SCCWRP

2021 ANNUAL REPORT

Enduring resonance of Bight regional monitoring

Southern California's signature monitoring collaboration continues to extend its reach and impact

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT

Applying next-generation science to aquatic ecosystems management

Contents

Introduction

Feature Articles

Courtesy of Ami Latker, City of San Diego Public Utilities Department

A field crew for the Southern California Bight Regional Monitoring Program uses a pair of plankton tow nets to collect small, shell-forming marine organisms vulnerable to coastal ocean acidification. SCCWRP is helping the Bight program investigate how acidification will affect coastal ecosystems – now and into the future. **Page 24**

Accomplishments with journal abstracts

People

Southern California Coastal Water Research Project 2021 Annual Report

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Cover photo
A pair of plankton nets is towed through coastal waters by a Southern California Bight Regional Monitoring Program field crew to collect small, shell-forming marine organisms vulnerable to coastal ocean acidification.

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Snapshot of Success

Steps taken by SCCWRP to improve aquatic science research and water-quality management in 2021

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

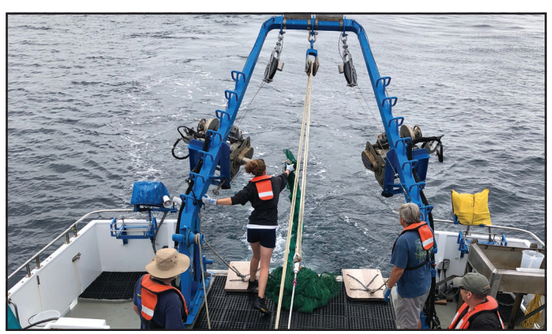
SCCWRP scientific staff published an average of **3.4** journal articles each per year over the past three years. This compares favorably with the **2** publications per year minimum that SCCWRP's partners at academic research institutions generally seek to achieve when being considered for promotion. **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 researchers. SCCWRP's goal is for other scientists to reference SCCWRP's work when publishing their own.

Accomplishment

SCCWRP publications were cited **2,422** times in 2021, according to Web of Science statistics, which represents a nearly **20%** increase in the number of citations compared to 2020.



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 researchers 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 **154** leadership roles with professional societies, advisory committees and scientific journals in 2021. **Page 69**

» 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 **177** different institutions in 2021. **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 illustrate how SCCWRP – as facilitator of the Southern California Bight Regional Monitoring Program – is helping the region's water-quality management community refine and evolve strategies to better monitor and protect the health of Southern California's coastal ocean.

» Characterizing issues

SCCWRP helps managers design robust environmental monitoring studies that illuminate potential threats to coastal ecosystems, as well as document improvements over time.

» Developing methods and tools

SCCWRP develops and test-drives new approaches for getting more insightful data faster and more cost-effectively.

» Assessing effectiveness of actions

SCCWRP helps evaluate the effectiveness of management interventions taken to better protect coastal ocean health.

Accomplishment

SCCWRP has helped managers build a robust, sustainable sediment quality monitoring program that is being leveraged to probe multiple additional aspects of coastal ecosystem health. **Page 11**

Accomplishment

SCCWRP has helped design rigorous trash monitoring surveys on land and at sea that are answering key questions about whether management actions to combat trash in aquatic environments have made a difference. **Page 17**

Accomplishment

SCCWRP has helped unify multiple ocean acidification monitoring programs, including the Bight program, to investigate how West Coast seawater chemistry is changing and how marine life are being affected. **Page 24**

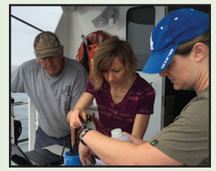
4 Long-term support

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 its 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 have spent more than **50,000** person-hours designing, facilitating and helping to manage the Bight '18 monitoring program.

Director's Message

Southern California's monumental monitoring leap

1990 started a paradigm shift in water-quality monitoring.

That was the year the book *Managing Troubled Waters* was published by the National Research Council, the operating arm of the prestigious National Academies of Sciences, Engineering and Medicine. The book was critical of the approaches being taken to monitor water quality, and the Southern California Bight was a primary case study in this critique.

Despite collecting thousands of samples across hundreds of sites annually, environmental managers could not answer simple questions posed by the Clean Water Act, the federal law that had been passed two decades earlier. Is it safe to swim? Is it safe to eat the seafood? Are ecosystems protected?

Southern California environmental managers responded, creating the Southern California Bight Regional Monitoring Program – we call it the Bight program – shortly thereafter to take all three of these questions head on.

Today, the Bight program is a national leader in large-scale regional monitoring. Multiple special issues of scientific journals, book chapters, expert panels and workshops have examined why the Bight program works and how it's been able to sustain itself when monitoring programs in other regions have faltered.

The answer is simple in concept, but difficult to achieve. As you'll learn on the following pages, the Bight program is a coordinated, integrated effort that has brought together nearly 150 monitoring agencies to develop powerful monitoring questions, use statistically robust sampling designs, maintain the highest-quality data, and arrive at conclusions and recommendations that all participants agree upon. All of the Bight participants do a small portion of the field and laboratory effort – in the process, building a community and the trust that ensures management responsiveness to the program's findings.

The Bight program has been so successful that it has spawned other integrated, coordinated regional monitoring programs in Southern California. Most notable is the Southern California Stormwater Monitoring Coalition (SMC) Regional Watershed Monitoring Program, now in its 15th year. Among the most productive of its type, SMC stream monitoring also has positively impacted management, including building the technical foundation for biological objectives aimed at protecting stream health.

Over the years, SCCWRP has facilitated a range of other coordinated regional monitoring programs, including those for beach water quality, riparian habitats, estuaries, kelp beds, and California's Areas of Special Biological Significance, among others. Our newest monitoring program is answering valuable questions about the performance of runoff control measures known as stormwater BMPs (best management practices), where billions of dollars will be invested over the next two decades.

SCCWRP also takes great care to integrate the Bight program with larger-scale monitoring that extends beyond Southern California. You'll read about the program joining efforts with other ocean acidification (OA) monitoring programs to track OA's burgeoning environmental challenge across the length of the California Current, from Alaska to Mexico. Comparable SCCWRP partnerships and collaborations exist for monitoring harmful algal blooms, contaminants of emerging concern, invasive species and more.

We've come a long way since *Managing Troubled Waters* was published, a testament to the ingenuity and adaptability of Southern California's management community.

Through it all, the Bight program has remained SCCWRP's flagship initiative – the premier activity we do to support our member agencies and the public they represent. I hope you enjoy this year's Annual Report, a snapshot of regional monitoring at its best.

Stephen B. Weisberg, Ph.D.
Executive Director

ENDURING RELEVANCE AND IMPACT OF BIGHT MONITORING

Regional monitoring of Southern California's coastal ocean has provided unprecedented insights into overall ecosystem health – along with a host of ancillary benefits

Three decades ago, Southern California was home to a flurry of siloed, site-specific coastal ocean monitoring activities.

Major sources of industrial and wastewater discharges were routinely monitored, as is required under coastal discharge permits. Meanwhile, many local researchers, nonprofits and environmental management agencies were independently conducting their own monitoring at dissimilar, localized scales.

These monitoring activities were costly: An estimated $31 million was being spent across coastal Southern California alone as of the mid-1990s.

But despite this level of investment, none of these monitoring data sets could be stitched together to answer overarching questions about the health of the coastal ocean.

Southern California's environmental management community struggled to provide baseline insights like: Are Southern California's coastal ecosystems being adequately protected? Can humans safely consume locally caught sport fish? Can beachgoers safely swim in coastal waters?

The problem was that none of the site-specific monitoring data were collected using unified, standardized methods with comparable quality-control checks, nor were the data sets collected from spatially representative sites so they could be extrapolated in an unbiased fashion to draw conclusions about overall ecological condition.

To be able to synthesize this monitoring information together in meaningful, managerially relevant ways, all of the existing monitoring activities needed to be unified around a robust monitoring design at a regional scale – supported by mutually agreeable methods, tools, scientific frameworks and governance processes.

Arriving at a common vision for regional monitoring would require extensive coordination, collaboration and trust-building.

Moreover, regional marine monitoring in Southern California could not represent a net increase in costs; existing monitoring resources would need to be reallocated and leveraged. Finally, participants could not be expected to pay a third party to do the monitoring surveys for them.

SCCWRP – whose membership is made up of many of the key players from the regulated and regulatory sides of the aisle necessary to develop such a program – stepped up to the plate, building a pilot monitoring survey in 1994 that would become the Southern California Bight Regional Monitoring Program.

The pilot survey was the realization of a monitoring paradigm

Participants of the Southern California Bight Regional Monitoring Program attend a SCCWRP-hosted kickoff meeting for the program's 2018 monitoring cycle, known as Bight '18. More than 80 organizations across Southern California and beyond are working collaboratively to examine how human activities have impacted the health of Southern California's coastal waters.

conceptualized by the U.S. Environmental Protection Agency – known as the Environmental Monitoring and Assessment Program – that calls for periodic, regional assessments of aquatic ecosystems.

Through the pilot initiative, SCCWRP and its member agencies pooled their resources and worked together to assess 1,539 square miles of Southern California coastal waters, from Santa Barbara to the U.S.-Mexico border.

The pilot project was an immediate success, with environmental management agencies able to reallocate resources they were already expending on site-specific monitoring to support the regional monitoring effort.

Soon, participants began planning to expand the pilot survey into a cyclical monitoring initiative.

The most recent five-year cycle – known as Bight '18 because field sampling kicked off in 2018 – brings together more than 80 participating organizations to get answers to some of the most pressing management questions about the ecological health of Southern California's coastal ocean.

"The Bight program truly is one of those situations where the final product is much more than the sum of its parts," said Dr. Peter Vroom, Deputy Director for the City of San Diego Public Utilities Department. "The expansive area monitored – coupled with decades of temporal data – are providing unprecedented insight into long-term trends and oscillations of currents, water quality, and species composition. Through Bight monitoring, we get the lines of evidence needed to show that our discharges are not negatively impacting the ocean environment."

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The key to the Bight program's enduring success is that it is a collaborative, consensus-driven initiative.

The Bight program involves participation by a broad cross section of organizations responsible for protecting Southern California's coastal ocean: wastewater management agencies, stormwater management agencies, water-quality regulatory agencies, natural resources agencies,

Bight '18 participating organizations

Algalita Marine Research and Education
Anchor QEA
Aquatic Bioassay and Consulting Laboratories
California Coastkeeper Alliance
California Department of Fish and Wildlife
California Ocean Protection Council
California Regional Water Quality Control Board, Los Angeles Region
California Regional Water Quality Control Board, San Diego Region
California Regional Water Quality Control Board, Santa Ana Region
California State University, Channel Islands
California State University, Long Beach
California State Water Resources Control Board
California Surface Water Ambient Monitoring Program
Catalina Sea Ranch
Channel Islands National Marine Sanctuary
Chevron USA Products Company
City of Avalon
City of Carson
City of El Segundo
City of Encinitas
City of Escondido
City of Hawthorne
City of Inglewood
City of Lawndale
City of Lomita
City of Los Angeles
City of Oceanside
City of Oxnard
City of San Diego
Dancing Coyote Environmental
Dominguez Channel Watershed Management Group
EcoAnalysts
Encina Wastewater Authority
Eurofins Calscience Environmental Laboratories
Greater Los Angeles and Long Beach Harbor Waters Regional Monitoring Coalition
Heal the Bay
Los Angeles County Department of Public Works
Los Angeles Department of Water and Power
Los Angeles County Natural History Museum
Los Angeles Waterkeeper
MBC Applied Environmental Sciences
Moss Landing Marine Laboratories
National Oceanic and Atmospheric Administration
Nautilus Environmental
Occidental College Vantuna Research Group
Orange County Coastkeeper
Orange County Department of Public Works
Orange County Public Health Department
Orange County Public Works
Orange County Sanitation District
Pacific EcoRisk
Physis Environmental Laboratories
Port of Long Beach
Port of Los Angeles
Port of San Diego
Reef Check California
Riverside County Flood Control and Water Conservation District
San Diego Coastkeeper
San Diego County Department of Environmental Health
San Diego County Department of Public Works
San Diego Regional Harbor Monitoring Program
San Elijo Joint Powers Authority
San Francisco Estuary Institute
Sanitation Districts of Los Angeles County
Santa Barbara Channelkeeper
Santa Monica Bay Restoration Commission
Southern California Coastal Ocean Observing System
Southern California Coastal Water Research Project
U.S. Bureau of Ocean Energy Management
U.S. Environmental Protection Agency, Region 9
U.S. Fish and Wildlife Service
U.S. Naval Facilities Engineering Command Southwest
Universidad Autónoma de Baja California
University of California, Irvine
University of California, Los Angeles
University of California, Riverside
University of California, San Diego Scripps Institution of Oceanography
University of California, Santa Barbara
University of Southern California
Ventura County Watershed Protection District
Ventura County Public Health Laboratory
Weck Laboratories
Weston Solutions
Wood Environment & Infrastructure Solutions

Bight '18 study elements

The five major study elements of the Bight '18 monitoring cycle strike a balance between the need to track ecosystem trends over time, and evolving the program to remain responsive to pressing issues of management concern across coastal Southern California. As with past program cycles, Bight '18 participants revised and reworked about half of the program's studies.

» **Sediment Quality** explores the ecosystem impacts of coastal sediment contamination across time and space. The monitoring design of the sediment quality surveys also enables the Bight program to explore multiple, diverse aspects of coastal ecosystem health via leveraged, add-on studies.
Page 11

» **Harmful Algal Blooms** examines how toxins created by some types of blooms can linger in seafloor sediment, where they have the potential to bioaccumulate through marine food webs and eventually contaminate seafood consumed by humans.

» **Trash** tracks the extent to which trash has spread across aquatic environments on land and at sea, as well as the effectiveness of aggressive, next-generation management actions being taken to combat trash in aquatic environments.
Page 17

» **Ocean Acidification** tracks how coastal seawater chemistry is changing as a result of ocean acidification. For the first time, the Bight program is documenting the relationship between the chemistry changes and how these changes affect vulnerable, shell-forming organisms at the base of marine food webs.
Page 24

» **Microbiology** examines the relevance and reliability of using coliphage viruses – a new indicator of aquatic fecal contamination – to track microbial water quality at Southern California beaches, and how coliphage compares to established, decades-old fecal contamination indicators.

Ancillary benefits of regional monitoring

In addition to providing a forum for dozens of organizations to monitor regional ecosystem health, the Bight program's infrastructure also enables it to:

» Facilitate quality-assurance and quality-control studies that ensure all data being generated by participating organizations – not just Bight program data – are comparable, of high quality and generated using standardized methods

» Enable new monitoring methods and emerging technologies to be tested across a broad spectrum of habitat conditions and environmental stresses

» Serve as a springboard for participants to collaborate on follow-up studies and site-specific monitoring – beyond the scope of the regional monitoring program – that provide more insights into ecosystem health

» Provide context for how site-specific monitoring data that are collected outside the regional monitoring program compare to regional condition

» Expand regional monitoring efforts to investigate habitats and contaminants that have historically been overlooked

Courtesy of Curtis Cash, City of Los Angeles

A field crew for the Southern California Bight 2018 Regional Monitoring Program retrieves a fishing trawl net that has been cast off the backside of a research vessel. The program offers participants a platform for working collaboratively to monitor coastal ecosystem health, as well as numerous ancillary benefits.

municipalities, academic researchers and environmental nonprofits.

These organizations with vastly different agendas, priorities, needs and sensibilities take shared ownership of the program – its design, its operation, its governance and, most importantly, its findings and bottom-line conclusions about how to optimally manage and protect the coastal ocean.

Every participating organization mutually agrees on what work should be conducted and how that work should be conducted. Every participant also provides expertise, perspective and both in-kind and financial resources to help sustain the program's operations cycle after cycle. And every participant agrees upfront on courses of action to pursue depending on the findings.

Because participants must work toward consensus on what the monitoring data say about coastal ocean health across time and space, participants are able to speak with a common voice, delivering unified messaging that helps amplify the resonance of the program's findings across Southern California and beyond.

"The Bight program is effective because it allows us to come to a consensus agreement on the overall condition of the coastal Bight that is based on a sound scientific foundation," said George Robertson, a Senior Scientist for the Orange County Sanitation District. "Being able to collaboratively establish and address priorities has proven to be a recipe for success."

Over the years, the Bight program has continued to grow and expand, with additional participating organizations joining each cycle and additional studies being pursued that shed new insights into additional facets of coastal ocean health – from examining contamination levels in sport fish and seabird eggs, to understanding which Southern California beaches are most polluted, to tracking the prevalence of harmful algal blooms.

What regional monitoring is not

The Southern California Bight Regional Monitoring Program is a complement to, but not a replacement for, site-specific monitoring. Site-specific monitoring is still needed to extract granular-level insights about the ecological health of specific, high-interest locations, particularly sites where land-based discharges that contain pollution are entering the coastal ocean.

Regional monitoring initiatives like the Bight program also are typically not diagnostic in nature. The purpose of regional monitoring is to document overall ecological health, not necessarily to identify why these conditions exist or the specific pollution sources responsible. Follow-up studies known as causal assessments are needed to determine the specific causes of ecological degradation.

The sixth cycle of the Southern California Bight Regional Monitoring Program – known as Bight '18 – builds on the collaborative spirit and commitment to scientific excellence that have been hallmarks of the Bight program since its inception in 1994. On the pages that follow are three feature articles that take an in-depth look at three major study areas, known as study elements, of the SCCWRP-facilitated Bight program. The articles describe how the program's findings – including from the ongoing Bight '18 monitoring cycle – are being applied and used to inform management thought processes, decisions and actions in Southern California and beyond.

1 » **Expanding sediment quality investigations** explores how the Bight program has leveraged its foundational sediment quality surveys to not only monitor coastal ocean health across space and time, but also to investigate other issues of pressing management concern. **Page 11**

2 » **Tracking effectiveness of trash management** examines how the Bight program is generating foundational data sets that are helping environmental managers to assess whether Southern California's aggressive, next-generation management strategies for combating trash pollution are working. **Page 17**

3 » **Tracking ocean acidification's biological effects** explores how the Bight program is working to methodically link changes in seawater chemistry triggered by ocean acidification to biological changes in sensitive aquatic life – foundational work that will explain the real-world consequences of this global phenomenon in Southern California and beyond. **Page 24**

EXPANDING SEDIMENT QUALITY INVESTIGATIONS

The Bight program's foundational sediment quality surveys over the past three decades have paved the way for a wide range of leveraged investigations probing diverse aspects of ecosystem health

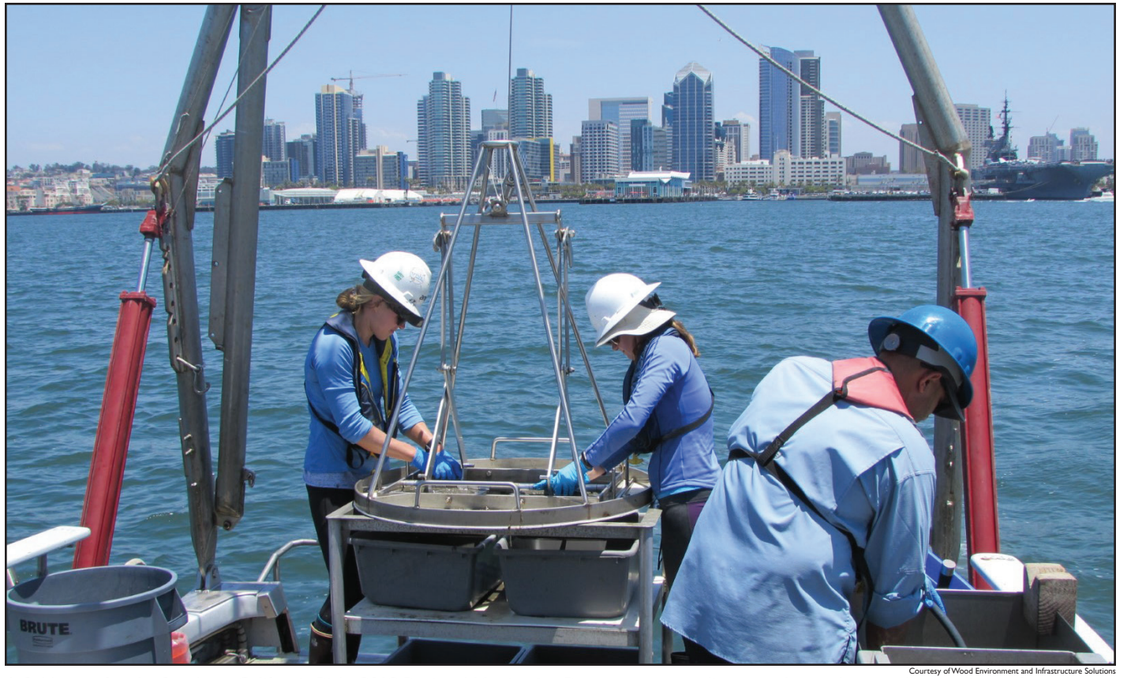
To conduct a robust, comprehensive assessment of the overall health of Southern California's coastal ocean, environmental managers don't measure contaminant levels in seawater.

The reason? The dynamic nature of ocean currents complicates efforts to predict adverse, long-term effects from pollutants in the water column.

Instead, environmental managers examine the quality of the seafloor's top layers of sediment.

Focusing on the most recently deposited layers of sediment

Background photo courtesy of Institute for Applied Marine Ecology/Marine Applied Research and Exploration (IAME/MARE)



Courtesy of Wood Environment and Infrastructure Solutions

A field crew for the Southern California Bight 2018 Regional Monitoring Program uses a sediment grab sampler to collect sediment from the seafloor of San Diego Bay. Sediment quality assessments provide insight into how contaminants introduced by humans to the coastal ocean are impacting the overall ecosystem health.

– which covers the vast majority of Southern California's coastal ocean seafloor – is a particularly effective indicator of how contaminants introduced by humans to the environment are impacting the overall health of coastal ecosystems.

Unlike ocean currents that quickly disperse contaminants in the water column, chemical contaminants stick to suspended particles and settle to the ocean floor, forming sediment layers that can remain toxic for decades.

To measure the ecological effects of this contamination, scientists have developed rigorous, quantitative sediment quality monitoring methods that go well beyond just measuring contamination in the sediment itself. These methods are designed to investigate how aquatic life are affected via exposure to the sediment contaminants.

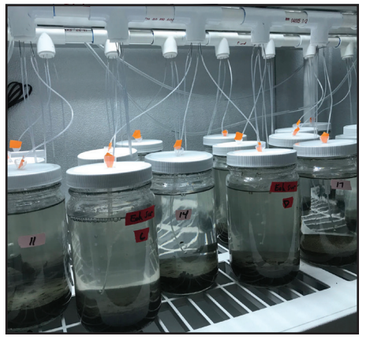
Collectively, sediment quality assessments provide multiple lines of evidence about overall ecosystem health, giving managers a higher degree of confidence in findings.

Indeed, across Southern California, much of what environmental managers know about how land-based contamination has impacted overall coastal ocean health over the past three decades comes from the findings of the Southern California Bight Regional Monitoring Program's foundational sediment quality surveys.

Moreover, the sediment quality monitoring surveys are used to generate more than just big-picture trend lines. The Bight program leverages its sediment monitoring infrastructure and study design to investigate multiple other aspects of coastal ocean health, from the spread of trash along the seafloor to biologically active contaminants that have more recently emerged as a management concern.

Other researchers, meanwhile, are leveraging the program's monitoring data to investigate additional aspects of coastal ocean health, extending the utility of the data sets beyond the Bight program itself.

"The study design of the Sediment Quality element makes it a highly leveraged, efficient way to pursue the answers to pressing management questions," said Rebecca Fitzgerald, Standards and Assessment Section Manager for the Division of Water Quality at the California State Water Resources Control Board. "Because the program is designed to collect sediment samples at hundreds of statistically representative locations, it's easy to add supplemental studies that piggyback off this scientifically rigorous study design."



Sediment samples that have been portioned into glass jars are analyzed via toxicity testing, which measures how organisms are affected by exposure to contaminants in the sediment. Sediment toxicity testing is one of multiple lines of evidence used by the Bight program to assess coastal sediment quality.

Rigorous, quantitative assessments

The Sediment Quality study element is the core of the Bight program. Since the program's inception in 1994, Southern California's environmental management community has been using sediment quality assessments to monitor the health of the coastal ocean.

The program's rich data sets have enabled managers to build comprehensive regional snapshots of ocean health across time and space. More than 2,000 sites – from Santa Barbara in the north to the U.S.-Mexico border in the south – have been sampled since 1994.

As part of the most recent 2018 monitoring cycle, known as Bight '18, 330 sites were sampled for sediment quality across 1,539 square miles. Sampling starts at a depth of just 3 feet along the shore and extends more than 20 miles offshore, to a depth of nearly 3,000 feet.

The program uses a stratified, random sampling design for selecting monitoring sites across Southern California. Stratification breaks the seafloor into specific habitats by depth and use, and randomized sampling removes possible bias and ensures findings are statistically representative.

Multiple lines of evidence

The Bight program uses multiple lines of evidence to provide greater confidence in the findings of sediment quality monitoring investigations. During each monitoring cycle, five main types of sediment quality studies are conducted to investigate the ecological impacts of both direct exposure to sediment contamination, as well as indirect exposure via bioaccumulation.

Assessment of direct effects

1. Sediment chemistry
2. Sediment toxicity
3. Sediment-dwelling biological communities

Assessment of indirect effects

4. Large, bottom-dwelling fish/invertebrate communities
5. Contaminant bioaccumulation

Sediment Quality Triad scoring tool used to quantify sediment quality impacts at sites less than 650 feet deep

Overall narrative assessment of how sediment contamination has impacted coastal ocean health

Since the Bight program began sediment quality monitoring in 1994, researchers have consistently found that the vast majority of the coastal seafloor – 96% or more – is not considered to be ecologically impacted by sediment contamination.

As a result, environmental managers can remain focused on the tiny portion of the overall seafloor – almost entirely within coastal embayments – where sediment contamination is continuing to disproportionately impact coastal ecosystem health.

Indeed, although the Bight program documented significant improvements to sediment quality in Southern California's ports, marinas, bays and estuaries from 1998 to 2008, these gains have largely plateaued over the past decade – with about a quarter of all embayment areas still ecologically impacted by sediment contamination.

"At a big-picture level, what the Bight '18 sediment quality findings tell us is that most of the coastal benthic ecology continues to be in good condition overall," said Dr. Jason Freshwater, an Environmental Scientist for the Santa Ana Regional Water Quality Control Board. "However, the data also support the argument that we really need to focus our resources and attention on the estuaries

Courtesy of Wood Environment and Infrastructure Solutions

A Bight '18 field crew retrieves a fishing trawl net that has been towed along the coastal seafloor to collect fish and other large invertebrates. The health of more than 46,000 organisms was assessed during Bight '18 to provide an additional line of evidence about sediment quality in Southern California's coastal ocean.

and embayments that are disproportionately – and in some cases, fairly severely – impacted."

The Bight program arrives at its sediment quality findings using a quantitative scoring tool known as the Sediment Quality Triad, which synthesizes three main lines of evidence – sediment toxicology, sediment chemistry and sediment-dwelling biological community health – to produce a single category score reflecting sediment quality.

In addition to this quantitative evaluation method, the Bight program also uses two other lines of evidence – assessments of large, bottom-dwelling fish and invertebrate communities and bioaccumulation of sediment contaminants in fish and birds – to provide additional insights into overall ecological health.

These latter two lines of evidence are designed to investigate sediment contamination's indirect ecological impacts, as opposed to the quantitative Sediment Quality Triad scoring tool, which generates scores reflecting the degree to which organisms at a site are impacted via direct exposure to contaminated sediment.

During Bight '18, more than 46,000 bottom-dwelling fish and large invertebrates were sampled by towing fishing trawl nets along the seafloor. Less than 0.05% were found to have abnormalities such as fin rot, lesions and tumors – the lowest portion of any Bight program survey to date, and well within expected background levels for fish populations.

Similarly, among sport fish commonly caught in Southern California, Bight '18 found that average levels of five key contaminants, including mercury, were relatively low in the tissues of these fish. None of the five contaminants exceeded average levels that would place the fish in the most restrictive "Do not consume" consumption advisory threshold, as defined by California's Office of Environmental Health Hazard Assessment (OEHHA). Some contaminants, however, were at concentrations elevated enough to trigger advisory limits on the number of servings considered safe to consume each week.

Contaminants like mercury in fish tissue are transferred through food webs from prey to predator through a process known as bioaccumulation.

Examining other contaminants in sediment

The Bight program's sediment quality data sets are critical to tracking the ecological health of the coastal ocean over time, but sediment quality monitoring provides more than just big-picture trend lines.

The monitoring infrastructure and workflows that support sediment quality monitoring can be readily leveraged to investigate other types of habitats and contaminants. These add-on studies have enabled the Bight program to be responsive to a range of focused questions of management concern.

For example, since the Bight program's inception in 1994, the same survey that is used to assess the health of large, bottom-dwelling fish and invertebrates also is used to track trash levels across the continental shelf. Indeed, at the same time that fishing trawl nets are towed along the coastal seafloor to sample fish and invertebrates, the trash captured in these trawl nets is sorted, counted and classified. These data sets are then used to calculate the overall portion of the coastal seafloor that contains trash.

Similarly, the sediment samples being collected at sites across the coastal seafloor are routinely analyzed in new ways to look for different contaminant types.

For example, beginning in 2008, the Bight program began tracking a now-banned class of flame retardant chemicals known as PBDEs (polybrominated diphenyl ethers). Between 2008 – the year a statewide ban went into effect – and the following monitoring cycle in 2013, average PBDE concentrations fell by 92%.

More recently, the Bight program has used its sediment monitoring effort to track the spread of a toxin known as domoic acid that is produced by the most ubiquitous type of harmful algae in coastal Southern California. During Bight '18, researchers for the first time examined how much domoic acid – which is produced by the *Pseudo-nitzschia* marine diatom – is settling into seafloor sediment and then being absorbed and ingested by sediment-dwelling aquatic life.

Bight '18 found domoic acid across 54% of Southern California's coastal seafloor. Moreover, domoic acid was consistently found throughout the year in the bodies of sediment-dwelling organisms, even at times of the year when domoic acid isn't being produced, and even in places where the toxin could not be detected in the surrounding sediment.

Also during Bight '18, the program for the first time screened sediment samples for the presence of bioactive contaminants, including industrial and pharmaceutical chemicals. The monitoring investigation used a novel technology known as bioanalytical cell assays, in which laboratory-grown cells are exposed to contaminants from sediment and then their cellular-level responses are tracked.

"The incorporation of new technologies like bioanalytical screening assays into Bight '18 is just the latest example of how Bight '18's sediment quality work is continuing to pay dividends by offering a platform for assessing new contaminants using new assessment tools," said Dr. Daniel Schlenk, Professor of Aquatic Ecotoxicology and Environmental Toxicology at the University of California, Riverside.

Leveraging sediment quality data sets

The sediment quality data sets that

Key Bight '18 sediment quality findings

Bight '18 sediment quality analyses found that sediment contamination levels are so low across the vast majority of the coastal seafloor – 98.6% – that these areas are considered ecologically unimpacted by sediment contamination.

Only about 1.4% of the 1,539 square miles assessed for Bight '18 are considered possibly, likely or clearly impacted.

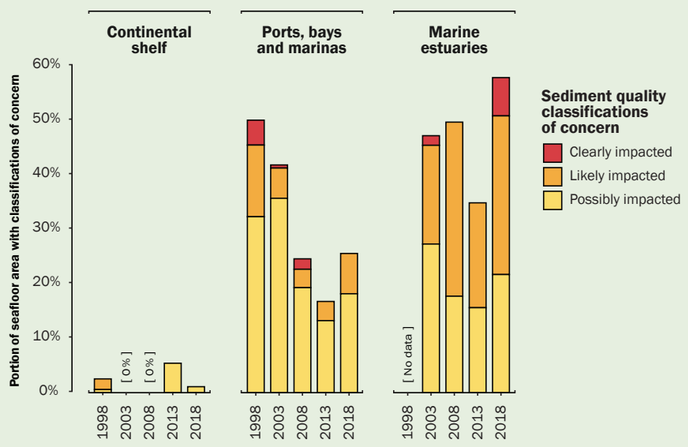
Bight '18 found, however, that coastal embayments, particularly estuaries, remain disproportionately impacted by sediment contamination.

About 67% of the assessed area of Southern California's brackish estuary seafloors is possibly or likely impacted – likely a consequence of the fact that brackish estuaries receive disproportionate levels of contaminated runoff and sediment from land.

Meanwhile, 56% of the assessed area of marine estuary seafloors is considered possibly or likely impacted. Compared to marine estuaries, brackish estuaries have lower salinity levels as a result of more freshwater inputs.

Sediment quality trends over time

Only a tiny fraction of the open waters of Southern California's continental shelf are impacted by sediment contamination. By contrast, Southern California embayments – ports, bays, marinas and estuaries – remain significantly impacted by sediment contamination. Sediment quality impacts to ports, bays and marinas are not as severe as they were two decades ago, but marine estuaries have not followed a similar trajectory.



Bioaccumulation of sediment contaminants

While much of the Bight program's sediment quality assessment work focuses on monitoring aquatic life directly exposed to sediment contamination, the Bight program also examines how sediment contamination can be passed through marine food webs from prey to predator – a process known as bioaccumulation.

Through bioaccumulation, humans who consume locally caught seafood can be indirectly exposed to sediment contamination.

During Bight '18, researchers analyzed the tissue of commonly caught sport fish for five key types of contaminants:

- Mercury
- Selenium
- Arsenic
- DDTs (dichlorodiphenyltrichloroethanes)
- PCBs (polychlorinated biphenyls)

DDTs and PCBs were banned in the U.S. decades ago, while the other three are tightly regulated today – meaning that some of this contamination likely entered the ocean many years ago.

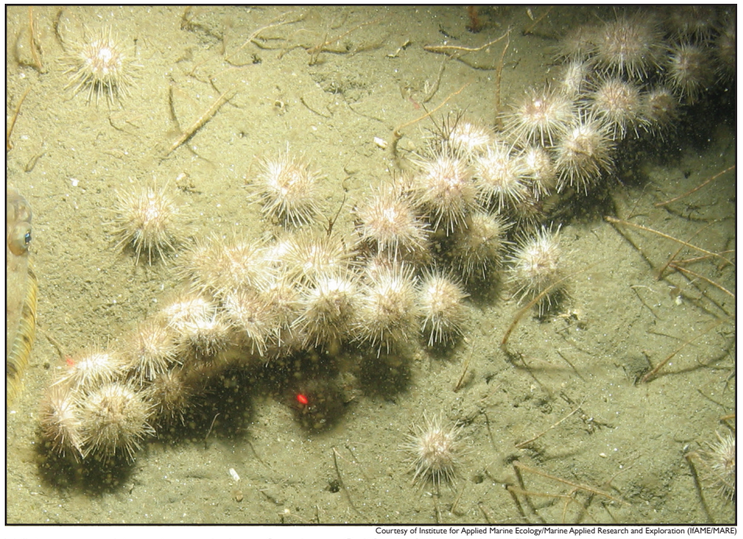
Bight '18 found that average levels of these contaminants in sport fish tissue were relatively low, with none of the five contaminants exceeding average levels that would place the fish in the most restrictive "Do not consume" consumption advisory threshold, as defined by California's Office of Environmental Health Hazard Assessment (OEHHA).

But of the five contaminants examined, average mercury levels and, to a lesser extent, total PCB levels exceeded thresholds that would trigger advisory limits on the number of servings that humans can safely consume each week.

That said, even among fish that had the highest average mercury levels, the mercury contamination was still below advisory thresholds that would restrict consumption to one serving or less per week.

Courtesy of Barbara Lloyd

A California halibut swims along the sediment bottom of Southern California's coastal seafloor. Humans who consume locally caught seafood can be exposed to sediment contamination through bioaccumulation, a process where contaminants pass through marine food webs from prey to predator.



Courtesy of Institute for Applied Marine Ecology/Marine Applied Research and Exploration (IIAME/MARE)

White sea urchins, pictured along Southern California's coastal seafloor, are vulnerable to changing seawater chemistry triggered by ocean acidification. A research team used 15 years of Bight program sediment quality monitoring data sets to show that sea urchin populations have decreased in deeper coastal waters.

have been generated through the Bight program represent the most encompassing, regional data sets of their kind.

For nearly three decades, the Bight program has been relying on these data sets to paint a rich, nuanced portrait of the health of Southern California's coastal ocean across time and space.

And significantly, the Bight program is no longer the sole beneficiary of these data sets. Other researchers routinely leverage the program's publicly accessible data sets to launch focused studies probing various aspects of coastal ocean health.

In 2016, for example, researchers at the at the Scripps Institution of Oceanography analyzed Bight program data to look for evidence that ocean acidification might already be threatening the survival of sea urchins. The shell-forming organisms depend on minerals in seawater that are becoming increasingly scarce as ocean acidification triggers changes to seawater chemistry.

The Scripps study – which used Bight program data focusing on the composition of large, bottom-dwelling fish and invertebrates – found that the number of sea urchins living in deeper coastal waters shrank over a 15-year period that ended in 2013. Moreover, the study identified low-pH deeper waters as the likely culprit.

More recently, the federal Bureau of Ocean and Energy Management, in partnership with SCCWRP, has been using Bight program data to develop baseline understanding of what the composition of deep-water organisms should look like in federal waters off Southern California.

The energy and mineral resources agency intends to use this information to inform how to proceed with decommissioning of offshore oil platforms – specifically, to make decisions about what kinds of clean-up activities, if any, are needed.

The Bight program data sets, which explain what undisturbed "reference" biological communities should look like based on various depth and habitat characteristics, are one of the few data sets available to help the Bureau of Ocean and Energy Management understand how biological community health near oil platforms compares to other areas.

As researchers continue turning to the Bight program for encompassing, comprehensive data sets on coastal ocean health, it will reinforce the strategic value of continuing to invest in regional sediment quality monitoring every five years.

"Sediment quality monitoring is a core element of estuarine and marine monitoring programs around the world," said Terry Fleming, an Environmental Scientist for the U.S. Environmental Protection Agency, Region 9. "However, the Bight program uses the sediment monitoring in novel ways to assess the presence and potential effect of new and emerging contaminants in marine sediments. I expect sediment monitoring to be a core feature of the Bight program for years to come."

The Bight program's sediment quality monitoring data sets are being used by the federal Bureau of Ocean and Energy Management to inform how to proceed with decommissioning of Southern California's offshore oil and gas infrastructure. The data sets help researchers understand how biological community health near oil platforms compares to other areas.

Background photo courtesy of Heal the Bay

TRACKING EFFECTIVENESS OF TRASH MANAGEMENT

The Bight program is helping environmental managers evaluate whether Southern California's aggressive, next-generation strategies for combating trash in aquatic environments are working

Most municipalities use a combination of anti-littering laws, public education initiatives and routine clean-up activities to reduce trash levels in aquatic environments.

This standard mix of management actions is commonplace in urban areas across the nation, but often, it's not nearly enough.

Southern California serves as a case in point: Trash is now found along more than 75% of the region's 4,600 miles of inland waterways and across 25% of Southern California's coastal seafloor, according to regional monitoring findings.

These eye-popping figures have become Southern California's wake-up call about the need to take more aggressive trash management actions.

Over the past decade, Southern California's water-quality management community has risen to meet this challenge, investing significant time and resources to dramatically and comprehensively

Ugly environmental problem

Perhaps the most visible of all pollutants, trash can strangle animals or be mistaken for food and starve the animals that eat it. Of all the types of trash, plastic is perhaps the most insidious. Plastic can excrete toxins used in its manufacture, and plastic also can adsorb environmental toxins, concentrating pollutants such as pesticides or pathogens – and amplifying potential biological effects on animals exposed to plastic particles.

A rainbow runner from the northern Pacific Ocean is dissected to reveal that the fish ingested more than a dozen pieces of plastic. Plastics are the most common type of trash found in Southern California's coastal ocean and inland waterways.

rethink how trash gets managed in aquatic environments.

Multiple, next-generation management strategies have been rolled out that represent the first of their kind in the nation. Notably, in the Los Angeles region, 15 water bodies have been added to federal 303(d) impaired water body lists because they are considered degraded by trash pollution – a regulatory action that, when first implemented, had never been done anywhere in the U.S.

The 303(d) listings have compelled the L.A. area's stormwater discharger community to take aggressive actions to combat trash loading, including installation of metal grates over thousands of storm drain inlets draining to trash-impaired waterways.

The State Water Resources Control Board, meanwhile, deemed this approach to be so effective that it incorporated elements of the L.A.-area program into a statewide trash regulatory program; eventually, the program will apply to all areas of California that have high trash-generating rates.

In parallel, Southern California municipalities have worked to achieve reductions in trash loading through product-specific bans. In the mid-2000s, the City of Malibu was among the first municipalities in California to ban polystyrene foam for food packaging and carry-out plastic bags. Dozens of other municipalities have since followed suit.

Meanwhile, in 2014, California voters approved a statewide ban on carry-out plastic bags at grocery stores and pharmacies; the ban took effect two years later.

Courtesy of Orange County Public Works

Southern California has taken aggressive actions in recent years to curb trash pollution in inland waterways and the coastal ocean. Increasingly, the environmental management community wants to know if these measures are making a difference.

Collectively, these aggressive, next-generation anti-trash measures represent tens of millions of dollars of planning, implementation and enforcement actions.

And increasingly, Southern California's water-quality management community and the public want to know: Are these anti-trash measures working as intended?

Especially with many areas of Southern California still in the process of rolling out their next-generation plans for combating trash, managers are looking for early, quantitative evidence that the interventions to date have measurably reduced trash loading in aquatic environments.

Southern California's regional monitoring community, which has built capacity to monitor trash on land and at sea, is well-positioned to begin answering the fundamental question about management effectiveness.

In cooperation with the Southern California Stormwater Monitoring Coalition (SMC), the Southern California Bight Regional Monitoring Program over the past decade has developed and implemented a regional trash monitoring program for about 4,600 miles of watersheds that drain to the coastal ocean.

Initial results from the most recent monitoring cycle for each program indicate that the management actions taken over the five years prior have had measurable, positive impacts.

These early success stories from regional trash monitoring are helping to buoy management confidence in the directions that Southern California is moving as it works toward solving this enormous regional pollution challenge.

Courtesy of Wood Environment and Infrastructure Solutions

A field crew for the Southern California Bight 2018 Regional Monitoring Program retrieves a fishing trawl net that has been towed along the coastal seafloor. By collecting, counting and sorting trash from these field sampling surveys, researchers can extrapolate what portion of Southern California's coastal seafloor contains trash.

"We are proud to report that we no longer have to work only with anecdotal evidence that the intense resources we're investing into combating trash in Southern California are working," said Capt. Charles Moore, founder of Algalita Marine Research and Education and the Moore Institute for Plastic Pollution Research. "Thanks to the Bight and SMC programs, we now have some of the very first scientific evidence showing that Southern California's aggressive actions to combat trash can and do work."

Collecting foundational trash monitoring data sets

Southern California is home to perhaps the most comprehensive, ongoing regional trash monitoring program in the world.

Not only do the Bight and SMC programs collaborate every five years to comprehensively monitor trash in marine and inland waterways, but these programs also have developed standardized trash monitoring methods that enable data to be collected in consistent, directly comparable ways.

Since 1994, when the Bight program's foundational sediment quality study was launched as a pilot regional monitoring survey, participants have been documenting the portion of the Southern California coastal ocean seafloor where trash can be found.

In that time span, the area of the Bight seafloor where trash can be found has roughly doubled, with the most recent Bight monitoring cycle estimating that trash can be found across 25% of the coastal seafloor – the vast majority of which is plastic.

Moreover, the Bight program's data points are likely underestimates of total trash, as smaller pieces of trash that slip through the mesh openings of deep-sea sampling nets aren't being counted.

The Bight program's marine monitoring data sets represent a key advance in managers' understanding of how trash pollution is spreading in the ocean.

Prior to the Bight program, information about the extent of Southern California's trash problem consisted largely of isolated, semi-quantitative data points, such as total weight of trash collected at a particular beach or stream during a clean-up event.

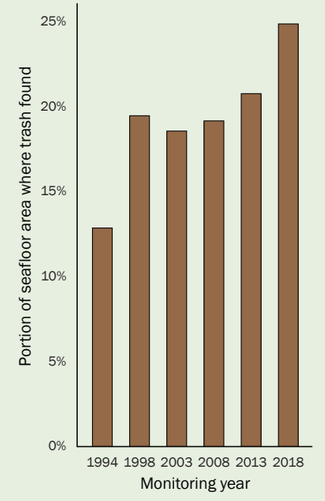
In 2021, for example, volunteers removed more than 300,000 pounds of trash along shorelines statewide during California's annual beach clean-up day, according to State data.

Although these data points play a key role in ensuring Southern California remains focused on cleaning up trash, the data points are of limited utility to managers because they don't put the problem into a regionally relevant context. In other words, researchers cannot build scientifically robust trend lines when multiple parties collect, count and identify trash using non-standardized methods.

The Bight program, by contrast, uses a probabilistic survey design to eliminate potential bias in estimates of where along the seafloor that trash will be found, as well as scientifically validated methods to quantify trash loading. The Bight program originally adapted and standardized these methods for use in Southern California in advance of its 1994 pilot survey, and has been training participants to use these methods for every monitoring cycle since.

Trash's spread along the coastal seafloor

For nearly three decades, the Bight program has been tracking the spread of trash across the continental shelf. The program has documented a steady increase in the area of the coastal seafloor where trash has accumulated.



During the Bight '18 trash monitoring survey, trash was collected from more than 140 locations by hauling nets along the coastal ocean floor at low speeds. The trash was counted and categorized, then researchers extrapolated what portion of the overall seafloor area – an area that spans more than 800 square miles – contains trash.

"With nearly three decades of monitoring data under our belt, we now have some really powerful, clear trend lines about how trash is spreading in the coastal ocean," said Kaitlyn Kalua, Water Quality Program Manager for the California Ocean Protection Council. "The trash data sets are incredibly valuable to inform upstream management solutions."

Building a case for more aggressive action

The Bight program's trash monitoring surveys have helped build a compelling case for the aggressive, next-generation management actions that Southern California has taken to reduce trash in its aquatic environments.

The earliest of these management actions dates back to 1996, when the Los Angeles Regional Water Quality Control Board began adding L.A.-area waterways to a federal 303(d) list of impaired water bodies.

This novel approach – which had never been implemented for a U.S. water body – enabled the L.A. Regional Board to develop total maximum daily load (TMDL) regulatory requirements for these water bodies that compel municipalities and other entities that discharge into the water bodies to reduce trash loading.

The L.A.-area trash TMDLs give the stormwater dischargers two main options for reducing trash levels:

» **Option 1**: Metal mesh screens and similar "full-capture" devices are installed at storm drain inlets, typically in catch basins at or just below street level. The custom-designed screens trap and hold back trash particles larger than 5 millimeters in diameter; then, maintenance crews manually remove the accumulated trash at regular intervals. Thousands of these full-capture devices have been installed over the past decade across the L.A. region.

» **Option 2**: Stormwater dischargers that prefer not to install these full-capture devices, or that cannot because of the physical configuration of their storm drain systems, can instead develop a plan for capturing trash at levels equivalent to full-capture devices. Option 2 typically includes a mix of improved source control, more intensive street sweeping and installation of bioswales and other multi-benefit projects.

Affected discharger agencies began coming into compliance with the L.A.-area trash TMDLs around 2010; full compliance for all 15 watersheds is expected in the coming years.

Inspired by this novel approach to regulating trash, the State Water Resources Control Board in the early 2010s began studying the feasibility of developing a similar statewide regulatory program for trash.

Instead of trying to address trash one water body at a time, as is done via the trash TMDL process, the State Water Board worked to develop a program that could apply to all water bodies across California impacted by high trash-generation rates. Like the L.A.-area trash TMDLs, the statewide program centers around two compliance options: installation of full-capture devices at storm drain inlets, or development of a plan to capture trash at equivalent rates.

Today, California's trash-reduction requirements are being incrementally codified into municipal stormwater discharge permits as the permits come up for renewal. Responsible municipalities then become tasked with coming into compliance over a 10- to 15-year period.

This stormwater-centric approach to combating trash is not the only regulatory approach that Southern California has taken. Over the past two decades, Southern California municipalities also have been enacting bans on specific products that commonly end up in aquatic environments.

In 2005, the City of Malibu became one of the first California municipalities to ban the use of polystyrene foam, commonly referred to as Styrofoam, for food packaging. Dozens of other municipalities followed suit.

In 2008, California enacted strict regulations on facilities that manufacture, handle and transport pre-production plastic pellets. The grain-sized particles, which serve as the raw materials for plastic production, can spill and become lost during transport.

More recently, in 2015, California approved a ban on the sale of personal care products that contain plastic microbeads; a similar federal ban was enacted the same year.

And in 2016, a statewide ban on carry-out plastic bags at grocery stores and pharmacies went into effect, following an unsuccessful referendum to overturn the ban.

"Over the past decade or so, California municipalities – as well as the State itself – have implemented some really aggressive, next-generation measures to curb trash loading in our aquatic environments," said Dr. Melissa Turcotte, Head Environmental Engineering Specialist for the Los Angeles County Department of Public Works. "We're now at a point with these strategic investments where we can start using regional trash monitoring surveys to assess whether our efforts have been effective."

Answering questions about management effectiveness

To investigate whether Southern California's most recent trash-reduction actions are working as designed, the Bight program recognized that trash would need to be tracked along more than just the coastal seafloor. Indeed, trash also needs to be monitored on land, closer to where it is originating.

Because robust, standardized methods for monitoring trash in inland waterways did not exist, the Bight program partnered with the SMC – which represents the region's largest stormwater management agencies – to develop these methods in the early 2010s.

The trash monitoring methods that the SMC developed call for all trash pieces to be counted and categorized along 100-foot-long stretches of inland waterways.

During Bight '13, the SMC deployed the monitoring methods for the first time, then completed a second trash monitoring survey using the same monitoring methods for Bight '18.

During both monitoring cycles, the Bight and SMC programs found trash along more than 75% of the 4,600 miles of streams that drain to the coastal ocean; the vast majority of this trash was plastic. In

Courtesy of Los Angeles County Department of Public Works

Metal mesh screens have been installed at thousands of storm drain inlets across Southern California over the past decade to combat the introduction of trash into aquatic environments. The screens, above, open automatically when obstructed by debris to prevent flooding.

Courtesy of Los Angeles County Department of Public Works

Metal mesh screens help block trash and other debris from entering storm drain pipes just below street level. These trash-capture devices are a key part of Southern California's next-generation strategy to combat trash pollution.

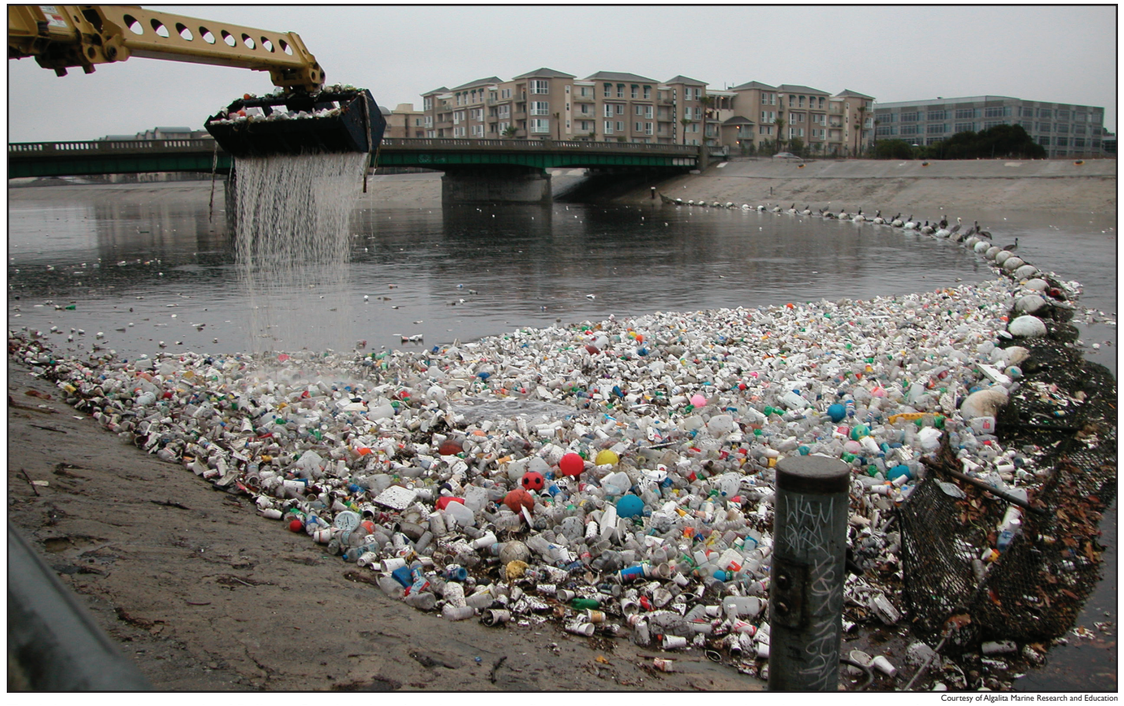
How trash monitoring is done on land and at sea

In Southern California, regional trash monitoring takes place during cyclical surveys on land and at sea:

» **Bight marine monitoring:** To quantify trash in marine environments, a research vessel drops a 25-foot-wide fishing trawl net to the seafloor, then tows it slowly for 10 minutes at about 2 mph. All debris captured by the net is counted and categorized. This trash monitoring effort is highly leveraged, as the Bight program simultaneously uses the same sampling effort to collect large, bottom-dwelling fish and invertebrates for one of the program's sediment quality studies.

» **SMC waterway monitoring:** To quantify trash in inland waterways that drain to the coastal ocean, all trash particles observed along a 100-foot-long stretch of waterway are collected by hand, then counted and sorted. Trash is collected along the banks of the site, up to the site's high-water mark or, when this mark is not discernable, up to the bankfull height, which is the maximum height that water can rise before spilling into the adjacent floodplain. This monitoring takes place during dry weather, typically between April and August.

A field crew counts and classifies trash particles in the Los Angeles River during a 2013 trash monitoring pilot survey that the Southern California Bight Regional Monitoring Program launched with the Southern California Stormwater Monitoring Coalition. The survey's data are helping researchers evaluate if Southern California's newest trash-reduction actions are working as designed.



Courtesy of Algalita Marine Research and Education

Trash booms at the mouth of Ballona Creek in Los Angeles capture floating debris before it reaches the coastal zone. An analysis by the Bight and SMC regional monitoring programs found that total trash levels in Ballona Creek and the other waterways draining to Santa Monica Bay dropped nearly tenfold following full implementation of a regulatory program to combat trash loading.

urban streams, trash was even more likely to be present, with at least one piece of trash every 100 feet in 90% of these miles of urban streams.

Perhaps the most significant insights provided by the trash monitoring, however, was examining the effectiveness of the most recent generation of management actions taken to combat trash in aquatic environments.

Between Bight '13 and Bight '18, Southern California's stormwater management community made significant progress implementing trash-control measures in certain areas – actions that enabled the Bight and SMC programs to directly begin answering the question of whether these management actions have had a positive influence on trash accumulation.

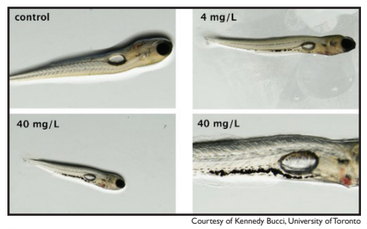
The Bight and SMC programs found early evidence that the answer is yes.

By comparing the Bight '13 and Bight '18 trash monitoring data sets, researchers obtained clear evidence that Southern California's management actions to combat trash can and do make a positive difference.

Two success stories emerged from this analysis:

» **Trash TMDLs in the Santa Monica Bay watershed**: Total trash levels in the waterways draining to Santa Monica Bay dropped nearly tenfold between Bight '13 and Bight '18 – a span of time between which the Santa Monica Bay watershed's TMDL for trash was fully implemented. Implementation of this TMDL included installation of screens across curb inlets to prevent trash from entering storm drains, as well as hydrodynamic separators that use water flow to remove items more than 2 inches in diameter. By contrast, in other nearby watersheds where TMDLs have yet to be implemented, researchers found no significant changes in overall trash levels between the two monitoring cycles.

» **Statewide ban on single-use plastic bags**: The number of single-use plastic bags found in and near Southern California's inland waterways dropped fivefold between Bight '13 and Bight '18. California enacted a statewide ban in 2016 prohibiting grocery stores and pharmacies from giving out single-use plastic bags – right in the middle of the two monitoring cycles – enabling researchers to attribute the drop to the statewide plastic-bag ban.



Courtesy of Kennedy Bucci, University of Toronto

Fish larvae that have been exposed to increasing concentrations of microplastics in a laboratory accumulate the particles in their digestive tracts; the particles appear as black flecks visible through the larvae's largely transparent bodies. As a result of a recent SCCWRP-facilitated effort to standardize laboratory methods for measuring microplastics in the environment, regional monitoring initiatives like the Bight program are positioned to begin tracking microplastics contamination at a regional scale.

"The Bight and SMC trash monitoring surveys have been hugely influential in building a scientific foundation for trash management in Southern California," said Turcotte with the Los Angeles County Department of Public Works. "As a result of these monitoring efforts, we can now say that actions we've taken over the past decade are moving the needle in the right direction."

The piloting of these methods for monitoring trash was deemed such a success during the two back-to-back monitoring cycles that the methods were subsequently standardized and published as California's official trash monitoring methods for inland waterways.

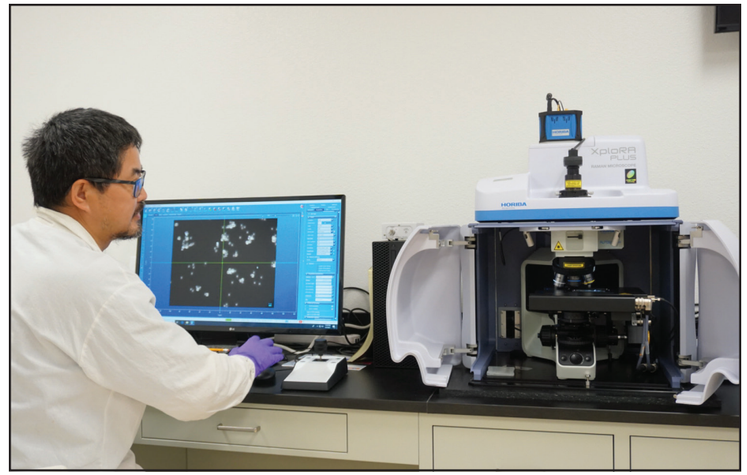
Expanding to focus on smaller trash

To date, the Bight and SMC regional monitoring programs have focused their trash monitoring on relatively large trash particles. In the marine environment, that means capturing trash pieces that don't slip through the mesh openings of fishing trawl nets used to collect trash along the seafloor.

But in recent years, California's approach to trash management increasingly is being expanded to also focus on micro-sized particles, especially microplastics in aquatic environments. The smallest of these particles is too small to be seen with the naked eye and, sometimes, not even under a standard light microscope.

Microplastics, defined as plastic particles less than 5 millimeters in size, are particularly concerning because they're ubiquitous everywhere that researchers look – from the guts of fish to human feces. They can cause false satiation and reduced nutrient absorption in aquatic life that ingest them, as well as oxidative stress and tissue damage when they move beyond the gut. Moreover, chemical contaminants can stick to microplastics, compounding the health risks for organisms that inadvertently ingest contaminated particles.

Meanwhile, because of microplastics' small size, the trash-capture strategies being used for larger trash particles don't work for microplastics. Plastics in aquatic environments tend to break down into smaller and smaller particles over time, making them increasingly difficult to remove – or even measure.



SCCWRP's Dr. Wayne Lao uses a Raman spectroscopy instrument to examine microplastic particles in a water sample. The laser-based microscope technology is one of the microplastics measurement methods that an international, SCCWRP-facilitated group of microplastics experts standardized for routine monitoring applications.

SCCWRP is part of an international group of microplastics experts working to build understanding of the effects of microplastics exposure on aquatic life.

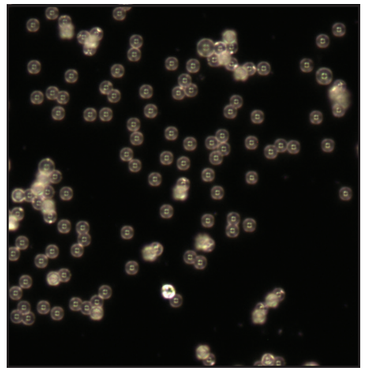
A foundational step in this work is being able to reliably measure microplastics in aquatic environments using standardized methods.

In 2019, SCCWRP began coordinating an international effort involving 40 laboratories in six countries to standardize laboratory methods for measuring microplastics levels in water, sediment and animal tissue.

With this effort now nearing completion, the Bight and SMC programs will have the option during future trash monitoring surveys to begin tracking microplastics levels on a regional scale.

Future monitoring surveys could focus on investigating and identifying specific major sources of plastics pollution, hotspots in the coastal ocean where microplastic particles are settling, and the biological consequences of microplastics exposure for aquatic life.

"What we're ultimately working toward is a comprehensive understanding of how much of a risk plastics and other trash poses to aquatic habitats on land and at sea," said Dr. Karen McLaughlin, a SCCWRP Principal Scientist and the Bight program coordinator. "When we have these answers, we become better-positioned to help managers decide how much effort they should devote to controlling trash vs. all of the other pollutants that we're also tracking through regional monitoring."



Microplastics particles just 5 microns in diameter and made of clear polystyrene glow in an image captured by Raman spectrometry technology in a SCCWRP laboratory. Combating microplastics pollution is fast becoming the next frontier in ongoing management efforts to better control the spread of trash in California's aquatic environments.

TRACKING OCEAN ACIDIFICATION'S BIOLOGICAL EFFECTS

The Bight program is working to link chemistry and biology data to understand how coastal acidification will influence ecosystem health – now and into the future

Fifteen years ago, ocean acidification was just emerging as an issue of management concern – and the focus was squarely on the Pacific Northwest.

In 2007, Washington's shellfish industry began experiencing mass die-offs of oyster and other shellfish larvae.

The cause was changes to seawater chemistry triggered by ocean acidification – changes that reduce shell-forming organisms' ability to draw minerals from seawater to build their shells.

A consequence of rising carbon dioxide emissions in the

Background photo courtesy of Ami Linker, City of Santa Monica Utilities Department

SCCWRP's Kelcey Chung collects tiny sea snails known as pteropods from a plankton net that has been towed through Southern California coastal waters. The Southern California Bight Regional Monitoring Program is investigating the effects of intensifying coastal ocean acidification on marine life vulnerable to these seawater chemistry changes.

atmosphere, ocean acidification has caused tens of millions of dollars of economic losses to Pacific Northwest shellfish growers. Ocean circulation patterns make this region especially vulnerable to seasonally corrosive conditions.

But as ocean pH continues to drop globally, these same corrosive conditions are gradually creeping farther down the West Coast.

For nearly a decade, the Southern California Bight Regional Monitoring Program has been tracking these low-pH conditions in Southern California's economically and ecologically important coastal waters.

During a first-of-its-kind survey as part of the Bight program's 2013 monitoring cycle, researchers found corrosive conditions in a minority of samples during the winter and spring months.

Although Southern California's low-pH conditions were nowhere near as severe as in the Pacific Northwest, these findings helped reshape understanding of how seawater chemistry in Southern California is changing in response to ocean acidification.

Indeed, instead of thinking this problem might still be years or even decades away, the Bight program established that corrosive conditions already are circulating at Southern California's coastal doorstep.

Going forward, the ongoing 2018 monitoring cycle of the Bight program is examining whether ocean acidification is beginning to adversely affect vulnerable marine life in Southern California. It's the next logical question as California begins weighing how to mount an aggressive, science-informed management response to this global challenge.

Preliminary results from ongoing acidification monitoring indicate that the biological effects in Southern California thus far are largely muted but pervasive, with mild signs of damage visible on the shells of especially sensitive organisms.

As the Bight program continues to investigate the linkage between changes to Southern California's seawater chemistry and how vulnerable aquatic life are affected, researchers and managers are simultaneously exploring potential options for specific actions that California could take to alleviate and mitigate acidification's effects.

Options being investigated include everything from revamping master plans and frameworks that guide how the coastal ocean is managed, to implementing site-specific solutions like kelp farming that may be able to extend protections to vulnerable marine life.

The Bight program also is coordinating with other West Coast monitoring programs – including training them in the collection of paired chemistry and biology data sets using prototype methods – so that researchers can generate a comprehensive, West Coast-wide picture of acidification's trajectory.

"The Bight program has been a leader in helping California build comprehensive statewide understanding of how ocean

acidification is manifesting in our coastal waters," said Dr. Justine Kimball, Senior Climate Change Program Manager for the California Ocean Protection Council. "When it comes to managing ocean acidification, we as coastal ocean managers rely on these foundational insights to inform where go from here."

Evaluating changing seawater chemistry

The Bight program's 2013 monitoring cycle – known as Bight '13 – marked the first effort to document seawater chemistry conditions in the relatively shallow, nearshore waters of Southern California's continental shelf in response to ocean acidification.

Although oceanographers have been monitoring seawater chemistry along the West Coast for more than three decades, this monitoring work is largely concentrated in continental basins and other areas farther from shore.

For example, the National Oceanic and Atmospheric Administration has been conducting periodic ocean acidification surveys since 2007, but collects data from just two nearshore stations in Southern California coastal waters. Similarly, the California Cooperative Fisheries Investigations (CALCOFI) program has been collecting carbonate chemistry data – a key indicator of ocean acidification – since 1986, but collects data from just five Southern California nearshore stations.

Bight '13, by contrast, monitored 72 sites quarterly in Southern California's shallow coastal waters – from about a half mile from shore to just over 10 miles. This study area has considerable overlap with where the Bight program's sediment quality monitoring is focused.

Bight '13 tracked seawater chemistry by monitoring a parameter known as aragonite saturation state, which reflects the portion of minerals in seawater that are available to shell-forming aquatic life, including tiny sea snails known as pteropods and tiny crustaceans known as krill at the base of marine food webs. Aragonite saturation state often changes in lockstep with ocean pH.

Southern California's aragonite saturation states averaged 2.0 annually during the Bight '13 acidification monitoring survey – well above the critical 1.0 threshold at which shells can dissolve spontaneously and seawater is considered "corrosive."

But during the spring months – when a natural phenomenon known as ocean upwelling brings low-pH waters close to shore – Bight '13 found that average aragonite saturation state dropped as low as 0.5 in shallow depths of about 65 feet. Upwelling off the Southern California coast is a seasonal process by which nutrient-rich waters are brought to the surface, driving ecosystem productivity and biodiversity.

Meanwhile, the average annual depth at which corrosive waters were documented in coastal waters during Bight '13 was only about 400 feet. And during the spring upwelling season, the average depth of corrosive waters crept up to about 260 feet.

Although these monitoring data have provided foundational insights into coastal acidification conditions, Bight '13 was not designed to answer questions about whether marine life are being adversely affected in Southern California.

Especially because the most corrosive conditions were present for relatively short durations in Southern California and not in the shallowest waters, researchers could not yet say if or how the seasonal seawater chemistry changes were manifesting as biological effects.

This linkage between chemistry and biology became the next logical area to investigate – and the basis for Bight '18's acidification monitoring study.

"For California to figure out what to do about managing coastal acidification, we first need to link chemistry and biology," said Ami Latker, Co-Chair of the Bight '18 Ocean Acidification study element and a Marine Biologist for the City of San Diego Public Utilities Department. "That's the only way to put the Bight '13 seawater chemistry findings into a managerially relevant context."

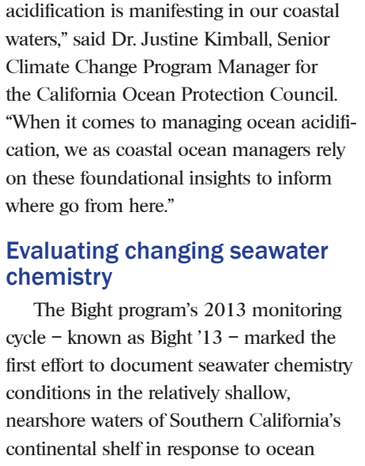
Linking chemistry to biology

For coastal acidification to rise to the level of a top management priority, ocean acidification must be doing more than just altering seawater chemistry. The chemical changes also must be shown to be having real-life consequences for aquatic organisms sensitive to these changes.

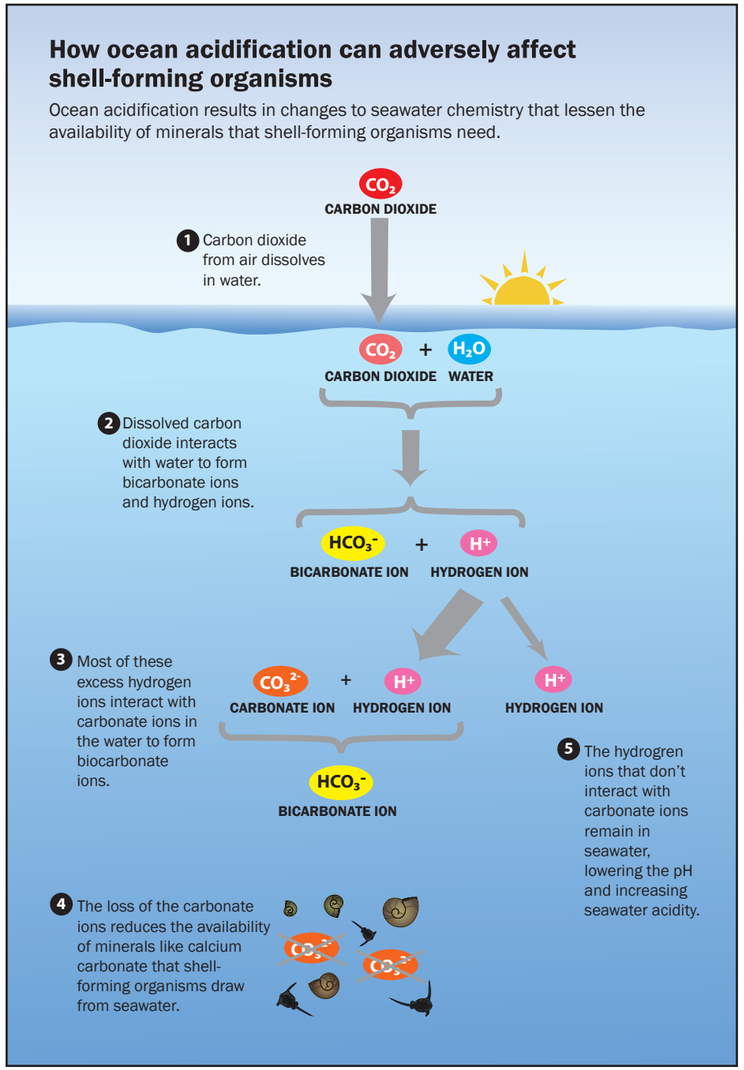
In the Pacific Northwest, the link between chemistry and biology is clear for commercially harvested shellfish. But the same relationships must be established for organisms that are found in abundance in Southern California – organisms that are intrinsic parts of marine food webs, helping to sustain the region's rich diversity and delicate ecological balance.

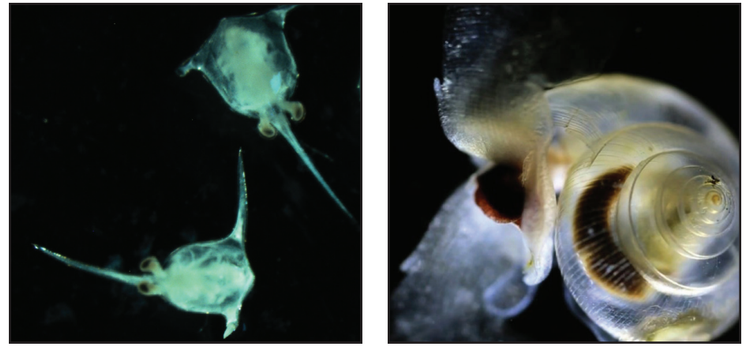
During a pilot survey in 2019 and 2020, Bight '18 took a series of seawater chemistry measurements at 20 coastal sites in tandem with collecting multiple types of shell-forming organisms, including crab larvae and pteropods.

Crab larvae and pteropods are at the base of marine food webs, so if their

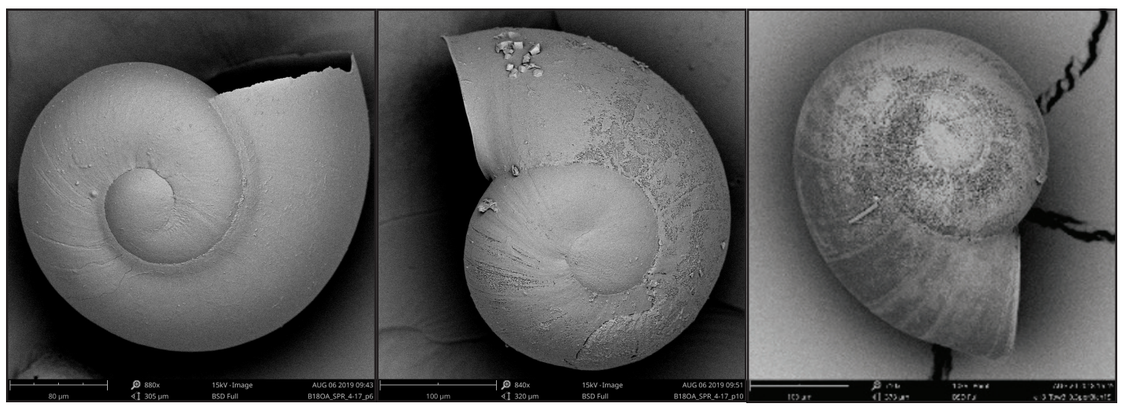


A field crew for the Bight monitoring program lowers a CTD (conductivity, temperature, depth) rosette into the coastal ocean to take a variety of measurements, including seawater pH. By tracking changing seawater chemistry, the Bight program has shown that corrosive conditions already are circulating seasonally in Southern California coastal waters.





Crab larvae, left, and tiny sea snails known as pteropods, right, are among the shell-forming organisms vulnerable to the corrosive seawater conditions triggered by ocean acidification. The Bight monitoring program is examining the shells of these species to look for evidence of damage.



A preliminary Bight '18 analysis of the shells of sea snails known as pteropods found that shell integrity already is being affected by ocean acidification in Southern California. While some pteropod shells were healthy, as shown at left, other pteropods were found to be experiencing mild to moderate shell dissolution, center and right, respectively. The shell damage manifests as tiny, dark-colored pit marks, holes and ridges that are visible under a scanning electron microscope.

survival is threatened, the biological consequences could reverberate through coastal ecosystems.

Then, using a scanning electron microscope, researchers looked for developmental abnormalities, especially pits, holes and ridges that indicate signs of dissolution of the organisms' shells.

As during the Bight '13 surveys, aragonite saturation state levels during Bight '18 fell into corrosive territory during the winter and spring months – dipping below 1.0 at depths of 350 feet and below, according to preliminary data.

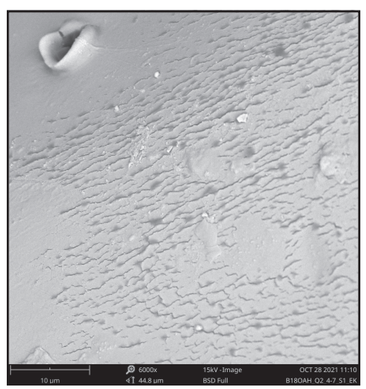
However, shell dissolution wasn't uniformly observed, and when it was, it was generally mild – and linked to the presence of low-pH conditions in colder, deeper waters.

Among crab larvae, less than 5% of each external shell – known as the carapace – was affected, although early signs of dissolution were pervasive across Southern California sampling sites.

In pteropods, one of the two species examined – *Limacina* – exhibited shell dissolution trends similar to the crab larvae, while the second pteropod species – *Heleconoides* – showed more intense shell dissolution patterns, underscoring the complexities of understanding how acidification affects sensitive marine life.

The Bight program is building on this pilot investigation, with more paired chemistry and biology data to be collected through 2023.

"We now have some of the earliest warning signs that we could be getting close to some of the ecological thresholds for acidification in Southern California," said Dr. Richard Feely, a Senior Scientist for the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Seattle. "Will the economic and ecological consequences be anywhere near as severe as the Pacific Northwest? That's still unclear, but Bight '18 has certainly made the case that we need to be vigilant about monitoring."



Crab larvae in Southern California are experiencing early signs of shell dissolution, which are visible under a scanning electron microscope, above, as tiny pit marks, holes and ridges. If the damage reaches the shell's mechanoreceptor openings – like the one visible at top left – it could threaten their survival.

Building monitoring capacity West Coast-wide

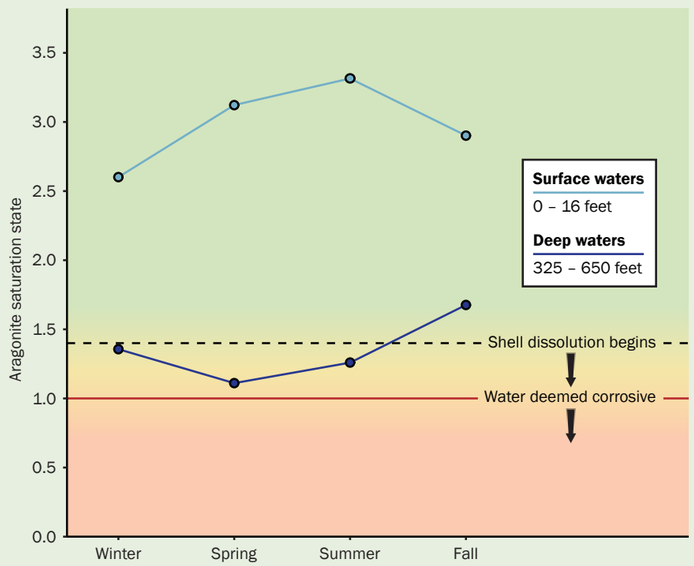
As the Bight program built capacity to collect paired chemistry and biology data in Southern California, the program recognized that sharing these methods with other monitoring groups could pave the way for researchers to generate even broader-scale insights into coastal acidification's trajectory.

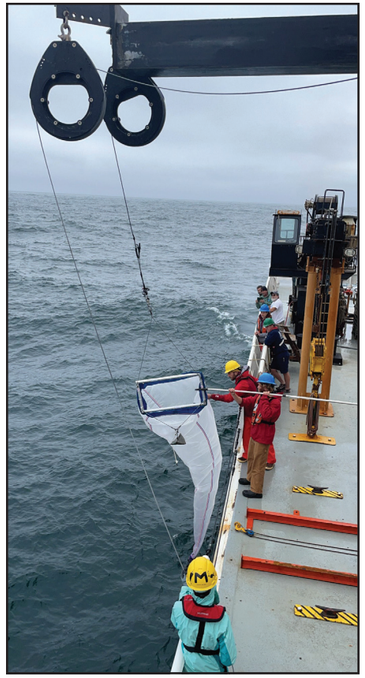
When multiple monitoring groups collect standardized, directly comparable data sets, researchers can stitch together a comprehensive portrait of how coastal acidification is unfolding – and will continue to unfold in the coming years – including how the seawater changes are affecting marine life. Moreover, monitoring acidification's trajectory in more northern regions can provide important context for what Southern California might expect in the coming years.

To build a West Coast-wide picture of acidification, the Bight program began by aligning its monitoring survey with the National Oceanic and Atmospheric Administration's ongoing West Coast Ocean Acidification Survey program, enabling the two monitoring groups to produce a single, seamless picture of acidification conditions from British Columbia to the U.S.-Mexico border.

Critical aragonite saturation state

In the spring, when a phenomenon known as ocean upwelling brings carbon dioxide-rich water close to shore, Bight '18 found that average aragonite saturation state in Southern California's deep coastal waters approaches levels considered corrosive to shell-forming organisms. The program is tracking two organisms – crab larvae and pteropods – to assess the biological consequences of changes to seawater chemistry.





The Bight monitoring program has partnered with the National Oceanic Atmospheric Administration's West Coast Ocean Acidification Survey – pictured during a 2021 monitoring cruise – to help produce a single, unified portrait of acidification conditions along the West Coast, stretching from British Columbia to the U.S.-Mexico border.

In advance of this joint 2021 monitoring pilot, SCCWRP worked with NOAA scientists and collaborators to test-drive new biology sampling protocols that are focused around analyzing the shells of pteropods and crab larvae.

In Southern California, the Bight program sampled in nearshore coastal waters as far as about 10 miles from shore, while NOAA sampled as close as about 5 miles from shore to about 120 miles offshore.

As the pilot monitoring effort got underway in 2021, the California Ocean Protection Council identified an opportunity to unify even more existing acidification monitoring in California, and began working with SCCWRP and NOAA to coordinate with two other monitoring programs: California Cooperative Fisheries Investigations (CalCOFI) and Applied California Current Ecosystem Studies (ACCESS) Program.

CalCOFI conducts acidification monitoring in Southern California's offshore areas, while ACCESS monitors in transects off the Northern California coast, including off San Francisco Bay.

Ultimately, SCCWRP trained all four programs to use the same paired chemistry and biology monitoring protocols, ensuring high-quality, standardized acidification data can be collected across California and beyond.

"Coordinating different monitoring groups that operate on different timelines and have different levels of resources is logistically challenging, but it's exactly what we need to be doing," said Kimball with the Ocean Protection Council. "In fact, scientific experts like the California Ocean Acidification and Hypoxia Science Task Force have been calling for coordination of acidification monitoring for many years – it's the best way to collect the most comprehensive, insightful data possible."

Establishing a scientific foundation for action

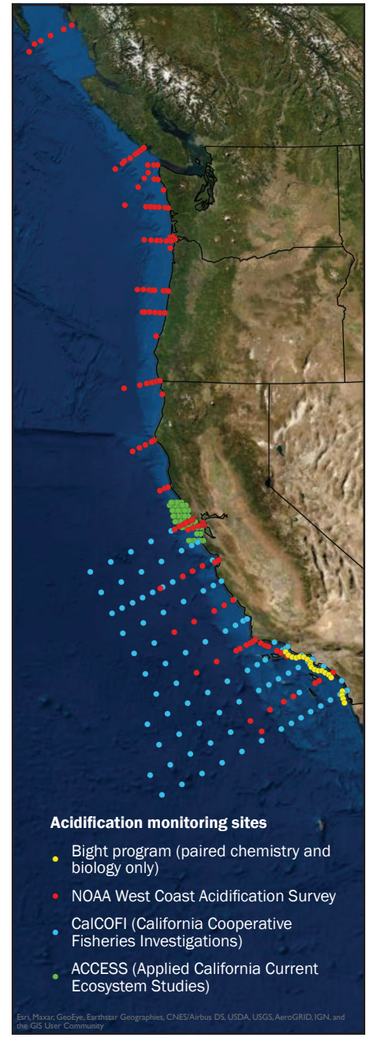
With coastal acidification projected to intensify in the coming years in lockstep with global climate change, California already has begun looking at how to mount a management response that matches the scope and scale of this global challenge.

Options being investigated include everything from revamping master plans and frameworks that guide how the coastal ocean is managed, to placing new requirements on the waste products that can be discharged into the coastal ocean, to implementing site-specific solutions like kelp farming that may be able to buffer vulnerable marine life from the worst of acidification's effects.

The Bight program has played a foundational role in collecting field data to help researchers investigate these potential solutions and strategies for offsetting coastal acidification.

At the same time, monitoring on its own cannot provide all of the answers that managers want and need. Monitoring is too costly and time-intensive to collect all of the data required to draw key conclusions. Moreover, monitoring data only provide insights into what is happening now – not years into the future.

To understand the pace and intensity of acidification, as well as how targeted management interventions might alter this



By coordinating acidification monitoring with three different West Coast programs, the Bight program has enabled all four groups to produce a single, unified portrait of coastal acidification conditions. Above, the monitoring sites where the Bight program has been collecting paired chemistry and biology data are plotted alongside all monitoring sites for the other three programs. As with the Bight program, the other three programs will collect paired data sets from only a subset of their monitoring sites.

trajectory, researchers rely on a trifecta of monitoring data, laboratory experiments and computer modeling simulations.

SCCWRP is part of a team of researchers worldwide that has been leading efforts to conduct both lab experiments and computer modeling simulations for Southern California's coastal ocean.

In 2019, SCCWRP constructed a state-of-the-art dynamic exposure laboratory to study how aquatic organisms respond to fluctuations in pH, dissolved oxygen and other environmental parameters in a controlled setting.

The exposure laboratory – one of the few of its kind in the world – creates different combinations of low pH and low dissolved oxygen levels in small chambers known as microcosms, enabling researchers to study precisely how sensitive marine life responds to different potential future environmental conditions. Field-collected data from the Bight program and other monitoring programs are serving as the starting "exposure" parameters for this laboratory work.

Meanwhile, both laboratory exposure data and field monitoring data are being used in the ongoing development of powerful computer models that predict acidification's coastal trajectory in the coming years.

To validate that these models are working as designed, researchers feed data from the field monitoring and laboratory exposure scenarios into the models. This validation step is critical to ensuring that the models can accurately reproduce what is happening in the real world, giving environmental managers assurance that the models can make predictions at the confidence levels necessary to be relied upon for decision-making.

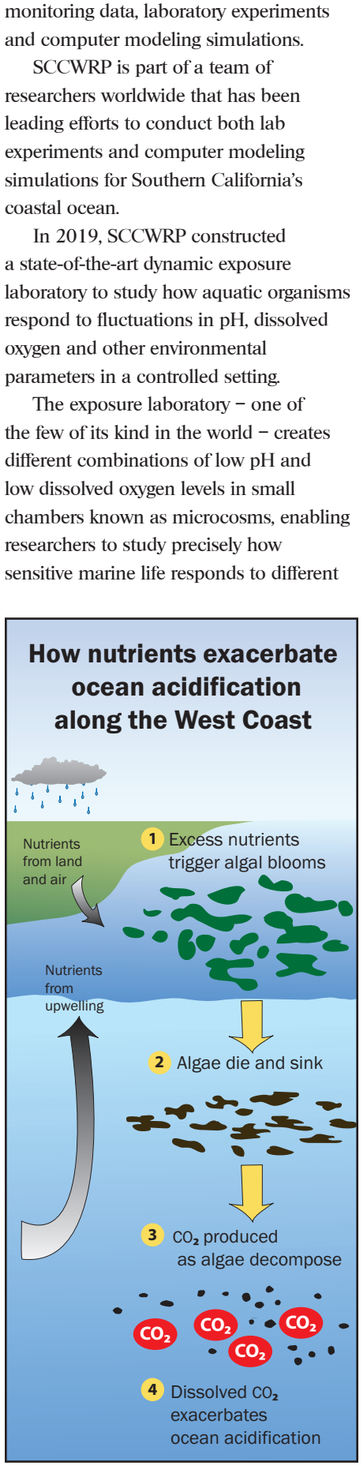
One of the highest-profile uses of the computer models to date has been investigating whether the trajectory of coastal acidification could be meaningfully altered if land-based nutrient discharges to Southern California's coastal ocean are reduced. The introduction of excess nutrients to coastal waters – from sources including treated wastewater and runoff discharges – can trigger complex ocean biogeochemical cycling processes that have the potential to exacerbate coastal acidification.

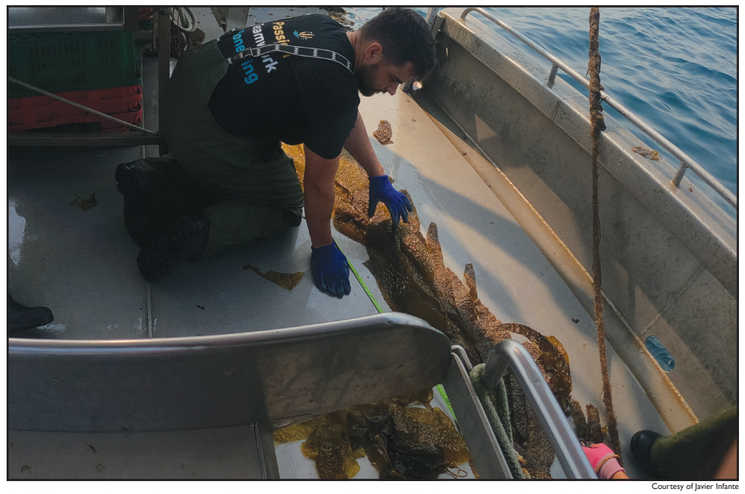
Through this ongoing modeling work, researchers will be able to answer fundamental questions about if and/or how Southern California could reduce its nutrient discharges to help buffer against acidification's most intensive effects.

Meanwhile, the same computer models also are being used to understand potential solutions for alleviating adverse biological effects. For example, researchers are studying if sensitive organisms could be better protected if they live near underwater kelp forests that can draw carbon dioxide out of the water via natural photosynthetic processes.

Ocean managers are considering cultivating kelp farms in specific coastal areas if these underwater plants can be shown to meaningfully alleviate biological effects on vulnerable organisms.

"The progress with building foundational data sets and ongoing modeling efforts provides a solid scientific basis for managing coastal acidification in California," said Katherine Walsh, Chief of the Ocean Standards Unit for the California State Water Resources Control Board. "As we move forward, we will have sound science to inform our decision-making processes."





Courtesy of Javier Infante

A field crew from the aquaculture company Ocean Rainforest examines kelp that has been growing on ropes suspended in an underwater farm off the coast of Santa Barbara. Researchers are using computer modeling to explore how offshore kelp farms might be used to reduce the ecological effects of intensifying coastal ocean acidification.

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 watersheds

Research themes

SCCWRP's research agenda is organized around eight major thematic areas

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

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

154 Number of leadership roles that SCCWRP scientists hold with professional societies, external advisory committees and editorial boards of scientific journals **Page 69**

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 invertebrates, algae and other organisms to evaluate ecological condition across a variety of environments, from streams to the coastal ocean.

Regional Monitoring

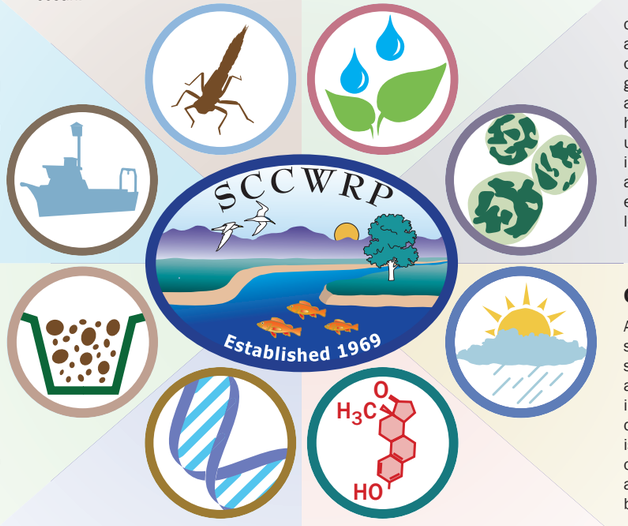
To give environmental managers comprehensive, big-picture snapshots of the condition of aquatic systems and how they are changing over time, SCCWRP facilitates the design and execution of multi-agency regional monitoring – notably, the Southern California Bight Regional Monitoring Program and the Southern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

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.

Eutrophication

With anthropogenic nutrient inputs a leading cause of eutrophication – or accelerated accumulation of organic matter from over-growth 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.



Stormwater BMPs

As stormwater BMPs (best management practices) are implemented to reduce contamination in wet- and dry-weather runoff, SCCWRP is building a technical foundation to help environmental managers optimize the long-term effectiveness of these stormwater control measures.

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.

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.

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.

Tool to help managers ID causes of poor stream condition

SCCWRP and its partners have developed an initial version of a user-friendly, web-based management tool for helping stream managers rapidly narrow down likely causes of poor stream condition.

The alpha version of the Rapid Screening Causal Assessment (RSCA) tool, completed in late 2021 for the San Gabriel River watershed in Los Angeles County, is intended to speed up the traditionally time-consuming process of analyzing site-specific stream bioassessment data to pinpoint which types of stressors are likely responsible for degraded biological condition.

Stream managers in California increasingly are being required under their wastewater and stormwater discharge permits to investigate likely causes of poor stream condition. These causal assessment analyses, which traditionally take six months or more, require specialized training to analyze and interpret bioassessment scores generated through stream scoring tools.

The RSCA tool will standardize and automate labor-intensive stream causal assessment analyses, displaying site-specific insights on an interactive, point-and-click mapping dashboard. The RSCA tool also will provide a high-level overview of major causes of stress across watershed-scale areas.

The RSCA tool represents the latest expansion in a line of SCCWRP-developed web tools designed to help managers understand the major causes of impairment to stream health.

A field crew collects data from a stream in the Big Bear Lake watershed as part of a stream condition assessment. SCCWRP and its partners have developed a web-based management tool intended to speed up causal assessment, a traditionally time-consuming process that involves analyzing site-specific stream bioassessment data to pinpoint which types of stressors are likely responsible for degraded biological condition.

Studies shed light on how bioassessment scores affected by channel hardening

SCCWRP and its partners have completed a series of analyses of bioassessment scores for Southern California and San Francisco Bay Area streams that have been hardened through channel lining to understand how channel modification affects the health of stream biology.

The investigations – the latest of which wrapped up in 2021 – found that these modified channels are associated with a distinctively lower range of scores than more natural, soft-bottom channels.

The findings have paved the way to expand bioassessment analyses to more areas of California, including agricultural areas like the Central Valley, where channel modification typically occurs without bank hardening.

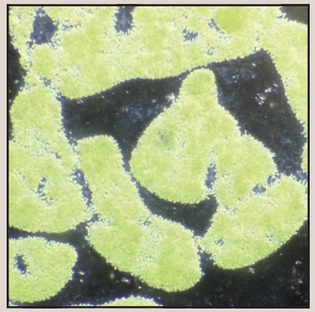
Understanding how channel modification influences bioassessment scores will provide key insights for managers working through the challenges associated with using bioassessment tools to quantify the overall ecological health of modified channels.

Consensus reached on best practices for DNA-based algae assessments

A statewide workgroup led by SCCWRP has developed scientific consensus on a set of best-practices approaches for sampling and analyzing stream algae using DNA-based methods, paving the way to promote broader incorporation of algae assessments into routine freshwater monitoring programs.

The Molecular Methods Workgroup, formed under the California Water Quality Monitoring Council, published a series of guidance documents that span a range of topics, including collection and analysis of environmental DNA from water.

SCCWRP also co-authored a seminal 2021 journal article with international researchers that offers guidance on how to improve quality, consistency and comparability of algae molecular data around the world. These consensus-building activities are critical to promoting more widespread adoption of algae as a stream monitoring tool.



Analyzing the composition of stream algae communities can serve as a key indicator of water body health. SCCWRP has built scientific consensus around best-practices recommendations for conducting DNA-based algae assessments – a key precursor to achieving more widespread adoption of these methods.

Benthic algae assessments in the EU and the US: Striving for consistency in the face of great ecological diversity

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Abstract

Freshwaters face multiple environmental problems including eutrophication, acidification, salinization, and climate-change, all of which can lead to impairment of ecosystem structure and function. Furthermore, these stressors often act in combination. Benthic algal-based assessments to quantify impairment are used in both the EU and US. In this review, we use case studies, experience, and the literature to compare concepts, approaches, and methods between the EU and US to offer an updated picture of benthic algal-based assessments. Both the US and EU are composed of numerous constituent states having considerable flexibility to adopt individual methods. The goal of this work is to synthesize the various approaches that are used across the EU and US. Specifically, we compare and contrast benthic algal assessment performed in response to core legislation – the Water Framework Directive in the EU and the Clean Water Act in the US, with a particular focus on the steps taken to ensure consistency at different stages of the process. This includes consideration of approaches to sampling design and field methods, taxonomic resolution and laboratory harmonization, metric selection and choice of algal groups, assessment of stressors and stressor/response relationships. A number of commonalities emerged during this process, particularly the focus on diatoms over other algal groups. However, there are also a number of key differences, including more widespread use of multimetric indices in the US compared with the EU. Finally, we consider emerging opportunities, including the potential for using metagenomic approaches for bioassessment in the future.

Citation

Charles, D.F., M.G. Kelly, R.J. Stevenson, S. Poikane, S. Theroux, A. Zgrundo, M. Cantonati. 2021. Benthic algae assessments in the EU and the US: Striving for consistency in the face of great ecological diversity. Ecological Indicators DOI:10.1016/j.ecolind.2020.107082.

SCCWRP Journal Article #1191
Full text available online: www.sccwrp.org/publications

Characterizing community structure of benthic infauna from the continental slope of the Southern California Bight

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Abstract

Infauna are an ecologically important component of marine benthic ecosystems and are the most common faunal assemblage used to assess habitat quality. Compared to the shallower waters of the continental shelf, less is known about the benthic fauna from the continental slope, especially how the communities are structured by natural gradients and anthropogenic stressors. The present study was conceived to rectify these data gaps and characterize the natural, baseline structure of the benthic infauna of the upper continental slope (200–100 m) of the Southern California Bight. We aggregated benthic infauna, sediment composition, and sediment chemistry data from different surveys across the Southern California Bight region (750 samples from 347 sites) collected between 1972 and 2016. We defined 208 samples to be in reference condition based upon sediment chemistry and proximity to known anthropogenic disturbances. Cluster analysis of the reference samples was used to identify distinct assemblages and the abiotic characteristics associated with each cluster were then used to define habitat characteristics for each assemblage. Three habitats were identified, delineated by geography, depth, and sediment composition. Across the habitats, there were detectable changes in community composition of the non-disturbed fauna through time. However, the uniqueness of the habitats was persistent, as the fauna from each habitat remained taxonomically distinct from irrespective of the decade of their collection. Within each habitat, subtle, assemblage-scale responses to disturbance could be detected, but no consistent patterns could be identified among the component taxa. As with the non-disturbed samples, there were compositional changes in the fauna of the disturbed samples through time. Despite the changes, fauna from disturbed and non-disturbed samples remained taxonomically distinct from each other within each decade of the dataset. After considering both the spatial and temporal patterns in the fauna of slope ecosystem, it became apparent that there was a high degree of stochasticity in the taxonomic organization of all three habitats. This would suggest that the benthic fauna from these communities may be neutrally organized, which in turn poses interesting challenges for future development of condition assessment tools based upon the benthic fauna in these habitats.

CITATION

Gillett, D.J., L. Gilbane, K.C. Schiff. 2021. Characterizing Community Structure of Benthic Infauna From the Continental Slope of the Southern California Bight. *Frontiers in Marine Science* DOI:10.3389/fmars.2021.605858/full.

SCCWRP Journal Article #1197
Full text available online: www.sccwrp.org/publications

Microbial drivers of methane emissions from unrestored industrial salt ponds

Jinglie Zhou[1], Susanna M. Theroux[1,2], Clifton P. Bueno de Mesquita[1], Wyatt H. Hartman[1], Ye Tian[3], Susannah G. Tringe[1,4]

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ABSTRACT

Wetlands are important carbon (C) sinks, yet many have been destroyed and converted to other uses over the past few centuries, including industrial salt making. A renewed focus on wetland ecosystem services (e.g., flood control, and habitat) has resulted in numerous restoration efforts whose effect on microbial communities is largely unexplored. We investigated the impact of restoration on microbial community composition, metabolic functional potential, and methane flux by analyzing sediment cores from two unrestored former industrial salt ponds, a restored former industrial salt pond, and a reference wetland. We observed elevated methane emissions from unrestored salt ponds compared to the restored and reference wetlands, which was positively correlated with salinity and sulfate across all samples. 16S rRNA gene amplicon and shotgun metagenomic data revealed that the restored salt pond harbored communities more phylogenetically and functionally similar to the reference wetland than to unrestored ponds. Archaeal methanogenesis genes were positively correlated with methane flux, as were genes encoding enzymes for bacterial methylphosphonate degradation, suggesting methane is generated both from bacterial methylphosphonate degradation and archaeal methanogenesis in these sites. These observations demonstrate that restoration effectively converted industrial salt pond microbial communities back to compositions more similar to reference wetlands and lowered salinities, sulfate concentrations, and methane emissions.

CITATION

Zhou, J., S. Theroux, C.P. Bueno de Mesquita, W.H. Hartman, Y. Tian, S.G. Tringe. 2021. Microbial drivers of methane emissions from unrestored industrial salt ponds. *The ISME Journal* DOI:10.1038/s41396-021-01067-w.

SCCWRP Journal Article #1226
Full text available online: www.sccwrp.org/publications

Methanogenesis and salt tolerance genes of a novel halophilic *Methanosarcinaceae* metagenome-assembled genome from a former solar saltern

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ABSTRACT

Anaerobic archaeal methanogens are key players in the global carbon cycle due to their role in the final stages of organic matter decomposition in anaerobic environments such as wetland sediments. Here we present the first draft metagenome-assembled genome (MAG) sequence of an unclassified Methanosarcinaceae methanogen phylogenetically placed adjacent to the *Methanolobus* and *Methanomethylovorans* genera that appears to be a distinct genus and species. The genome is derived from sediments of a hypersaline (97–148 ppt chloride) unrestored industrial saltern that has been observed to be a significant methane source. The source sediment is more saline than previous sources of Methanolobus and *Methanomethylovorans*. We propose a new genus name, *Methanosalis*, to house this genome, which we designate with the strain name SBSPR1A. The MAG was binned with CONCOCT and then improved via scaffold extension and reassembly. The genome contains pathways for methylotrophic methanogenesis from trimethylamine and dimethylamine, as well as genes for the synthesis and transport of compatible solutes. Some genes involved in acetoclastic and hydrogenotrophic methanogenesis are present, but those pathways appear incomplete in the genome. The MAG was more abundant in two former industrial salterns than in a nearby reference wetland and a restored wetland, both of which have much lower salinity levels, as well as significantly lower methane emissions than the salterns.

CITATION

Bueno de Mesquita, C.P., J. Zhou, S. Theroux, S.G. Tringe. 2021. Methanogenesis and Salt Tolerance Genes of a Novel Halophilic Methanosarcinaceae Metagenome-Assembled Genome from a Former Solar Saltern. *Genes* 12:1609.

SCCWRP Journal Article #1231
Full text available online: www.sccwrp.org/publications

Predicting burrowing crab impacts on salt marsh plants

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ABSTRACT

Burrowing animals profoundly influence plant communities, and changes in the burrower and plant communities together with changing abiotic parameters can shift the influence of burrowers on plants. However, we lack an ability to predict when, where, and how burrowers will influence vegetation. To begin to understand how naturally, varying environmental conditions influence the impacts of burrowers, we need to examine how burrower impacts on marsh plants differ across sites differing in environmental conditions. We manipulated crab presence for multiple years and measured the responses of the dominant plants, Pacific cordgrass (*Spartina foliosa*) and perennial pickleweed (*Sarcocornia pacifica*), at three sites in northern California and two sites in southern California. Southern California (Point Conception, CA, to the U.S.–Mexico border) experiences higher air and water temperatures, lower precipitation, and higher porewater salinity levels. Combining data from these field studies with laboratory studies allowed us to generate predictions about burrowing crab effects in salt marshes. Our models included (1) an estimate of grazing pressure on marsh plants by the dominant burrowing crab (*Pachygrapsus crassipes*) and (2) several soil biogeochemical measurements. Crab effects varied from strongly positive to strongly negative and depended upon estimated crab grazing pressure and edaphic conditions (salinity, ammonium, and nitrate). Relative to crabs at other sites, crabs enhanced cordgrass at sites with intermediate levels of ammonium and extreme salinities. The dependence of crab effects on edaphic conditions suggests that projected interannual variability in temperature, precipitation, and nutrients could lead to more temporally variable impacts of crabs on cordgrass. Understanding the environmental controls on these interactions will help promote cordgrass productivity and stabilize salt marsh ecosystems.

CITATION

Walker, J.B., E.D. Grosholz, J.D. Long. 2021. Predicting burrowing crab impacts on salt marsh plants. *Ecosphere* 12:e03803.

SCCWRP Journal Article #1232
Full text available online: www.sccwrp.org/publications

Genetic diversity and clonal structure of *Spartina alterniflora* in a Virginia Marsh

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ABSTRACT

We asked how genetic diversity of *Spartina alterniflora* (Smooth Cordgrass) partitions across multiple spatial scales in mid-Atlantic salt marshes. We analyzed samples from 5 Virginia marshes, spanning ~35 km of coastline, using microsatellite markers to examine genetic diversity and genotype clustering. In a single marsh, nested spatial analysis of the genotypes allowed indirect evaluation of colonization dynamics. Samples collected ≥10 m apart had clonal and allelic diversity levels similar to those of other geographic locations; however, genotypic richness and evenness of samples collected 0.2 and 1.0 m apart were reduced. Sampling scale had little effect on allelic diversity. Expected heterozygosity exceeded observed heterozygosity values at all sites and spatial scales, suggesting Smooth Cordgrass inbreeding is common in these marshes. We hypothesize that the observed spatial patterns indicate there is genetic dominance of a few, well-adapted clones balanced by sexual reproduction and recruitment, especially after disturbance, thereby creating genetically diverse and potentially resilient marshes.

CITATION

Walker, J.B., A.L. Bijak, L. Blum. 2021. Genetic Diversity and Clonal Structure of Spartina alterniflora in a Virginia Marsh. *Northeastern Naturalist* 28:357-370.

SCCWRP Journal Article #1219
Full text available by request: pubrequest@sccwrp.org

Stream flow classification tool released by EPA, USACE

A SCCWRP-developed tool that can help watershed managers determine which streams the federal government has jurisdiction to regulate under the Clean Water Act has been released in beta form for use across the nation's arid western states.

The Beta Streamflow Duration Assessment Method for the Arid West (Beta SDAM AW), released in 2021 by the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers, is designed to help managers rapidly distinguish among intermittent, ephemeral and perennial stream reaches.

This distinction is important because under rules established by federal policy and court decisions, entities that discharge into certain ephemeral streams may not be required to obtain discharge permits from the federal government.

In Southern California, the SDAM AW tool also can be used to help identify stream reaches that watershed managers would want to consider evaluating during routine stream assessments, and to identify stream reaches where stream biological integrity goals may need to be adjusted.

Ephemeral streams, which are streams that only experience brief surface flows as a direct result of rain events, are often difficult to distinguish from intermittent streams, which experience sustained seasonal flows.

The U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers have released a SCCWRP-developed tool that can rapidly distinguish among perennial, intermittent and ephemeral streams in arid western states, including this tributary of Agua Caliente Creek in San Diego, above, that is classified as an ephemeral stream.

Agreement reached on scientific process for evaluating environmental flow needs of L.A. River

A diverse coalition of water-quality managers has reached agreement on a scientific process for evaluating how the ecological and recreational benefits provided by the Los Angeles River's flows would be affected if flows are reduced for water reuse purposes.

The agreed-upon process for evaluating environmental flow requirements – described in a SCCWRP technical report published in 2021 – represents the culmination of three years of research and extensive deliberations about how to use science to inform managers' options for balancing competing demands on the L.A. River's limited flows.

The study, which was co-led by SCCWRP, is expected to serve as a precedent-setting template that paves the way for managers to set environmental flow decisions statewide.

Two agencies that discharge into the L.A. River already have used the process to independently develop proposals for diverting some of their discharges for reuse purposes.

Treated wastewater effluent is discharged into the Los Angeles River from a nearby water reclamation plant. SCCWRP helped lead a diverse group of water-quality managers in developing a scientific process for evaluating the effects of reducing L.A. River flows for water reuse purposes.

Study demonstrates how to use environmental flows in stream restoration planning

SCCWRP and its partners have completed a three-year study demonstrating how watershed managers can build a rigorous scientific foundation for integrating environmental flow considerations into their stream restoration planning efforts.

The study, completed in late 2021, used a standardized, multi-tiered framework known as the California Environmental Flows Framework to systematically prioritize 23,000 linear feet of degraded stream habitat in southern Orange County for restoration, with a focus on evaluating how altered, unnatural flow patterns are contributing to poor stream biology.

Stream managers will be able to use the study's insights to decide what actions they should take where to reverse the area's unnatural flow patterns and work toward achieving the greatest improvements to ecological health – such as installation of flow-capture devices to reduce unnatural dry-weather flows.

The California Environmental Flows Framework: Meeting the challenges of developing a large-scale environmental flows program

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[3]*Center for Watershed Sciences, University of California, Davis, Davis, CA*
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Abstract

Environmental flow programs aim to protect aquatic habitats and species while recognizing competing water demands. Often this is done at the local or watershed level because it is relatively easier to address technical and implementation challenges at these scales. However, a consequence of this approach is that ecological flow criteria are developed for only a few areas as dictated by funding and interest with many streams neglected. Here we discuss the collaborative development of the California Environmental Flows Framework (CEFF) as an example process for developing environmental flow recommendations at a statewide scale. CEFF uses a functional flows approach, which focuses on protecting a broad suite of ecological, geomorphic, and biogeochemical functions instead of specific species or habitats, and can be applied consistently across diverse stream types and spatial scales. CEFF adopts a tiered approach in which statewide models are used to estimate *ecological flow needs* based on natural functional flow ranges, i.e., metrics that quantify the required magnitude, timing, duration, frequency, and/or rate of-change of functional flow components under reference hydrologic conditions, for every stream reach in the state. Initial flow needs can then be revised at regional, or watershed, scales based on local constraints, management objectives, and available data and resources. The third tier of CEFF provides a process for considering non-ecological flow needs to produce a final set of *environmental flow recommendations* that aim to balance of all desired water uses. CEFF was developed via a broad inclusive process that included technical experts across multiple disciplines, representatives from federal and state agencies, and stakeholders and potential end-users from across the state. The resulting framework is therefore not associated with any single agency or regulatory program but can be applied under different contexts, mandates and end-user priorities. The inclusive development of CEFF also allowed us to achieve consensus on the technical foundations and commitment to applying this approach in the future.

Citation

Stein, E.D., J. Zimmerman, S.M. Yarnell, B. Stanford, B. Lane, K.T. Taniguchi-Quan, A. Obester, T.E. Grantham, R.A. Lusardi, S. Sandoval-Solis. 2021. The California Environmental Flows Framework: Meeting the Challenges of Developing a Large-Scale Environmental Flows Program. Frontiers in Environmental Science 9:769943.

SCCWRP Journal Article #1228
Full text available online: www.sccwrp.org/publications

Implementing an operational framework to develop a streamflow duration assessment method: A case study from the Arid West United States

Raphael D. Mazor[1], Brian J. Topping[2], Tracie-Lynn Nadeau[3], Ken M. Fritz[4], Julia E. Kelso[2,5], Rachel A. Harrington[6], Whitney S. Beck[2], Kenneth McCune[1], Aaron O. Allen[7], Robert Leidy[8], James T. Robb[9], Gabrielle C. L. David[10]

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Abstract

Streamflow duration information underpins many management decisions. However, hydrologic data are rarely available where needed. Rapid streamflow duration assessment methods (SDAMs) classify reaches based on indicators that are measured in a single brief visit. We evaluated a proposed framework for developing SDAMs to develop an SDAM for the Arid West United States that can classify reaches as perennial, intermittent, or ephemeral. We identified 41 candidate biological, geomorphological, and hydrological indicators of streamflow duration in a literature review, evaluated them for a number of desirable criteria (e.g., defensibility and consistency), and measured 21 of them at 89 reaches with known flow durations. We selected metrics for the SDAM based on their ability to discriminate among flow duration classes in analyses of variance, as well as their importance in a random forest model to predict streamflow duration. This approach resulted in a "beta" SDAM that uses five biological indicators. It could discriminate between ephemeral and non-ephemeral reaches with 81% accuracy, but only 56% accuracy when distinguishing 3 classes. A final method will be developed following expanded data collection. This Arid West study demonstrates the effectiveness of our approach and paves the way for more efficient development of scientifically informed SDAMs.

CITATION

Mazor, R.D., B.J. Topping, T. Nadeau, K.M. Fritz, J.E. Kelso, R.A. Harrington, W.S. Beck, K. McCune, A.O. Allen, R. Leidy, J. Robb, G. David. 2021. Implementing an Operational Framework to Develop a Streamflow Duration Assessment Method: A Case Study from the Arid West United States. *Water* 13:3310.

SCCWRP Journal Article #1236
Full text available online: www.sccwrp.org/publications

Advancing the science of environmental flow management for protection of temporarily closed estuaries and coastal lagoons

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ABSTRACT

The science needed to inform management of environmental flows to temporarily closed estuaries and coastal lagoons is decades behind the state of knowledge for rivers and large embayments. These globally ubiquitous small systems, which are often seasonally closed to the ocean's influence, are under particular threat associated with hydrologic alteration because of changes in watershed land use, water use practices, and climate change. Managing environmental flows in these systems is complicated by their tight coupling with watershed processes, variable states because of intermittently closing mouths, and reliance on regional scale sediment transport and littoral processes. Here we synthesize our current understanding of ecohydrology in temporarily closed estuaries (TCEs) and coastal lagoons and propose a prioritized research agenda aimed at advancing understanding of ecological responses to altered flow regimes in TCEs. Key research needs include agreeing on a consistent typology, improving models that couple watershed and ocean forcing at appropriate spatial and temporal scales, quantifying stress–response relationships associated with hydrologic alteration, improving tools to establish desired conditions that account for climate change and consider cultural/indigenous objectives, improving tools to measure ecosystem function and social/cultural values, and developing monitoring and adaptive management programs that can inform environmental flow management in consideration of other stressors and across different habitat types. Coordinated global efforts to address the identified research gaps can help guide management actions aimed at reducing or mitigating potential impacts of hydrologic alteration and climate change through informed management of freshwater inflows.

CITATION

Stein, E.D., E.M. Gee, J.B. Adams, K. Irving, L.V. Niekerk. 2021. Advancing the Science of Environmental Flow Management for Protection of Temporarily Closed Estuaries and Coastal Lagoons. *Water* DOI:10.3390/w13050595.

SCCWRP Journal Article #1182
Full text available online: www.sccwrp.org/publications

Disentangling the effect of climatic and hydrological predictor variables on benthic macroinvertebrate distributions from predictive models

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[2]Department of Biology, Chemistry and Pharmacy, Freie Universität Berlin, Berlin, Germany
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ABSTRACT

Lotic freshwater macroinvertebrate species distribution models (SDMs) have been shown to improve when hydrological variables are included. However, most studies to date only include data describing climate or stream flow-related surrogates. We assessed the relative influence of climatic and hydrological predictor variables on the modelled distribution of macroinvertebrates, expecting model performance to improve when hydrological variables are included. We calibrated five SDMs using combinations of bioclimatic (bC), hydrological (H) and hydroclimatic (hC) predictor datasets and compared model performance as well as variance partition of all combinations. We investigated the difference in trait composition of communities that responded better to either bC or H configurations. The dataset bC had the most influence in terms of proportional variance, however model performance was increased with the addition of hC or H. Trait composition demonstrated distinct patterns between associated model configurations, where species that prefer intermediate to slow-flowing current conditions in regions further downstream performed better with bC–H. Including hydrological variables in SDMs contributes to improved performance, it is however, species-specific and future studies would benefit from hydrology-related variables to link environmental conditions and diverse communities. Consequently, SDMs that include climatic and hydrological variables could more accurately guide sustainable river ecosystem management.

CITATION

Irving, K., S.C. Jähnig, M. Kuemmerlen. 2021. Disentangling the effect of climatic and hydrological predictor variables on benthic macroinvertebrate distributions from predictive models. *Hydrobiologia* 2021:1-20.

SCCWRP Journal Article #1243
Full text available online: www.sccwrp.org/publications

Process and decision support tools for evaluating flow management targets to support aquatic life and recreational beneficial uses of the Los Angeles River: Los Angeles River Environmental Flows Project

Eric D. Stein[1], Kristine Taniguchi-Quan[1], Jordyn Wolfand[2], Elizabeth Gallo[3], Katie Irving[1], Daniel Philippus[3], Reza Abdi[3], Victoria Hennon[3], Anna Tinoco[2], Peter Mohammadi[2], Ashley Rust[3], Terri S. Hogue[3]

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CITATION

Stein, E.D., K.T. Taniguchi-Quan, J. Wolfand, E. Gallo, K. Irving, D. Philippus, R. Abdi, V. Hennon, A. Tinoco, P. Mohammadi, A. Rust, T.S. Hogue. 2021. Process and Decision Support Tools for Evaluating Flow Management Targets to Support Aquatic Life and Recreational Beneficial Uses of the Los Angeles River: Los Angeles River Environmental Flows Project. Technical Report 1196. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1196
Full text available online: www.sccwrp.org/publications

Assessment of aquatic life use needs for the Los Angeles River: Los Angeles River Environmental Flows Project

Eric D. Stein[1], Jordyn Wolfand[2], Reza Abdi[3], Katie Irving[1], Victoria Hennon[3], Kristine Taniguchi-Quan[1], Daniel Philippus[3], Anna Tinoco[2], Ashley Rust[3], Elizabeth Gallo[3], Colin Bell[3], Terri S. Hogue[3]

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CITATION

Stein, E.D., J. Wolfand, R. Abdi, K. Irving, V. Hennon, K.T. Taniguchi-Quan, D. Philippus, A. Tinoco, A. Rust, E. Gallo, C. Bell, T.S. Hogue. 2021. Assessment of Aquatic Life Use Needs for the Los Angeles River. Technical Report 1154. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1154
Full text available online: www.sccwrp.org/publications

Development of an assessment framework for dry ephemeral and intermittent streams in California and Arizona

Raphael D. Mazor[1], Jeff Brown[1], Eric D. Stein[1], John R. Olson[2], Matthew D. Robinson[2], Andrew Caudillo[2], Savannah Johnson[2], Gilbert Mak[2], Cara Clarke[3], Kevin O'Connor[3], Kamille Hammerstrom[3], Ross Clark[3]

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[3]Central Coast Wetlands Group, Moss Landing, CA

CITATION

Mazor, R.D., J.S. Brown, E.D. Stein, J.R. Olson, M.D. Robinson, A. Caudillo, S. Johnson, G. Mak, C. Clarke, K. O'Connor, K.K. Hammerstrom, R. Clark. 2021. Development of an Assessment Framework for Dry Ephemeral and Intermittent Streams in California and Arizona. Technical Report 1176. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1176
Full text available online: www.sccwrp.org/publications

Review of flow duration methods and indicators of flow duration in the scientific literature: Western Mountains

Raphael D. Mazor[1], Kenneth McCune[1]

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

CITATION

Mazor, R.D., K. McCune. 2021. Review of flow duration methods and indicators of flow duration in the scientific literature: Western Mountains. Technical Report 1222. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1222
Full text available online: www.sccwrp.org/publications

Workshop teaches stakeholders how to evaluate model uncertainty

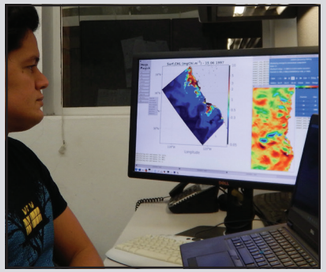
Stakeholders of an ongoing West Coast modeling initiative that is examining how ocean acidification and hypoxia (OAH) will manifest in coastal waters in the coming years took part in a multi-component workshop in spring 2021 to learn how to evaluate modeling uncertainty.

The workshop, held over a six-week period and co-organized by SCCWRP, educated Southern California and San Francisco Bay Area stakeholders about the uncertainty associated with the West Coast physical-biogeochemical ocean models that were developed to estimate how OAH will intensify in the coming years. The workshop also examined the uncertainty associated with predicting how marine life will respond to changing OAH conditions.

The modeling uncertainty workshop coincided with initial work by modelers to estimate OAH's intensifying effects on marine life, including what role, if any, land-based nutrient discharges play in exacerbating adverse biological effects.

To make decisions based on the models' predictions, environmental managers will need assurances that the models can make these predictions at acceptable confidence levels.

The workshop was co-organized by two SCCWRP member agencies – the Sanitation Districts of Los Angeles County and City of San Diego – as well as the San Francisco Estuary Institute and Bay Area Clean Water Agencies. The culmination of the workshop was a panel discussion among researchers and stakeholders about how stakeholders can optimally provide input and perspectives on modeling uncertainty analyses.



SCCWRP's Dr. Fayçal Kessouri works on a computer model that predicts which West Coast habitats and marine communities will be most vulnerable to corrosive seawater conditions in the coming years. SCCWRP co-organized a workshop in 2021 to help educate stakeholders of the ongoing modeling effort about how to evaluate modeling uncertainty.

Statewide HABs early-warning system developed to predict coastal blooms

SCCWRP and its partners have developed a statewide early-warning system for coastal harmful algal blooms (HABs) that relies on autonomous microscopes to alert water-quality managers that a bloom event could be imminent.

The pilot network, which became operational in 2021, marks a key expansion of the statewide Harmful Algal Bloom Monitoring and Alert Program (HABMAP), which has been collecting coastal HABs data for more than a decade via weekly grab sampling at piers. Technology advances in recent years have paved the way for automated, real-time HABs monitoring in coastal waters.

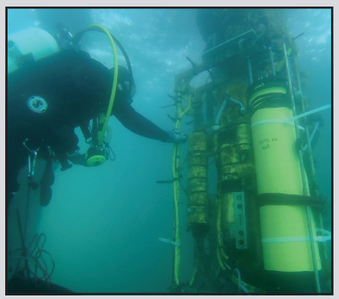
Multiple Imaging FlowCytobot (IFCB) units are being deployed off California piers and offshore moorings for several months at a time to capture hourly images of phytoplankton a few meters beneath the water's surface. The underwater images are being transmitted wirelessly to computers.

Study examines feasibility of using human cyanotoxin thresholds to protect aquatic life

SCCWRP and its partners have completed an initial investigation into whether existing cyanotoxin thresholds intended to protect the health of humans exposed to cyanotoxins in freshwater systems also could be used to protect the health of fish, invertebrates and amphibians.

The two-year study, published in 2021 by the journal *Science of the Total Environment*, found that existing, national health-based toxicity levels should be adequate for protecting aquatic life from acute exposure to a major class of cyanotoxins known as microcystins. These same levels, however, may not fully protect aquatic life from chronic exposure.

The study, which involved examining cyanotoxin data from more than 150 aquatic life toxicity studies, is one of the first efforts to examine whether existing cyanotoxin thresholds for human health protection also could be applicable to aquatic life. Thresholds already exist to protect humans exposed to toxins via recreational water-contact activities.



A diver deploys an Imaging FlowCytobot (IFCB) unit at Newport Beach Pier in Orange County as part of a pilot early-warning network for coastal HABs. The submerged instrument captures continual microscope images of phytoplankton, providing a stream of real-time HABs monitoring data.

Configuration and validation of an oceanic physical and biogeochemical model to investigate coastal eutrophication in the Southern California Bight

Fayçal Kessouri[1,2], Karen McLaughlin[1], Martha Sutula[1], Daniele Bianchi[2], Minna Ho[1], James C McWilliams[2], Lionel Renault[2,3], Jeroen Molemaker[2], Curtis Deutsch[4], Anita Leinweber[2]

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Abstract

The Southern California Bight (SCB), an eastern boundary upwelling system, is impacted by global warming, acidification and oxygen loss, and receives anthropogenic nutrients from a coastal population of 20 million people. We describe the configuration, forcing, and validation of a realistic, submesoscale resolving ocean model as a tool to investigate coastal eutrophication. This modeling system represents an important achievement because it strikes a balance of capturing the forcing by U.S. Pacific Coast-wide phenomena, while representing the bathymetric features and submesoscale circulation that affect the transport of nutrients from natural and human sources. Moreover, the model allows simulations at timescales that approach the interannual frequencies of ocean variability. The model simulation is evaluated against a broad suite of observational data throughout the SCB, showing realistic depiction of the mean state and its variability with satellite and *in situ* measurements of state variables and biogeochemical rates. The simulation reproduces the main structure of the seasonal upwelling front, the mean current patterns, the dispersion of wastewater plumes, as well as their seasonal variability. Furthermore, it reproduces the mean distributions of key biogeochemical and ecosystem properties and their variability. Biogeochemical rates reproduced by the model, such as primary production and nitrification, are also consistent with measured rates. This validation exercise demonstrates the utility of using fine-scale resolution modeling and local observations to identify, investigate, and communicate uncertainty to stakeholders to support management decisions on local anthropogenic nutrient discharges to coastal zones.

Citation

Kessouri, F., K. McLaughlin, M. Sutula, D. Bianchi, M. Ho, J.C. McWilliams, L. Renault, J. Molemaker, C. Deutsch, A. Leinweber. 2021. Configuration and validation of an oceanic physical and biogeochemical model to investigate coastal eutrophication in the Southern California Bight. *Journal of Advances in Modeling Earth Systems* 13:e2020MS002296.

SCCWRP Journal Article #1229
Full text available online: www.sccwrp.org/publications

Influence of anthropogenic nutrient inputs on rates of coastal ocean nitrogen and carbon cycling in the Southern California Bight, United States

Karen McLaughlin[1], Meredith D. A. Howard[1,2], George Robertson[3], Carly D. A. Beck[1,4], Minna Ho[1], Fayçal Kessouri[1], Nikolay P. Nezlin[1,5], Martha Sutula[1], Stephen B. Weisberg[1]

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[3]*Orange County Sanitation District, Fountain Valley, CA*
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Abstract

Coastal nitrogen enrichment is a global environmental problem that can influence acidification, deoxygenation, and subsequent habitat loss in ways that can be synergistic with global climate change impacts. In the Southern California Bight, an eastern boundary upwelling system, modeling of wastewater discharged through ocean outfalls has shown that it effectively doubles nitrogen loading to urban coastal waters. However, effects of wastewater outfalls on rates of primary production and respiration, key processes through which coastal acidification and deoxygenation are manifested, have not been directly linked to observed trends in ambient chlorophyll *a*, oxygen, or pH. Here, we follow a "reference-area" approach and compare nutrient concentrations and rates of nitrification, primary production, and respiration observed in areas within treated wastewater effluent plumes to areas spatially distant from ocean outfalls where we expected minimal plume influence. We document that wastewater nutrient inputs had an immediate, local effect on nutrient stoichiometry, elevating ammonium and nitrite concentrations by 4 μM and 0.2 μM (on average), respectively, and increasing dissolved nitrogen-to-phosphorus ratios 7-fold within the plume. Chlorophyll *a* increased slightly by 1 μg L^{-1} in the upper 60 m of the water column (on average), and $\delta^{13}C$ and $\delta^{15}N$ of suspended particulate matter, an integrated measure of primary production, increased by 1.3% and 1%, respectively (on average). Nitrification rates within the plume increased by 17 nmol L^{-1} day^{-1} (on average). We did not observe a significant near-plume effect on $\delta^{18}O$ and $\delta^{15}N$ of dissolved nitrate + nitrite, an indicator of nitrogen assimilation into biomass, on rates of primary production and respiration or on dissolved oxygen concentration, suggesting that any potential impact from wastewater on these key features is moderated by other factors, notably water mass mixing. These results indicate that a "reference-area" approach may be insufficient to document regional-scale impacts of nutrients.

CITATION

McLaughlin, K., M.D.A. Howard, G. Robertson, C.D.A. Beck, M. Ho, F. Kessouri, N.P. Nezlin, M. Sutula, S.B. Weisberg. 2021. Influence of anthropogenic nutrient inputs on rates of coastal ocean nitrogen and carbon cycling in the Southern California Bight, United States. *Elementa: Science of the Anthropocene* 9:00145.

SCCWRP Journal Article #1233
Full text available online: www.sccwrp.org/publications

High-resolution nonhydrostatic outfall plume modeling: Cross-flow validation

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ABSTRACT

Marine outfalls discharge wastewater on the inner shelf and are designed to encourage rapid effluent mixing sufficient to maintain a submerged wastefield. A high-resolution nonhydrostatic Regional Ocean Modeling System (ROMS) model was used to resolve concomitantly the intermediate- and far-field submarine plume development. ROMS simulations were validated with cross-flow laboratory experiments. Generally, results showed that the nonhydrostatic high-resolution ROMS is capable of resolving plume dynamics in typical cross-flow conditions. Top-of-plume elevation was quantified and found to be highly variable. The ROMS model is relatively insensitive to changes in horizontal effluent input parameterization. Multiple grid resolutions were tested, and good model–data agreement was achieved in low to medium cross-flow experiments. Additional resolution improved high cross-flow results. This intermediate- and far-field three-dimensional nonhydrostatic model resolves plume development over multiple spatiotemporal scales and can include natural oceanic processes currently absent in many plume models. Integrated outfall plume and marine process modeling will advance future wastewater management.

CITATION

Ho, M., J.M. Molemaker, F. Kessouri, J.C. McWilliams, T.W. Gallien. 2021. High-Resolution Nonhydrostatic Outfall Plume Modeling: Cross-Flow Validation. *Journal of Hydraulic Engineering* DOI:10.1061/(ASCE)HY.1943-7900.0001896.

SCCWRP Journal Article #1205
Full text available by request: pubrequest@sccwrp.org

Coastal eutrophication drives acidification, oxygen loss, and ecosystem change in a major oceanic upwelling system

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ABSTRACT

Global change is leading to warming, acidification, and oxygen loss in the ocean. In the Southern California Bight, an eastern boundary upwelling system, these stressors are exacerbated by the localized discharge of anthropogenically enhanced nutrients from a coastal population of 23 million people. Here, we use simulations with a high-resolution, physical–biogeochemical model to quantify the link between terrestrial and atmospheric nutrients, organic matter, and carbon inputs and biogeochemical change in the coastal waters of the Southern California Bight. The model is forced by large-scale climatic drivers and a reconstruction of local inputs via rivers, wastewater outfalls, and atmospheric deposition; it captures the fine scales of ocean circulation along the shelf; and it is validated against a large collection of physical and biogeochemical observations. Local land-based and atmospheric inputs, enhanced by anthropogenic sources, drive a 79% increase in phytoplankton biomass, a 23% increase in primary production, and a nearly 44% increase in subsurface respiration rates along the coast in summer, reshaping the biogeochemistry of the Southern California Bight. Seasonal reductions in subsurface oxygen, pH, and aragonite saturation state, by up to 50 mmol m^{-3}, 0.09, and 0.47, respectively, rival or exceed the global open-ocean oxygen loss and acidification since the preindustrial period. The biological effects of these changes on local fisheries, proliferation of harmful algal blooms, water clarity, and submerged aquatic vegetation have yet to be fully explored.

CITATION

Kessouri, F., J.C. McWilliams, D. Bianchi, M. Sutula, L. Renault, C. Deutsch, R.A. Feely, K. McLaughlin, M. Ho, E.M. Howard, N. Bednaršek, P. Damien, J. Molemaker, S.B. Weisberg. 2021. Coastal eutrophication drives acidification, oxygen loss, and ecosystem change in a major oceanic upwelling system. *Proceedings of the National Academy of Sciences of the United States of America* DOI:10.1073/pnas.2018856118.

SCCWRP Journal Article #1204
Full text available by request: pubrequest@sccwrp.org

Synthesis of ecotoxicological studies on cyanotoxins in freshwater habitats – Evaluating the basis for developing thresholds protective of aquatic life in the United States

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ABSTRACT

In recent decades, cyanobacteria harmful algal blooms (cyanoHABs) have increased in magnitude, frequency, and duration in freshwater ecosystems. CyanoHABs can impact water quality by the production of potent toxins known as cyanotoxins. Environmental exposure to cyanotoxins has been associated with severe illnesses in humans, domestic animals, and wildlife. However, the effects of sustained exposure to cyanotoxins on aquatic life are poorly understood. In this study, over 150 peer-reviewed articles were critically evaluated to better understand the ecotoxicity of 5 cyanotoxin classes (microcystins, cylindrospermopsin, anatoxin-a, saxitoxins, nodularin) on fish, amphibians, aquatic invertebrates, and birds exclusively feeding in freshwater habitats. The systemic review demonstrated that microcystins, and more specifically microcystin-LR, were the most studied cyanotoxins. Ecotoxicological investigations were typically conducted using a fish or aquatic invertebrate model, with mortality, bioaccumulation, and biochemical responses as the most frequently measured endpoints. After excluding the studies that did not meet our acceptability criteria, remaining studies were examined to identify the no-observed and lowest observed effect concentrations (NOEC and LOEC) for microcystins; the limited amount of data for other cyanotoxins did not allow for analysis. The published ecotoxicity data suggests that the U.S. EPA recreational water quality criteria for microcystin (8 µg/L) may be protective of acute toxicity in aquatic organisms but does not appear to protect against chronic toxicity. Individual U.S. states have developed more stringent recreational health-based thresholds, such as 0.8 µg/L in California. Comparisons of this threshold to the chronic NOEC and LOEC data indicate that more restrictive microcystins thresholds may be required to be protective of aquatic life. Additional research is needed to evaluate the sublethal effects of a wider array of microcystin congeners and other cyanotoxins on organisms relevant to U.S. watersheds to better support nationwide thresholds protective of aquatic life.

CITATION

Mehinto, A.C., J. Smith, E. Wenger, B. Stanton, R. Linville, B.W. Brooks, M.A. Saluta, M.D.A. Howard. 2021. Synthesis of ecotoxicological studies on cyanotoxins in freshwater habitats – Evaluating the basis for developing thresholds protective of aquatic life in the United States. *Science of the Total Environment* DOI:10.1016/j.scitotenv.2021.148864.

SCCWRP Journal Article #1214
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Multiple co-occurring and persistently detected cyanotoxins and associated cyanobacteria in adjacent California lakes

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ABSTRACT

The global proliferation of toxin producing cyanobacterial blooms has been attributed to a wide variety of environmental factors with nutrient pollution, increased temperatures, and drought being three of the most significant. The current study is the first formal assessment of cyanotoxins in two impaired lakes, Canyon Lake and Lake Elsinore, in southern California that have a history of cyanobacterial blooms producing high biomass as measured by chl-a. Cyanotoxins in Lake Elsinore were detected at concentrations that persistently exceeded California recreational health thresholds, whereas Canyon Lake experienced persistent concentrations that only occasionally exceeded health thresholds. The study results are the highest recorded concentrations of microcystins, anatoxin-a, and cylindrospermopsin detected in southern California lakes. Concentrations exceeded health thresholds that caused both lakes to be closed for recreational activities. Cyanobacterial identifications indicated a high risk for the presence of potentially toxic genera and agreed with the cyanotoxin results that indicated frequent detection of multiple cyanotoxins simultaneously. A statistically significant correlation was observed between chlorophyll-a (chl-a) and microcystin concentrations for Lake Elsinore but not Canyon Lake, and chl-a was not a good indicator of cylindrospermopsin, anatoxin-a, or nodularin. Therefore, chl-a was not a viable screening indicator of cyanotoxin risk in these lakes. The study results indicate potential acute and chronic risk of exposure to cyanotoxins in these lakes and supports the need for future monitoring efforts to help minimize human and domestic pet exposure and to better understand potential effects to wildlife.

The frequent co-occurrence of complex cyanotoxin mixtures further complicates the risk assessment process for these lakes given uncertainty in the toxicology of mixtures.

CITATION

Howard, M.D.A., R.M. Kudela, K. Hayashi, A.O. Tatters, D.A. Caron, S. Theroux, S. Oehrle, M. Roethler, A. Donovan, K. Loftin, Z. Laughrey. 2021. Multiple co-occurring and persistently detected cyanotoxins and associated cyanobacteria in adjacent California lakes. *Toxicon* 192:1-14.

SCCWRP Journal Article #1172
Full text available online: www.sccwrp.org/publications

The tide turns: Episodic and localized cross-contamination of a California coastline with cyanotoxins

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ABSTRACT

The contamination of coastal ecosystems from a variety of toxins of marine algal origin is a common and well-documented situation along the coasts of the United States and globally. The occurrence of toxins originating from cyanobacteria along marine coastlines is much less studied, and little information exists on whether toxins from marine and freshwater sources co-occur regularly. The current study focused on the discharge of cyanotoxins from a coastal lagoon (Santa Clara River Estuary) as a consequence of an extreme tide event (King Tides; December 3-5, 2017) resulting in a breach of the berm separating the lagoon from the ocean. Monthly monitoring in the lagoon throughout 2017 documented more than a dozen co-occurring cyanobacterial genera, as well as multiple algal and cyanobacterial toxins. Biotoxin monitoring before and following the King Tide event using Solid Phase Adsorption Toxin Tracking (SPATT) in the lagoon and along the coast revealed the co-occurrence of microcystins, anatoxin, domoic acid, and other toxins on multiple dates and locations. Domoic acid was ubiquitously present in SPATT deployed in the lagoon and along the coast. Microcystins were also commonly detected in both locations, although the beach berm retained the lagoonal water for much of the year. Mussels collected along the coast contained microcystins in approximately half the samples, particularly following the King Tide event. Anatoxin was observed in SPATT only in late December, following the breach of the berm. Our findings indicate both episodic and persistent occurrence of both cyanotoxins and marine toxins may commonly contaminate coastlines in proximity to cyanobacteria-laden creeks and lagoons.

CITATION

Tatters, A.O., J. Smith, R.M. Kudela, K. Hayashi, M.D.A. Howard, A.R. Donovan, K.A. Loftin, D.A. Caron. 2021. The tide turns: Episodic and localized cross-contamination of a California coastline with cyanotoxins. *Harmful Algae* DOI:10.1016/j.hal.2021.102003.

SCCWRP Journal Article #1188
Full text available by request: pubrequest@sccwrp.org

Persistent domoic acid in marine sediments and benthic infauna along the coast of Southern California

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ABSTRACT

Blooms of the diatom genus *Pseudo-nitzschia* occur annually in the Southern California Bight (SCB), and domoic acid (DA) associated with these events can contaminate fisheries, presenting both human and wildlife health risks. Recent studies have suggested that marine sediments may act as a reservoir for DA, extending the risk of food web contamination long after water column blooms have ended. In this study, we conducted a regional assessment of the extent and magnitude of DA in the benthic environment, and monthly observations of sediments and benthic infauna at multiple stations over a 16-month period. DA was widespread in continental shelf sediments of the SCB. The toxin was detected in 54% of all shelf habitats sampled. Detectable concentrations ranged from 0.11 ng/g to 1.36 ng/g. DA was consistently detected in benthic infauna tissues over the monthly timeseries, while the DA concentrations in sediments during the same period were commonly below detection or at low concentrations. The presence of DA in the benthic environment did not always have an apparent water column source, raising the possibility of lateral transport, retention/preservation in sediments or undetected blooms in subsurface waters. In most cases, DA was detected in tissues but not in the co-located surface sediments. Coarse taxonomic sorting of the infauna revealed that the accumulation of DA varied among taxa. We observed that DA was widespread among lower trophic level organisms in this study, potentially acting as a persistent source of DA to higher trophic levels in the benthos.

CITATION

Smith, J., D. Shultz, M.D.A. Howard, G. Robertson, V. Phonsiri, V. Renick, D.A. Caron, R.M. Kudela, K. McLaughlin. 2021. Persistent domoic acid in marine sediments and benthic infauna along the coast of Southern California. *Harmful Algae* DOI:10.1016/j.hal.2021.102103.

SCCWRP Journal Article #1223
Full text available by request: pubrequest@sccwrp.org

A baseline of terrestrial freshwater and nitrogen fluxes to the Southern California Bight, USA

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ABSTRACT

Time series were compiled of terrestrial nitrogen, phosphorus, carbon, iron, and silica fluxes to the Southern California Bight (SCB), a U.S. West Coast embayment (Sutula et al., 2021). Monitoring data and model output were used to construct a baseline of inputs from direct point source (PS) discharges of wastewater treatment (WWT) effluent (via ocean outfalls) and PS, non-point and natural sources from coastal rivers. The baseline covers 1971—2017 for large WWT plants discharging >50 million gallons per day (MGD) and 1997–2017 for small WWT plants and rivers. PS are the dominant nitrogen source, with contributions of 70% of the total annual freshwater discharge and 95% of nitrogen loads. WWT upgrades have reduced organic nitrogen loads by 73% since 1971. Inorganic nitrogen loads have generally held constant (35–40 Gg y^{-1}) for the large WWT plants. This baseline represents a period prior to extensive wastewater and stormwater recycling that is increasing in the region.

CITATION

Sutula, M., M. Ho, A. Sengupta, F. Kessouri, K. McLaughlin, K. McCune, D. Bianchi. 2021. A baseline of terrestrial freshwater and nitrogen fluxes to the Southern California Bight, USA. *Marine Pollution Bulletin* DOI:10.1016/j.marpolbul.2021.112669.

SCCWRP Journal Article #1212
Full text available online: www.sccwrp.org/publications

Dataset of terrestrial fluxes of freshwater, nutrients, carbon, and iron to the Southern California Bight, U.S.A.

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ABSTRACT

The Southern California Bight (SCB) is an upwelling-dominated, open embayment on the U.S. West Coast and receives discharges of anthropogenically-enhanced freshwater, nutrients, carbon, and other materials. These inputs include direct point sources discharged from wastewater treatment (WWT) plants via ocean outfalls and point, non-point, and natural sources discharged via coastal rivers. We assembled a daily time series over 1971–2017 of discharges from large WWT plants ≥ 50 million gallon per day (MGD) and 1997–2017 from small WWT plants and coastal rivers. Constituents include nitrogen, phosphorus, organic carbon, alkalinity, iron, and silica. Data from research studies, several government and non-government agency databases containing discharge monitoring reports, river flow gauges, and other collateral information were compiled to produce this dataset. Predictive models and expert analysis addressed unmonitored sources and data gaps. The time series of terrestrial discharge and fluxes are provided with location of coastal discharge point or tributary. The data are deposited in a repository found in Sutula et al.

CITATION

Sutula, M., M. Ho, A. Sengupta, F. Kessouri, K. McLaughlin, K. McCune, D. Bianchi. 2021. Dataset of terrestrial fluxes of freshwater, nutrients, carbon, and iron to the Southern California Bight, U.S.A.. *Data in Brief* DOI:10.1016/j.dib.2021.106802.

SCCWRP Journal Article #1179
Full text available online: www.sccwrp.org/publications

Biogeochemical variability in the California Current System

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ABSTRACT

The biological productivity and diversity of the California Current System (CCS) is at the leading edge of major emerging climate trends, including hypoxia and acidification. We present results from a hindcast simulation (reanalysis) of an eddy-resolving oceanic physical-biogeochemical model of the CCS, to characterize its mean state and its patterns and drivers of variability in marine biogeochemical and ecosystem processes from 1995 to 2010. This is a companion paper to a physical analysis in Renault et al. (2021). The model reproduces long-term mean distributions of key ecosystem metrics, including surface nutrients and productivity and subsurface O_2 and carbonate undersaturation. The spatial patterns of Net Primary Productivity (NPP) are broadly consistent with measured and remotely sensed rates, and they reflect a predominant limitation by nitrogen, with seasonal and episodic limitation by *Fe* nearshore in the central CCS, and in the open ocean northern CCS. The vertical distribution of NPP is governed by the trade-off between nutrient and light limitation, a balance that reproduces and explains the observed spatial variations in the depth of the deep *Chl* maximum. The seasonal to interannual variability of biogeochemical properties and rates is also well captured by model simulations. Because of the prevailing nutrient

limitation, fluctuations in the depth of the pycnocline and associated nutricline are the leading single factor explaining interannual variability in the interior biogeochemical state, and the relationships between density and biogeochemical rates and tracers are consistent between model and observations. The magnitude and relationship between density structure and biogeochemical processes is illustrated by the 1997–98 El Niño event, which faithfully reproduces the single largest deviation from the mean state in the simulated period. A slower decadal shoaling of the pycnocline also accounts for the concomitant trends in hypoxic and corrosive conditions on the shelf. The resulting variability is key to understanding the vulnerability of marine species to oceanic change, and to the detection of such changes, soon projected to exceed the range of conditions in the past century.

CITATION

Deutsch, C., H. Frenzel, J.C. McWilliams, L. Renault, F. Kessouri, E. Howard, J.H. Liang, D. Bianchi, S. Yang. 2021. Biogeochemical variability in the California Current System. *Progress in Oceanography* DOI:10.1016/j.pocean.2021.102565.

SCCWRP Journal Article #1207
Full text available by request: pubrequest@sccwrp.org

Evaluation of high-resolution atmospheric and oceanic simulations of the California Current System

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ABSTRACT

This paper is the first of two that present a 16-year hindcast solution from a coupled physical and biogeochemical model of the California Current System (CCS) along the U. S. West Coast and validate the physical solution with respect to mean, seasonal, interannual, and subseasonal fields and, to a lesser degree, eddy variability. Its companion paper is Deutsch et al. (2021). The intent is to construct and demonstrate a modeling tool that will be used for mechanistic explanations, attributive causal assessments, and forecasts of future evolution for circulation and biogeochemistry, with particular attention to the increasing oceanic stratification, deoxygenation, and acidification. A well-resolved mesoscale (dx = 4 km) simulation of the CCS circulation is made with the Regional Oceanic Modeling System over a hindcast period of 16 years from 1995 to 2010. The oceanic solution is forced by a high-resolution (dx = 6 km) regional configuration of the Weather and Research Forecast (WRF) atmospheric model. Both of these high-resolution regional oceanic and atmospheric simulations are forced by lateral open boundary conditions taken from larger-domain, coarser-resolution parent simulations that themselves have boundary conditions from the Mercator and Climate Forecast System reanalyses, respectively. We show good agreement between the simulated atmospheric forcing of the oceanic and satellite measurements for the spatial patterns and temporal variability for the surface fluxes of momentum, heat, and freshwater. The simulated oceanic physical fields are then evaluated with satellite and *in situ* measurements. The simulation reproduces the main structure of the climatological upwelling front and cross-shore isopycnal slopes, the mean current patterns (including the California Undercurrent), and the seasonal, interannual, and subseasonal variability. It also shows agreement between the mesoscale eddy activity and the windwork energy exchange between the ocean and atmosphere modulated by influences of surface current on surface stress. Finally, the impact of using a high frequency wind forcing is assessed for the importance of synoptic wind variability to realistically represent oceanic mesoscale activity and ageostrophic inertial currents.

CITATION

Renault, L., J.C. McWilliams, F. Kessouri, A. Jousse, H. Frenzel, R. Chen, C. Deutsch. 2021. Evaluation of high-resolution atmospheric and oceanic simulations of the California Current System. *Progress in Oceanography* DOI:10.1016/j.pocean.2021.102564.

SCCWRP Journal Article #1206
Full text available by request: pubrequest@sccwrp.org

Oxygen budget of the north-western Mediterranean deep-convection region

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ABSTRACT

The north-western Mediterranean deep convection plays a crucial role in the general circulation and biogeochemical cycles of the Mediterranean Sea. The DEWEX (DEnse Water EXperiment) project aimed to better understand this role through an intensive observation platform combined with a modelling framework. We developed a three-dimensional coupled physical and biogeochemical model to estimate the cycling and budget of dissolved oxygen in the entire north-western Mediterranean deep-convection area over the period September 2012 to September 2013. After showing that the simulated dissolved oxygen concentrations are in a good agreement with the in-situ data collected from research cruises and Argo floats, we analyse the seasonal cycle of the air–sea oxygen exchanges, as well as physical and biogeochemical oxygen fluxes, and we estimate an annual oxygen budget. Our study indicates that the annual air-to-sea fluxes in the deep-convection area amounted to 20 mol $m^{-2}yr^{-1}$. A total of 88% of the annual uptake of atmospheric oxygen, i.e. 18 mol m^{-2}, occurred during the intense vertical mixing period. The model shows that an amount of 27 mol m^{-2} of oxygen, injected at the sea surface and produced through photosynthesis, was transferred under the euphotic layer, mainly during deep convection. An amount of 20 mol m^{-2} of oxygen was then gradually exported in the aphotic layers to the south and west of the western basin, notably, through the spreading of dense waters recently formed. The decline in the deep-convection intensity in this region predicted by the end of the century in recent projections may have important consequences on the overall uptake of atmospheric oxygen in the Mediterranean Sea and on the oxygen exchanges with the Atlantic Ocean, which appear necessary to better quantify in the context of the expansion of low-oxygen zones.

CITATION

Ulses, C., C. Estournel, M. Fourrier, L. Coppola, F. Kessouri, D. Lefevre, P. Marsaleix. 2021. Oxygen budget of the north-western Mediterranean deep-convection region. *Biogeosciences* 18:937-960.

SCCWRP Journal Article #1178
Full text available online: www.sccwrp.org/publications

Progress toward restoring the Everglades: The Eighth Biennial Review - 2020

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ABSTRACT

During the past century, the Everglades, one of the world's treasured ecosystems, has been dramatically altered by drainage and water management infrastructure to improve flood management, urban water supply, and agricultural production. The remnants of the original Everglades now compete for water with urban and agricultural interests and are impaired by contaminated runoff from these two sectors. The Comprehensive Everglades Restoration Plan (CERP), a joint effort launched by the state and the federal government in 2000, seeks to reverse the decline of the ecosystem. The multibillion-dollar project was originally envisioned as a 30- to 40-year effort to achieve ecological restoration by reestablishing the natural hydrologic characteristics of the Everglades, where feasible, and to create a water system that serves the needs of both the natural and the human systems of South Florida. The National Academies of Sciences, Engineering, and Medicine established the Committee on Independent Scientific Review of Everglades Restoration Progress in 2004 in response to a request from the U.S. Army Corps of Engineers, with support from the South Florida Water Management District (SFWMD) and the U.S. Department of the Interior, based on Congress's mandate in the Water Resources Development Act of 2000. The committee is charged to submit biennial reports that review the CERP's progress in restoring the natural ecosystem. This is the committee's eighth report. Each report provides an update on progress toward natural system restoration during the previous 2 years, describes substantive accomplishments (Chapter 3), and reviews developments in research, monitoring, and assessment that inform restoration decision making (Chapters 3 and 6). The committee also identifies issues for in-depth evaluation given new CERP program developments, policy initiatives, or improvements in scientific knowledge that have implications for restoration progress (see Chapter 1 for the committee's full statement of task). For the 2020 report, the committee reviewed the recently developed Combined Operational Plan (COP), which is a prerequisite for CERP progress in the central Everglades (Chapter 4), and examined issues facing the northern and southern estuaries, including priorities for science to support restoration decision making (Chapter 5). Additionally, the committee examined the capacity of CERP monitoring, modeling, and synthesis to support decision makers (Chapter 6).

CITATION

Driscoll, C.T., W.G. Boggess, C. Brown, R.K. Craig, T. Dunne, M.S. Fennessy, J.W. Jawitz, E.A. Meselhe, D.J. Reed, J. Saiers, E.P. Smith, M. Sutula, J.R. Walters, D.H. Wardrop. 2021. Progress Toward Restoring the Everglades: The Eighth Biennial Review - 2020. Technical Report 1198. National Academies of Sciences, Engineering, and Medicine. Washington, DC.

SCCWRP Book Publication #1198
Full text available by request: pubrequest@sccwrp.org

California Water Boards' framework and strategy for freshwater harmful algal bloom monitoring: Full report with appendices

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CITATION

Smith, J., M. Sutula, K. Bourma-Gregson, M. Van Dyke. 2021. California Water Boards' Framework and Strategy for Freshwater Harmful Algal Bloom Monitoring: Full Report with Appendices. Technical Report 1141.B. California State Water Resources Control Board. Sacramento, CA.

SCCWRP Technical Report #1141.B
Full text available online: www.sccwrp.org/publications

Study examines climate change's influence on eutrophication

SCCWRP and its partners have completed a three-year study examining how climate change is expected to influence eutrophication in the Santa Margarita River watershed – the final piece of a decade-long effort to build a scientific foundation for how to reduce ecologically disruptive algal bloom events in Santa Margarita and similar watersheds.

The study, completed in late 2021, evaluated how changing rainfall patterns and water temperatures stemming from climate change will alter the trajectory of algal blooms and low dissolved oxygen levels in the watershed, which spans Riverside and northern San Diego Counties.

Water-quality managers for Santa Margarita and beyond will need to understand how climate change influences watershed health as they begin developing scientifically defensible limits for the nutrient loading levels that can be sustainably discharged into these systems. The climate change study found that climate change will make it harder for water-quality managers to manage eutrophication in these watersheds.

The San Diego Regional Water Quality Control Board is planning to release a draft of its comprehensive water-quality management plan for protecting the Santa Margarita watershed as early as 2023. The State Water Resources Control Board, meanwhile, is using Santa Margarita as a case study that will help inform the development of a planned biointegrity-biostimulatory policy to protect wadeable stream health.

A SCCWRP field crew wades into the Santa Margarita River, which spans Riverside and San Diego Counties, to collect algae samples. Researchers have completed a study shedding light on how climate change will influence eutrophication.

Modeling effort examines kelp farms' potential to buffer against acidification

SCCWRP and its partners have completed the initial phases of integrating a pair of Southern California Bight computer models to investigate how offshore kelp farms might be used to reduce the ecological effects of intensifying coastal ocean acidification and hypoxia (OAH).

Researchers are using the two models, which are being coupled in a stepwise fashion, to generate solutions-focused insights about specific potential locations that could be optimal for cultivating kelp farms offshore. Communities in other parts of the world already have started growing kelp offshore as a management strategy for improving coastal water quality, including mitigating OAH conditions. Kelp farms could remove nutrients and carbon dioxide from the water via the plants' natural photosynthetic processes.

The initial phases of the model integration work, completed in 2021, involved coupling a model that predicts how Southern California coastal waters will be impacted by OAH to a second model that explains how kelp farming influences physical and biogeochemical ocean processes.

Courtesy of Javier Infante

A field crew from the aquaculture company Ocean Rainforest examines kelp that has been growing on ropes suspended in an underwater farm off the coast of Santa Barbara. Offshore kelp farms could buffer against intensifying coastal ocean acidification and hypoxia.

Study explores how to alter sediment dredging in wetlands to offset rising seas

SCCWRP and the University of California, Irvine have completed a four-year study exploring how altering sediment dredging practices in coastal wetlands vulnerable to sea level rise could reduce anticipated ecological impacts to plant and animal communities.

The coastal resiliency study, published in 2021, found that the habitats of species like the endangered Ridgway's rail are expected to be inundated by rising sea levels by the late 21st century, but that reduced sediment dredging in areas like upper Newport Bay in Orange County could partially offset the projected ecosystem impacts.

The study will help environmental managers more readily evaluate tradeoffs associated with various dredging frequencies and intensities under multiple sea level rise scenarios.

Pteropods make thinner shells in the upwelling region of the California Current Ecosystem

Lisette Mekkes[1,2], Willem Renema[1,2], Nina Bednaršek[3,4], Simone R. Alin[5], Richard A. Feely[5], Jef Huisman[2], Peter Roessingh[2], Katja T. C. A. Peijnenburg[1,2]

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[2]*Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Amsterdam, The Netherlands*
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[5]*NOAA Pacific Marine Environmental Laboratory, Seattle, WA*

Abstract

Shelled pteropods are widely regarded as bioindicators for ocean acidification, because their fragile aragonite shells are susceptible to increasing ocean acidity. While short-term incubations have demonstrated that pteropod calcification is negatively impacted by ocean acidification, we know little about net calcification in response to varying ocean conditions in natural populations. Here, we examine *in situ* calcification of Limacina helicina pteropods collected from the California Current Ecosystem, a coastal upwelling system with strong spatial gradients in ocean carbonate chemistry, dissolved oxygen and temperature. Depth-averaged pH ranged from 8.03 in warmer offshore waters to 7.77 in cold CO_2-rich waters nearshore. Based on high-resolution micro-CT technology, we showed that shell thickness declined by ~ 37% along the upwelling gradient from offshore to nearshore water. Dissolution marks covered only ~ 2% of the shell surface area and were not associated with the observed variation in shell thickness. We thus infer that pteropods make thinner shells where upwelling brings more acidified and colder waters to the surface. Probably the thinner shells do not result from enhanced dissolution, but are due to a decline in calcification. Reduced calcification of pteropods is likely to have major ecological and biogeochemical implications for the cycling of calcium carbonate in the oceans.

Citation

Mekkes, L., W. Renema, N. Bednaršek, S.R. Alin, R.A. Feely, J. Huisman, P. Roessingh, K.T.C.A. Peijnenburg. 2021. Pteropods make thinner shells in the upwelling region of the California Current Ecosystem. *Scientific Reports* DOI:10.1038/s41598-021-81131-9.

SCCWRP Journal Article #1202
Full text available online: www.sccwrp.org/publications

Biological impact of ocean acidification in the Canadian Arctic: Widespread severe pteropod shell dissolution in Amundsen Gulf

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Abstract

Increasing atmospheric CO_2, cold water temperatures, respiration, and freshwater inputs all contribute to enhanced acidification in Arctic waters. However, ecosystem effects of ocean acidification (derived from anthropogenic and/or natural sources) in the Arctic Ocean are highly uncertain. Zooplankton samples and oceanographic data were collected in August 2012–2014 and again in August 2017 to investigate the pelagic sea snail, *Limacina helicina*, a biological indicator of the presence and potential impact of acidified waters in the Canadian Beaufort Sea. Between 2012 and 2014 *L. helicina* abundance ranged from 85% of *L. helicina* assessed (n = 134) from the Amundsen Gulf region displayed shell dissolution and advanced levels of dissolution occurred at all stations. The severity of dissolution was not significantly different between 2014 and 2017 despite the presence of larger individuals that are less prone to dissolution, and higher food availability that can provide some physiological benefits in 2014. Corrosive water conditions were not widespread in the Amundsen Gulf at the time of sampling in 2017, and aragonite undersaturation (Ω_{ar} 150 m. The majority of dissolution was observed on the first whorl of the shells strongly indicating that damage was initiated during the larval stage of growth in May or early June when sea ice is still present. Evidence of shell modification was present in 2014, likely supported by abundant food availability in 2014 relative to 2017. The proportion of damaged *L. helicina* collected from coastal embayments and offshore stations is higher than in other Arctic and temperate locations indicating that exposure to corrosive waters is spatially widespread in the Amundsen Gulf region, and periods of exposure are extreme enough to impact the majority of the population.

Citation

Niemi, A., N. Bednaršek, C. Michel, R.A. Feely, W. Williams, K. Azetsu-Scott, W. Walkusz, J.D. Reist. 2021. Biological Impact of Ocean Acidification in the Canadian Arctic: Widespread Severe Pteropod Shell Dissolution in Amundsen Gulf. *Frontiers in Marine Science* DOI:10.3389/fmars.2021.600184.

SCCWRP Journal Article #1203
Full text available online: www.sccwrp.org/publications

Integrated assessment of ocean acidification risks to pteropods in the northern high latitudes: Regional comparison of exposure, sensitivity and adaptive capacity

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Abstract

Exposure to the impact of ocean acidification (OA) is increasing in high-latitudinal productive habitats. Pelagic calcifying snails (pteropods), a significant component of the diet of economically important fish, are found in high abundance in these regions. Pteropods have thin shells that readily dissolve at low aragonite saturation state (Ωar), making them susceptible to OA. Here, we conducted a first integrated risk assessment for pteropods in the Eastern Pacific subpolar gyre, the Gulf of Alaska (GoA), Bering Sea, and Amundsen Gulf. We determined the risk for pteropod populations by integrating measures of OA exposure, biological sensitivity, and resilience. Exposure was based on physical-chemical hydrographic observations and regional biogeochemical model outputs, delineating seasonal and decadal changes in carbonate chemistry conditions. Biological sensitivity was based on pteropod morphometrics and shell-building processes, including shell dissolution, density and thickness. Resilience and adaptive capacity were based on species diversity and spatial connectivity, derived from the particle tracking modeling. Extensive shell dissolution was found in the central and western part of the subpolar gyre, parts of the Bering Sea, and Amundsen Gulf. We identified two distinct morphotypes: *L. helicina helicina* and *L. helicina pacifica*, with high-spired and flatter shells, respectively. Despite the presence of different morphotypes, genetic analyses based on mitochondrial haplotypes identified a single species, without differentiation between the morphological forms, coinciding with evidence of widespread spatial connectivity. We found that shell morphometric characteristics depends on omega saturation state (Ω_{ar}); under Ω_{ar} decline, pteropods build flatter and thicker shells, which is indicative of a certain level of phenotypic plasticity. An integrated risk evaluation based on multiple approaches assumes a high risk for pteropod population persistence with intensification of OA in the high latitude eastern North Pacific because of their known vulnerability, along with limited evidence of species diversity despite their connectivity and our current lack of sufficient knowledge of their adaptive capacity. Such a comprehensive understanding would permit improved prediction of ecosystem change relevant to effective fisheries resource management, as well as a more robust foundation for monitoring ecosystem health and investigating OA impacts in high-latitudinal habitats.

Citation

Bednaršek, N., K.A. Naish, R.A. Feely, C. Hauri, K. Kimoto, A.J. Hermann, C. Michel, A. Niemi, D. Pilcher. 2021. Integrated Assessment of Ocean Acidification Risks to Pteropods in the Northern High Latitudes: Regional Comparison of Exposure, Sensitivity and Adaptive Capacity. *Frontiers in Marine Science* 8:671497.

SCCWRP Journal Article #1230
Full text available online: www.sccwrp.org/publications

Synthesis of thresholds of ocean acidification impacts on decapods

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[9]*Marine Biology and Ecology Research Centre, University of Plymouth, Plymouth, United Kingdom*
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Abstract

Assessing decapod sensitivity to regional-scale ocean acidification (OA) conditions is limited because of a fragmented understanding of the thresholds at which they exhibit biological response. To address this need, we undertook a three-step data synthesis: first, we compiled a dataset composed of 27,000 datapoints from 55 studies of decapod responses to OA. Second, we used statistical threshold analyses to identify OA thresholds using pH as a proxy for 13 response pathways from physiology to behavior, growth, development and survival. Third, we worked with the panel of experts to review these thresholds, considering the contributing datasets based on quality of the study, and assign a final thresholds and associated confidence scores based on quality and consistency of findings among studies. The duration-dependent thresholds were within a pH range from 7.40 to 7.80, ranging from behavioral and physiological responses to mortality, with many of the thresholds being assigned medium-to-high confidence. Organism sensitivity increased with the duration of exposure but was not linked to a specific life-stage. The thresholds that emerge from our analyses provide the foundation for consistent interpretation of OA monitoring data or numerical ocean model simulations to support climate change marine vulnerability assessments and evaluation of ocean management strategies.

Citation

Bednaršek, N., R. Ambrose, P. Calosi, R.K. Childers, R.A. Feely, S.Y. Litvin, W.C. Long, J.I. Spicer, J. Strus, J. Taylor, F. Kessouri, M. Roethler, M. Sutula, S.B. Weisberg. 2021. Synthesis of Thresholds of Ocean Acidification Impacts on Decapods. *Frontiers in Marine Science* 8:651102.

SCCWRP Journal Article #1235
Full text available online: www.sccwrp.org/publications

Synthesis of thresholds of ocean acidification impacts on echinoderms

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Abstract

Assessing the vulnerability of marine invertebrates to ocean acidification (OA) requires an understanding of critical thresholds at which developmental, physiological, and behavioral traits are affected. To identify relevant thresholds for echinoderms, we undertook a three-step data synthesis, focused on California Current Ecosystem (CCE) species. First, literature characterizing echinoderm responses to OA was compiled, creating a dataset comprised of >12,000 datapoints from 41 studies. Analysis of this data set demonstrated responses related to physiology, behavior, growth and development, and increased mortality in the larval and adult stages to low pH exposure. Second, statistical analyses were conducted on selected pathways to identify OA thresholds specific to duration, taxa, and depth-related life stage. Exposure to reduced pH led to impaired responses across a range of physiology, behavior, growth and development, and mortality endpoints for both larval and adult stages. Third, through discussions and synthesis, the expert panel identified a set of eight duration-dependent, life stage, and habitat-dependent pH thresholds and assigned each a confidence score based on quantity and agreement of evidence. The thresholds for these effects ranged within pH from 7.20 to 7.74 and duration from 7 to 30 days, all of which were characterized with either medium or low confidence. These thresholds yielded a risk range from early warning to lethal impacts, providing the foundation for consistent interpretation of OA monitoring data or numerical ocean model simulations to support climate change marine vulnerability assessments and evaluation of ocean management strategies. As a demonstration, two echinoderm thresholds were applied to simulations of a CCE numerical model to visualize the effects of current state of pH conditions on potential habitat.

Citation

Bednaršek, N., P. Calosi, R.A. Feely, R.F. Ambrose, M. Byrne, K.Y. Chan, S. Dupont, J.L. Padilla-Gamino, J.I. Spicer, F. Kessouri, M. Roethler, M. Sutula, S.B. Weisberg. 2021. Synthesis of Thresholds of Ocean Acidification Impacts on Echinoderms. *Frontiers in Marine Science* DOI:10.3389/fmars.2021.602601.

SCCWRP Journal Article #1201
Full text available online: www.sccwrp.org/publications

Modelling future changes to the hydrological and thermal regime of unaltered streams using projected changes in climate to support planning for sensitive species management

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Abstract

Climate change will alter stream habitats through precipitation and air temperature changes and potentially threaten species that rely on contemporary streamflow and stream temperature regimes. Habitat projections are therefore critical to inform management decisions. Past and ongoing research has improved streamflow and temperature modelling in ungauged regions, but no studies merge these advancements with climate modelling for regional streamflow and stream temperatures predictions that describe stream habitat change. Here, we predict change in streamflow and stream temperature at the reach scale using projections from downscaled global climate models (GCMs) and the 'business as usual' carbon emission scenario. We focus on unaltered streams in six southern California watersheds using data from baseline (1982–2014) and projected end-of-century (2082–2100). Stream temperature is projected to increase regionally, with high-elevation stream reaches increasing most rapidly. There is less consistency in the streamflow projections, but a spatial and temporal homogenization of stream flow characteristics was predicted, that is, flows become more similar across the region with less inter-annual variation. Additionally, there is a regional trend towards larger high flow magnitudes and more storm events. Despite the increased frequency and magnitude of storm events, high-elevation streams are predicted to become drier for a greater portion of the year. Conversely, low-elevation streams

are predicted to have longer hydroperiods. Mapping future streamflow and stream temperatures at the reach scale can direct conservation efforts to streams that remain suitable, restoration to areas that decrease in suitability for target species, and support water policies that consider future stream condition.

CITATION

Rogers, J.B., E.D. Stein, M.W. Beck, K. Flint, A. Kinoshita, R.F. Ambrose. 2021. Modelling future changes to the hydrological and thermal regime of unaltered streams using projected changes in climate to support planning for sensitive species management. *Ecohydrology* DOI:10.1002/eco.2299.

SCCWRP Journal Article #1199
Full text available by request: pubrequest@sccwrp.org

Simulating the thermal impact of substrate temperature on ecological restoration in shallow urban rivers

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ABSTRACT

Managing river temperature in highly urbanized stream systems is critical for maintaining aquatic ecosystems and associated beneficial uses. In this work, we updated and utilized a mechanistic river temperature model, i-Tree Cool River, to evaluate the cooling impacts of two ecological restoration scenarios: (1) an alternative streambed material limecrete and (2) shading effects of tree planting in riparian areas. The i-Tree Cool River model was modified to account for diurnal fluctuations of streambed temperature, which is relevant in shallow urban streams where lack of natural shading combined with low heat capacity of the water column can make diurnal fluctuations relatively extreme. The model was calibrated and validated on a 4.2 km reach of Compton Creek in the Los Angeles River watershed, California. Two native fish, arroyo chub (*Gila orcuttii*) and unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*), were considered the target species for assessing thermal habitat suitability. Key findings include: (1) model performance was improved when accounting for diurnal fluctuations in bed temperature (R^2 increased from 0.43 to 0.68); and (2) substrate rehabilitation and tree planting can potentially reduce summertime temperatures to within the documented spawning temperature thresholds for the focal fish species. Using limecrete as an alternative material for the concrete bottom decreased the median river temperature metrics: maximum weekly maximum, maximum weekly average, and minimum weekly minimum temperatures by an average of 3 °C (13%) to 20.4 °C, 19.7 °C, and 17.8 °C, respectively. Tree planting in the riparian corridor decreased the average river temperature metrics by an average of 0.9 °C (4%) to 22.7 °C, 22 °C, and 19 °C, respectively. Combining the two scenarios decreased the river temperature metrics by an average of 4 °C (18%) to 18.2 °C. Therefore, water temperature would not be a limiting factor in potential reintroduction of the focal fish species to Compton Creek if restoration were implemented. Implications of this work could be used by urban forest and water managers for restoring thermally polluted rivers in other urban areas.

CITATION

Abdi, R., J.B. Rogers, A. Rust, J.M. Wolfand, D. Philippus, K.T. Taniguchi-Quan, K. Irving, E.D. Stein, T.S. Hogue. 2021. Simulating the thermal impact of substrate temperature on ecological restoration in shallow urban rivers. *Journal of Environmental Management* DOI:10.1016/j.jenvman.2021.112560.

SCCWRP Journal Article #1195
Full text available by request: pubrequest@sccwrp.org

Multi-decadal simulation of estuarine sedimentation under sea level rise with a response-surface surrogate model

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ABSTRACT

Multi-decadal prediction of estuarine sedimentation with high-fidelity hydromorphodynamic models presents high computation costs, especially when accounting for stochasticity and uncertainty. A StochAstic model for Multi-decadaL Estuarine Sedimentation (SeAMLESS) is formulated here to support a specific decision-need related to resilience planning and coastal management: estimating future sedimentation and dredging within a sedimentation basin for different scenarios of sea level rise and rules for dredging. SeAMLESS combines a reduced-dimension process model and a response-surface surrogate model to yield an ordinary differential equation that can be integrated over stochastic time series of storm events. Applications show that SeAMLESS can predict probabilities and amounts of future basin sedimentation and dredging with minimal loss of accuracy, compared to a high-fidelity model, while delivering *O*(104 – 105) reduction in computational costs.

CITATION

Brand, M.W., L. Guo, E.D. Stein, B.F. Sanders. 2021. Multi-decadal simulation of estuarine sedimentation under sea level rise with a response-surface surrogate model. *Advances in Water Resources* DOI:10.1016/j.advwatres.2021.103876.

SCCWRP Journal Article #1187
Full text available by request: pubrequest@sccwrp.org

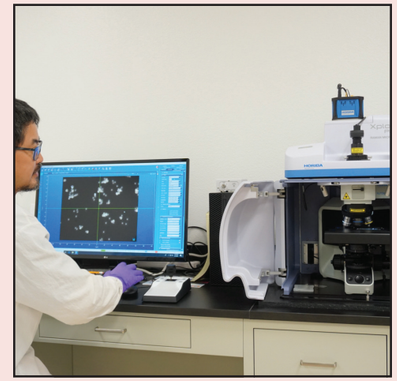
Microplastics measurement methods inform draft policy

An international, SCCWRP-facilitated effort to develop standardized methods for measuring microplastics has become the scientific foundation for a draft State Water Resources Control Board policy that would require drinking water agencies to monitor microplastics over an initial four-year period.

The measurement methods – which use infrared spectroscopy and Raman spectroscopy – were standardized in 2021 via a year-long study spanning 40 laboratories in six countries, including 22 laboratories that worked specifically on standardizing the drinking water methods.

Almost as soon as the study was completed, the draft microplastics policy for drinking water was developed; it is expected to be considered for adoption in mid-2022. SCCWRP already has begun working to help California develop a formal process for accrediting laboratories to measure microplastics.

Microplastics contamination is a growing management concern worldwide, with researchers finding microplastics in nearly every water body around the globe, although health effects from exposure are poorly understood. Treatment processes are generally thought to be effective at reducing microplastics levels in drinking water.



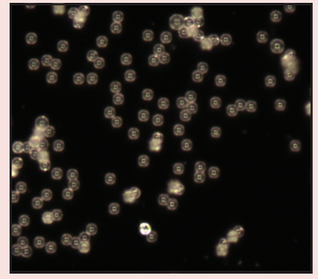
SCCWRP's Dr. Wayne Lao uses a Raman spectroscopy instrument to examine microplastic particles in a water sample. The State Water Board has developed a draft drinking water policy for microplastics monitoring following an international, SCCWRP-facilitated effort to standardize measurement methods.

Consensus reached on how to set thresholds for aquatic life exposed to microplastics

A group of international experts on aquatic microplastics pollution has reached consensus on a recommended framework that California could use to implement health-based thresholds that explain when microplastics contamination at different levels can be expected to trigger adverse biological effects in aquatic life.

The proposed management framework, unveiled in mid-2021, features four numeric thresholds for microplastics that, when exceeded, would trigger specific follow-up management actions, such as targeted microplastics monitoring, initiation of mitigation strategies, or posting of fish consumption advisories.

The framework, along with the initial proposed thresholds that are aligned to it, already has helped inform development of a proposed statewide management strategy for mitigating the ecological risks of microplastics pollution in coastal marine ecosystems.



Clear polystyrene microplastic particles glow in an image captured by Raman spectrometry. A group of international experts facilitated by SCCWRP has developed an initial set of numeric thresholds for aquatic life exposed to microplastics.

The framework and thresholds are the product of nine months of SCCWRP-facilitated deliberations with microplastics researchers from around the world during the Microplastics Health Effects Workshop.

Monitoring of bioactive contaminants using cell assays expands to more habitats

SCCWRP and its partners have expanded monitoring of bioactive contaminants in aquatic systems to encompass multiple types of habitats on land and at sea – part of an ongoing effort to test-drive the technology on a wider scale.

First, researchers in 2021 completed screening sediment samples collected during the Southern California Bight 2018 Regional Monitoring Program for bioactive contaminants using three bioanalytical cell assays. Second, researchers applied the same assays to screen for evidence of bioactive contaminants around an ocean wastewater outfall.

In freshwater systems, researchers in 2021 began screening water from the San Gabriel River and Santa Ana River watersheds for bioactive contaminants.

Researchers are using the expanded monitoring efforts to ensure the screening technology can be used to help zero in on emerging classes of chemicals that could be triggering adverse biological impacts.

Application of an effects-based monitoring strategy to assess the impact of contaminants on fish health in an urbanized watershed

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ABSTRACT

Effects-based monitoring frameworks that combine the use of analytical chemistry with *in vitro* cell bioassays, as well as *in vivo* whole organism tests offer an integrative approach to broadly screen for chemical contaminants and link their presence with adverse effects on aquatic organisms. California (USA) is currently evaluating the use of such a framework to assess the impact of contaminants of emerging concern (CECs) on biota in urbanized rivers and other waterbodies. In the present study, the occurrence and effects of contaminants found in the Los Angeles River (Los Angeles County, CA, USA) were examined using analytical chemistry and *in vitro* and *in vivo* bioassays. Male fathead minnows were deployed in field-based exposure units and exposed to river water for 21 d. The 2 field sites (above Bull Creek [BLC] and below Glendale Water Reclamation Plant [GWR]) were selected based on their unique characteristics and different contaminant discharge sources. In addition, 2 control units (filtered city water and estrone-spiked water) were added to the experimental design. Chemical analyses revealed differences in abundance of CECs between the 2 field sites and the controls, with GWR having the highest number and concentrations of CECs and metals. Cell bioassays screening for estrogenic, glucocorticoid, progestin, and dioxin-like activities were near or below detection limits in all river water samples, indicating a low potential for endocrine-related toxicity and tissue damage. Cell bioassay results were corroborated by the *in vivo* analyses. Field-exposed fish exhibited no changes in plasma hormones (e.g., estradiol), vitellogenin, or gonad maturation, but gene biomarkers of chemical exposure (cytochrome p450 1A and metallothionein) were significantly elevated, confirming exposure of the fish to complex chemical mixtures. The results demonstrate the value of a tiered monitoring approach to assess the sublethal effects of chemical mixtures on aquatic life.

CITATION

Mehinto, A.C., H.L. Schoenfuss, E. Wenger, D.W. Diehl, S.M. Bay. 2021. Application of an Effects-Based Monitoring Strategy to Assess the Impact of Contaminants on Fish Health in an Urbanized Watershed. *Environmental Toxicology and Chemistry* 40:402-412.

SCCWRP Journal Article #1177
Full text available by request: pubrequest@sccwrp.org

Transcriptomic response patterns of hornyhead turbot (*Pleuronichthys verticalis*) dosed with polychlorinated biphenyls and polybrominated diphenyl ethers

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ABSTRACT

To evaluate the impact of environmental contaminants on aquatic health, extensive surveys of fish populations have been conducted using bioaccumulation as an indicator of impairment. While these studies have reported mixtures of chemicals in fish tissues, the relationship between specific contaminants and observed adverse impacts remains poorly understood. The present study aimed to characterize the toxicological responses induced by persistent organic pollutants in wild-caught hornyhead turbot (*P. verticalis*). To do so, hornyhead turbot were interperitoneally injected with a single dose of PCB or PBDE congeners prepared using environmentally realistic mixture proportions. After 96-hour exposure, the livers were excised and analyzed using transcriptomic approaches and analytical chemistry. Concentrations of PCBs and PBDEs measured in the livers indicated clear differences across treatments, and congener profiles closely mirrored our expectations. Distinct gene profiles were characterized for PCB and PBDE exposed fish, with significant differences observed in the expression of genes associated with immune responses, endocrine-related functions, and lipid metabolism. Our findings highlight the key role that transcriptomics can play in monitoring programs to assess chemical-induced toxicity in heterogeneous group of fish (mixed gender and life stage) as is typically found during field surveys. Altogether, the present study provides further evidence of the potential of transcriptomic tools to improve aquatic health assessment and identify causative agents.

CITATION

Mehinto, A.C., L.M. Thornton Hampton, D.E. Vidal-Dorsch, N. Garcia-Reyero, M.A. Arick, K.A. Maruya, W. Lao, C.D. Vulpe, M. Brown-Augustine, A. Loguinov, S.M. Bay. 2021. Transcriptomic response patterns of hornyhead turbot (Pleuronichthys verticalis) dosed with polychlorinated biphenyls and polybrominated diphenyl ethers. *Comparative Biochemistry and Physiology - Part D: Genomics and Proteomics* DOI:10.1016/j.cbd.2021.100822.

SCCWRP Journal Article #1194
Full text available by request: pubrequest@sccwrp.org

Development and field evaluation of the organic-diffusive gradients in thin-films (o-DGT) passive water sampler for microcystins

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ABSTRACT

The presence of microcystins (MCs) in waterbodies requires a simple and reliable monitoring technique to characterize better their spatiotemporal distribution and ecological risks. An organic-diffusive gradients in thin films (o-DGT) passive sampler based on polyacrylamide diffusive gel and hydrophilic-lipophilic balance (HLB) binding gel was developed for MCs in water. The mass accumulation of three MCs (MC-LR, –RR, and -YR) was linear over 10 days ($R^2 \geq 0.98$). Sampling rates (2.68–3.22 mL d^{-1}) and diffusion coefficients (0.90–1.08 × 10^{-6} cm^2 s^{-1}) of three MCs were obtained at 20 °C. Two different passive samplers, o-DGT and the Solid Phase Adsorption Toxin Tracking device (SPATT), were co-deployed to estimate MC levels at three lakes in California, USA. Measured total MC concentrations were up to 10.9 μg L^{-1}, with MC-LR the primary variant at a measured maximum concentration of 2.74 μg L^{-1}. Time-weighted average MC concentrations by o-DGT were lower than grab water samples, probably because grab sampling measures both dissolved and particulate phases (i.e., MCs in cyanobacteria). Passive water samplers by design can only measure dissolved-phase MCs, which are considerably less during the cyanobacteria-laden periods observed. Both o-DGT and grab samples gave comparable results for three MC variants at low levels of MCs, e.g., <0.1 μg L^{-1}. o-DGT showed a higher correlation with grab sampling than SPATT did. This study demonstrates that o-DGT can be effectively used for monitoring and evaluation of dissolved MCs in waters.

CITATION

Wang, P., B. Du, J. Smith, W. Lao, C.S. Wong, E.Y. Zeng. 2021. Development and field evaluation of the organic-diffusive gradients in thin-films (o-DGT) passive water sampler for microcystins. *Chemosphere* 287:132079. DOI:10.3389/fmicb.2021.674214.

SCCWRP Journal Article #1220
Full text available by request: pubrequest@sccwrp.org

Scrutinizing surficial sediment along a 600-km-long urban coastal zone: Occurrence and risk assessment of fipronil and its three degradates

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ABSTRACT

Contamination in the coastal zone is closely linked to urbanization and has become a global issue. The coastal aquatic environment is the terminal sink for many chemicals; however, little is known about the occurrence and variation among habitats as well as integrative toxicity for pesticides, i.e., fipronil, and its three major degradates (-desulfinyl, -sulfide, and -sulfone, fiproles hereafter) in sediments in urban coastlines. In the present study, we report results of a random stratified survey for fiproles in surficial sediments in five embayment habitats (strata) along the Southern California Bight (SCB), USA coastline. Fiproles were present in a small areal extent (6.8%) of the SCB embayment, and detected in 14 out of 174 stations with a total concentration of the four analytes ranging from 0.50 to 17.5 μg/kg dry weight. The area-weighted mean concentrations were 3.16 ± 3.37, 0.584 ± 0.558, 0.071 ± 0.103, and 0.005 ± 0.009 μg/kg in brackish estuaries, estuaries, bays, and marinas, respectively, with the results below the detection limits in ports. Fipronil sulfone had the greatest detection frequency (8.05%) and highest mean concentration (3.24 ± 3.36 μg/kg) among the four compounds. A screening-level deterministic risk assessment for invertebrates found that, region-wide, fiproles generally posed an insignificant to low acute risk to the amphipod *Eohaustorius estuaries* in 7.36% of the SCB embayment area. In addition, high risk to the midge *Chironomus dilutes* was found in 77.5% of the fiproles-detectable area in the brackish estuary stratum that is a part of the Los Angeles River. Fipronil sulfone was identified as the major contributor of these effects. The results of this study establish a baseline of occurrence and toxicity potential for fiproles in coastal sediments of southern California.

CITATION

Du, B., W. Lao, C.S. Wong, K. McLaughlin, K.C. Schiff. 2021. Scrutinizing surficial sediment along a 600-km-long urban coastal zone: Occurrence and risk assessment of fipronil and its three degradates. *Science of the Total Environment* 807:151071 DOI:10.1016/j.scitotenv.2021.151071.

SCCWRP Journal Article #1227
Full text available by request: pubrequest@sccwrp.org

An introduction to the benchmarking and publications for non-targeted analysis working group

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Abstract

Non-targeted analysis (NTA) encompasses a rapidly evolving set of mass spectrometry techniques aimed at characterizing the chemical composition of complex samples, identifying unknown compounds, and/or classifying samples, without prior knowledge regarding the chemical content of the samples. Recent advances in NTA are the result of improved and more accessible instrumentation for data generation and analysis tools for data evaluation and interpretation. As researchers continue to develop NTA approaches in various scientific fields, there is a growing need to identify, disseminate, and adopt community-wide method reporting guidelines. In 2018, NTA researchers formed the Benchmarking and Publications for Non-Targeted Analysis Working Group (BP4NTA) to address this need. Consisting of participants from around the world and representing fields ranging from environmental science and food chemistry to 'omics and toxicology, BP4NTA provides resources addressing a variety of challenges associated with NTA. Thus far, BP4NTA group members have aimed to establish a consensus on NTA-related terms and concepts and to create consistency in reporting practices by providing resources on a public Web site, including consensus definitions, reference content, and lists of available tools. Moving forward, BP4NTA will provide a setting for NTA researchers to continue discussing emerging challenges and contribute to additional harmonization efforts.

Citation

Place, B.J., E.M. Ulrich, J.K. Challis, A. Chao, B. Du, K. Favela, Y. Feng, C.M. Fisher, P. Gardinali, A. Hood, A.M. Knolhoff, A.D. McEachran, S.L. Nason, S.R. Newton, B. Ng, J. Nuñez, K.T. Peter, A.L. Phillips, N. Quinete, R. Renslow, J.R. Sobus, E.M. Sussman, B. Warth, S. Wickramasekara, A.J. Williams. 2021. An Introduction to the Benchmarking and Publications for Non-Targeted Analysis Working Group. *Analytical Chemistry* 93:16289-16296.

SCCWRP Journal Article #1242
Full text available by request: pubrequest@sccwrp.org

Crushed recycled glass as a substrate for constructed wetland wastewater treatment: A case study of its potential to facilitate pharmaceutical removal

Luis G. Chaves-Barquero[1,2], Braedon W. Humeniuk[1], Kim H. Luong[3], Nazim Cicek[4], Charles S. Wong[1,2,3,5], Mark L. Hanson[1]

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

Abstract

The use of recycled glass as a substrate for constructed wetlands was assessed through two studies. The first study examined the dissipation of atenolol, carbamazepine, and sulfamethoxazole in mesocosm-modeled wetlands using glass or limestone gravel as substrates, with or without cattails (*Typha* spp.). Following pseudo-first-order kinetics, atenolol dissipated the fastest from the water surface of the mesocosms ($t_{1/2}$~1 day), followed by sulfamethoxazole ($t_{1/2}$~14 days), and carbamazepine ($t_{1/2}$~48 days), with no significant differences across treatments. Increased half-lives were observed at greater depth, likely due to light screening. A Monte Carlo sensitivity analysis diagnosed sunlight absorption rates and second-order hydroxyl-mediated indirect photolysis rates to be the main sources of uncertainty in our dissipation rate estimates, compared to our observed rates. The second study examined *in situ* pharmaceutical removal in tertiary pilot-scale subsurface filters made of crushed recycled glass or sand in a wastewater treatment facility in Manitoba, Canada. Glass and sand showed no significant differences for pharmaceutical removals; atenolol and metoprolol were removed below limits of detection, while carbamazepine and sulfamethoxazole persisted over a retention time of 24 h. Overall, recycled glass performed similarly to traditional substrates for wetland-based wastewater treatment.

Citation

Chaves-Barquero, L.G., B.W. Humeniuk, K.H. Luong, N. Cicek, C.S. Wong, M.L. Hanson. 2021. Crushed recycled glass as a substrate for constructed wetland wastewater treatment: a case study of its potential to facilitate pharmaceutical removal. *Environmental Science and Pollution Research* 28:52306-52318 DOI:10.1007/s11356-021-14483-4.

SCCWRP Journal Article #1200
Full text available by request: pubrequest@sccwrp.org

Photolysis of the nonsteroidal anti-inflammatory drug sulindac: Elucidation of kinetic behaviour and photodegradation pathways in water

Aura Ledezma-Espinoza[1], Jonathan K. Challis[2], Floria Roa-Gutierrez[1], Andrés Sánchez-Kopper[1], Erick Castellón[3], Charles S. Wong[1,4]

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Abstract

Non-steroidal anti-inflammatory drugs are recognized widely as emerging contaminants. Sulindac has received additional attention as a prodrug in cancer treatment and because of its detection in drinking water and wastewaters. Nevertheless, there is limited knowledge about its kinetic behaviour and fate in the aquatic environment. In this work, the direct photolysis of sulindac, in which photochemical reactions were monitored and phototransformation products identified, was investigated under prolonged periods using UV-A and UV-B radiation and pH conditions (2 and 7) to evaluate the effect of the protonation state and the efficiency of the photolytic process. A novel kinetic mechanism has been proposed in which sulindac exhibits a consecutive reaction pathway, with pseudo-first order kinetics for rapid and reversible *Z* to *E* isomerization. Once photoequilibrium was reached, second-order degradation of the isomers in the presence of the new photodegradation products was observed. Photochemical transformation was faster under UV-B irradiation and lower pH, which suggests greater persistence of sulindac at more relevant environmental conditions of UV-A and pH 7. Two novel and major byproducts were identified, corresponding to the oxidative cleavage of the alkene *exo* to the indene system. The degradation pathway is mainly photoinduced, enhanced by acidic conditions and presumes the double bond as the most reactive site for the parent compound. This research demonstrates an approach for determining kinetics of compounds under challenging conditions, including, absorption from multiple electronic transitions, photoinduced products with unknown extinction coefficients, concentration dependence, photoinduced sensitizing intermediates, and speciation effects. Our work greatly improves our understanding of the degradation process of sulindac and will contribute to exposure assessments and treatment methodologies for this compound in impacted waters.

Citation

Ledezma-Espinoza, A., J.K. Challis, F. Roa-Gutierrez, A. Sanchez-Kopper, E. Castellon, C.S. Wong. 2021. Photolysis of the nonsteroidal anti-inflammatory drug sulindac: elucidation of kinetic behaviour and photodegradation pathways in water. *Environmental Science Processes & Impacts* 23:1405-1417.

SCCWRP Journal Article #1224
Full text available by request: pubrequest@sccwrp.org

Developmental thyroid disruption causes long-term impacts on immune cell function and transcriptional responses to pathogen in a small fish model

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Abstract

Current evidence suggests thyroid hormones (THs) impact development of the immune system, but few studies have explored the connection between the thyroid and immune systems, especially in fish. This is important as some environmental contaminants disrupt TH homeostasis and may thus have negative impacts on the immune system. To determine the long-term consequences of early life stage (ELS) hypothyroidism on immune function, fathead minnows were exposed to the model thyroid hormone suppressant propylthiouracil (PTU) from < 1 to 30 days post hatch. Fish were transferred to clean water and raised to adulthood (5–7 months post hatch) at which time, several aspects of immune function were evaluated. Ex vivo assessment of immune cell function revealed significant decreases (1.2-fold) in the phagocytic cell activity of PTU-treated fish relative to the controls. Fish were also injected with *Yersinia ruckeri* to evaluate their *in vivo* immune responses across a suite of endpoints (i.e., transcriptomic analysis, leukocyte counts, spleen index, hematocrit, bacterial load and pathogen resistance). The transcriptomic response to infection was significantly different between control and PTU-treated fish, though no differences in bacterial load or pathogen resistance were noted. Overall, these results suggest that early life stage TH suppression causes long-term impacts on immune function at the molecular and cellular levels suggesting a key role for TH signaling in normal immune system development. This study lays the foundation for further exploration into thyroid-immune crosstalk in fish. This is noteworthy as disruption of the thyroid system during development, which can occur in response to chemicals present in the environment, may have lasting effects on immune function in adulthood.

Citation

Thornton Hampton, L.M., M.G. Finch, C.J. Martyniuk, B.J. Venables, M.K. Sellin-Jeffries. 2021. Developmental thyroid disruption causes long-term impacts on immune cell function and transcriptional responses to pathogen in a small fish model. *Scientific Reports* DOI:10.1038/s41598-021-93929-8.

SCCWRP Journal Article #1213
Full text available online: www.sccwrp.org/publications

Study paves way to improve COVID-19 virus measurements

SCCWRP and its partners have developed improved understanding of what contributes to sources of variability in methods for measuring COVID-19 virus levels in wastewater streams – key insights that can help water-quality managers use wastewater influent to track the prevalence of COVID-19 infections in communities.

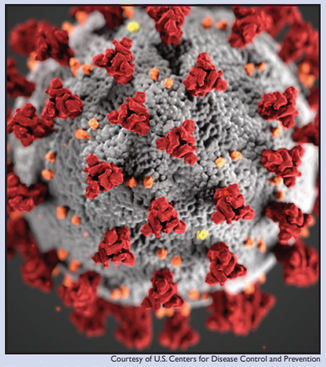
The SARS-CoV-2 measurement methods comparison study, completed in mid-2021, examined how efforts to quantify virus levels in wastewater can be impacted by numerous sources of variability in the specific measurement methods used.

Since the virus emerged in 2019, multiple measurement methods – and multiple variations of methods – came into use for storing, processing and analyzing wastewater samples for the virus. Improved standardization will help ensure that the methods can produce reliable, comparable data.

Water-quality managers need to understand the impacts of all of these potential sources of variability as part of an ongoing effort to build a wastewater surveillance system that can provide routine, ongoing monitoring of COVID-19 community infection rates.

COVID-19 wastewater monitoring has the potential to provide an early-warning indicator of upticks in community infections, providing critical lead time for public health officials working to contain outbreaks.

Although the data are being reported to public health officials, researchers still need to understand how variations in the methods used to measure virus levels may have affected the accuracy and comparability of the data.



Courtesy of U.S. Centers for Disease Control and Prevention

The SARS-CoV-2 virus, pictured in this artist rendering, is prevalent in wastewater streams entering treatment plants. Researchers have improved understanding of how variability in the methods used to measure virus levels in wastewater can impact the reliability and comparability of measurement data.

Scientific foundation established to evaluate California shellfish water-quality objective

SCCWRP and its partners have completed a study that calls into question the appropriateness of a bacterial water-quality numeric objective designed to protect the health of people who consume shellfish from Newport Bay in Orange County.

The two-year study, completed in spring 2021, found that bacterial and pathogen levels in Newport Bay do not correlate with potentially unsafe levels of viral pathogens found in bivalve shellfish harvested from the bay. The existing water-quality objective for recreational shellfish – abbreviated SHEL – is intended to protect recreational shellfish harvesters by limiting bacterial levels in coastal waters where shellfish can grow.

The study is expected to help inform decision-making about a looming regulatory compliance deadline regarding Newport Bay's SHEL objective.

Method shows promise for detecting leaks in underground sewer pipes

SCCWRP and its partners have developed a promising new method for measuring leaks in underground sewer pipes that has the potential to detect volumetric losses of as little as one quart out of 1,000 gallons.

The exfiltration detection method, which underwent testing at three sites in San Diego County in 2021, involves pumping a known volume of water at a controlled rate through an isolated, 300- to 400-foot-long section of pipe, then looking for a difference in the volume pumped in vs. recovered.

Researchers' goal is to develop a novel, field-based method for reliably and precisely detecting potential, relatively small leaks across a given section of underground pipe. Sanitation agencies, which run robust pipe inspection programs for detecting and preempting raw-sewage spills, rely on cameras and other tools that are not necessarily optimized to detect all exfiltration.

The method is intended to support an ongoing, multi-year effort to identify the origins of widespread fecal contamination in Southern California waterways during wet weather.

A field crew recovers water from a sewer manhole in San Diego County as part of an effort to develop a new method for measuring leaks in underground sewer pipes. The exfiltration detection method has the potential to detect volumetric losses of as little as a half gallon.

SARS-CoV-2 wastewater surveillance for public health action

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[17]Department of Life Sciences Communication, University of Wisconsin-Madison, and Morgridge Institute for Research, Madison, WI

Abstract

Wastewater surveillance for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has garnered extensive public attention during the coronavirus disease pandemic as a proposed complement to existing disease surveillance systems. Over the past year, methods for detection and quantifi cation of SARS-CoV-2 viral RNA in untreated sewage have advanced, and concentrations in wastewater have been shown to correlate with trends in reported cases. Despite the promise of wastewater surveillance, for these measurements to translate into useful public health tools, bridging the communication and knowledge gaps between researchers and public health responders is needed. We describe the key uses, barriers, and applicability of SARS-CoV-2 wastewater surveillance for supporting public health decisions and actions, including establishing ethics consideration for monitoring. Although wastewater surveillance to assess community infections is not a new idea, the coronavirus disease pandemic might be the initiating event to make this emerging public health tool a sustainable nationwide surveillance system, provided that these barriers are addressed.

Citation

McClary-Gutierrez, J.S., M.C. Mattioli, P. Marcenac, A.I. Silverman, A.B. Boehm, K. Bibby, ... S.L. McLellan. 2021. SARS-CoV-2 Wastewater Surveillance for Public Health Action. *Emerging Infectious Diseases* 27:1-8.

SCCWRP Journal Article #1247
Full text available online: www.sccwrp.org/publications

RNA viromics of Southern California wastewater and detection of SARS-CoV-2 single-nucleotide variants

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Abstract

Municipal wastewater provides an integrated sample of a diversity of human-associated microbes across a sewershed, including viruses. Wastewater-based epidemiology (WBE) is a promising strategy to detect pathogens and may serve as an early warning system for disease outbreaks. Notably, WBE has garnered substantial interest during the coronavirus disease 2019 (COVID-19) pandemic to track disease burden through analyses of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) RNA. Throughout the COVID-19 outbreak, tracking SARS-CoV-2 in wastewater has been an important tool for understanding the spread of the virus. Unlike traditional sequencing of SARS-CoV-2 isolated from clinical samples, which adds testing burden to the health care system, in this study, metatranscriptomics was used to sequence virus directly from wastewater. Here, we present a study in which we explored RNA viral diversity through sequencing 94 wastewater influent samples across seven wastewater treatment plants (WTPs), collected from August 2020 to January 2021, representing approximately 16 million people in Southern California. Enriched viral libraries identified a wide diversity of RNA viruses that differed between WTPs and over time, with detected viruses including coronaviruses, influenza A, and noroviruses. Furthermore, single-nucleotide variants (SNVs) of SARS-CoV-2 were identified in wastewater, and we measured proportions of overall virus and SNVs across several months. We detected several SNVs that are markers for clinically important SARS-CoV-2 variants along with SNVs of unknown function, prevalence, or epidemiological consequence. Our study shows the potential of WBE to detect viruses in wastewater and to track the diversity and spread of viral variants in urban and suburban locations, which may aid public health efforts to monitor disease outbreaks.

Citation

Rothman, J.A., T.B. Loveless, J. Kapcia III, E.D. Adams, J.A. Steele, A.G. Zimmer-Faust, K. Langlois, D. Wanless, M.L. Griffith, L. Mao, J. Chokry, J.F. Griffith, K.L. Whiteson. 2021. RNA Viromics of Southern California Wastewater and Detection of SARS-CoV-2 Single-Nucleotide Variants. *Applied and Environmental Microbiology* 87:e01448-21.

SCCWRP Journal Article #1237
Full text available online: www.sccwrp.org/publications

Standardizing data reporting in the research community to enhance the utility of open data for SARS-CoV-2 wastewater surveillance

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Abstract

SARS-CoV-2 RNA detection in wastewater is being rapidly developed and adopted as a public health monitoring tool worldwide. With wastewater surveillance programs being implemented across many different scales and by many different stakeholders, it is critical that data collected and shared are accompanied by an appropriate minimal amount of meta-information to enable meaningful interpretation and use of this new information source and intercomparison across datasets. While some databases are being developed for specific surveillance programs locally, regionally, nationally, and internationally, common globally-adopted data standards have not yet been established within the research community. Establishing such standards will require national and international consensus on what meta-information should accompany SARS-CoV-2 wastewater measurements. To establish a recommendation on minimum information to accompany reporting of SARS-CoV-2 occurrence in wastewater for the research community, the United States National Science Foundation (NSF) Research Coordination Network on Wastewater Surveillance for SARS-CoV-2 hosted a workshop in February 2021 with participants from academia, government agencies, private companies, wastewater utilities, public health laboratories, and research institutes. This report presents the primary two outcomes of the workshop: (i) a recommendation on the set of minimum meta-information that is needed to confidently interpret wastewater SARS-CoV-2 data, and (ii) insights from workshop discussions on how to improve standardization of data reporting.

Citation

McClary-Gutierrez, J.S., Z.T. Aanderud, M. Al-faliti, C. Duvallet, R. Gonzalez, J. Guzman, R.H. Holm, M.A. Jahne, R.S. Kantor, P. Katsivelis, K.G. Kuhn, L.M. Langan, C. Mansfeldt, S.L. McLellan, L.M. Mendoza-Grijalva, K.S. Murnane, C.C. Naughton, A.I. Packman, S. Paraskevopoulos, T.S. Radniecki, F.A. Roman, A. Shrestha, L.B. Stadler, J.A. Steele, B.M. Swalla, P. Vikesland, B. Wartell, C.J. Wilusz, J.C. Ching-Wong, A.B. Boehm, R.U. Halden, K. Bibby, J.D. Vela. 2021. Standardizing data reporting in the research community to enhance the utility of open data for SARS-CoV-2 wastewater surveillance. *Environmental Science Water Research & Technology* DOI:10.1039/d1ew00235j.

SCCWRP Journal Article #1215
Full text available online: www.sccwrp.org/publications

Application of ddPCR for detection of *Enterococcus* spp. in coastal water quality monitoring

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Abstract

Droplet digital polymerase chain reaction (ddPCR) was evaluated for the detection of fecal indicator bacteria (FIB), *Enterococcus* spp., in San Diego County beach water samples collected under diverse conditions, from multiple pollution sources, as part of regulatory monitoring activities over 20 months. Two US EPA-approved methods, qPCR (EPA 1609.1) and Enterolert (SM9230D), were used as reference comparator methods. A total of 361 samples were assayed by both ddPCR and qPCR and yielded an acceptable Index of Agreement (IA) of 0.89, based on EPA Site-Specific analysis guidelines. A Pearson's correlation coefficient of $r = 0.87$ ($p < 0.001$), further indicated a strong relationship between the methods results. From the 361 samples, 185 split samples with ddPCR and Enterolert values within the limits of quantification, were used as a 'training' data set to derive an intrinsic copy number equation (ICE) for scaling ddPCR gene copy number to Enterolert most probable number (MPN). Of the 1993 samples that comprised the complete 'test' data set assayed by ddPCR and Enterolert, 1086 generated results that fell within the limits of quantification for Enterolert and yielded an overall IA of 0.64. *Re*-analysis using median as a measure of central tendency to account for significant skewing of Enterolert data yielded an IA of 0.72. Beach grouping-specific IA values ranged from 0.63 to 0.93. Pearson's correlation coefficient, *r*, ranged from 0.13 to 0.94 within beach groupings and generated a combined value of 0.60 for all groupings. Using the ICE, a ddPCR advisory threshold of 1413 DNA copy number/100 mL was empirically determined to be the equivalent to the California Enterolert beach action threshold of 104 MPN/100 mL, based on comparison with all 1993 paired ddPCR and Enterolert results. Using the 1413 DNA copy number/100 mL as a beach action threshold for ddPCR resulted in a 90.4% agreement with Enterolert (6.0% false negative and 3.7% false positive). Together these findings support the conclusion that ddPCR readouts align closely with Enterolert MPN for identifying FIB exceedance levels of *Enterococcus spp*. in coastal waters of San Diego, CA.

Citation

Crain, C., K. Kezer, S. Steele, J. Owiti, S. Rao, M. Victorio, B. Austin, A. Volner, W. Draper, J.F. Griffith, J.A. Steele, M. Seifert. 2021. Application of ddPCR for detection of Enterococcus spp. in coastal water quality monitoring. *Journal of Microbiological Methods* DOI:10.1016/j.mimet.2021.106206.

SCCWRP Journal Article #1192
Full text available by request: pubrequest@sccwrp.org

A combined digital PCR and next generation DNA-sequencing based approach for tracking nearshore pollutant dynamics along the Southwest United States/Mexico border

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Abstract

Ocean currents, multiple fecal bacteria input sources, and jurisdictional boundaries can complicate pollution source tracking and associated mitigation and management efforts within the nearshore coastal environment. In this study, multiple microbial source tracking tools were employed to characterize the impact and reach of an ocean wastewater treatment facility discharge in Mexico northward along the coast and across the Southwest United States- Mexico Border. Water samples were evaluated for fecal indicator bacteria (FIB), *Enterococcus* by culture-based methods, and human-associated genetic marker (HF183) and *Enterococcus* by droplet digital polymerase chain reaction (ddPCR). In addition, 16S rRNA gene sequence analysis was performed and the SourceTracker algorithm was used to characterize the bacterial community of the wastewater treatment plume and its contribution to beach waters. Sampling dates were chosen based on ocean conditions associated with northern currents. Evidence of a gradient in human fecal pollution that extended north from the wastewater discharge across the United States/Mexico border from the point source was observed using human-associated genetic markers and microbial community analysis. The spatial extent of fecal contamination observed was largely dependent on swell and ocean conditions. These findings demonstrate the utility of a combination of molecular tools for understanding and tracking specific pollutant sources in dynamic coastal water environments.

Citation

Zimmer-Faust, A.G., J.A. Steele, X. Xiong, C. Staley, M.L. Griffith, M.J. Sadowsky, M. Diaz, J.F. Griffith. 2021. A Combined Digital PCR and Next Generation DNA-Sequencing Based Approach for Tracking Nearshore Pollutant Dynamics Along the Southwest United States/Mexico Border. *Frontiers in Marine Science* DOI:10.3389/fmicb.2021.674214.

SCCWRP Journal Article #1218
Full text available online: www.sccwrp.org/publications

Pathogenic *Vibrio* species are associated with distinct environmental niches and planktonic taxa in Southern California (USA) aquatic microbiomes

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[2]*Department of Pediatrics, University of California, San Diego, La Jolla, CA*
[3]*Microbial and Environmental Genomics Group, J. Craig Venter Institute, La Jolla, CA*
[4]*Southern California Coastal Water Research Project, Costa Mesa, CA*

Abstract

Interactions between vibrio bacteria and the planktonic community impact marine ecology and human health. Many coastal *Vibrio* spp. can infect humans, representing a growing threat linked to increasing seawater temperatures. Interactions with eukaryotic organisms may provide attachment substrate and critical nutrients that facilitate the persistence, diversification, and spread of pathogenic *Vibrio* spp. However, vibrio interactions with planktonic organisms in an environmental context are poorly understood. We quantified the pathogenic *Vibrio* species *V. cholerae*, *V. parahaemolyticus*, and *V. vulnificus* monthly for 1 year at five sites and observed high abundances, particularly during summer months, with species-specific temperature and salinity distributions. Using

metabarcoding, we established a detailed profile of both prokaryotic and eukaryotic coastal microbial communities. We found that pathogenic *Vibrio* species were frequently associated with distinct eukaryotic amplicon sequence variants (ASVs), including diatoms and copepods. Shared environmental conditions, such as high temperatures and low salinities, were associated with both high concentrations of pathogenic vibrios and potential environmental reservoirs, which may influence vibrio infection risks linked to climate change and should be incorporated into predictive ecological models and experimental laboratory systems.

CITATION

Diner, R.E., D. Kaul, A. Rabines, H. Zheng, J.A. Steele, J.F. Griffith, A.E. Allen. 2021. Pathogenic Vibrio Species Are Associated with Distinct Environmental Niches and Planktonic Taxa in Southern California (USA) Aquatic Microbiomes. *mSystems* DOI:10.1128/mSystems.00571-21.

SCCWRP Journal Article #1216
Full text available online: www.sccwrp.org/publications

Quantification of sources of fecal pollution at Mule Creek

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CITATION

Zimmer-Faust, A.G., J.F. Griffith, S.B. Weisberg. 2021. Quantification of Sources of Fecal Pollution at Mule Creek. Technical Report 1186. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1186
Full text available online: www.sccwrp.org/publications

Regional monitoring network to evaluate BMP performance

SCCWRP has begun working with the Southern California Stormwater Monitoring Coalition (SMC) to build a regional monitoring network for tracking the performance of a wide variety of stormwater BMPs (best management practices) – a critical step toward being able to optimize the long-term effectiveness of these water-quality control measures.

The three-year initiative, which got underway in 2021, will develop a regional BMP monitoring program that stormwater managers across coastal Southern California can use to rapidly collect high-quality, comparable data sets on the field performance of structural BMPs. Structural BMPs are a ubiquitous class of engineered field solutions – everything from vegetated swales to permeable pavement – that are implemented to improve runoff water quality.

The SMC's Regional BMP Monitoring Network, expected to be operational by 2023, will help address significant, persistent knowledge gaps in managers' and BMP designers' regional understanding of structural BMP performance.

Southern California managers spend tens of millions of dollars every year to implement stormwater BMPs, but lack the tools and data necessary to meaningfully evaluate the long-term performance effectiveness of structural BMPs – and to compare performance across the jurisdictions that have implemented BMPs.

A bioretention system that abuts the shoreline in Long Beach filters and removes stormwater contaminants, helping to protect beach water quality. Researchers have begun building a regional monitoring network to track the performance of a wide variety of bioswales and other stormwater BMPs.

Prototype L.A. County tool developed for rating BMP performance

SCCWRP has developed an index scoring tool for Los Angeles County that rates the overall performance of various structural stormwater BMPs (best management practices) based on multiple discrete metrics.

The BMP performance index tool, unveiled as an initial prototype in 2021, is intended to bring consistency and standardization to how L.A. County stormwater managers weigh and consider various performance-related data points – including for water quality, hydrology, maintenance and design – as they evaluate overall BMP performance.

L.A. County managers already collect data on BMP performance, but have historically not had access to a standardized tool for systematically integrating and comparing these data points. Researchers hope the index tool can aid managers in deciding where and how to implement BMPs.

Study underway to improve mechanistic understanding of bioretention planters

Southern California researchers working to optimize the ability of bioretention planters to treat stormwater runoff have launched a two-year project with the U.S. Environmental Protection Agency's Office of Research and Development (ORD) to improve mechanistic understanding of this type of stormwater BMP (best management practice).

The project, which got underway in 2021, is documenting how the physical design and configuration of bioretention planters contributes to their effectiveness in slowing down and reducing the volume of runoff flowing through them. This foundational understanding will help researchers optimize the design of this BMP type to remove contaminants from urban runoff, particularly rooftop runoff.

The project, which complements a similar ongoing East Coast effort, is a partnership between EPA ORD, SCCWRP and the Riverside County Flood Control and Water Conservation District, which will host the research at its Low Impact Development (LID) facility.

A field crew constructs a bioretention planter in Riverside County to study its mechanistic inner workings. SCCWRP is part of a research team working to understand how to optimize the design of this BMP type to remove contaminants from urban runoff.

Sources and impacts of uncertainty in uncalibrated bioretention models using SWMM 5.1.012

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Abstract

Using the USEPA's Storm Water Management Model version 5.1.012 (SWMM), a case study of a street right-of-way bioretention system (ROWB) configured as a storage node is compared against SWMM's Low Impact Development (LID) Controls for urban runoff retention, detention, and the timing of discharge. Through 12,000 one-year continuous simulations, single parameter perturbations and Monte-Carlo simulation of the uncalibrated models result in predicted annual runoff coefficients (representing stormwater retention) of 0.19–0.55 for an exfiltrating ROWB compared to 0.61 and 0.72 for a storage node with low and high assumed exfiltration capacity, respectively. Stormwater detention was represented by the frequency of event peak discharges exceeding an arbitrary low threshold value. The storage node simulations predicted peak discharges near or exceeding the upper values for the LID Control simulations. The dynamic representation of flow through porous media in the LID Control predicts greater retention and detention compared to the storage node over the range of uncalibrated models investigated. Sensitivity analysis of the LID Control parameterization indicates that the relative difference between the engineered media's porosity and field capacity have the most significant influence on predicted performance. Poor runoff retention results in scenarios where the engineered media exhibits a high field capacity relative to its porosity, whereas high field capacity is a desirable trait that should lead to superior performance. The model's calculation procedures and neglect of unsaturated flow or preferential pathways bias model output toward more frequent runoff bypass. The sensitivity analysis also demonstrates that the timing and duration of the discharge hydrograph are highly variable depending on parameterization. The wide range of potential performance generated from uncalibrated model parameterization leads to significant concerns for infrastructure planning and implementation, leading potentially to underperforming infrastructure, or excessive cost. Allocating resources to collect field performance data that enables robust model development, calibration, and verification at the green infrastructure (GI) stormwater control measure (SCM) scale offers the opportunity to reduce uncertainty in model predictions.

Citation

Fassman-Beck, E., F. Saleh. 2021. Sources and Impacts of Uncertainty in Uncalibrated Bioretention Models Using SWMM 5.1.012. *Journal of Sustainable Water in the Built Environment* 7:04021006.

SCCWRP Journal Article #1238
Full text available by request: pubrequest@sccwrp.org

Evaluating different machine learning methods to simulate runoff from extensive green roofs

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Abstract

Green roofs are increasingly popular measures to permanently reduce or delay storm-water runoff. The main objective of the study was to examine the potential of using machine learning (ML) to simulate runoff from green roofs to estimate their hydrological performance. Four machine learning methods, artificial neural network (ANN), M5 model tree, long short-term memory (LSTM) and k nearest neighbour (kNN), were applied to simulate storm-water runoff from 16 extensive green roofs located in four Norwegian cities across different climatic zones. The potential of these ML methods for estimating green roof retention was assessed by comparing their simulations with a proven conceptual retention model. Furthermore, the transferability of ML models between the different green roofs in the study was tested to investigate the potential of using ML models as a tool for planning and design purposes. The ML models yielded low volumetric errors that were comparable with the conceptual retention models, which indicates good performance in estimating annual retention. The ML models yielded satisfactory modelling results (NSE > 0.5) in most of the roofs, which indicates an ability to estimate green roof detention. The variations in ML models' performance between the cities was larger than between the different configurations, which was attributed to the different climatic characteristics between the four cities. Transferred ML models between cities with similar rainfall events characteristics (Bergen–Sandnes, Trondheim–Oslo) could yield satisfactory modelling performance (Nash–Sutcliffe efficiency NSE > 0.5 and percentage bias |PBIAS| < 25 %) in most cases. However, we recommend the use of the conceptual retention model over the transferred ML models, to estimate the retention of new green roofs, as it gives more accurate volume estimates. Follow-up studies are needed to explore the potential of ML models in estimating detention from higher temporal resolution datasets.

Citation

Abdalla, E.M.H., V. Pons, V. Stovin, S. De-Ville, E. Fassman-Beck, K. Alfredsen, T.M. Muthanna. 2021. Evaluating different machine learning methods to simulate runoff from extensive green roofs. *Hydrology and Earth System Sciences* 25:5917–5935.

SCCWRP Journal Article #1244
Full text available by request: pubrequest@sccwrp.org

North Orange County municipal separate storm sewer system (MS4) monitoring evaluation

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[2]*Tampa Bay Estuary Program, Tampa, FL*

Citation

Schiff, K.C., M. Beck, E. Fassman-Beck. 2021. North Orange County Municipal Separate Storm Sewer System (MS4) Monitoring Evaluation. Technical Report 1221. Costa Mesa, CA.

SCCWRP Technical Report #1221
Full text available online: www.sccwrp.org/publications

Marina del Rey Harbor site-specific objective study

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

Citation

Parks, A.N., D.J. Greenstein, K.C. Schiff. 2021. Marina del Rey Harbor Site-Specific Objective Study. Technical Report 1208. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1208
Full text available online: www.sccwrp.org/publications

Monitoring framework developed to assess estuaries

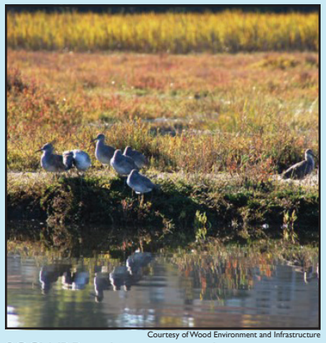
SCCWRP and its partners have developed and field-tested a proposed statewide monitoring framework for assessing the health of California's coastal estuaries, including two dozen estuarine Marine Protected Areas (MPAs).

The proposed framework, tested at more than a dozen sites statewide in 2021, is intended to bring consistency to estuarine monitoring efforts statewide. Although monitoring programs exist for estuaries across California, these programs have never been coordinated, limiting data comparability and managers' ability to track the overall health of estuaries statewide.

During field testing, researchers found that the assessment framework's approach to evaluating ecological functioning allows for greater flexibility and comparability across California's highly heterogeneous estuaries. Assessing ecological functioning also is directly tied to the beneficial-use goals that environmental managers are working to protect.

The draft monitoring framework focuses on evaluating priority ecological functions using a set of biotic and abiotic factors, which can be customized for specific regions of the state and/or estuary types. The framework is accompanied by a set of field protocols that allow an estuary to be sampled over a three-day period.

The California Ocean Protection Council intends to use this monitoring framework to report on the health of California's estuarine MPAs.



Courtesy of Wood Environment and Infrastructure

SCCWRP and its partners have developed and field-tested a standardized monitoring framework for assessing the condition of California's coastal estuaries, including Upper Newport Bay in Orange County, above, one of the State's estuarine Marine Protected Areas (MPAs).

Four-way regional monitoring partnership expanding understanding of acidification

The Southern California Bight Regional Monitoring Program has forged partnerships with three other West Coast marine monitoring groups to produce the most comprehensive picture to date of how ocean acidification (OA) is changing coastal seawater chemistry and how marine organisms are being affected.

The four-way partnership, forged in 2021, will generate unprecedented insights into the pace at which OA conditions are changing along the West Coast, as well as enable researchers to directly compare Southern California changes to West Coast-wide trends.

The coordinated sampling effort is the product of a joint partnership between the SCCWRP-facilitated Bight program and the National Oceanic and Atmospheric Administration (NOAA), California Cooperative Fisheries Investigations (CalCOFI) and Applied California Current Ecosystem Studies (ACCESS) Program. Extensive OA data sets are foundational to helping managers intervene effectively to mitigate OA's intensifying effects.

Third cycle launched for SMC's regional stream monitoring program

The Southern California Stormwater Monitoring Coalition (SMC) has launched the third cycle of its Regional Watershed Monitoring Program with an updated monitoring design that builds on previous stream surveys, while simultaneously expanding the collaborative, regional program into new frontiers.

Among the study design features is a stream causal assessment investigation that will work to determine specifically why some stream sites with degraded water quality score low using bioassessment-based stream scoring tools. Other new studies will target building out more bioassessment sampling data for certain high-interest areas, and mapping wet and dry channels in the region to better understand which streams are ephemeral vs. perennially flowing.

The expanded survey, launched in 2021 and led by SCCWRP, is cost-neutral for program participants, as the extensive stream data that were collected during previous program cycles has reduced the need to collect as much core monitoring data going forward.

A field crew conducts an intercalibration exercise in Agoura Hills in Los Angeles County for the SMC's Regional Watershed Monitoring Program. The program is investigating new questions and collecting new types of data during its third monitoring cycle.

Regional assessment of contaminant bioaccumulation in sport fish tissue in the Southern California Bight, USA

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[2]*San Francisco Estuary Institute, Richmond, CA*
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Abstract

Marine recreational fisheries in California are economically and culturally important; however, consumption of contaminated seafood may be a human health risk. The California Environmental Protection Agency Office of Environmental Health Hazard Assessment developed Advisory Tissue Levels (ATLs) to be used in developing consumption recommendations protecting the health of fish consumers. This study characterizes extent and magnitude of bioaccumulation of contaminants in sport fish in Southern California relative to ATLs. Most zones exceeded the ATL for mercury corresponding to consumption of not more than 3 servings per week in one or more target species. A third of zones exceeded the ATL for total polychlorinated biphenyls (PCBs) corresponding to consumption of not more than 7 servings per week. However, neither mercury nor total PCBs exceeded the most restrictive, "do not consume", thresholds in measured tissues. Contaminant concentrations in fish tissues have remained the same or decreased since a similar survey in 2009.

Citation

McLaughlin, K., J. Davis, A. Bonnema, B. Du, G. Ichikawa, W. Jakl, W. Heim, K.C. Schiff. 2021. Regional assessment of contaminant bioaccumulation in sport fish tissue in the Southern California Bight, USA. *Marine Pollution Bulletin* DOI:10.1016/j.marpolbul.2021.112798.

SCCWRP Journal Article #1217
Full text available by request: pubrequest@sccwrp.org

Enhanced monitoring of life in the sea is a critical component of conservation management and sustainable economic growth

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Abstract

Marine biodiversity is a fundamental characteristic of our planet that depends on and influences climate, water quality, and many ocean state variables. It is also at the core of ecosystem services that can make or break economic development in any region. Our purpose is to highlight the need for marine biological observations to inform science and conservation management and to support the blue economy. We provide ten recommendations, applicable now, to measure and forecast biological Essential Ocean Variables (EOVs) as part of economic monitoring efforts. The UN Decade of Ocean Science for Sustainable Development (2021–2030) provides a timely opportunity to implement these recommendations to benefit humanity and enable the USD 3 trillion global ocean economy expected by 2030.

Citation

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Southern California Bight 2018 Regional Marine Monitoring Program: Volume IV. Demersal fishes and megabenthic invertebrates

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Southern California Bight 2018 Regional Monitoring Program: Volume VIII. Harmful Algal Blooms

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CITATION

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Field testing report for the statewide Trash Monitoring Methods Project

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Hale, T., S.L. Moore, P. Kauhanen, L. Flores, S.B. Weisberg. 2021. Field Testing Report for the Statewide Trash Monitoring Methods Project. Technical Report 1190. San Francisco Estuary Institute. San Francisco, CA.

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California trash monitoring methods and assessments playbook

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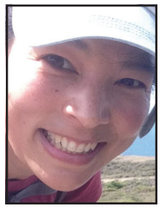

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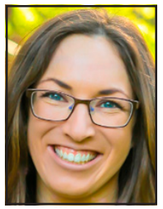

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