detected simultaneously in some systems, indicating multiple stressors, the risk of which is uncertain since health thresholds are based on exposures to single toxins. Anatoxin-a was detected for the first time from lakes in southern California. The persistence of detectable microcystins across years and seasons indicates a low-level, chronic risk through both direct and indirect exposure. The influence of toxic cyanobacterial blooms is a more complex stressor than presently recognized and should be included in water quality monitoring programs.

CITATION

Tatters, A.O., M.D.A. Howard, C. Nagoda, L. Busse, A.G. Gellene, D.A. Caron. 2017. Multiple stressors at the land-sea interface: Cyanotoxins at the land-sea interface in the Southern California Bight. *Toxins* 9:95.

SCCWRP Journal Article #0997
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/997_MicrocystinPrevalenceThroughoutLenticWaterbodies.pdf

Novel analyses of long-term data provide a scientific basis for chlorophyll-a thresholds in San Francisco Bay

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ABSTRACT

San Francisco Bay (SFB), USA, is highly enriched in nitrogen and phosphorus, but has been resistant to the classic symptoms of eutrophication associated with over-production of phytoplankton. Observations in recent years suggest that this resistance may be weakening, shown by: significant increases of chlorophyll-a (*chl-a*) and decreases of dissolved oxygen (DO), common occurrences of phytoplankton taxa that can form Harmful Algal Blooms (HAB), and algal toxins in water and mussels reaching levels of concern. As a result, managers now ask: what levels of *chl-a* in SFB constitute tipping points of phytoplankton biomass beyond which water quality will become degraded, requiring significant nutrient reductions to avoid impairments? We analyzed data for DO, phytoplankton species composition, *chl-a*, and algal toxins to derive quantitative relationships between three indicators (HAB abundance, toxin concentrations, DO) and *chl-a*. Quantile regressions relating HAB abundance and DO to *chl-a* were significant, indicating SFB is at increased risk of adverse HAB and low DO levels if *chl-a* continues to increase. Conditional probability analysis (CPA) showed *chl-a* of 13 mg m^{-3} as a "protective" threshold below which probabilities for exceeding alert levels for HAB abundance and toxins were reduced. This threshold was similar to *chl-a* of 13-16 mg m^{-3} that would meet a SFB-wide 80% saturation Water Quality Criterion (WQC) for DO. Higher "at risk" *chl-a* thresholds from 25 to 40 mg m^{-3} corresponded to 0.5 probability of exceeding alert levels for HAB abundance, and for DO below a WQC of 5.0 mg L^{-1} designated for lower South Bay (LSB) and South Bay (SB). We submit these thresholds as a basis to assess eutrophication status of SFB and to inform nutrient management actions. This approach is transferrable to other estuaries to derive *chl-a* thresholds protective against eutrophication.

CITATION

Sutula, M., R. Kudela, J.D. Hagy, L.W. Harding, D. Senn, J.E. Cloern, S. Bricker, R. Dugdale, G.M. Berg, and M. Beck. 2017. Novel analyses of long-term data provide a scientific basis for chlorophyll-a thresholds in San

In some places, in some cases, and at some times, harmful algal blooms are the greatest threat to inland water quality

Bryan W. Brooks[1], James M. Lazorchak[2], Meredith D.A. Howard[3], Mari-Vaughn V. Johnson[4], Steve L. Morton[5], Dawn A.K. Perkins[6], Euan D. Reavie[7], Geoffrey I. Scott[8], Stephanie A. Smith[9,10], Jeffery A. Stevens[11]

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[3]Southern California Coastal Water Research Project, Costa Mesa, CA
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[10]Yellow-Springs Instruments, A Xylem Company, Yellow Springs, OH
[11]U.S. Geological Survey, Columbia, MO

ABSTRACT

The summer season brings surges in outdoor recreational activities each year, with increased visitor attendance to National Parks and protected areas and annual peaks in fishing and swimming in many rivers, lakes, and beaches. The warmer months routinely bring field sampling campaigns for environmental scientists, time for academics to catch up following final exams, and vacations with family or friends. Unfortunately, headlines in North America during summer 2016 reminded us that the incidence of harmful algal blooms (HABs), particularly of cyanobacteria, also tends to increase in summer months and cause impairment to inland recreational waterbodies. In addition to the highly publicized issues in Lake Erie and the HAB event stretching hundreds of miles in the Ohio River, other inland water bodies were impacted by HABs from the east to west coasts of the United States. A state of emergency was declared in four Florida counties, Utah closed access to Utah Lake, and California responded to multiple HAB events from the southern to northern parts of the state. Similarly, HABs severely impacted water quality of inland systems in many other regions of the world.

CITATION

Brooks, B.W., J.M. Lazorchak, M.D.A. Howard, M-V.V. Johnson, S.L. Morton, D.A.K. Perkins, E.D. Reavie, G.I. Scott, S.A. Smith, J.A. Stevens. 2017. In some places, in some cases, and at some times, harmful algal blooms are the greatest threat to inland water quality. *Environmental Toxicology and Chemistry* 36:1125-1127.

SCCWRP Journal Article #1003
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/1003_HarmfulAlgalBloomsWaterQuality.pdf

Status of eutrophication in San Elijo Lagoon and relevance for its restoration

Martha Sutula, David J. Gillett, Aaron Jones

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Sutula, M., D.J. Gillett, A. Jones. 2017. Status of eutrophication in San Elijo Lagoon and relevance for its restoration. Technical Report 938. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0938
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/938_SanElijoLagoon.pdf

Scientific basis to assess the effects of nutrients on San Francisco Bay beneficial uses

Martha Sutula, David Senn

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Sutula, M., and D. Senn. 2017. Scientific Basis to Assess the Effects of Nutrients on San Francisco Bay Beneficial Uses. Technical Report 864. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0864
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/864_SFBayAssessmentFramework.pdf

Spatial and temporal patterns of chlorophyll concentration in the Southern California Bight

Nikolay P. Nezlin1, Karen McLaughlin[1], J. Ashley T. Booth[2], Curtis L. Cash[2], Dario W. Diehl[1], Kristen Davis[3], Adriano Feit[4], Ralf Goericke[5], Joseph R. Gully[6], Meredith D.A. Howard[1], Scott Johnson[7], Ami Latker[4], Michael J. Mengel[8], George L. Robertson[8], Alex Steele[6], Laura Terriquez[8], Libe Washburn[9], Stephen B. Weisberg[1]

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[9]University of California, Santa Barbara, Santa Barbara, CA

CITATION

Nezlin, N.P., K. McLaughlin, J.A.T. Booth, C.L. Cash, D.W. Diehl, K. Davis, A. Feit, R. Goericke, J.R. Gully, M.D.A. Howard, S. Johnson, A. Latker, M.J. Mengel, G.L. Robertson, A. Steele, L. Terriquez, L. Washburn, S.B. Weisberg. 2017. Spatial and Temporal Patterns of Chlorophyll Concentration in the Southern California Bight. Technical Report 998. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0998
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/998_BightChlorophyllPatterns.pdf

Pteropod experts convened to develop acidification thresholds

SCCWRP has convened a 10-member panel of leading global experts on pteropods, or sea snails, to develop consensus around biologically relevant thresholds at which these ubiquitous marine calcifying organisms are affected by ocean acidification (OA).

The international pteropod panel, convened in fall 2017, is the first of three expert panels that will be convened and facilitated by SCCWRP and its partners over the next few years. Researchers' goal is to use the consensus opinion of experts to develop an interpretation framework that coastal resource managers can use to glean ecologically relevant insights from the copious data they collect via chemistry-based measures of OA, including seawater pH.

Pteropods, which depend on minerals in seawater to form their highly soluble calcified shells, are sensitive to changes in seawater chemistry, enabling them to serve as early-warning indicators for how ocean acidification can be expected to impact the health of marine ecosystems.

During three days of deliberations, the international pteropod panel reached consensus on the biological tipping points at which various specific environmental conditions linked to intensifying acidification in the California Current Ecosystem are expected to trigger specific biological changes in pteropods and similar calcifying organisms. Seminal biological impacts include shell dissolution, mortality and problems with egg development.

Courtesy of National Oceanic and Atmospheric Administration

Pteropods are sensitive to ocean acidification, enabling researchers to use them as early-warning indicators for how ocean acidification can be expected to impact the health of marine ecosystems.

Model evaluates vulnerability of 96 wetlands to sea level rise

SCCWRP and its partners have developed a vulnerability index model that predicts how all of Southern California's major coastal wetland sites will be impacted by sea level rise over the next century.

The wetlands vulnerability index, slated to be published in a journal in 2018, is intended to help California's wetlands management community prioritize resources and make strategic decisions that will preserve maximum ecological functioning for the region's wetlands.

The vulnerability index model was applied to 96 low-lying coastal wetland areas to understand their relative vulnerability to rising sea levels triggered by climate change.

The modeling work found that an estimated 48% of vegetated marsh and unvegetated flat areas in Southern California – the areas the public typically associates with wetlands – will become submerged by 2100. Small coastal lagoons generally will be less vulnerable to sea level rise than large, complex systems, according to the analysis.

However, with aggressive planning and interventions, wetlands managers could migrate wetlands inland, allowing coastal Southern California to experience a net gain of wetlands area, according to the analysis.

Malibu Lagoon is among 96 low-lying wetland areas across coastal Southern California that were analyzed by researchers to understand their relative vulnerability to sea level rise through the year 2100.

Study launched to monitor marine, freshwater HABs at land-sea interface

SCCWRP and its partners have launched a study to improve understanding of the relationship between harmful algal blooms (HABs) in freshwater and marine ecosystems.

The study, launched in 2017 with field sampling, will track how single-celled organisms such as toxin-producing cyanobacteria can travel through Southern California waterways, introducing toxins to marine environments and triggering ecologically disruptive blooms downstream. Cyanobacterial blooms are becoming more prevalent as waters warm in response to climate change.

The findings of the study will help water-quality managers rethink historical HABs management paradigms, which traditionally have considered management of freshwater and marine HABs to be distinct.

From the study, researchers hope to develop best-practices strategies for monitoring and managing HABs across the coastal continuum, from land to sea.

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New ocean, new needs: Application of pteropod shell dissolution as a biological indicator for marine resource management

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Abstract

Pteropods, planktonic marine snails with a cosmopolitan distribution, are highly sensitive to changing ocean chemistry. Graphical abstract shows pteropod responses to be related to aragonite saturation state, with progressing decrease in Ω_{ar} causing deteriorating biological conditions. Under high saturation state ($\Omega_{ar} > 1.1$; zone 0), pteropods are healthy with no presence of stress or shell dissolution. With decreasing Ω_{ar} (zone 1), pteropod stress is demonstrated through increased dissolution and reduced calcification. At $\Omega_{ar} < 0.8$ (zones 2 and 3), severe dissolution and absence of calcification prevail; the impairment is followed by significant damages. Pteropods responses to OA are closely correlated to shell dissolution that is characterized by clearly delineated thresholds. Yet the practical utility of these species as indicators of the status of marine ecosystem integrity has been overlooked. Here, we set out the scientific and policy rationales for the use of pteropods as a biological indicator appropriate for low-cost assessment of the effect of anthropogenic ocean acidification (OA) on marine ecosystems. While no single species or group of species can adequately capture all aspects of ecosystem change, pteropods are sensitive, specific, quantifiable indicators of AO's effects on marine biota. In an indicator screening methodology, shell dissolution scored highly compared to other indicators of marine ecological integrity. As the socioeconomic challenges of changing ocean chemistry continue to grow in coming decades, the availability of such straightforward and sensitive metrics of impact will become indispensable. Pteropods can be a valuable addition to suites of indicators intended to support OA water quality assessment, ecosystem-based management, policy development, and regulatory applications.

Citation

Bednaršek, N.A, T. Klinger, C.J. Harvey, S. Weisberg, R.M. McCabe, R.A. Feely, J. Newton, and N. Tolimieri. 2017. New ocean, new needs: Application of pteropod shell dissolution as a biological indicator for marine resource management. *Ecological Indicators* 76:240–244.

SCCWRP Journal Article #0966
Full text available by request: pubrequest@sccwrp.org

Exposure history determines pteropod vulnerability to ocean acidification along the US West Coast

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Abstract

The pteropod Limacina helicina frequently experiences seasonal exposure to corrosive conditions ($\Omega_{ar} < 1$) along the US West Coast and is recognized as one of the species most susceptible to ocean acidification (OA). Yet, little is known about their capacity to acclimatize to such conditions. We collected pteropods in the California Current Ecosystem (CCE) that differed in the severity of exposure to Ω_{ar} conditions in the natural environment. Combining field observations, high-CO2 perturbation experiment results, and retrospective ocean transport simulations, we investigated biological responses based on histories of magnitude and duration of exposure to $\Omega_{ar} < 1$. Our results suggest that both exposure magnitude and duration affect pteropod responses in the natural environment. However, observed declines in calcification performance and survival probability under high CO2 experimental conditions do not show acclimatization capacity or physiological tolerance related to history of exposure to corrosive conditions. Pteropods from the coastal CCE appear to be at or near the limit of their physiological capacity, and consequently, are already at extinction risk under projected acceleration of OA over the next 30 years. Our results demonstrate that Ω_{ar} exposure history largely determines pteropod response to experimental conditions and is essential to the interpretation of biological observations and experimental results.

Citation

Bednaršek, N., R.A. Feely, N. Tolimieri, A.J. Hermann, S.A. Siedlecki, G.G. Waldbusser, P. McElhany, S.R. Alin, T. Klinger, B. Moore-Maley, H.O. Pörtner. 2017. Exposure history determines pteropod vulnerability to ocean acidification along the US West Coast. *Scientific Reports* 7:4526.

SCCWRP Journal Article #1004
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/1004_PteropodVulnerabilityToOceanAcidification.pdf

An evaluation of ISFET sensors for coastal pH monitoring applications

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Abstract

The accuracy and precision of ion-sensitive field effect transistor (ISFET) pH sensors have been well-documented, but primarily by ocean chemistry specialists employing the technology at single locations. Here we examine their performance in a network context through comparison to discrete measurements of pH, using different configurations of the Honeywell DuraFET pH sensor deployed in six coastal settings by operators with a range of experience. Experience of the operator had the largest effect on performance. The average difference between discrete and ISFET pH was 0.005 pH units, but ranged from −0.030 to 0.083 among operators, with more experienced operators within ±0.02 pH units of the discrete measurement. In addition, experienced operators achieved a narrower range of variance in difference between discrete bottle measurements and ISFET sensor readings compared to novice operators and novice operators had a higher proportion of data failing quality control screening. There were no statistically significant differences in data uncertainty associated with sensor manufacturer or deployment environment (pier-mounted, flowthrough system, and buoy-mounted). The variation we observed among operators highlights the necessity of best practices and training when instruments are to be used in a network where comparison across data streams is desired. However, while opportunities remain for improving the performance of the ISFET sensors when deployed by less experienced operators, the uncertainty associated with their deployment and validation was several-fold less than the observed natural temporal variability in pH, demonstrating the utility of these sensors in tracking local changes in acidification.

Citation

McLaughlin, K., A. Dickson, S.B. Weisberg, K. Coale, V. Elrod, C. Hunter, K.S. Johnson, S. Kram, R. Kudela, T. Martz, K. Negrey, U. Passow, F. Shaughnessy, D. Tadesse, L. Washburn, and K.R. Weis. 2017. An evaluation of ISFET sensors for coastal pH monitoring applications. *Regional Studies in Marine Science* 12:11-18.

SCCWRP Journal Article #0975
Full text available by request: pubrequest@sccwrp.org

An evaluation of potentiometric pH sensors in coastal monitoring applications

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Abstract

A wealth of historical coastal water pH data has been collected using potentiometric glass electrodes, but the accuracy and stability of these sensors is poorly understood. Here we compared pH measurements from five potentiometric sensors incorporated into profiling Sea-Bird instrument packages and compared them to spectrophotometric measurements on discrete bottle samples collected at two to three depths associated with each cast. Differences ranged from 20.509 to 10.479 with a mean difference of 20.055 pH units. Ninety-two percent of the measurements were within60.2 pH units, but 1% of the measurements had differences greater than 0.322. Sensor performance was affected by depth, but most of the difference was associated with calibration shortcomings. Sensor drift within a day was negligible; moreover, differences between bottle samples and electrode measurements within a sampling day were smaller than differences across days. Bootstrap analysis indicated that conducting a daily *in situ* calibration would reduce the mean difference to 0.002 pH units and increase the number of samples within a 0.2 pH unit error to 98%.

Citation

McLaughlin, K., N.P. Nezlin, S.B. Weisberg A. Dickson, C.L. Cash, A. Feit, J.R. Gully, S. Johnson, A. Latker, M.J. Mengel, G.L. Robertson, A. Steele, and L. Terriquez. 2017. An evaluation of potentiometric pH sensors in coastal monitoring applications. *Limnology and Oceanography Methods* 15:679-689.

SCCWRP Journal Article #1009
Full text available by request: pubrequest@sccwrp.org

Increasing probability of mortality during Indian heatwaves

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Abstract

Rising global temperatures are causing increases in the frequency and severity of extreme climatic events, such as floods, droughts, and heat waves. We analyze changes in summer temperatures, the frequency, severity, and duration of heat waves, and heat-related mortality in India between 1960 and 2009 using data from the India Meteorological Department. Mean temperatures across India have risen by more than 0.5 °C over this period, with statistically significant increases in heat waves. Using a novel probabilistic model, we further show that the increase in summer mean temperatures in India over this period corresponds to a 146% increase in the probability of heat-related mortality events of more than 100 people. In turn, our results suggest that future climate warming will lead to substantial increases in heat-related mortality, particularly in developing low-latitude countries, such as India, where heat waves will become more frequent and populations are especially vulnerable to these extreme temperatures. Our findings indicate that even moderate increases in mean temperatures may cause great increases in heat-related mortality and support the efforts of governments and international organizations to build up the resilience of these vulnerable regions to more severe heat waves.

Citation

Mazdiyasni, O., A. AghaKouchak, S.J. Davis, S. Madadgar, A. Mehran, E. Ragno, M. Sadegh, A. Sengupta, S. Ghosh, C.T. Dhanya, M. Niknejad. 2017. Increasing probability of mortality during Indian heatwaves. *Science Advances* 3:e1700066.

SCCWRP Journal Article #0990
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/990_MortalityDuringIndianHeatwaves.pdf

Framework developed to assess sediment's human health impacts

SCCWRP and its partners have completed development of a standardized sediment assessment framework intended to better protect the health of humans who consume seafood caught in enclosed bays and estuaries in California.

The draft framework, completed in fall 2017, is being considered for adoption by the State Water Board to define for environmental managers how to implement California's Sediment Quality Objective (SQO) for protection of human health.

The human health SQO – one of three adopted by the State Water Board in 2008 for enclosed bays and estuaries – is a one-sentence regulatory target that calls on sediment contamination to not be present "at levels that will bioaccumulate in aquatic life to levels that are harmful to human health."

SCCWRP and its partners have spent more than a decade conceptualizing, building and vetting the human health SQO framework to create a standardized technical definition of what it means to be in compliance with this regulatory target.

California's environmental management community will be able to use the framework to inform decision-making on issues like setting appropriate sediment clean-up targets.

The human health framework is designed to complement California's SQO assessment framework for the protection of sediment-dwelling aquatic life, which was adopted by the State Water Board and approved for regulatory use in enclosed bays and estuaries in 2009.

A field crew retrieves sediment samples from Los Angeles Harbor. Researchers have developed a standardized framework for assessing sediment quality to better protect the health of humans who consume locally caught seafood.

Study offers guidance for optimizing study design of toxicity identification evaluations

SCCWRP and its partners have completed a two-year study examining how to optimize the design of toxicity identification evaluation (TIE) studies to improve confidence in the results.

The project, completed in 2017, involved oversampling in Consolidated Slip, an area of the Los Angeles Harbor with high sediment toxicity levels, and then using statistical analysis to develop best-practices recommendations for TIE study design.

Among the study's recommendations is to conduct TIEs at a minimum of three locations within a study site. Researchers also should compare observed contaminant concentrations to known toxicity thresholds to help reduce uncertainty in interpreting results.

TIEs are the primary method used by water-quality managers to determine the cause of toxicity in a water or sediment sample. The analysis typically includes a series of chemical treatments of the sample to selectively remove or alter the toxicity of specific contaminant groups, such as trace metals, nonpolar organics and pyrethroid pesticides.

Data analysis tool developed to implement SQO human health framework

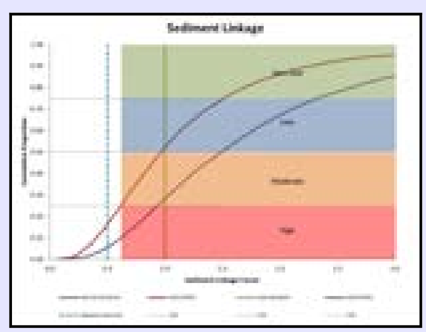
SCCWRP and its partners have developed a data analysis tool that can automatically score the condition of sediment based on the risk it poses to humans who consume seafood caught in enclosed bays and estuaries in California.

The Decision Support Tool, unveiled in fall 2017, is intended to facilitate implementation of California's Sediment Quality Objective (SQO) for protection of human health.

From within a single Excel workbook, environmental managers can enter data on chemical contamination levels found in water, sediment and the tissue of sportfish at a particular site. The Decision Support Tool then integrates the data with a food web-based bioaccumulation model and runs a series of analyses.

The tool compares chemical exposure data for sportfish tissue to the advisory tissue contamination levels developed by California's Office of Environmental Health Hazard Assessment (OEHHA). The tool also evaluates the linkage between sediment contamination at the site and the contamination concentrations in sportfish tissue.

Each site is given a final assessment score and classified into one of five sediment condition categories, ranging from "unimpacted" to "clearly impacted."



The Decision Support Tool runs a series of analyses that scores the condition of sediment at a given site based on the risk it poses to humans who consume seafood from enclosed bays and estuaries.

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The Sequential Probability Ratio Test: An efficient alternative to exact binomial testing for Clean Water Act 303(d) evaluation

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ABSTRACT

The United States' Clean Water Act stipulates in section 303(d) that states must identify impaired water bodies for which total maximum daily loads (TMDLs) of pollution inputs into water bodies are developed. Decision-making procedures about how to list, or delist, water bodies as impaired, or not, per Clean Water Act 303(d) differ across states. In states such as California, whether or not a particular monitoring sample suggests that water quality is impaired can regarded as a binary outcome variable, and California's current regulatory framework invokes a version of the exact binomial test to consolidate evidence across samples and assess whether the overall water body complies with the Clean Water Act. Here, we contrast the performance of California's exact binomial test with one potential alternative, the Sequential Probability Ratio Test (SPRT). The SPRT uses a sequential testing framework, testing samples as they become available and evaluating evidence as it emerges, rather than measuring all the samples and calculating a test statistic at the end of the data collection process. Through simulations and theoretical derivations, we demonstrate that the SPRT on average requires fewer samples to be measured to have comparable Type I and Type II error rates as the current fixed-sample binomial test. Policymakers might consider efficient alternatives such as SPRT to current procedure.

CITATION

Chen, C., M.O. Gribble, J. Bartroff, S.M. Bay, L. Goldstein. 2017. The sequential probability ratio test: An efficient alternative to exact binomial testing for Clean Water Act 303(d) evaluation. *Journal of Environmental Management* 192:89-93.

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Full text available by request: pubrequest@sccwrp.org

Measuring freely dissolved DDT and metabolites using solid phase microextraction and performance reference compounds

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ABSTRACT

The coupling of disposable solid-phase microextraction (SPME) with performance reference compounds (PRCs) has been recently introduced to measure time-averaged freely dissolved concentrations (C_{free}) of hydrophobic organic contaminants in sediments under laboratory conditions. To explore the use of PRCSPME for *in situ* sampling in seawater, disposable PDMS fibers (35-μm and 100-μm coating) preloaded with stable isotope-labeled analogues as PRCs were deployed at six stations (each with three depths) in the open ocean of the Palos Verdes Shelf (CA, USA) Superfund site for 33 days to measure Cfree of DDT and its degradates. The observed values of fractional equilibration (f_{eq}) of PRCs were mostly b0.85, suggesting nonequilibrium conditions at the end of deployment. The observed f_{eq}s for the samplers varied with compound, sampling station and depth, validating the need for calibration to derive accurate C_{free}. The C_{free} values of DDE and DDD determined with PRC-SPME were in good agreement with those previously measured by *in situ* large-volume water sampling or polyethylene devices. The highest C_{free} in seawater 5 m off the ocean floor was 750 pg L−1 for o,p′-DDE, 2170 pg L−1 for *p,p′*-DDE, 24 pg L−1 for *o,p′*-DDD, and 75 pg L−1 for *p,p′*-DDD. Results of this study demonstrated the feasibility and advantages of using disposable PDMS fiber coupled with PRCs for *in situ* sampling.

CITATION

Lin, K., W. Lao, Z. Lu, F. Jia, K. Maruya, J. Gan. 2017. Measuring freely dissolved DDT and metabolites using solid phase microextraction and performance reference compounds. *Science of the Total Environment* 599-600:364-371.

SCCWRP Journal Article #0985
Full text available by request: pubrequest@sccwrp.org

San Diego Bay fish consumption study

Steven J. Steinberg and Shelly Moore

Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Steinberg, S.J. and S.L. Moore. 2017. San Diego Bay fish consumption study. Technical Report 976. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0976
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/976_SanDiegoFishConsumptionStudy.pdf

Development of a sediment quality assessment framework for human health effects

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Citation

Bay, S.M., A.N. Parks, A.R. Melwani, and B.K. Greenfield. 2017. Development of a sediment quality assessment framework for human health effects. Technical Report 1000. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1000
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1000_SQOHumanHealthFramework.pdf

Bioanalytical assays used to screen for CECs in pilot study

SCCWRP and its partners have shown in a pair of initial studies that bioanalytical screening tools have the potential to be used to screen receiving waters across California for CECs.

The studies, completed in 2017, were conducted on a range of Southern California waterways, including inland freshwater streams and rivers dominated by effluent from wastewater treatment plants, and in the Russian River, a watershed north of San Francisco that receives agricultural runoff.

The bioassay results showed strong agreement with traditional chemistry-based analyses of the receiving water samples, indicating that this cell-based technology has the potential to be useful as a CEC screening tool.

Even in water samples with minimal CEC impacts, the bioassays were not prone to high noise levels – an important finding given that sensitivity is often a concern with new methods.

The bioassay screenings found that the potential for endocrine-disrupting impacts, such as impaired reproduction in fish, is moderate to low across the watersheds examined.

The studies are part of an ongoing effort to develop efficient, cost-effective ways to zero in on the CECs that pose the greatest potential health risks.

Researchers have shown that bioanalytical tools have the potential to be used to screen receiving waters across California for CECs, including the Russian River in Northern California, above.

Expert panel updates recommendations for monitoring CECs in recycled water

An expert advisory panel convened by SCCWRP on behalf of the State Water Board to update recommendations for monitoring CECs in recycled water has released its final draft report.

The draft recommendations, developed over a seven-month period in 2017, will be considered for adoption by the State Water Board in 2018 as part of a comprehensive update to California's recycled water policy. California's existing policy for monitoring CECs in recycled water is based on the expert panel's original 2010 recommendations.

Among the CEC Recycled Water Advisory Panel's updated recommendations is a revised list of priority chemicals to monitor in potable reuse applications.

The panel also has recommended implementing a more comprehensive CEC screening framework that incorporates use of commercially available bioanalytical tools. These tools have the potential to provide a cost-effective method for rapidly screening recycled water for CECs.

While California's existing recycled water policy covers non-potable landscape irrigation and groundwater recharge for indirect potable reuse, proposed amendments to the policy will extend it to cover additional applications, including crop irrigation and augmentation of drinking water reservoirs.

An expert panel tasked with updating recommendations for monitoring CECs in recycled water discusses its findings with state environmental officials in Sacramento.

Laboratory-based passive-sampling method used to measure sediment contamination

SCCWRP and its partners have successfully used prototype passive-sampling methods in a laboratory to measure the freely dissolved concentrations of organic contaminants in sediment.

Unlike previous applications of passive-sampling technology that require the devices to be deployed in the field, the laboratory-based method would enable data to be obtained in a matter of days instead of weeks; it also would reduce the chances of vandalism of the devices and other unforeseen field disruptions.

The laboratory testing, completed in late 2017, was conducted on sediment samples collected from San Diego Bay. Pyrethroids and fipronil – commonly used as insecticides – are among the CECs being studied.

Researchers are now working to conduct toxicity and bioaccumulation testing on the sediment samples to understand the relationship between the passive-sampling data and observed biological impacts on test organisms.

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High throughput *in vitro* and *in vivo* screening of inland waters of southern California

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[2]*University of California, Davis, Davis, CA*
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Abstract

The impact of unmonitored contaminants, also known as contaminants of emerging concern (CECs), on freshwater streams remains largely uncharacterized. Water samples from 31 streams representing urban, agricultural and undeveloped (i.e., open space) land use in Southern California (USA) were analyzed for *in vitro* and *in vivo* bioactivity. The extent and magnitude of bioactivity screened using endocrine-responsive cell bioassays and a fish embryo screening assay were low. In contrast, a wider gradient of responses for the aryl hydrocarbon receptor (AhR) assay was observed, which was negatively correlated with a measure of benthic community structure. Both aromatic and non-aromatic CECs were tentatively identified in these samples, but polycyclic aromatic hydrocarbons (PAHs), known AhR agonists in urban environments, were not present at detectable levels. These results suggest that a combination of *in vitro* and *in vivo* show potential as screening techniques for biological condition *in situ*, but that more advanced, comprehensive analytical methods are needed to identify bioactive contaminants.

Citation

Mehinto, A.C., D.R. Vandervort, W. Lao, G. He, M.S. Denison, S.M. Vliet, D.C. Volz, R.D. Mazor, K.A. Maruya. 2017. High throughput *in vitro* and *in vivo* screening of inland waters of southern California. *Environmental Science Processes and Impacts* 19:1142-1149.

SCCWRP Journal Article #0995
Full text available by request: pubrequest@sccwrp.org

Derivation and evaluation of putative adverse outcome pathways for the effects of cyclooxygenase inhibitors on reproductive processes in female fish

Dalma Martinovic-Weigelt[1], Alvina C. Mehinto[2,3], Gerald T. Ankley[4], Jason P. Berninger[4], Timothy W. Collette[5], John M. Davis[5], Nancy D. Denslow[2], Elizabeth J. Durhan[4], Evan Eid[4], Drew R. Ekman[5], Kathleen M. Jensen[4], Michael D. Kahl[4], Carlie A. LaLone[4], Quincy Teng5, Daniel L. Villeneuve[4]

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Abstract

Cyclooxygenase (COX) inhibitors are ubiquitous in aquatic systems and have been detected in fish tissues. The exposure of fish to these pharmaceuticals is concerning because COX inhibitors disrupt the synthesis of prostaglandins (PGs), which modulate a variety of essential biological functions, including reproduction. In this study, we investigated the effects of well-characterized mammalian COX inhibitors on female fathead minnow reproductive health. Fish (n¼8) were exposed for 96h to water containing indomethacin (IN; 100 mg/l), ibuprofen (IB; 200 mg/l) or celecoxib (CX; 20 mg/l), and evaluated for effects on liver metabolome and ovarian gene expression. Metabolomic profiles of IN, IB and CX were not significantly different from control or one another. Exposure to IB and CX resulted in differential expression of comparable numbers of genes (IB¼433, CX¼545). In contrast, 2558 genes were differentially expressed in IN-treated fish. Functional analyses (canonical pathway and gene set enrichment) indicated extensive effects of IN on PG synthesis pathway, oocyte meiosis, and several other processes consistent with physiological roles of PGs. Transcriptomic data were congruent with PG data; IN-reduced plasma PG F2a concentration, whereas IB and CX did not. Five putative AOPs were developed linking the assumed molecular initiating event of COX inhibition, with PG reduction and the adverse outcome of reproductive failure via reduction of: (1) ovulation, (2) reproductive behaviors mediated by exogenous or endogenous PGs, and (3) oocyte maturation in fish. These pathways were developed using, in part, empirical data from the present study and other publicly available data.

Citation

Martinovic-Weigelt, D., A.C. Mehinto, G.T. Ankley, J.P. Berninger, T.W. Collette, J.M. Davis, N.D. Denslow, E.J. Durhan, E. Eid, D.R. Ekman, K.M. Jensen, M.D. Kahl, C.A. LaLone, Q. Teng, D.L. Villeneuve. 2017. Derivation and evaluation of putative adverse outcome pathways for the effects of cyclooxygenase inhibitors on reproductive processes in female fish. *Toxicological Sciences* 156:344-61.

SCCWRP Journal Article #0996
Full text available by request: pubrequest@sccwrp.org

Enantiomer-specific measurements of current-use pesticides in aquatic systems

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Abstract

Some current-use pesticides are chiral and have nonsuperimposable mirror images called enantiomers that exhibit identical physical–chemical properties but can behave differently when in contact with other chiral molecules (e.g.,

regarding degradation and uptake). These differences can result in variations in enantiomer presence in the environment and potentially change the toxicity of pesticide residues. Several current-use chiral pesticides are applied in urban and agricultural areas, with increased potential to enter watersheds and adversely affect aquatic organisms. The present study describes a stereoselective analytical method for the current-use pesticides fipronil, cis-bifenthrin, cis-permethrin, cypermethrin, and cyfluthrin. We show use of the method by characterizing enantiomer fractions in environmental sample extracts (sediment and water), and laboratory-dosed fish and concrete extracts previously collected by California organizations. Enantiomer fractions for most environmental samples are the same as racemic standards (equal amounts of enantiomers, enantiomer fraction = 0.5) and therefore are not expected to differ in toxicity from racemic mixtures typically tested. In laboratory-derived samples, enantiomer fractions are more frequently nonracemic and favor the less toxic enantiomer; permethrin enantiomer fractions range from 0.094 to 0.391 in one type of concrete runoff and enantiomer fractions of bifenthrin in dosed fish range from 0.378 to 0.499. We use enantiomer fractions as a screening tool to understand environmental exposure and explore ways this uncommon measurement could be used to better understand toxicity and risk.

Citation

Ulrich, E.M., P.L. Tenbrook, L.M. McMillan, Q. Wang, W. Lao. 2018. Enantiomer-Specific Measurements of Current-Use Pesticides in Aquatic Systems. *Environmental Toxicology and Chemistry* 37:99-106.

SCCWRP Journal Article #1013
Full text available by request: pubrequest@sccwrp.org

Nontargeted screening of halogenated organic compounds in bottlenose dolphins (Tursiops truncatus) from Rio de Janeiro, Brazil

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[3]*Aquatic Mammals and Bioindicator Laboratory, School of Oceanography, Rio de Janeiro State University, Rio de Janeiro, Brazil*
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Abstract

To catalog the diversity and abundance of halogenated organic compounds (HOCs) accumulating in high trophic marine species from the southwestern Atlantic Ocean, tissue from bottlenose dolphins (Tursiops truncatus) stranded or incidentally captured along the coast of Rio de Janeiro, Brazil, were analyzed by a nontargeted approach based on GCXGC/TOF-MS. A total of 158 individual HOCs from 32 different structural classes were detected in the blubber of 4 adult male T. truncatus. Nearly 90% of the detected compounds are not routinely monitored in the environment. DDT-related and mirex/dechlorane-related compounds were the most abundant classes of anthropogenic origin. Methoxy-brominated diphenyl ethers (MeO-BDEs) and chlorinated methyl- and dimethyl bipyrroles (MBPs and DMBPs) were the most abundant natural products. Reported for the first time in southwestern Atlantic cetaceans and in contrast to North American marine mammals, chlorinated MBPs and DMBPs were more abundant than their brominated and/or mixed halogenated counterparts. HOC profiles in coastal T. truncatus from Brazil and California revealed a distinct difference, with a higher abundance of MeO-BDEs, mirex/dechloranes and chlorinated bipyrroles in the Brazilian dolphins. Thirty-six percent of the detected HOCs had an unknown structure. These results suggest broad geographical differences in the patterns of bioaccumulative chemicals found in the marine environment and indicate the need to develop more complete catalogs of HOCs from various marine environments.

Citation

Alonso, M.B., K.A. Maruya, N.G. Dodder, J. Lailson-Brito, A. Azevedo, E. Santos-Neto, J.P.M. Torres, O. Malm, E. Hoh. Non-targeted screening of halogenated organic compounds in bottlenose dolphins (Tursiops truncatus) from Rio de Janeiro, Brazil. *Environmental Science & Technology* 51:1176-1185.

SCCWRP Journal Article #0965
Full text available by request: pubrequest@sccwrp.org

Newly identified DDT-related compounds accumulating in southern California bottlenose dolphins

Mackintosh, Susan A.[1,2,3], Nathan G. Dodder[1,2,3], Nellie J. Shaul[1,4], Lihini I. Aluwihare[1,4], Keith A. Maruya[5], Susan J. Chivers[6], Kerri Danil[6], David W. Weller[6], and Eunha Hoh[1,2]

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Abstract

Nontargeted GC×GC-TOF/MS analysis of blubber from eight common bottlenose dolphins (Tursiops truncatus) inhabiting the Southern California Bight was performed to identify novel, bioaccumulative DDT-related compounds and to determine their abundance relative to the commonly studied DDT-related compounds. We identified 45 bioaccumulative DDT-related compounds, of which the majority (80%) is not typically monitored in environmental media. Identified compounds include transformation products, technical mixture impurities such as tris(chlorophenyl)methane (TCPM), the presumed TCPM metabolite tris(chlorophenyl)- methanol (TCPMOH), and

structurally related compounds with unknown sources, such as hexa- to octachlorinated diphenylethene. To investigate impurities in pesticide mixtures as possible sources of these compounds, we analyzed technical DDT, the primary source of historical contamination in the region, and technical Dicofol, a current-use pesticide that contains DDT-related compounds. The technical mixtures contained only 33% of the compounds identified in the blubber, suggesting that transformation products contribute to the majority of the load of DDT-related contaminants in these sentinels of ocean health. Quantitative analysis revealed that TCPM was the second most abundant compound class detected in the blubber, following DDE, and TCPMOH loads were greater than DDT. QSPR estimates verified 4,4′,4″-TCPM and 4,4′4,″-TCPMOH are persistent and bioaccumulative.

CITATION

Mackintosh, S.A., N.G. Dodder, N.J. Shaul, L. Aluwihare, K.A. Maruya, S.A. Chivers, K. Danil, D.W. Weller, E. Hoh. 2016. Newly identified DDT-related compounds accumulating in Southern California bottlenose dolphins. *Environmental Science & Technology* 50:12129-12137.

SCCWRP Journal Article #0954
Full text available by request: pubrequest@sccwrp.org

Linkage of *in vitro* assay results with *in vivo* endpoints final report – Phase 1 and 2

CITATION

Denslow, N., K. Kroll, S. Jayasinghe, O. Adeyemo, C. Lavelle, E. Li, A.C. Mehinto, S. Bay, K. Maruya. 2017. Linkage of *In Vitro* Assay Results With *In Vivo* Endpoints Final Report – Phase 1 and 2. Technical Report 983. San Francisco Estuary Institute Clean Water Program. Richmond, CA.

SCCWRP Technical Report #0983
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/998_BightChlorophyllPatterns.pdf

Beaches ranked for fecal contamination risk using DNA

SCCWRP and its member agencies and other partners have completed a study evaluating the feasibility of using DNA-based methods to rank Southern California beaches for their risk of human fecal contamination.

The study, published in 2017 as part of the Southern California Bight 2013 Regional Monitoring Program, found that tracking HF183 – a genetic marker specific to human waste – in waterways that drain to the coastal ocean offers a viable way to understand the relative cleanliness of beaches across Southern California.

The HF183 marker was ubiquitous in the nearly two dozen coastal watersheds examined; researchers detected the genetic marker at all but two of the sites during dry weather and at all sites during wet weather.

However, the HF183-based ranking differed significantly from the ranking obtained by tracking *Enterococcus* in coastal watersheds. *Enterococcus* bacteria are closely associated with fecal contamination, but not human fecal matter specifically.

Thus, researchers recommended that both *Enterococcus* and HF183 be tracked together to provide a more accurate picture of the risk of water-contact illness at Southern California beaches.

The DNA-based method used to track fecal contamination was the quantitative polymerase chain reaction (qPCR). The U.S. Environmental Protection Agency already has endorsed this method for tracking *Enterococcus*; the SCCWRP-led study shows that it could be adapted to track HF183 as well.

Environmental managers will be able to use the Southern California beach rankings to help effectively direct resources and prioritize clean-up efforts.

Researchers have shown that a genetic marker specific to human waste in Southern California waterways can be used to evaluate the risk of human fecal contamination in coastal beach water.

Initial testing completed for field-portable microbial contamination detection device

SCCWRP and its member agencies have completed an initial round of field testing on a field-portable instrument prototype designed to improve the speed at which beach water can be analyzed for microbial contamination.

During testing in spring 2017, researchers found that the instrument did not perform reliably; a component of the machine that uses a DNA-based approach to quantify microbial contamination appeared to be misaligned.

Such issues are not unusual for a prototype instrument, and the device is undergoing additional development.

Unlike traditional methods that require water samples to be brought to a lab for analysis – a process that can take up to 24 hours – the instrument is being designed as a field-deployable device, capable of producing results within two hours. The system is intended to be so simple to use that it could be operated by a lifeguard.

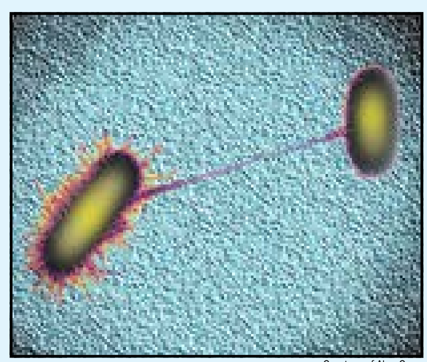
Study developed to track antibiotic-resistant bacteria, genes in effluent

SCCWRP and its four wastewater treatment member agencies have launched a study examining whether viable antibiotic-resistant bacteria – and the genes that code for antibiotic resistance – are being discharged into the environment following the wastewater treatment process.

The study, which began in summer 2017, will track whether bacteria and genetic material are surviving treatment at 10 facilities across Southern California, including an international plant at the U.S.-Mexico border.

The study's goal is to develop a baseline understanding of how prevalent antibiotic resistance genes are in wastewater effluent at Southern California's treatment facilities. If these genes are surviving the treatment processes that destroy most bacterial cells, this genetic material could be traveling via treated effluent into aquatic systems, where potentially pathogenic bacteria in the environment could be taking up the antibiotic resistance genes.

In this way, antibiotic resistance could be conferred to bacterial strains that make humans sick – a phenomenon that research has shown can lead to multi-drug-resistant "superbugs."



Courtesy of Alan Cann

Bacterial conjugation, shown above, is one way that bacterial cells can swap genetic material, potentially conferring antibiotic resistance. Researchers are examining whether wastewater treatment plants are discharging antibiotic resistance genes to the environment.

Acute illness among surfers following dry and wet weather seawater exposure

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ABSTRACT

Rainstorms increase levels of fecal indicator bacteria in urban coastal waters, but it is unknown whether exposure to seawater after rainstorms increases rates of acute illness. Our objective was to provide the first estimates of rates of acute illness after seawater exposure during both dry- and wet-weather periods and to determine the relationship between levels of indicator bacteria and illness among surfers, a population with a high potential for exposure after rain. We enrolled 654 surfers in San Diego, California, and followed them longitudinally during the 2013–2014 and 2014–2015 winters (33,377 days of observation, 10,081 surf sessions). We measured daily surf activities and illness symptoms (gastrointestinal illness, sinus infections, ear infections, infected wounds). Compared with no exposure, exposure to seawater during dry weather increased incidence rates of all outcomes (e.g., for earache or infection, adjusted incidence rate ratio (IRR) = 1.86, 95% confidence interval (CI): 1.27, 2.71; for infected wounds, IRR = 3.04, 95% CI: 1.54, 5.98); exposure during wet weather further increased rates (e.g., for earache or infection, IRR = 3.28, 95% CI: 1.95, 5.51; for infected wounds, IRR = 4.96, 95% CI: 2.18, 11.29). Fecal indicator bacteria measured in seawater (Enterococcus species, fecal coliforms, total coliforms) were strongly associated with incident illness only during wet weather. Urban coastal seawater exposure increases the incidence rates of many acute illnesses among surfers, with higher incidence rates after rainstorms.

CITATION

Arnold, B.F., K.C. Schiff, A. Ercumen, J. Benjamin-Chung, J.A. Steele, J.F. Griffith, S.J. Steinberg, P. Smith, C.D. McGee, R. Wilson, C. Nelsen, S.B. Weisberg, and J.M. Colford, Jr. 2017. Acute illness among surfers following dry and wet weather seawater exposure. *American Journal of Epidemiology* 186: 866–875.

SCCWRP Journal Article #0986
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/986_Acute_IllnessAmongSurfersSeawaterDry-Wet-Weather.pdf

Incidence of gastrointestinal illness following wet weather recreational exposures: Harmonization of quantitative microbial risk assessment with an epidemiologic investigation of surfers

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ABSTRACT

We modeled the risk of gastrointestinal (GI) illness associated with recreational exposures to marine water following storm events in San Diego County, California. We estimated GI illness risks via quantitative microbial risk assessment (QMRA) techniques by consolidating site specific pathogen monitoring data of stormwater, site-specific dilution estimates, literature-based water ingestion data, and literature-based pathogen dose-response and morbidity information. Our water quality results indicated that human sources of contamination contribute viral and bacterial pathogens to streams draining an urban watershed during wet weather that then enter the ocean and affect nearshore water quality. We evaluated a series of approaches to account for uncertainty in the norovirus dose-response model selection and compared our model results to those from a concurrently conducted epidemiological study that provided empirical estimates for illness risk following ocean exposure. The preferred norovirus dose-response approach yielded median risk estimates for water recreation-associated illness (15 GI ill-nesses per 1000 recreation events) that closely matched the reported epidemiological results (12 excess GI illnesses per 1,000 wet weather recreation events). The results are consistent with norovirus, or other pathogens associated with norovirus, as an important cause of gastrointestinal illness among surfers in this setting. This study demonstrates the applicability of QMRA for recreational water risk estimation, even under wet weather conditions, and describes a process that might be useful in developing site-specific water quality criteria in this and other locations.

CITATION

Soller, J.A., M. Schoen, J.A. Steele, J.F. Griffith, K.C. Schiff. 2017. Incidence of gastrointestinal illness following wet weather recreational exposures: Harmonization of quantitative microbial risk assessment with an epidemiologic investigation of surfers. *Water Research* 121:280-289.

SCCWRP Journal Article #0994
Full text available by request: pubrequest@sccwrp.org

Child environmental exposures to water and sand at the beach: Findings from studies of over 68,000 subjects at 12 beaches

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ABSTRACT

Swimming and recreating in lakes, oceans, and rivers is common, yet the literature suggests children may be at greater risk of illness following such exposures. These effects might be due to differences in immunity or differing behavioral factors such as poorer hygiene, longer exposures to, and greater ingestion of potentially contaminated water and sand. We pooled data from 12 prospective cohorts (n = 68,685) to examine exposures to potentially contaminated media such as beach water and sand among children compared with adults, and conducted a simulation using self-reported time spent in the water and volume of water swallowed per minute by age to estimate the total volume of water swallowed per swimming event by age category. Children aged 4–7 and 8–12 years had the highest exposures to water, sand and algae compared with other age groups. Based on our simulation, we found that children (6–12 years) swallow a median of 36 ml (90th percentile = 150 ml), whereas adults aged ≥ 35 years swallow 9 ml (90th percentile = 64 ml) per swimming event, with male children swallowing a greater amount of water compared with females. These estimates may help to reduce uncertainty surrounding routes and durations of recreational exposures and can support the development of chemical and microbial risk assessments.

CITATION

DeFlorio-Barker, S., B.F. Arnold, E.A. Sams, A.P. Dufour, J.M. Colford, S.B. Weisberg, K.C. Schiff, and T.J. Wade. 2017. Child environmental exposures to water and sand at the beach: Findings from studies of over 68,000 subjects at 12 beaches. *Journal of Exposure Science and Environmental Epidemiology* DOI:10.1038/jes.2017.23.

SCCWRP Journal Article #1007
Full text available via the journal's free SharedIt content-sharing initiative: http://rdcu.be/ydcZ

Coliphages and gastrointestinal illness in recreational waters: pooled analysis of six coastal beach cohorts

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[3]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[4]*National Exposure Research Laboratory, U. S. Environmental Protection Agency, Cincinnati, OH*

ABSTRACT

Background: Coliphages have been proposed as indicators of fecal contamination in recreational waters because they better mimic the persistence of pathogenic viruses in the environment and wastewater treatment than fecal indicator bacteria. We estimated the association between coliphages and gastrointestinal illness and compared it to the association with culturable enterococci.

Methods: We pooled data from six prospective cohort studies that enrolled coastal beachgoers in California, Alabama, and Rhode Island. Water samples were collected and gastrointestinal illness within 10 days of the beach visit was recorded. Samples were tested for enterococci and male-specific and somatic coliphages. We estimated cumulative incidence ratios (CIR) for the association between swimming in water with detectable coliphage and gastrointestinal illness when human fecal pollution was likely present, not likely present, and under all conditions combined. The reference group was unexposed swimmers. We defined continuous and threshold-based exposures (coliphage present/absent, enterococci>35 vs. <=35 CFU/100 ml).

Results: Under all conditions combined, there was no association between gastrointestinal illness and swimming in water with detectable coliphage or enterococci. When human fecal pollution was likely present, coliphage and enterococci were associated with increased gastrointestinal illness, and there was an association between male-specific coliphage level and illness that was somewhat stronger than the association between enterococci and illness. There were no substantial differences between male-specific and somatic coliphage.

Conclusion: Somatic coliphage and enterococci had similar associations with gastrointestinal illness; there was some evidence that male-specific coliphage had a stronger association with illness than enterococci in marine waters with human fecal contamination.

CITATION

Benjamin-Chung, J., B.F. Arnold, T.J. Wade, K. Schiff, J.F. Griffith, A.P. Dufour, S.B. Weisberg and J.M. Colford. 2017. Coliphages and gastrointestinal illness in recreational waters: pooled analysis of six coastal beach cohorts. *Epidemiology* 28:644-652.

SCCWRP Journal Article #0987
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/987_ColiphagesAndGastroIntestinalIllnessInRecreationalWaters.pdf

Regional assessment of human fecal contamination in southern California coastal drainages

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[4]*Orange County Department of Public Works, Orange, CA*
[5]*Los Angeles County Department of Public Works, Alhambra, CA*
[6]*Los Angeles County Sanitation District, Carson, CA*
[7]*Orange County Public Health Laboratory, Newport Beach, CA*
[8]*National Oceanic and Atmosphere Administration, Ocean Chemistry and Ecosystems Division, Atlantic Oceanographic and Meteorological Laboratory, Miami, FL*
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[10]*City of Encinitas, Encinitas, CA*
[11]*Orange County Sanitation District, Fountain Valley, CA*
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ABSTRACT

Host-associated genetic markers that allow for fecal source identification have been used extensively as a diagnostic tool to determine fecal sources within watersheds, but have not been used in routine monitoring to prioritize remediation actions among watersheds. Here, we present a regional assessment of human marker prevalence among drainages that discharge to the U.S. southern California coast. Approximately 50 samples were analyzed for the HF183 human marker from each of 22 southern California coastal drainages under summer dry weather conditions, and another 50 samples were targeted from each of 23 drainages during wet weather. The HF183 marker was ubiquitous, detected in all but two sites in dry weather and at all sites during wet weather. However, there was considerable difference in the extent of human fecal contamination among sites. Similar site ranking was produced regardless of whether the assessment was based on frequency of HF183 detection or site average HF183 concentration. However, site ranking differed greatly between dry and wet weather. Site ranking also differed greatly when based on enterococci, which do not distinguish between pollution sources, vs. HF183, which distinguishes higher risk human fecal sources from other sources, indicating the additional value of the human-associated marker as a routine monitoring tool.

CITATION

Cao, Y., M.R. Raith, P.D. Smith, J.F. Griffith, S.B. Weisberg, A. Schriewer, G. Amenu, A. Sheldon, C. Crompton, X. Yu, J. Gregory, J. Guzman, K. D. Goodwin, L. Othman, M. Manasjan, S. Choi, S. Rapoport, S. Steele, and T. Nguyen. 2017. Regional assessment of human fecal contamination in southern California coastal drainages. *International Journal of Environmental Research and Public Health* 14:874.

SCCWRP Journal Article #0999
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/999_RegionalAssessmentOfFecalContamination.pdf

A human fecal contamination score for ranking recreational sites using the HF183/BacR287 quantitative real-time PCR method

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ABSTRACT

Human fecal pollution of recreational waters remains a public health concern worldwide. As a result, there is a growing interest in the application of human-associated fecal source identification quantitative real-time PCR (qPCR) technologies for water quality research and management. However, there are currently no standardized approaches for field implementation and interpretation of qPCR data. In this study, a standardized HF183/BacR287 qPCR method was combined with a water sampling strategy and a novel Bayesian weighted average approach to establish a human fecal contamination score (HFS) that can be used to prioritize sampling sites for remediation based on measured human waste levels. The HFS was then used to investigate 975 study design scenarios utilizing different combinations of sites with varying sampling intensities (daily to once per week) and number of qPCR replicates per sample (2e14 replicates). Findings demonstrate that site prioritization with HFS is feasible and that both sampling intensity and number of qPCR replicates influence reliability of HFS estimates. The novel data analysis strategy presented here provides a prescribed approach for the implementation and interpretation of human associated HF183/BacR287 qPCR data with the goal of site prioritization based on human fecal pollution levels. In addition, information is provided for future users to customize study designs for optimal HFS performance.

CITATION

Cao, Y., M. Sivaganesan, C.A. Kelty, D. Wang, A.B. Boehm, J.F. Griffith, S.B. Weisberg, O.C. Shanks. 2018. A human fecal contamination score for ranking recreational sites using the HF183/BacR287 quantitative real-time PCR method. *Water Research* 128:148-156.

SCCWRP Journal Article #1008
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/1008_FecalContaminationScore.pdf

Effect of freshwater sediment characteristics on the persistence of fecal indicator bacteria and genetic markers within a southern California watershed

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Abstract

In this study, the aging of culturable FIB and DNA representing genetic markers for Enterococcus spp. (ENT1A), general Bacteroides (GB3), and human-associated Bacteroides (HF183) in freshwater sediments was evaluated. Freshwater sediment was collected from four different sites within the upper and lower reach of the Topanga Creek Watershed and two additional comparator sites within the Santa Monica Bay, for a total of six sites. Untreated (ambient) and oven-dried (reduced microbiota) sediment was inoculated with 5% sewage and artificial freshwater. Microcosms were held for a 21-day period and sampled on day 0, 1, 3, 5, 7, 12, and 21. There were substantial differences in decay among the sediments tested, and decay rates were related to sediment characteristics. In the ambient sediments, smaller particle size and higher levels of organic matter and nutrients (nitrogen and phosphorus) were associated with increased persistence of the GB3 marker and culturable Escherichia coli (cEC) and enterococci (cENT). The HF183 marker exhibited decay rates of -0.50 to -0.96 day-1, which was 2e5 times faster in certain ambient sediments than decay of culturable FIB and the ENT1A and GB3 markers. The ENT1A and GB3 markers decayed at rates of between -0.07 and -0.28 and -0.10 to -0.44 day-1, and cEC and cENT decayed at rates of between -0.22 and -0.81 and -0.03 and -0.40 day-1, respectively. In the oven-dried sediments, increased persistence of all indicators and potential for limited growth of culturable FIB and the GB3 and ENT1A markers was observed. A simplified two-box model using the HF183 marker and cENT decay rates generated from the microcosm experiments was applied to two reaches within the Topanga Canyon watershed in order to provide context for the variability in decay rates observed. The model predicted lower ambient concentrations of enterococci in sediment in the upper (90 MPN g-1) versus lower Topanga watershed (530 MPN g-1) and low ambient levels of the HF183 marker (below the LLOQ) in sediments in both lower and upper watersheds. It is important to consider the variability in the persistence of genetic markers and FIB when evaluating indicators of fecal contamination in sediments, even within one watershed.

Citation

Zimmer-Faust, A.G., V. Thulsiraj, C. Marambio-Jones, Y. Cao, J.F. Griffith, P.A. Holden, J.A. Jay. 2017. Effect of freshwater sediment characteristics on the persistence of fecal indicator bacteria and genetic markers within a Southern California watershed. *Water Research* 119:1-11.

SCCWRP Journal Article #0984
Full text available by request: pubrequest@sccwrp.org

Determination of DNA-based fecal marker aging characteristics for use in quantitative microbial source tracking

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Citation

Cao, Y., G.L. Andersen, A.A. Boehm, P. Holden, J.A. Jay, J.F. Griffith. 2017. Determination of DNA-based fecal marker aging characteristics for use in quantitative microbial source tracking. Technical Report 978. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Journal Article #0978
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/978_DNA_FecalMarkerAgingQuantMicrobialSourceTracking.pdf

Tracking human fecal sources in an urban watershed during wet weather

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Citation

Steele, J., J. Griffith, R. Noble, K. Schiff. 2017. Tracking human fecal sources in an urban watershed during wet weather. Technical Report 1002. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Journal Article #1002
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1002_HumanMarkerTracking.pdf

Bight '18 kicks off with five study elements

Participants of the Southern California Bight Regional Monitoring Program have developed five main study elements for the program's 2018 cycle that will explore different facets of how human activities have impacted the ecological health of the region's coastal waters.

The regional marine monitoring collaborative, known as Bight '18, kicked off in fall 2017 at SCCWRP and includes participation by about 100 environmental organizations. The five study elements will be:

» Sediment Quality, which will examine the ecosystem impacts of sediment contamination across time and space, including via assessments of contamination in seafood.

» Ocean Acidification, which will track corrosive conditions in coastal waters across time and space, as well as examine whether larval fish and other species sensitive to ocean acidification are experiencing biological impacts.

» Harmful Algal Blooms, which will track how long domoic acid created during bloom events lingers in seafloor sediment, as well as whether cyanotoxins from land-based blooms are being washed into coastal waters.

» Trash, which will track the extent to which trash has spread across aquatic environments on land and at sea, and the types and abundance of trash in these settings.

» Microbiology, which will explore the utility of adapting coliphage viruses as an indicator of microbial contamination.

Field sampling will begin in summer 2018. Program participants already have created robust study designs for each element, and have begun developing quality-assurance exercises to ensure all data collected are comparable and of high quality.

Courtesy of Amec Foster Wheeler

A field crew collects sediment samples in San Diego Bay for the Southern California Bight 2013 Regional Monitoring Program. Sampling for the program's next cycle starts in summer 2018.

The Southern California Bight Regional Monitoring Program, which has been facilitated by SCCWRP since its inception in 1994, mobilizes Southern California environmental management agencies to collect data from across a much greater expanse than just their local discharge zones. Both regulated and regulatory agencies, as well as non-governmental and academic organizations, come together to collaboratively design the study and interpret findings.

Southern California's environmental management community relies on the Bight program to better direct resources and to maintain focus on the areas and issues that are disproportionately impacted by human activities.

Field sampling completed for Year 3 of SMC stream monitoring program

The Southern California Stormwater Monitoring Coalition has completed Year 3 of field sampling for the second cycle of its Regional Watershed Monitoring Program.

Year 3 field sampling, which was conducted in summer 2017, included a focus on assessing sediment quality in wadeable streams. Researchers evaluated sediment toxicity and measured levels of a class of insecticides known as pyrethroids.

The second five-year cycle of the monitoring program, which is facilitated by SCCWRP, will resample about one-third of the sites sampled during the first cycle, ensuring results will be comparable.

The inaugural monitoring cycle found that 75% of Southern California's 4,300 miles of perennial wadeable streams are degraded; the findings have helped inform decision-making for a number of stream management programs statewide.

Members of the Southern California Stormwater Monitoring Coalition collect data at Madea Creek in the Santa Monica Mountains. Participants have completed Year 3 of field sampling for the program's second cycle.

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Development of restoration performance curves for streams in southern California using an integrative condition index

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Abstract

Determining success of stream restoration projects is challenging, due to the disconnection between required monitoring periods and the actual time necessary to achieve ecological success. Performance curves could help address this challenge by illustrating likely developmental trajectories of restored streams. We applied the California Rapid Assessment Method (CRAM), an integrative index of stream condition, in a 10 year chronosequence to create performance curves that project the development of functional streams for 30 years following restoration. CRAM scores for high functioning sites between zero and 10 years were plotted against time since restoration. Best-fit curves were derived using either power functions or polynomial functions, depending on the CRAM metric. We tested the curves' ability to predict conditions for other projects across a range of ages, flow conditions (ephemeral to perennial), and physiographic settings. The curves are able to predict the time required for projects to achieve reference-level scores for the CRAM index and Hydrology and Biotic Structure attributes, but underestimate the time required for projects to achieve reference-level scores for the Physical Structure attribute. Our research demonstrates the potential to use modeled restoration performance curves based on CRAM scores to guide expectations for restoration project performance.

Citation

Fong, L.S., E.D. Stein, and R.F. Ambrose. 2017. Development of Restoration Performance Curves for Streams in Southern California Using an Integrative Condition Index. *Wetlands* 37:289-299.

SCCWRP Journal Article #0962
Full text available online: http://rdcu.be/obdb

2015 report on the Stormwater Monitoring Coalition regional stream survey

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[1]Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Mazor, R., and E. Stein. 2017. 2015 Report on the Stormwater Monitoring Coalition Regional Stream Survey. Technical Report 963. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0963
Full text available online: www.sccwrp.org/documents

Southern California Bight 2013 Regional Monitoring Program: Volume VIII. Contaminant impact assessment synthesis report

Southern California Bight 2013 Regional Monitoring Program Contaminant Impact Assessment Planning Committee

[1]Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Bight '13 Contaminant Impact Assessment Planning Committee. 2017. Southern California Bight 2013 Regional Monitoring Program: Volume VIII. Contaminant Impact Assessment Synthesis Report. Technical Report 973. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0973
Full text available online: www.sccwrp.org/documents

Southern California Bight 2013 Regional Monitoring Program contaminant impact assessment synthesis report executive summary

Southern California Bight 2013 Regional Monitoring Program Contaminant Impact Assessment Planning Committee

[1]Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Bight '13 Contaminant Impact Assessment Planning Committee. 2017. Southern California Bight 2013 Regional Monitoring Program Contaminant Impact Assessment Synthesis Report Executive Summary. Technical Report 970. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0970
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/970_Bight13CIASynthesisReportExecutiveSummary.pdf

Southern California Bight 2013 Regional Monitoring Program: Volume VI. Benthic infauna

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CITATION

Gillett, D.J., L.L. Lovell, K.C. Schiff. 2017. Southern California Bight 2013 Regional Monitoring Program: Volume VI. Benthic Infauna. Technical Report 971. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0971
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/971_B13BenthicInfauna.pdf

Southern California Bight 2013 Regional Monitoring Program: Volume VII. Demersal fishes and megabenthic invertebrates

Shelly M. Walther[1], Jonathan P. Williams[2], Ami K. Latker[3], Don B. Cadien[1], Dario W. Diehl[4], Karin Wisenbaker[5], Eric Miller[6], Robin Gartman[3], Chris Stransky[7] and Kenneth Schiff[4]

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CITATION

Walther, S.M., J.P. Williams, A.K Latker, D.B. Cadien, D.W. Diehl, K. Wisenbaker, E. Miller, C. Stransky, K. Schiff. 2017. Southern California Bight 2013 Regional Monitoring Program: Volume VII. Demersal Fishes and Megabenthic Invertebrates. Technical Report 972. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0972
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/972_B13TrawlReport.pdf

Southern California Bight 2013 Regional Monitoring Program: Volume IX. Shoreline microbiology

Yiping Cao[1], Meredith R. Raith[1], Paul D. Smith[1], John F. Griffith[1], Stephen B. Weisberg[1], Alexander Schriewer[2], Andrew Sheldon[3], Chris Crompton[4], Geremew G. Amenu[5], Jason Gregory[6], Joe Guzman[7], Kelly D. Goodwin[8], Laila Othman[9], Mayela Manasjan[10], Samuel Choi[11], Shana Rapoport[12], Syreeta Steele[13], Tommy Nguyen[14], and Xueyuan Yu[15]

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[14]City of Los Angeles Environmental Monitoring Division, Playa del Rey, CA
[15]San Diego Regional Water Quality Control Board, San Diego, CA

CITATION

Cao, Y., M.R. Raith, P.D. Smith, J.F. Griffith, S.B. Weisberg, A. Schriewer, A. Sheldon, C. Crompton, G.G. Amenu, J. Gregory, J. Guzman, K.D. Goodwin, L. Othman, M. Manasjan, S. Choi, S. Rapaport, S. Steele, T. Nguyen, X. Yu. 2017. Southern California Bight 2013 Regional Monitoring Program: Volume IX. Shoreline Microbiology. Technical Report 1005. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1005
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1005_B13_BightShorelineMicrobiology.pdf

Progress assessment and final recommendations by the Expert Review Panel for the State of California's Environmental Laboratory Accreditation Program: Year Two final report

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[4]Eurofins QC Inc. (retired), Horsham, PA

CITATION

Phelps, L., J. Adelson, S. Arms, D. Speis. 2017. Progress assessment and final recommendations by the Expert Review Panel for the State of California's Environmental Laboratory Accreditation Program: Year Two Final Report. Technical Report 977. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #0977
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/977_ELAPReviewYear2.pdf

A framework for informing permitting decisions on scientific activities in marine protected areas

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[7]*Southern California Coastal Water Research Project, Costa Mesa, CA*

Citation

Saarman, E.T., B. Owens, R.F. Ambrose, M.H. Carr, J.C. Field, S.N. Murray, K.J. Nielsen, and S.B. Weisberg. 2017. A framework for informing permitting decisions on scientific activities in marine protected areas. Technical Report 991. California Ocean Protection Council Science Advisory Team. Sacramento, CA.

SCCWRP Technical Report #0991
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/991_CollectingPermitsInMPAsFramework.pdf

Tijuana River Valley historical ecology investigation

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Citation

Safran, S.M., S.A. Baumgarten, E.E. Beller, J.A. Crooks, R.M. Grossinger, J. Lorda, T.R. Longcore, D.L. Bram, S.J. Dark, E.D. Stein, T. McIntosh. 2017. Tijuana River Valley historical ecology investigation. SCCWRP Technical Report 967. San Francisco Estuary Institute. Richmond, CA.

SCCWRP Technical Report #0967
Full text available online: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/967_TijuanaRiverValleyHistoricalEcologyInvestigation.pdf

Open data management workflows developed

SCCWRP has developed a series of tools and automations designed to improve the quality and speed with which environmental field and laboratory data can be collected, processed and published.

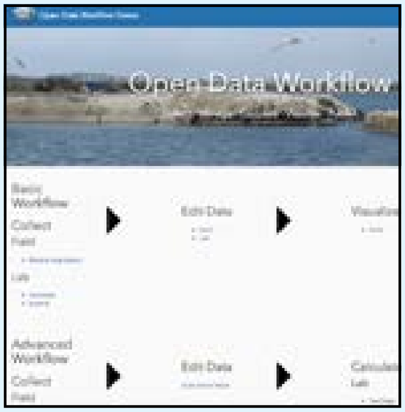
Known as an open data workflow, this data management solution will eliminate the cumbersome version-control issues associated with sharing databases and performing analyses and quality-control checks.

The solution was pioneered in 2017 to streamline the Southern California Bight 2018 Regional Monitoring Program; Bight '18 is expected to feature about 100 participating agencies contributing to data collection and analysis. The solution also will be expanded to the Southern California Stormwater Monitoring Coalition's Regional Watershed Monitoring Program.

Instead of requiring participants to manually download databases as ZIP files from a SCCWRP-maintained server, and then analyze a non-master copy before reuploading the database, the open data workflow will enable participants to work directly from a master copy maintained within the cloud-based data portal.

Furthermore, all edits and changes to a database will be tracked in the data portal, giving all participants visibility over data management activities.

Finally, the open data workflow will enable finalized data sets to be easily published to a publicly accessible data portal, improving data accessibility and visualization opportunities.



The open data workflow is a comprehensive data management system built by SCCWRP to streamline submission of field data, quality-control checks and data analysis. The web-based system was built for the Southern California Bight 2018 Regional Monitoring Program.

Field data made accessible to project researchers in real time

SCCWRP has shown that automated data analysis tools can be used to provide continuous, real-time previews of data from field studies as the data are being generated.

During a study examining the fish consumption habits of San Diego Bay anglers, field staff who interviewed 1,000 anglers over a year-long period were able to transmit interview responses to SCCWRP using mobile devices, enabling researchers to continuously monitor the logged data.

The San Diego Bay fish consumption study, published in spring 2017, found that average consumption rates were below thresholds of concern, although certain demographic populations consumed fish from the bay at significantly higher rates that, in some cases, exceeded fish consumption guidelines.

The survey data were gathered by individually approaching and interviewing anglers at public piers, on boat ramps and along the shoreline. Anglers were asked what types of fish they catch, how often they consume these fish and whether they are aware of existing consumption advisories.

Field test completed to adapt UAS to monitor blooms in lakes

SCCWRP and its partners have completed an initial field test for a project that aims to adapt commercially available unmanned aerial systems (UAS) to routinely monitor lakes susceptible to ecologically disruptive cyanobacteria blooms.

UAS technology – commonly known as drones – offers the potential to conduct more comprehensive, frequent monitoring at a lower cost than is feasible with boat-based field sampling.

During initial test flights in summer 2017, digital cameras and multispectral imaging sensors mounted to UAS were flown over Lake Elsinore in Riverside County to map chlorophyll-a concentrations across the lake's surface.

Researchers then analyzed patterns in the chlorophyll-a concentrations to look for evidence of harmful algal blooms (HABs).

Researchers are using the findings to develop standardized, reliable methods for conducting UAS-based surveys and analyzing the chlorophyll-a maps, including being able to differentiate cyanobacteria from other phytoplankton groups.

HABs events have led to multiple lake closures across California in recent years.

A field crew prepares to fly a multispectral imaging sensor mounted to an unmanned aerial system (UAS), bottom left, over Lake Elsinore in Riverside County. Researchers are working to adapt UAS technology to cost-effectively monitor lakes for evidence of harmful algal blooms.

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King County, Washington
Ken Schiff, Member, Water Quality Advisory Committee

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Los Angeles Freshwater Mussel Restoration Project
Dr. **Raphael Mazor**, Member, Technical Advisory Group

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Dr. **Stephen Weisberg**, Member, Exposure and Effects Workgroup

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Society of Environmental Toxicology and Chemistry

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Urban and Regional Information Systems Association

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and the Commission's Technical Advisory Group (CTAG)

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Alternate Commissioner

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CTAG Representative

Sanitation Districts of Los Angeles County

Grace Hyde
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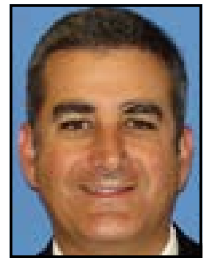

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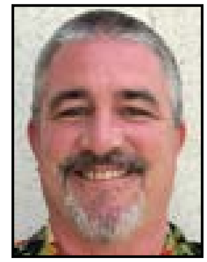
Alternate Commissioner



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CTAG Representative

Orange County Sanitation District

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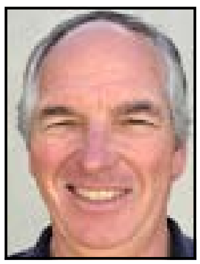
Commissioner

Jim Colston
Alternate Commissioner



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CTAG Representative

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Dr. Peter Vroom
Alternate Commissioner

Dr. Tim Stebbins
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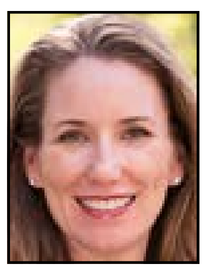

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Chris Crompton
Alternate Commissioner
and CTAG Representative

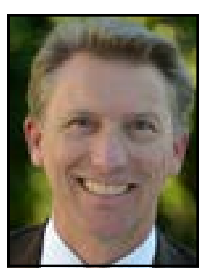
San Diego County Watershed Protection Program

Todd Snyder
Commissioner

Richard Crompton
Alternate Commissioner

Jo Ann Weber
CTAG Representative

Ventura County Watershed Protection District



Arne Anselm
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Dave Laak
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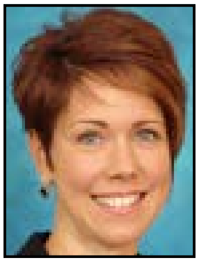
Water-Quality Regulatory Agencies

California State Water Resources Control Board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Darrin Polhemus
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CTAG Representative

U.S. Environmental Protection Agency, Region IX


Janet Hashimoto
Alternate Commissioner


Terry Fleming
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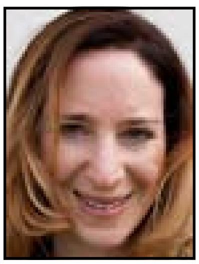
California Ocean Protection Council


Deborah Halberstadt
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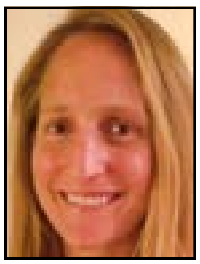
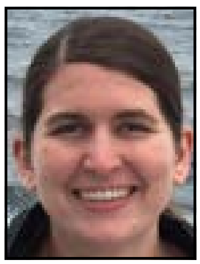

Jennifer Phillips
Alternate Commissioner


Holly Wyer
CTAG Representative

Los Angeles Regional Water Quality Control Board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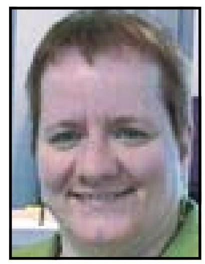
Commissioner


Deborah Smith
Alternate Commissioner


Dr. Jun Zhu
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Santa Ana Regional Water Quality Control Board


Hope Smythe
Commissioner

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David Gibson
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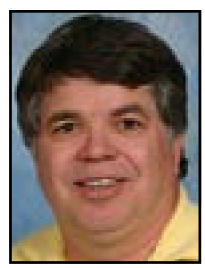
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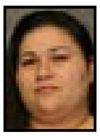
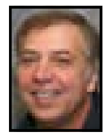

Marisol Gonzalez
Office Manager


Maribel Gonzalez
Administrative Assistant


Christina Steidley
Adminstrative Assistant

Cross-Departmental Tech Support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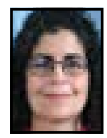
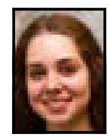
Marine Programs Coordinator


Scott Martindale
Communications Coordinator

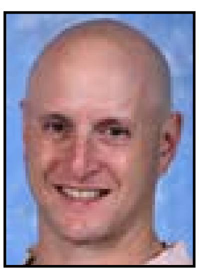

Dr. Nabiul Afrooz
Scientist


Dr. Olivia Rhoades
Visiting Scientist


Valerie Raco-Rands
Research Technician


Rebeccah Glaser
Laboratory Assistant

Biology


Dr. Eric Stein
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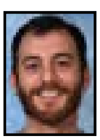
Dr. Raphael Mazor
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Dr. David Gillett
Senior Scientist


Dr. Marcus Beck
Scientist


Dr. Dovi Kacev
Postdoctoral Scientist


Jeff Brown
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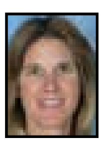
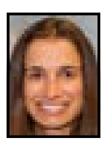
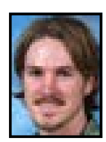
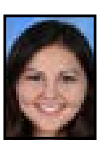
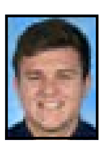

Liesl Tiefenthaler
Sr. Research Technician


Jennifer Taylor
Sr. Research Technician


Kenneth McCune
Research Technician


Cheryl Doughty
Ph.D. Student


Brianna Feld
Laboratory Assistant


Cody Fees
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Tyler Vu
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Amber Sanderson
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Kelly Flint
Laboratory Assistant

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Biogeochemistry


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Dr. Karen McLaughlin
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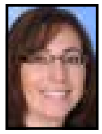
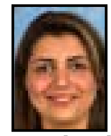

Dr. Meredith Howard
Senior Scientist


Dr. Susanna Theroux
Scientist


Dr. Nina Bednaršek
Scientist


Dr. Fayçal Kessouri
Postdoctoral Scientist


Dr. Morvarid Azizian
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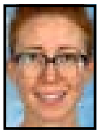
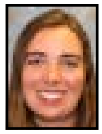

Kelly Ramin
Laboratory Assistant


Miranda Roethler
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Minna Ho
Laboratory Assistant

Toxicology


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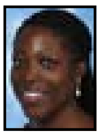
Principal Scientist


Dr. Alvina Mehinto
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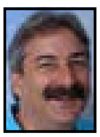
Dr. Ashley Parks
Scientist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Syd Kotar
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Chemistry


Dr. Keith Maruya
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Dr. Bowen Du
Scientist


Dr. Wenjian Lao
Sr. Research Technician

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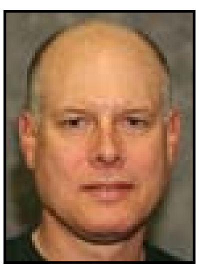
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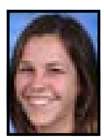
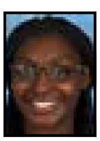
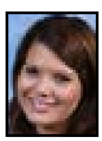
Dr. Joshua Steele
Scientist


Dr. Yawei Wang
Visiting Scientist


Lindsay Darjany
Sr. Research Technician


Lucy Mao
Research Technician


Elishebah Tate-Pulliam
Laboratory Assistant

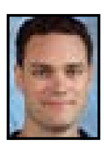

Maddie Griffith
Laboratory Assistant

Information Management and Analysis


Dr. Steven Steinberg
Principal Scientist


Shelly Moore
Senior Scientist


Dr. Nikolay Nezlin
Scientist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Network Administrator


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Sr. Research Technician


Kristin Chlentzos
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Jordan Golemo
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