SCCWRP

2023 ANNUAL REPORT

Informing microplastics management

SCCWRP helps California develop strategies and tools for managing microplastics pollution

SCCWRP
Established 1969

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT

Applying next-generation science to aquatic ecosystems management

Welcome to the interactive version of SCCWRP's 2023 Annual Report! Click on the links below to jump directly to specific areas of the report. To request a printed copy of this report, contact pubrequest@sccwrp.org.

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Southern California Coastal Water Research Project 2023 Annual Report

Editor
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Cover photo
Brine shrimp swim alongside microplastic particles of different sizes, colors and materials under a microscope in a SCCWRP laboratory. The microplastic particles include orange-colored polyester fibers about 10 micrometers thick, as well as white-colored polyethylene beads about 50 micrometers in diameter.

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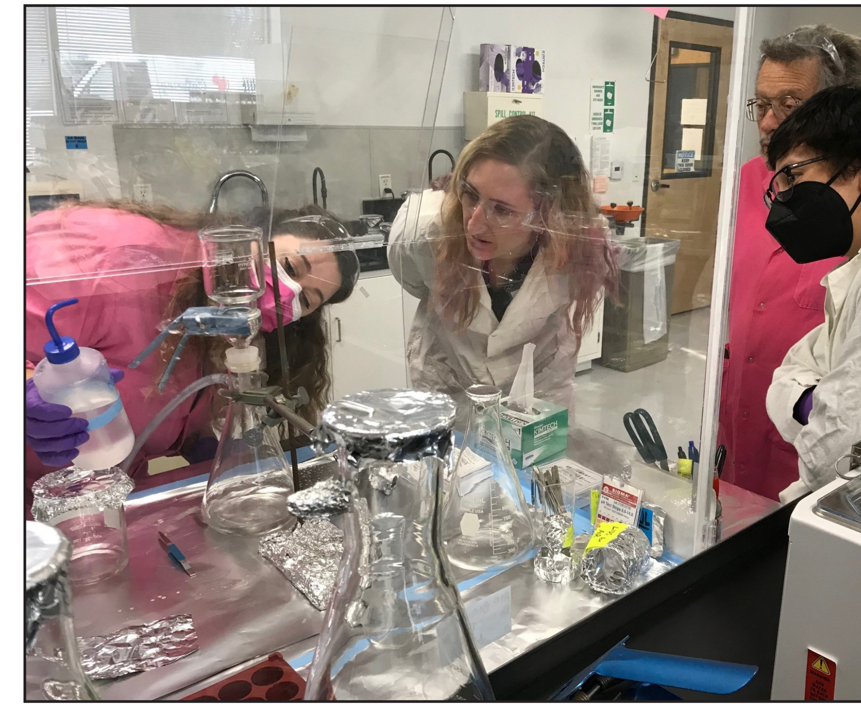

SCCWRP's Sydney Dial, left, demonstrates how to prepare drinking water samples for microplastics analysis during a hands-on training for microplastics measurement methods. Researchers are standardizing and vetting microplastics measurement methods so that California can produce high-quality, comparable microplastics measurement data across a range of aquatic settings. **Page 8**

Accomplishments with journal abstracts

People

Snapshot of Success

Steps taken by SCCWRP to improve aquatic science research and water-quality management in 2023

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 **4.0** journal articles each per year over the past three years. This compares favorably with the **2** publications per year minimum that SCCWRP's partners at academic research institutions generally seek to achieve when being considered for promotion. **Page 23**

» 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 **2,362** times in 2023, according to Web of Science statistics.

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 **129** leadership roles with professional societies, advisory committees and scientific journals in 2023.
Page 57

» 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 **160** different institutions in 2023.
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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 SCCWRP's efforts to help California's environmental management community develop strategies and tools for monitoring and managing microplastics pollution across diverse aquatic settings.

» Standardizing methods

SCCWRP is helping to vet and standardize methods that managers use to measure microplastics contamination.

» Tracking extent and sources

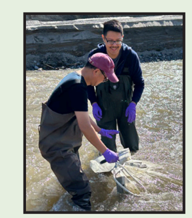
SCCWRP is helping to build monitoring tools for understanding where microplastics are originating and how they're spreading.

» Building a foundation for action

SCCWRP is helping to build a scientific foundation for managers to take informed actions to curb microplastics pollution.

Accomplishment

SCCWRP has paved the way for California to develop a robust suite of standardized microplastics measurement methods, starting with measuring microplastics in drinking water. **Page 8**



Accomplishment

SCCWRP has helped design and facilitate multiple types of monitoring investigations that are illuminating how microplastics are spreading through aquatic systems. **Page 13**

Accomplishment

SCCWRP has helped lay the foundation for California to develop risk-based thresholds that quantify for managers the levels at which microplastics exposure begins to adversely affect aquatic life and humans. **Page 18**

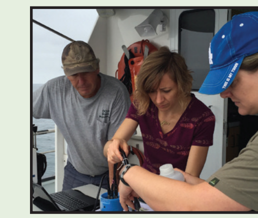
4 Long-term support

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.

Accomplishment

SCCWRP staff spent more than **11,800** person-hours in 2023 providing implementation support to member agencies.

Director's Message

A challenge and an opportunity at the same time

A decade ago, microplastics was barely a blip on the scientific radar. Few scientists were tracking the spread of microplastics or evaluating its health consequences. Microplastics was absent from the public consciousness as well.

Today, microplastics makes headlines on an almost daily basis. Scientists find microplastics nearly everywhere they look, including remote habitats like the deep ocean and the Arctic. Microplastics also occur in the water we drink, the food we eat and in human tissue.

As a result, calls for action are increasing, particularly in California, where Senate Bills 1422 and 1263 required development of comprehensive, coordinated science-based strategies for tracking and managing the spread of microplastics in drinking water and the coastal ocean, respectively. Environmental managers are being challenged to identify solutions at the same time as scientists are still learning about the problem, with more than 95% of the peer-reviewed literature on microplastics having been published in just the past five years.

That translates to a challenge for scientists. No longer do we have the luxury of conducting successive individual research projects. We must develop a comprehensive research program in which multiple interrelated projects are being conducted simultaneously. For instance, we are developing microplastics measurement methods at the same time as we are using those methods to quantify exposure and conduct laboratory toxicology tests. The pessimistic way of looking at this is we are trying to build the car at the same time as we are driving it.

However, we look at microplastics as an opportunity. SCCWRP's mission is to create a scientific foundation for California's water quality management community. Rarely is there as much receptivity for our science as there is for our present work on microplastics. Research and management communities share a sense of urgency around advancing microplastics science. Managers are turning to SCCWRP and our many research partners to both gauge the extent of the problem, and simultaneously identify effective potential solutions for combating it.

The feature articles in this year's Annual Report chronicle the multi-pronged approach that California is taking to build this foundation. One article summarizes efforts to bring standardization and consistency to how microplastics are measured in a range of aquatic settings (**Page 8**). A second article explains how standardized measurement methods are paving the way for monitoring how microplastics move through aquatic environments (**Page 13**). A third article chronicles efforts to quantify the health consequences of microplastics exposure (**Page 18**).

I hope you enjoy learning about the impressive – and continuing – growth of microplastics science. It's a story that provides an insightful look at how researchers conduct science in a rapidly evolving field – and simultaneously work to connect this science to management.

Stephen B. Weisberg, Ph.D.
Executive Director

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INFORMING
MICROPLASTICS MANAGEMENT

SCCWRP and other researchers are learning how microplastics are spreading, evaluating solutions for combatting their spread, and quantifying how they affect aquatic life and humans

Microplastic pollution can be found just about everywhere that scientists look for it.

The tiny plastic particles – many too small to be seen with the naked eye – are found in air, water, and soil. They've been documented in the stomachs and tissues of wildlife, in the foods that humans eat, even crossing the blood-brain barrier. And they are being transported readily via wind and water to some of the most remote parts of the planet.

There is no one-size-fits-all description for microplastics – they can be found in sizes between 1 nanometer and 5 millimeters in diameter, and in different forms, colors, and types.

In a 2019 study of microplastics in San Francisco Bay – the most comprehensive to date in California – researchers estimated that 7 trillion microplastic particles are entering the Bay every year in runoff.

Not only are these tiny plastic fibers, fragments and other particles finding their way into aquatic environments, but larger plastic trash is being continually broken down by waves, water and sunlight into smaller pieces that persist indefinitely.

Despite microplastics' ubiquity in aquatic environments, scientists have relatively limited understanding of the ecological consequences of

Courtesy of Cole Brookson, University of Toronto

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Courtesy of Heal the Bay

A field crew surveys plastic trash and other debris on a Santa Monica beach adjacent to a storm drain. Larger plastic particles that are broken down by waves, water and sunlight can eventually become microplastics.

exposure. Emerging toxicology studies have found that aquatic life can be adversely affected by exposure to microplastics, with potential effects ranging from development and reproduction problems to increased mortality.

But these toxicology studies have not yet conclusively determined the degree to which aquatic life – and humans – are being affected. Research is still ongoing to characterize real-world effects.

The lack of scientific knowledge about microplastics exposure has presented California's environmental management community with a conundrum: How aggressively and decisively should California move in the short term to curb microplastics pollution in aquatic environments?

On the one hand, microplastics are a ubiquitous and growing form of pollution that environmental managers can treat like other types of environmental contaminants. On the other hand, the evidence isn't yet clear about how much of a risk microplastic exposure poses, especially relative to other ubiquitous pollutants that also require attention and resources to manage.

"We cannot simply delay taking any actions to mitigate plastic pollution while we wait to have a clearer understanding of the extent of microplastics' impacts on ourselves and the environment," said Dr. Scott Coffin, Research Scientist for the California State Water Resources Control Board. "That means we need to be judicious in our approach to both assessing and managing the issue."

California's environmental management agencies are walking the fine line on microplastics pollution with the development of a master strategy finalized in 2023 that balances the need to advance scientific knowledge for microplastics, with the need to begin taking immediate actions to combat the spread of plastic and microplastic pollution.

Authored by the California Ocean Protection Council in coordination with other environmental management agencies statewide, the Statewide Microplastics Strategy is divided into two halves: Management actions that should be prioritized to combat the spread of microplastics, and priority research investments to expand scientific knowledge.

The short-term actions that California is investing in now are known as "no regrets" actions – meaning that California is committed to taking these actions because of their clear environmental benefits, even as scientific knowledge is still growing. These actions include banning or restricting the use of plastics in a range of consumer products, working with manufacturers to substitute and reformulate products to remove plastics, and evaluating promising technologies and methods for filtering and removing microplastics particles from aquatic environments.

Microplastics by the numbers

- **7 trillion:** Estimated number of microplastic particles discharged annually into San Francisco Bay via stormwater runoff[1]
- **0.017 trillion:** Estimated number of microplastic particles discharged into San Francisco Bay via wastewater effluent[1]
- **>1,000 metric tons:** Estimated weight of microplastic particles that fall annually from the atmosphere into western U.S. national parks and other protected wilderness areas[2]
- **82-358 trillion:** Range for the estimated number of microplastic particles floating on the global ocean surface[3]
- **500-800:** Range for the estimated number of microplastic particles that humans ingest daily via food, drink and air[4]

Sources: [1]San Francisco Estuary Institute; [2]2020 *Science* article; [3]2023 *PLOS One* article; [4]2021 *Environmental Science & Technology* article

Simultaneously, California is bringing the microplastics research community together to coordinate and collaborate in filling the many research gaps that California will need to address to comprehensively manage microplastics in aquatic environments.

"The research we're doing right now on microplastics is designed to help managers make decisions and take actions that match the scope and scale of the environmental challenge posed by microplastics pollution," said Dr. Leah Thornton Hampton, a SCCWRP Senior Scientist.

◆ ◆ ◆

The genesis of California's microplastics management strategy dates back to 2018, when the State Legislature passed two Senate bills to combat the spread of microplastics in aquatic systems.

Senate Bill 1422 and Senate Bill 1263 – which call on California to combat microplastics pollution in drinking water and the coastal

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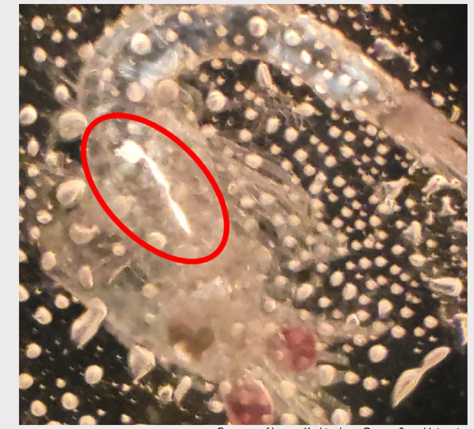

Courtesy of Lauren Kashiwabara, Oregon State University

A mysid shrimp, pictured under a microscope and surrounded by air bubbles, has a white microplastic fiber, circled in red above, embedded in the center of its body following exposure to microplastics contamination in a laboratory.

ocean, respectively – paved the way for multiple California environmental agencies to make microplastics a statewide management priority.

At the time, much of the science that had been done on microplastics consisted of smaller-scale, site-specific studies scattered across academic research laboratories.

California's environmental management agencies – led by the State Water Resources Control Board and the California Ocean Protection Council – recognized that microplastics researchers would need to coordinate and work collaboratively to build a scientific foundation for California to manage microplastics holistically and comprehensively.

In response, the agencies convened scientific workshops that attracted microplastics researchers from around the world to strategize how to expeditiously advance different pieces of microplastics science. From these deliberations, scientists developed a comprehensive, multi-pronged microplastics research agenda for California – now codified in the Statewide Microplastics Strategy.

The research portion of California's microplastics management strategy is designed to yield relevant, immediately actionable information that informs management decision-making. California's research agenda consists of four main goals:

- Standardize methods for measuring microplastics levels in aquatic environments, paving the way for California to collect consistently high-quality, comparable data sets
- Build monitoring programs and computer models to comprehensively document where microplastics are found and how they're spreading
- Reach consensus on health risk exposure thresholds that explain how microplastics may adversely affect aquatic life and humans
- Investigate potential management solutions and other steps for effectively curbing the spread of microplastics in aquatic environments

California, which is making progress simultaneously on all four fronts, has already begun seeing tangible results from its investments.

As a direct result of California's efforts to standardize the laboratory methods used to quantify and characterize microplastics, the California State Water Resources Control Board in 2022 adopted these methods for analyzing microplastics in drinking water. This action has paved the way for the methods' inclusion in California's laboratory accreditation program and a pilot monitoring program for drinking water.

SCCWRP is part of a community of microplastics researchers working to advance California's microplastics research agenda and help build the scientific foundation for microplastics management statewide.

SCCWRP is facilitating California's efforts to understand where microplastics are coming from and how they're spreading, evaluate potential solutions for combatting the spread of microplastics, and quantify the biological consequences of microplastics exposure for aquatic life and humans.

"Our entire microplastics research agenda is driven by California's research strategy for microplastics," said Dr. Stephen Weisberg, SCCWRP's Executive Director. "It's focused and aligned to build a comprehensive scientific foundation for microplastics management."

The three articles that follow in this Annual Report chronicle three key pieces of California's microplastics research agenda for which scientists, including at SCCWRP, already have made significant progress:

1 » **Standardizing methods for measuring microplastics** examines how researchers have been helping California to bring standardization and consistency to how microplastics levels are measured in a range of aquatic settings – the foundation for producing high-quality, comparable data sets. **Page 8**

2 » **Tracking the spread of microplastics** explores how researchers are using California's newly standardized measurement methods to help expand California's capacity to monitor and model how and where microplastics are found in the environment – the foundation for investigating what actions and solutions will be most effective to combat their spread. **Page 13**

3 » **Determining how much microplastics pollution is too much** examines how researchers are working to quantify the biological consequences of microplastics exposure for aquatic life and humans – the foundation for establishing thresholds that quantify the health risks associated with microplastics exposure. **Page 18**

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STANDARDIZING METHODS FOR MEASURING MICROPLASTICS

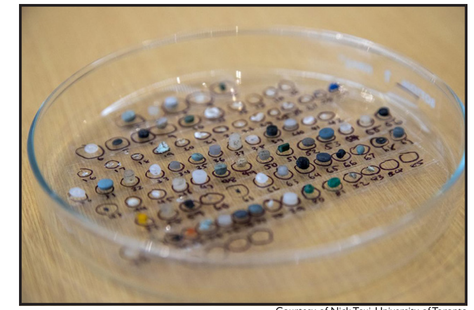
Researchers are bringing consistency to how environmental samples are collected and their microplastics content measured – paving the way for monitoring across California's diverse aquatic environments

For more than a decade, researchers have been test-driving multiple methods – and multiple variations of methods – to measure microplastic levels in drinking water, aquatic ecosystems, and other settings.

Significantly, these approaches have incorporated newer, more powerful technologies for measuring microplastic particles of increasingly smaller sizes – especially particles too small to be seen with the naked eye.

The newer methods have the potential to provide more accuracy and precision for data sets characterizing both levels and types of microplastics pollution.

At the same time, the many measurement methods available have produced data sets that are not necessarily directly comparable. In other words, researchers lack confidence that data generated via one measurement method or variation of the same method are directly comparable to data generated via another method. Similarly, researchers lack confidence that the measurement data from one laboratory are comparable to the data generated by another laboratory – even when they use similar methods.



Courtesy of Nick Tsui, University of Toronto

Microplastic particles of different sizes, colors and materials are sorted on a petri dish. While some microplastic particles are large enough to be visible to the naked eye, smaller particles can only be identified and quantified with the help of laboratory instrumentation.

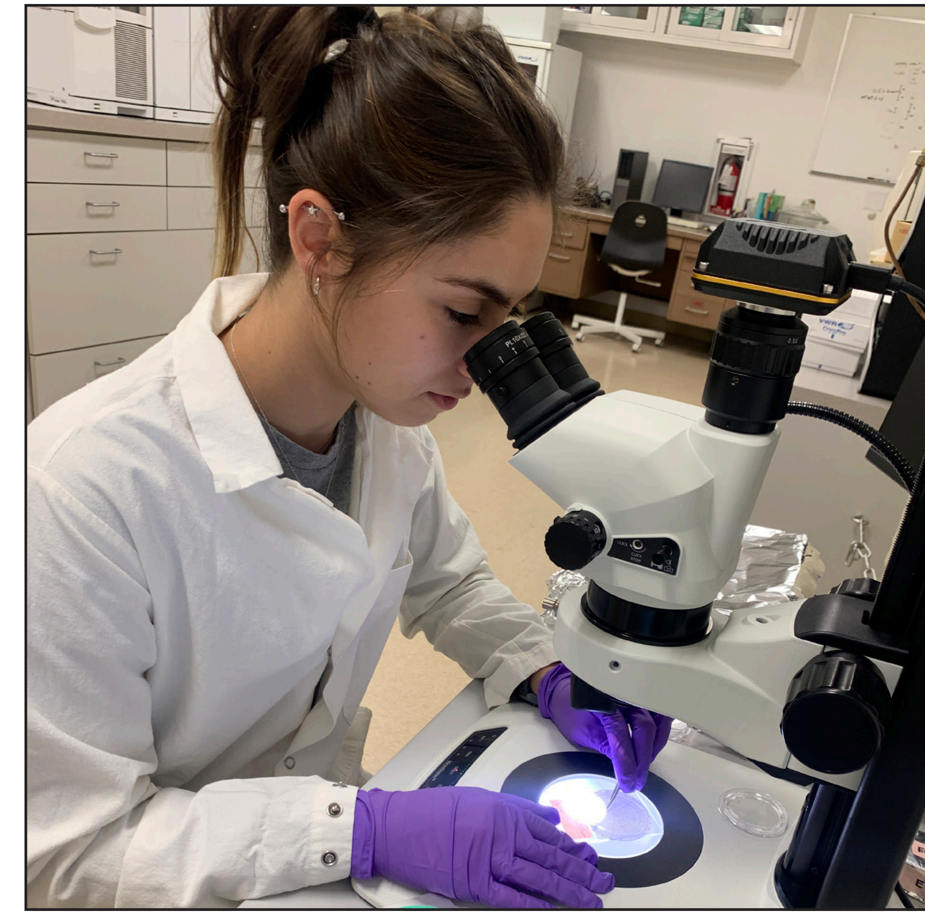
In California, this lack of method standardization has presented significant barriers for implementing monitoring programs at the scales necessary to comprehensively understand how and where microplastics are spreading through diverse aquatic settings statewide.

Recognizing the need for consistent, standardized, vetted methods, California in recent years has begun evaluating a range of commonly used methods for collecting, processing, and analyzing samples for microplastics analysis. Microplastic researchers from around the world are being invited to compare the performance of measurement methods and variations of methods during side-by-side studies being facilitated in California.

The goal is to establish best practices for how samples should be collected and processed, including for drinking water – which is the furthest along in California's standardization efforts.

Ultimately, researchers hope to build a comprehensive framework for ensuring that environmental and drinking water managers have access to a suite of consistent, standardized tools for cost-effectively and efficiently monitoring microplastics statewide.

"To align the purpose and direction for statewide microplastics monitoring, microplastic scientists and environmental policy-makers and water quality managers need to work closely to define the priority management questions and monitoring data needs," said Dr. Diana Lin, Senior Scientist for the San Francisco Estuary Institute. "This will also inform the data quality needs from standardized microplastic measurement methods."



SCCWRP's Ashton Espino uses forceps to sort through small particulate matter that has been filtered from a field sample – an effort to isolate particles that could be plastic for further analysis and quantification. Researchers are working to standardize how microplastics content is measured in field samples collected from across California, ensuring that measurement data are high quality and comparable.

Standardizing methods for collecting microplastics

The first step to reliably measuring microplastics content in a sample is to collect the sample using standardized, vetted methods.

In recent years, California has emerged as a central hub bringing together researchers from around the world to independently evaluate multiple microplastics collection methods – both older, established methods and newer, emerging methods.

By comparing method performance side by side, researchers are working to develop for California a robust set of standardized collection methods for collecting a range of samples for microplastics analysis – including drinking water, wastewater, stormwater, sediment and aquatic life.

Collecting these samples can be complex, with different collection methods having a potentially significant influence on the microplastics data generated.

Consequently, when comparing microplastics measurement data generated using different collection methods, researchers have traditionally been forced to assign a high degree of uncertainty to the comparability of the data.

For example, the highly variable rates associated with stormwater flows can lead to highly variable levels of microplastics being suspended in these flows, which, in turn, can lead to highly variable

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Courtesy of Andrew Gray, University of California, Riverside

A University of California, Riverside field crew lowers a sampling instrument into the center of a stream following heavy rains to capture tiny particulate matter on a filter inside the instrument. Researchers are working to standardize the method used to collect stormwater samples in preparation for measuring their microplastics content.

measurements. In 2023, SCCWRP and the University of California, Riverside began working toward standardizing a collection method for stormwater – testing different methods side by side in a controlled environment using a flume, followed by field testing.

Similarly, when collecting surface water samples in the ocean and other water bodies, researchers have traditionally dragged a manta trawl net along the surface to collect floating debris. However, because smaller microplastics particles can slip through the mesh netting, some researchers also have recognized the value of collecting bulk water samples. The challenge with bulk sample collection, however, is that results can vary dramatically from sample to sample, as the relatively tiny volume of the samples can influence the number and types of microplastics collected.

Researchers are working through these issues. They are exploring how to improve and refine collection methods, developing guidance on when and where managers should use one collection method over others, and clarifying if and how the microplastics measurement data generated via one method might be comparable to others.

"Microplastics enter the environment via diverse pathways, where it can be quite tough to collect samples in consistent ways and extract reliable, high-quality measurement data from them," said Dr. Andrew Gray, Associate Professor of Watershed Hydrology at the University of California, Riverside. "So that's why it's really important that we invest in developing best practices for microplastics sample collection methods to try to reduce that variability."

Standardizing methods for processing, identifying samples

Even as California continues working to standardize the methods used to collect samples in the field, researchers already have made significant progress standardizing methods for processing and identifying samples once they've reached the laboratory.

To process samples, researchers must first separate microplastics from most non-plastic particles using techniques that vary depending on the type of sample; for example, processing steps will differ for ocean water vs. sediment. Particles are then concentrated on a filter. Researchers may then visually count and characterize color, morphology, and shape of all particles.

A technology known as spectroscopy – which uses electromagnetic waves to analyze the particles – is commonly used to confirm if the particles are plastic and what type of plastic they are.

In recent years, California has been examining multiple types of spectroscopy-based technologies, along with other types of measurement methods, in side-by-side evaluation studies.

About 30 research laboratories from around the world participated in a SCCWRP-facilitated laboratory intercalibration study in 2020 that examined accuracy, precision, repeatability, cost, and other issues associated with three of the most frequently used analysis methods: Raman spectroscopy, Fourier-transform infrared spectroscopy (FTIR), and stereoscopy.

Already, participants have reached scientific consensus on the relative effectiveness of these methods, agreed on appropriate uses for the methods, and developed standardized best practices for processing and identifying microplastic particles via the methods.

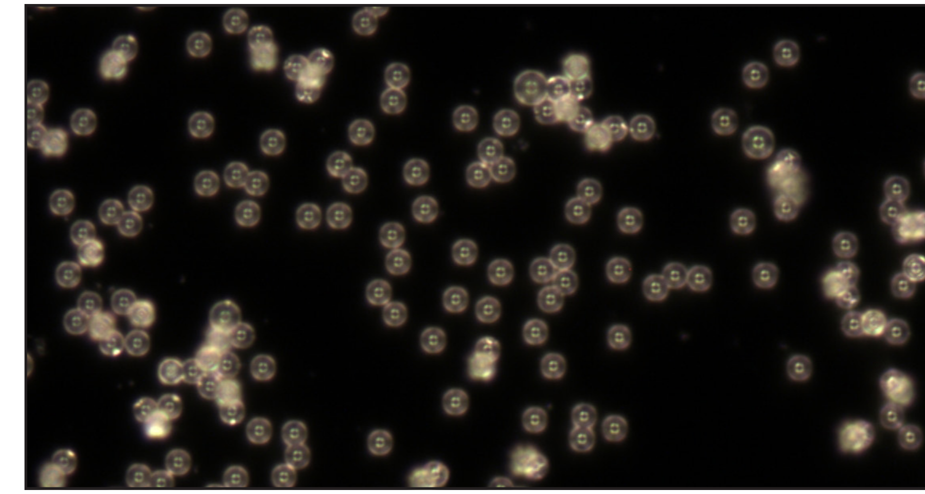
Based on this work, California's Environmental Laboratory Accreditation Program (ELAP) has begun developing performance standards that will enable public and private laboratories that routinely measure microplastic particles in samples to be evaluated for method proficiency.

"I am proud of the collaboration between the State Water Resources Control Board, scientists and stakeholders throughout this process. We have achieved an impressive amount of work on an aggressive timeline, but we have much more to do," said Dr. Theresa Slifko, Chemistry Unit Manager at the Metropolitan Water District of Southern California. "Before moving forward, we must develop, standardize, and validate microplastics analytical methods and procedures and identify practical surrogates that allow water systems to conduct this important research. These steps will ensure we have cost-effective analytical tools that will yield reliable and meaningful monitoring results."

Developing a multi-tiered monitoring approach

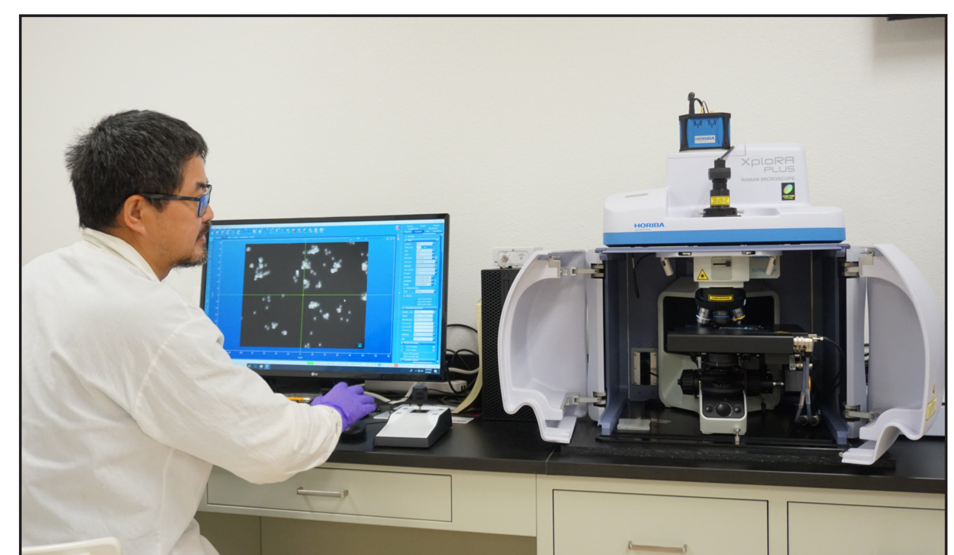
Even with California's newly standardized measurement methods for microplastics, there's still more work to be done to build a foundation for routine microplastics monitoring.

That's because California's microplastic measurement methods are based on the



Microplastics particles just 5 microns in diameter and made of clear polystrene glow in an image captured by Raman spectroscopy in a SCCWRP laboratory.

A SCCWRP field crew collects microplastics from the Los Angeles River using a mesh sampling device known as a box frame net. As water flows through the net, microplastics and other particles become trapped at the far end.



SCCWRP's Dr. Wayne Lao uses a Raman spectroscopy instrument to examine microplastic particles in a water sample. California has been developing standardized best practices for using this technology and other methods to measure microplastics in various types of samples.

Measuring smaller microplastic particles

Although standardized measurement methods have been developed for measuring microplastic particles, the existing methods are unreliable for measuring smaller particles less than about 20 micrometers.

In California, microplastics are defined as plastic particles as small as 1 nanometer – 1,000 times smaller than a micrometer.

California is not yet focused on measuring these smaller microplastic particles, but it is expected to become a future frontier for microplastics research.

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assumption that every particle in every sample that can be quantified will be quantified – a prohibitively time- and labor-intensive proposition for routine monitoring applications.

Consequently, the next frontier in standardizing measurement methods is developing methods that enable environmental managers to more rapidly and cost-effectively collect the insights they are seeking from monitoring data.

As envisioned by SCCWRP and other microplastics researchers, the additional methods would be used broadly to screen large areas and water bodies. For the subsets of sites that are identified as a concern, more intensive confirmatory methods – including the methods that California has already vetted and standardized – would be deployed.

Researchers are working to organize these methods under a three-tiered monitoring framework that guides managers in deciding when to deploy the different methods in a strategic and cost-effective manner, based on the specific insights that managers want to know.

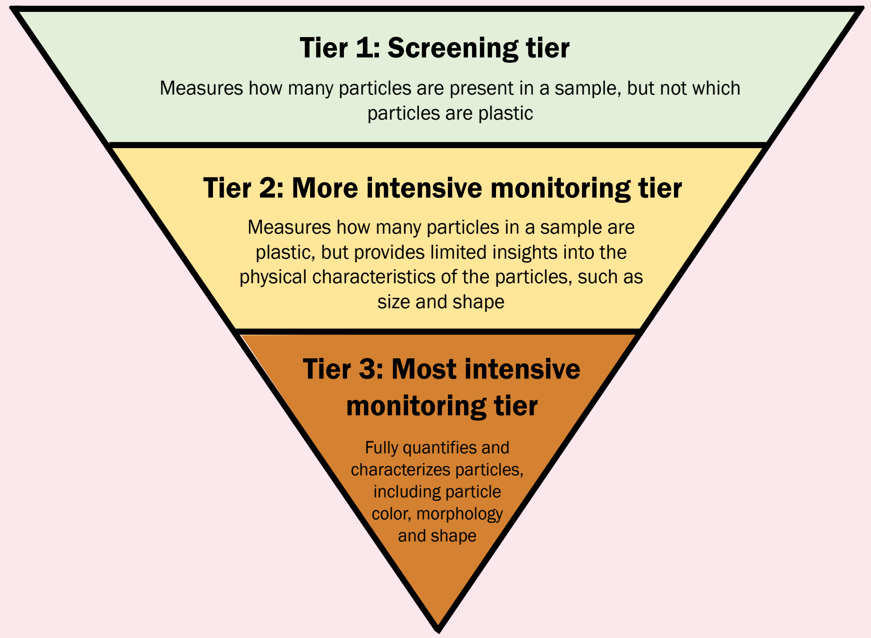
Tiers 1 and 2 would involve the use of simpler, more rapid methods designed to illuminate how many particles are present in the sample and/or which particles are plastic, but would not involve full characterization of every particle. Full characterization of the particles would be reserved for Tier 3.

Scientists have not yet reached agreement on what the less intensive Tier 1 and 2 monitoring methods should be, while Tier 3 would consist of California's existing standardized methods.

"To monitor microplastics at the scale that California envisions, managers are going to need a robust and reliable set of tools that they can pick and choose from, depending on the different types of questions they're trying to answer," said Dr. Violet Renick, Assistant Deputy Director for the City of San Diego Public Utilities Department. "A multi-tiered monitoring framework that provides flexibility with different measurement tools is going to be key to achieving California's vision in a timely manner while balancing monitoring costs and feasibility."

Three-tiered microplastics monitoring framework

Researchers are in the process of conceptualizing a three-tiered framework to enable routine microplastics monitoring across California's diverse aquatic systems. The goal is to help environmental managers rapidly and cost-effectively zero in on the settings and scenarios where managers should be focusing and directing resources.



Courtesy of Scott Coffin, California State Water Resources Control Board

Dr. Charles Moore, co-founder of the Moore Institute for Plastic Pollution Research, demonstrates how to extract microplastic particles from drinking water in preparation for measuring microplastics content. The demonstration at the institute's laboratory in Long Beach was part of a workshop to train State accreditors in how to evaluate the proficiency of environmental laboratories that routinely measure microplastics content in various types of samples.

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TRACKING THE SPREAD OF MICROPLASTICS

California is working to gain foundational mass-balance insights about where microplastics levels are highest and where microplastics are coming from

To combat microplastics pollution in aquatic systems, environmental managers need to know, as with other contaminants, where the pollution is coming from and how it's spreading.

The answers to these questions require generating copious amounts of data. Managers need data to pinpoint major sources of microplastics entering aquatic environments, to identify which places and settings are disproportionately affected by microplastics pollution, and to tease apart the relative accumulation rates of microplastics in water vs. sediment vs. the tissues of living organisms.

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Collectively known as "mass balance" data, these insights play a critical role in shaping how managers allocate limited attention and resources to optimally reduce and eliminate microplastics pollution in the environment.

Around the world, mass balance insights are helping managers take decisive action on microplastics, from bans and restrictions on plastics and microplastics intended to reduce their introduction into the environment, to next-generation methods and technologies for filtering and removing microplastics that have already entered the environment.

California is investing in building statewide capacity to generate high-quality, comparable mass balance data for microplastics across diverse aquatic systems. Much of this work is made possible by California's recent investments in vetting and standardizing methods for measuring microplastics in a range of different aquatic settings.

California's goal is to comprehensively understand when and where microplastics are being introduced to aquatic systems, and how microplastics are spreading through these systems and creating exposure routes for both humans and aquatic life.

Already, California has begun using these mass-balance insights to inform how it invests in a range of potential source-control solutions.

A field crew member for the Southern California Bight 2023 Regional Monitoring Program places sediment collected from the coastal ocean seafloor into jars. Among the contaminants that Bight '23 will measure in sediment are microplastic particles as small as 125 micrometers.

In particular, Southern California has become a leading research hub investigating how engineered and non-engineered stormwater management solutions known as best management practices (stormwater BMPs) might be used to reduce microplastics loading in aquatic ecosystems.

"Understanding how microplastics enter the environment and spread throughout the environment is foundational to understanding the extent of the microplastics problem," said Dr. Chelsea Rochman, Assistant Professor of Ecology at the University of Toronto and a close collaborator on microplastics research in California. "The more reliable data that we generate, the more expeditiously and effectively that managers can move to reduce and prevent major sources of microplastics from contaminating our aquatic systems."

Building microplastics monitoring capacity

California has long recognized the importance of building monitoring capacity to understand how microplastics are spreading through aquatic environments.

But it has taken years of investments to get monitoring methods to a place where California could take advantage of the latest, most powerful methods.

As early as 2013, the Southern California Bight Regional Monitoring Program was monitoring where microplastics can be found across the coastal seafloor sediment. This original analysis, however, was limited to tracking microplastics at least 1 millimeter in size. At the time, California lacked vetted methods for identifying and counting smaller particles.

Meanwhile, to determine plastic type, Bight '13 used a float test and treated particles with various solvents, as California had not yet vetted and standardized more precise methods like spectroscopy for identifying particles.

SCCWP's Samuel Lillywhite, center, demonstrates to a Southern California Bight 2023 Regional Monitoring Program field crew how to collect shellfish in Newport Harbor. During this Bight '23 study, researchers will investigate the degree to which microplastics and other contaminants are accumulating in the tissues of shellfish.

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Following passage in 2018 of two key pieces of microplastics legislation – Senate Bill 1422 and Senate Bill 1263 – California began making significant investments in vetting and standardizing a new generation of measurement methods.

In Southern California, these investments have paved the way for a range of recently initiated monitoring activities – initiatives that are helping managers build a comprehensive, managerially relevant understanding of how microplastics are spreading through aquatic environments.

For the latest 2023 cycle of the Southern California Bight Regional Monitoring Program, participants are tracking where microplastics as small as 125 micrometers can be found, both in the coastal sediment seafloor and in the tissue of bottom-dwelling aquatic organisms.

In addition to initiating microplastics monitoring at broad regional scales, Southern California is also using its latest generation of measurement methods to gain more focused insights into how microplastics are spreading through aquatic environments.

SCCWRP and its partners, for example, are monitoring microplastics levels in two major coastal rivers – Los Angeles and San Gabriel – that terminate at the San Pedro Shelf. Researchers are collecting data on levels and types of microplastics found in stormwater that runs off into the rivers, plus in the water column and along the coastal shelf seafloor. The goal is to improve understanding of specifically how, when and where microplastics spread through coastal watersheds.

Similarly, researchers are quantifying the levels and types of microplastics entering aquatic environments from wastewater effluent discharges up and down the California coast; the goal is to determine the degree to which wastewater discharges are contributing to microplastics contamination in California coastal waters. As part of this work, researchers are documenting how many microplastic particles are entering wastewater treatment plants and being removed at different stages of the treatment process.

"To understand where we should direct attention and public resources, we need to know where microplastics are coming and how they're spreading," said Jared Voskuhl, Manager of Regulatory Affairs for the California Association of Sanitation Agencies. "Special studies and monitoring are foundational in our ability to answer these questions."

A SCCWRP field crew hikes to a spot in a river where environmental samples will be collected for microplastics analysis. Researchers are monitoring coastal rivers in Los Angeles County to better understand how microplastics in stormwater runoff spread through coastal watersheds.

Using monitoring data to inform actions

By generating high-quality, comparable data on the spread of microplastics in diverse aquatic settings, California stands poised to invest in a range of informed source-control actions.

First, improved understanding of where microplastics originate could help California move decisively to enact bans and other restrictions, as appropriate, on the manufacture of plastic and microplastic products.

The Los Angeles River, above, and the San Gabriel River are the focus of a study that is collecting data on the levels and types of microplastics found in stormwater runoff, as well as in the water column and along the coastal shelf seafloor. Researchers' goal is to improve understanding of specifically how, when and where microplastics are spreading through coastal watersheds.

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Courtesy of Central Contra Costa Sanitary District

A Central Contra Costa Sanitary District team filters wastewater samples through a sieve to capture microplastic particles. The San Francisco Bay Area wastewater treatment plant is a key participant in a study measuring the degree to which wastewater discharges are contributing to microplastics loading in coastal waters statewide.

For example, California in 2008 began regulating the manufacture, handling and transport of pre-production plastic pellets to prevent these tiny plastic particles from inadvertently escaping into the environment. Similarly, a 2015 California law banned the sale of personal care products containing plastic microbeads – only a few months prior to enactment of a similar federal ban.

In addition to regulatory actions, more information about where major sources of microplastics are originating could help California develop targeted partnerships and financial incentive programs that encourage manufacturers to reformulate products in ways that remove or reduce plastic content.

Improved mass-balance insights also could help California decide how much focus to put on reducing microplastics levels in stormwater vs. wastewater vs. industrial discharges.

A 2019 comprehensive study by the San Francisco Estuary Institute, for example, found that runoff from tributaries contributes an estimated 300 times more microplastic particles annually to San Francisco Bay than wastewater discharges. The study also found that about half of the microplastics in this runoff comes from a single source: vehicle tires wearing down. Most of the rubber in tires is synthetic, made of plastic.

California subsequently has been working to assess if similar trends hold true statewide; researchers are measuring the degree to which wastewater discharges are contributing to microplastics loading in California coastal waters.

Examining stormwater BMPs

Another major focus area for California has been evaluating multiple engineered and non-engineered stormwater management strategies – known as stormwater best management practices (BMPs) – for removing microplastics in runoff.

Stormwater BMPs are already widely used to prevent a range of pollutants in runoff from entering storm drain systems, including pesticides, bacteria, nutrients, and metals. In Southern California, researchers are investigating the potential for two types of ubiquitous BMPs – bioretention and biofiltration systems – to filter and remove microplastics in runoff.

A research team made up of California State University, Long Beach, California State University, Los Angeles, and SCCWRP is examining how specific characteristics of different types of engineered media may be influencing microplastics removal rates in runoff; the goal is to understand how to optimize the design and maintenance regimes for these systems to promote long-term microplastics removal.

Separately, SCCWRP is working with the Southern California Stormwater Monitoring Coalition (SMC) and the City of Santa Barbara to examine the effectiveness of routine street sweeping in preventing microplastic particles – as well as a range of other pollutants that collect on roadways – from entering storm drain systems. Street sweeping is classified as a non-engineered, or non-structural, stormwater BMP.

"The key to managing environmental microplastics is not just to pursue potential remediation options, but also to look upstream at microplastic sources," said Dr. Ezra Miller, Environmental Scientist for the San Francisco Estuary Institute.

"The most effective management will be to simultaneously pursue a range of promising mitigation strategies, from preventive measures reducing the use and release of microplastics and associated chemicals, to measures for collecting and removing microplastics after their release. The scientific community is working hard to provide the science managers need to take management actions to address the microplastics problem."

Computer modeling to fill knowledge gaps

While monitoring can illuminate where microplastics are found and major sources of microplastics in aquatic environments, monitoring cannot fully explain or predict how microplastics are spreading.

Computer modeling has the ability to help fill in these knowledge gaps. By feeding monitoring data into computer models, scientists can track the movement and fate of microplastics particles based on a combination of ocean physics and the size and density of the particles.

These insights have the potential to help pinpoint the settings, scenarios and even specific species and populations of aquatic life that may be disproportionately affected by microplastics exposure.

Pre-production plastic pellets are tiny pellets used in the early stages of plastic production. California has been regulating the manufacture, handling and transport of these plastic particles since 2008, part of a statewide microplastics source-control effort.

A SCCWRP field crew deploys a custom-built rainfall generator, left, to create controlled wet-weather conditions in a Long Beach parking lot. Researchers' goal is to study the effectiveness of routine street sweeping, right, in preventing a range of roadway pollutants, including microplastics, from entering storm drain systems.

Courtesy of Los Angeles County Public Works

A field crew constructs a bioretention planter in Riverside County to study its mechanistic inner workings. California is evaluating the potential for stormwater BMPs – specifically, bioretention and biofiltration systems – to filter and remove microplastics and other pollutants from runoff.

What about microplastics in air?

California's focus on monitoring and modeling microplastics contamination in aquatic systems is not the only place where microplastics may need to be tracked. Microplastics in air also is thought to be potentially a significant contributor to the total mass balance of microplastics contamination in the environment, as it transports microplastics over potentially long distances and deposits the particles in both aquatic and terrestrial habitats.

For now, California is primarily focused on curbing microplastics pollution in aquatic systems. But researchers also have begun exploring solutions for microplastics in air. For example, in 2023, researchers began studying the efficacy of installing special filters in clothes dryers that would capture microplastic fibers coming off synthetic fabrics; the goal of this project – which is being conducted by the San Francisco Estuary Institute, 5 Gyres Institute and Desert Research Institute – is to prevent these fibers from being released via dryer exhaust into the air.

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Courtesy of Kennedy Bucci, University of Toronto

Microplastic particles can accumulate in the guts of aquatic life that mistake the contaminants for food. From top, a fathead minnow larval fish that served as a control for a microplastics exposure study appears normal; a larval fish that was exposed to a relatively low concentration of tire wear compounds accumulates some plastic in its digestive system, which appears as black flecks visible through its translucent body; and a larval fish that was exposed to a relatively high concentration of tire wear compounds accumulates proportionately more plastic in its digestive system.

DETERMINING HOW MUCH MICROPLASTICS POLLUTION IS TOO MUCH

Scientists are working to define the levels at which microplastics exposure begins to adversely affect aquatic life and humans

No form of plastic trash belongs in aquatic environments or is desirable there.

But microplastics stand apart from plastics of other sizes in that microplastics are more prevalent and potentially more likely to be consumed, ingested, and absorbed by aquatic life.

More than just another form of trash that degrades aquatic environments, microplastic particles can be mistaken for food by fish. Shellfish and other filter feeders can absorb microplastics unwittingly into their bodies. And humans can ingest microplastics when they consume fish and shellfish that have microplastics.

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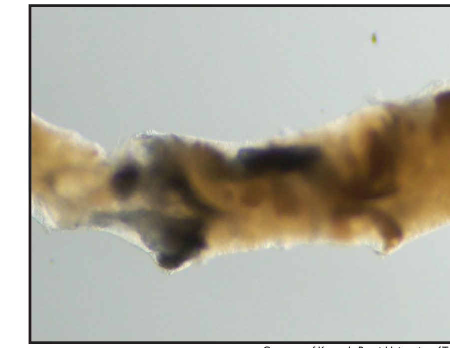

Courtesy of Kennedy Bucci, University of Toronto

Fathead minnow fish larvae, left, are exposed to different types of microplastic particles during a toxicology study seeking to understand the pathways by which fish can be exposed to microplastics pollution. Larvae that were exposed to thin microplastic fibers excrete the fibers in their feces, top right, while larvae that were exposed to dark-colored microplastic pieces excrete these pieces, bottom right.

To prevent aquatic life and humans from being harmed by exposure to microplastics, the environmental management community needs to know the levels at which microplastics exposure begins to trigger adverse effects – such as depriving aquatic life of energy and nutrients, or triggering tissue inflammation.

In other words, scientists need to answer the fundamental – but complex – question of: How much microplastics pollution is too much?

The scientific process that microplastics toxicity researchers use to answer this question is known as threshold development. Microplastics risk-based thresholds quantify for environmental managers the exposure levels at which microplastics begin to trigger adverse biological effects.

In recent years, California has made key investments toward advancing threshold development, bringing together leading microplastics toxicity researchers to discuss and debate the conditions that define when aquatic life and humans will be affected by microplastics exposure, as well as to analyze data from the best available toxicology studies.

From these conversations, scientists have begun developing conceptual frameworks to organize their thought processes, preliminary health risk thresholds for microplastics exposure, and recommendations for what additional toxicity studies are still needed to close gaps in scientists' understanding of the biological consequences of microplastics exposure.

In the coming years, California is expected to gain the clarity that the environmental management community needs to develop informed policies for managing microplastics pollution and take informed actions to protect aquatic life and humans from the adverse effects of exposure.

Simultaneously, California is exploring how to evaluate the risks that microplastics pose to aquatic life relative to other contaminants, as well as to other environmental stresses such as changes in water temperature triggered by climate change.

"Before we can allocate resources appropriately to mitigate the impacts of microplastics exposure, we need a clear understanding of the hazards and exposure-response relationships of microplastics," said Dr. Susanne Brander, Associate Professor of Environmental Toxicology and Chemistry at Oregon State University and co-chair of a scientific working group that developed a microplastics risk assessment framework for California's marine environment. "California is investing in building the scientific foundation for managers to take informed actions to protect aquatic life and humans from exposure to microplastics."

Defining health risks from exposure

The first step to setting thresholds for microplastics exposure is to reach consensus on what are the most prominent adverse biological effects on both aquatic life and humans from microplastics exposure.

California started down this path in 2020, convening a multi-part scientific workshop for international microplastics researchers to decide on the prominent adverse effects of microplastics exposure that should become the focal points of threshold development.

The 17 participants, whose year-long deliberations were facilitated by SCCWRP, reviewed existing microplastics toxicity studies, and ultimately reached consensus on three prominent pathways through

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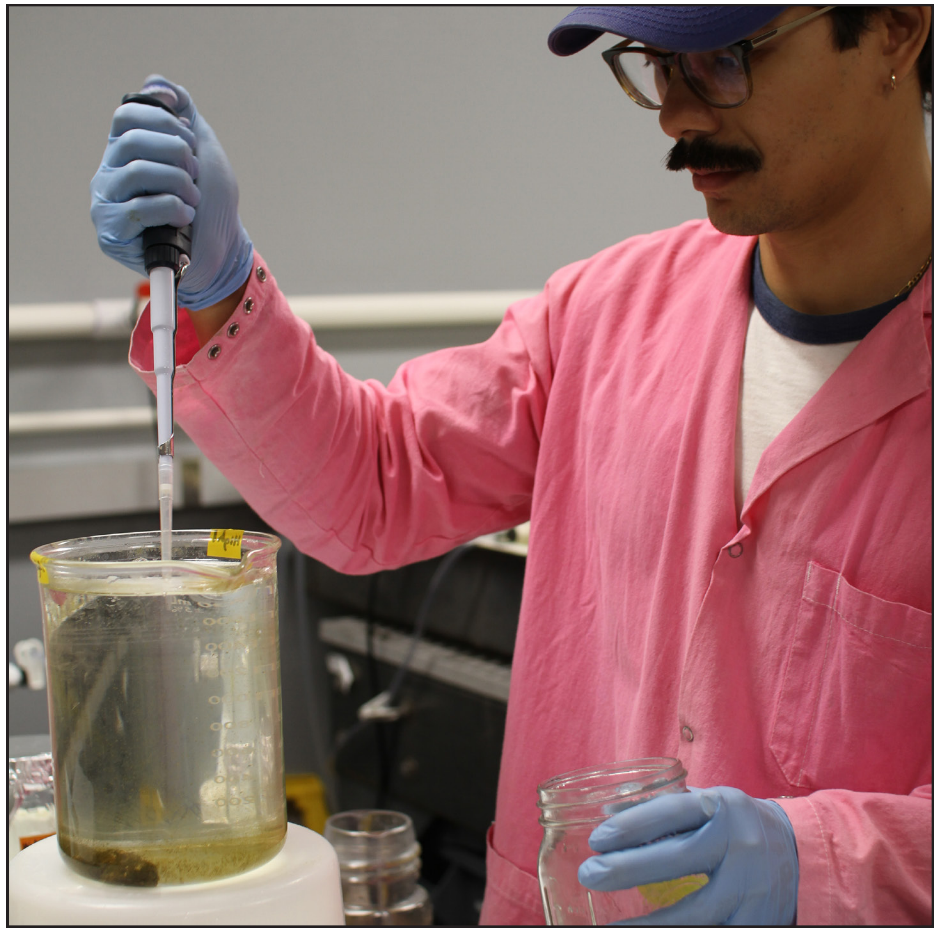


Thomas Rocca from California State University, Long Beach adds microplastic particles to a beaker containing juvenile Pacific oysters in a SCCWRP laboratory, part of a study seeking to understand adverse health effects from microplastics exposure. Among the ways that microplastics can harm aquatic life are food dilution, inflammation and oxidative stress, which can trigger cell and tissue damage.

which aquatic life and humans have the potential to experience adverse effects from microplastics exposure:

» **Food dilution**: When aquatic life inadvertently mistake microplastics for food, microplastics displaces food in their gut, potentially depriving them of adequate nutrients and energy.

» **Inflammation and oxidative stress**: When smaller microplastic particles – typically less than 100 microns – move from the guts of aquatic life and humans to other tissues, such as muscle or the liver, they have the potential to cause inflammation and oxidative stress, which can lead to cellular and tissue damage.

» **Chemical contaminants**: Hazardous chemicals that are either intentionally added during the manufacturing process, or that become inadvertently attached, or sorbed, to plastic particles in the environment, have the potential to magnify the harmful effects of microplastics exposure.

Workshop participants agreed to focus initially on developing thresholds for California based on the first two types of effects: food dilution, and inflammation and oxidative stress.

The boundaries that researchers put on the initial threshold development work are a reflection of the fact that the science of microplastics toxicity is still a nascent field. Researchers can only set thresholds when they have access to sufficient, high-quality microplastics toxicity data. And there are not yet enough toxicity studies for some areas, including chemicals sorbed to plastic, and effects of microplastics exposure on humans.

"Much of the work that's been done to date has been focused on understanding the effects of microplastics toxicity on aquatic life," said Dr. Elaine Khan, Chief of the Pesticide and Environmental Toxicology Branch for California's Office of Environmental Health Hazard Assessment. "There's still much more work to be done to understand how microplastics affect humans, but we expect to see significant progress on this front by the end of this decade."

Developing microplastics thresholds

Once scientists agree on how aquatic life and humans can be adversely affected by microplastics exposure, they can work toward agreement on the levels – known as risk-based thresholds – at which microplastics exposure can be expected to exert the adverse effects.

Having these thresholds enables managers to know when and how to intervene to protect aquatic life and humans from the adverse effects of microplastics exposure.

To decide how to set these thresholds, scientists begin by reviewing as much relevant, high-quality microplastics toxicity data as they can find in peer-reviewed literature. Reviewing data from multiple published studies provides scientists with more evidence about where thresholds should be set.

In California, scientists are working toward establishing four threshold levels for aquatic life for each of two classes of effects: food dilution, and inflammation and oxidative stress.

Each of the four threshold levels – low concern, moderate concern, elevated concern, and highest concern – would correspond to specific actions that managers could take in response to mitigate and offset the risk posed.

A low concern, for example, might trigger more monitoring, while an elevated concern might trigger initiating specific mitigation measures.

The microplastics framework is expected to set lower thresholds conservatively, meaning at levels intended to prevent harm before it happens. By contrast, the higher thresholds are expected to be set at levels where there is more certainty of adverse effects from microplastics exposure.

"Our risk assessment working group, facilitated by SCCWRP, laid a really strong foundation for establishing microplastics thresholds with the development of a proposed multi-tiered framework," said Dr. Chelsea Rochman, Assistant Professor of Ecology at the University of Toronto and a member of the risk assessment working group. "This is a direction a lot of other entities around the world should take, and is already being considered in the Laurentian Great Lakes region."

Filling data gaps and decreasing uncertainty

When scientists are reviewing toxicity data to set risk-based thresholds for a contaminant like microplastics, they typically compile data from published studies into a toxicity database.

The database is traditionally just a static spreadsheet, but microplastics toxicity experts decided to create a more sophisticated, interactive version of a standard toxicity database for microplastics.

Unveiled in 2021 and known as the Toxicity of Microplastics Explorer (ToMEx) database, the publicly accessible web-based tool features an integrated R Shiny web application that can automatically derive threshold values for California based on published toxicity studies that have been entered into the database.

A key advantage of ToMEx is that it can automatically regenerate updated thresholds as more toxicity studies are published and their data are added. ToMEx was co-developed and is being co-managed by SCCWRP.

ToMEx, with its focus on presenting toxicity data visually, also has made it easy for scientists to zero in on gaps in microplastics toxicity data that must be filled before scientists can finish all of their threshold development work.

For example, so little high-quality microplastics toxicity data are available for humans that scientists to date have only felt comfortable deriving a single conservative threshold level; this threshold would trigger more intensive monitoring of microplastics in drinking water.

Moreover, even when high-quality toxicity data are available, the data are not necessarily from the types of studies that scientists are looking for.

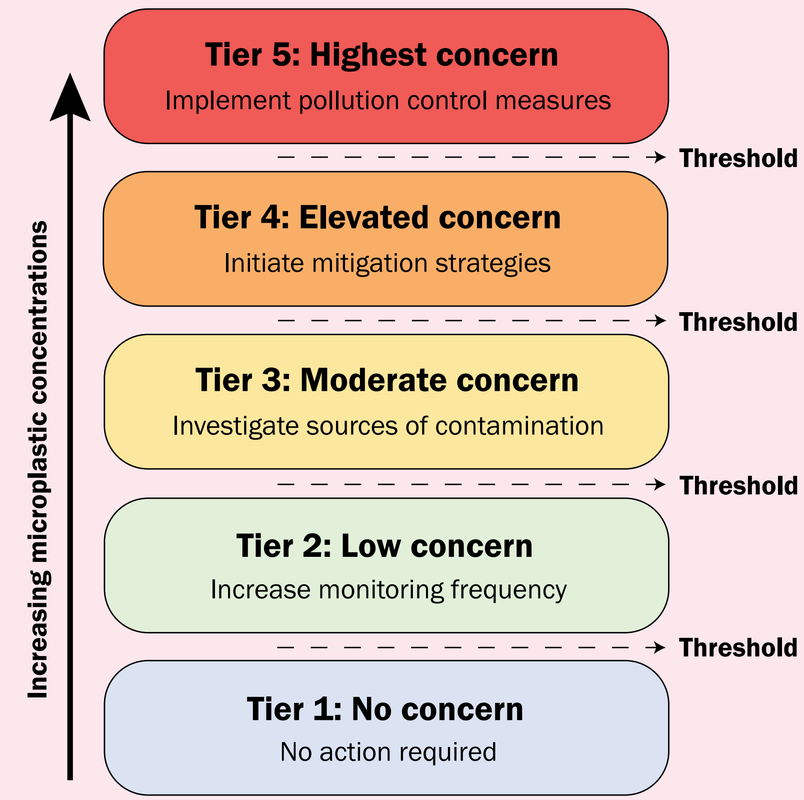
Microplastics toxicity studies are controlled laboratory experiments that involve dosing, or intentionally exposing, organisms to microplastics to trigger a response. Sometimes the microplastics used are homogenous and thus not representative of the diversity of the types, sizes, shapes and levels of weathering associated with microplastics in the real world. Other times, organisms are exposed to higher concentrations of microplastics than they would be in the real world.

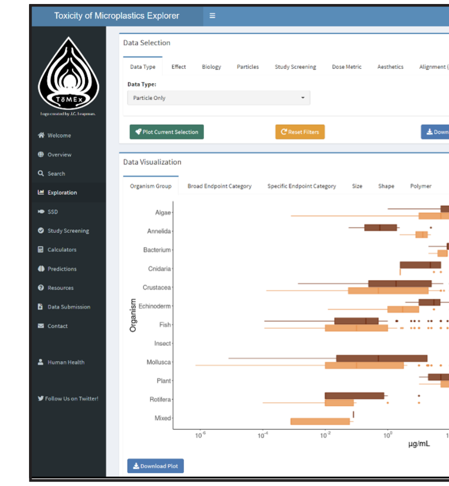
Thus, these studies have limited applicability for developing health-based thresholds for real-world conditions.

SCCWRP is among the many researchers working to fill these types

Risk-based thresholds for microplastics exposure

Researchers have proposed a multi-tiered scientific framework that California could adopt to inform how and when environmental managers would intervene to protect aquatic life and humans from the adverse health effects of microplastics exposure. The framework would contain four risk-based thresholds for microplastics exposure. Scientists have begun working to decide where these numerical thresholds should be set; more microplastics toxicology studies are needed to better inform scientists' threshold recommendations.





The Toxicity of Microplastics Explorer (ToMEx) tool is a public, web-based repository of toxicity data from published microplastics health effects studies that also contains integrated data analysis tools. ToMEx has helped researchers readily identify gaps in microplastics toxicity data.

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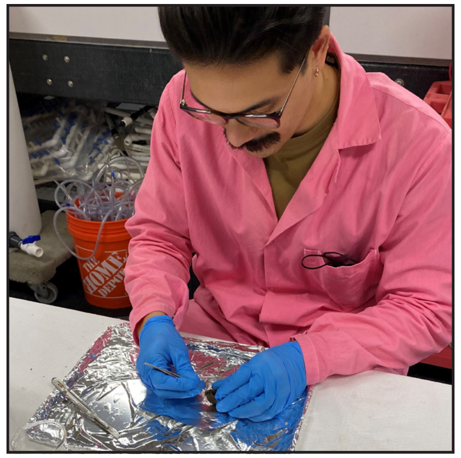
of data gaps. SCCWRP is working, for example, to understand how inland silverside fish and Pacific oysters respond when exposed to environmentally realistic levels of microplastic fibers.

"There are a lot of microplastic toxicity studies out there, so we need to be sure we're only developing thresholds that are based on data that scientists can trust," said Dr. Todd Gouin, an independent environmental fate and exposure modeler based in the U.K. "And sometimes that means we don't trust any of the existing data. Consequently, the most effective course of action to best inform policy makers may be to conduct new research and collect reliable and relevant data."



Thomas Rocca from California State University, Long Beach dissects a juvenile Pacific oyster that was exposed to a specific concentration of microplastics in a SCCWRP laboratory. The toxicology study will help close gaps in scientists' understanding of the biological consequences of microplastics exposure.

Protecting populations from adverse effects

Microplastics toxicity studies typically examine the effects of microplastics exposure on a limited number of organisms in a controlled setting.

But when environmental managers work to protect organisms from microplastics, their goal is to manage microplastics in ways that promote the survival and well-being of entire populations in their own habitats – populations that are potentially exposed to multiple environmental stresses beyond just microplastics.

To accomplish this goal, researchers integrate toxicity data with environmental monitoring data to quantitatively assess exposure risks for an entire population in a given habitat.

California has already begun laying a foundation to assess population-level risks. In 2021, the California Ocean Science Trust convened a group of scientific experts to conduct a risk assessment of microplastics in coastal habitats statewide.

SCCWRP's goal is to use these insights to work toward developing a computer model for assessing the effects of microplastics and other contaminants on population levels over time. This model would integrate chemical, toxicity and ecological data to assess health risks.

Courtesy of Occidental College Vantuna Research Group

A Southern California rocky reef, above, teems with rich biological diversity. Researchers are working toward being able to quantitatively assess microplastics exposure risks for entire populations in a given habitat.

Furthermore, because microplastics are not the only environmental stress on aquatic life, scientists also are working toward being able to quantify microplastic risks relative to other pollutants and environmental stresses, such as increases in temperature caused by climate change.

Researchers are working toward building a scientific framework that enables managers to identify the contaminants and/or environmental stresses of greatest biological concern, as well as quantify the probability, magnitude, and uncertainty of predicted adverse effects now and in the future.

While microplastics are being used as a model contaminant to develop this approach, scientists' long-term goal is to see this framework eventually be applied to a wide variety of contaminants and other environmental stresses, enabling environmental managers to better prioritize and allocate resources.

"The information that managers need is not just how much microplastics exposure is too much, but how much microplastics exposure in combination with all of the other stressors on aquatic life is too much," said Dr. Alvina Mehinto, Head of SCCWRP's Toxicology Department. "This is the central question that will help managers figure out how much attention and resources to direct to curbing the spread of microplastics – as well as other types of environmental stresses – in aquatic environments."

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Accomplishments

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

SCCWRP mission

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

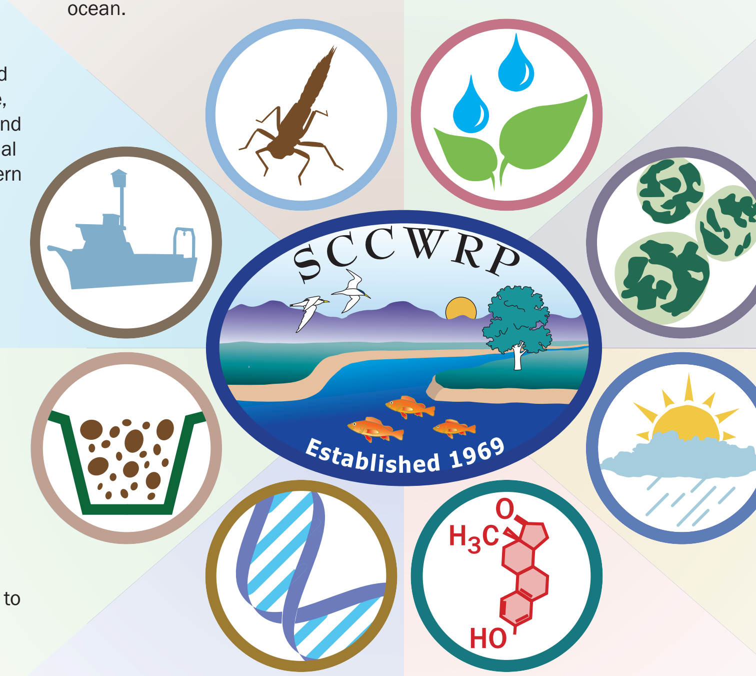
Research themes

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

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

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

129 Number of leadership roles that SCCWRP scientists hold with professional societies, external advisory committees and editorial boards of scientific journals **Page 59**



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.

Ecohydrology

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

Regional Monitoring

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

Eutrophication

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

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SCCWRP member agencies help inform national eDNA strategy

The SCCWRP Commission's Technical Advisory Group (CTAG) hosted an all-day workshop in 2023 to identify opportunities and challenges associated with incorporating environmental DNA (eDNA) methods into aquatic monitoring programs nationwide – part of an effort to help inform development of a coordinated national eDNA-based monitoring strategy.

The insights from the workshop were summarized by SCCWRP and submitted as a response to a request for information. All public comments will be reviewed by a White House-appointed federal team that is developing the national eDNA strategy. The strategy is expected to be released in mid-2024.

The development of a national strategy around eDNA-based monitoring aims to help transition eDNA-based monitoring methods from pilot-scale studies to broadscale adoption by the end-user management community.

For the past decade, researchers and environmental management agencies across the nation have explored how to use eDNA-based methods as a cost-effective complement and/or alternative to traditional morphology-based monitoring methods. However, these agencies have worked largely in siloes to develop eDNA sampling, processing and analytical protocols.

The federal eDNA strategy team invited public comment in 2023 to gather perspectives and insights prior to developing the national strategy.

Following the strategy's release, SCCWRP is expected to play a leading role in helping to align the national strategy with California's ongoing efforts to standardize and build capacity around eDNA monitoring methods.

A federal team has begun developing a national eDNA strategy to help expeditiously transition eDNA-based monitoring methods from pilot-scale studies to broadscale adoption by the end-user management community. eDNA monitoring has the potential to complement traditional monitoring, including for fish like kelp bass, above.

Monitoring SOPs to enable eelgrass beds to be assessed based on ecological functioning

SCCWRP has developed a set of standardized assessment protocols for assessing the health of eelgrass beds based on their ecological functioning.

The eelgrass beds monitoring SOPs (standard operating procedures) – completed in 2023 – will enable managers to take a consistent, bioassessment-based approach to evaluating the ability of this ecologically fragile habitat to provide refugia to fish and other animals, as well as attenuate ocean waves and sequester carbon.

Researchers developed the SOPs by reviewing existing assessment protocols already in use by disparate agencies and programs, working to identify field and laboratory best practices.

These new SOPs will be applied in ongoing regional monitoring programs for eelgrass, including the Regional Eelgrass Survey of Condition and Quality (RESCQ) and the 2023 cycle of the Southern California Bight Regional Monitoring Program.

In a separate but parallel development, researchers also have developed a modeling tool for predicting where along Southern California's coastline eelgrass beds are most likely to survive and thrive.

Researchers have developed standardized protocols for assessing the health of Southern California eelgrass beds, which provide refugia for aquatic life like the nudibranch, above.

Sampling underway to evaluate sediment impacts from offshore oil platforms

SCCWRP and its partners have initiated field sampling to evaluate sediment quality near offshore oil platforms in the Santa Barbara Channel – part of a three-year study to understand how contamination from the original construction may still be adversely affecting marine life.

The project, which began field work in 2023, focuses on piles of seafloor debris known as shell mounds that were created during installation of the offshore oil platforms decades ago. The shell mounds may be leaching chemical contaminants into the water column over time, creating potential exposure routes for sediment-dwelling marine life.

Sediment quality will be evaluated via traditional sediment quality triad analyses and passive sampling. The study's insights will help inform ongoing development of plans by federal and State agencies to decommission and remove the Southern California oil platforms in the coming years.

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Zeta diversity patterns in metabarcoded lotic algal assemblages as a tool for bioassessment

Ariel Levi Simons[1], Susanna Theroux[2], Melisa Osborne[1], Sergey Nuzhdin[1], Raphael Mazor[2], and Joshua Steele[2]

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ABSTRACT

Assessments of the ecological health of algal assemblages in streams typically focus on measures of their local diversity and classify individuals by morphotaxonomy. Such assemblages are often connected through various ecological processes, such as dispersal, and may be more accurately assessed as components of regional-, rather than local-scale assemblages. With recent declines in the costs of sequencing and computation, it has also become increasingly feasible to use metabarcoding to more accurately classify algal species and perform regional-scale bioassessments. Recently, zeta diversity has been explored as a novel method of constructing regional bioassessments for groups of streams. Here, we model the use of zeta diversity-based bioassessments of regional stream health. From 96 stream samples in California, we used various diversity to construct models of biotic integrity for multiple assemblages of diatoms, as well as hybrid assemblages of diatoms in combination with soft-bodied algae, using taxonomy data generated with both DNA sequencing as well as traditional morphotaxonomic approaches. We compared our ability to evaluate the ecological health of stream with the performance of multiple algal indices of biological condition. Our zeta diversity-based models of regional biotic integrity were more strongly correlated with existing indices for algal assemblages classified using metabarcoding compared to morphotaxonomy. Metabarcoding for diatoms and hybrid algal assemblages involved rbcL and 18S V9 primers, respectively. Importantly, we also found that these algal assemblages, independent of the classification method, are more likely to be assembled under a process of niche differentiation rather than stochastically. Taken together, these results suggest the potential for zeta diversity patterns of algal assemblages classified using metabarcoding to inform stream bioassessments.

CITATION

Simons, A.L., S. Theroux, M. Osborne, S. Nuzhdin, R.D. Mazor, J.A. Steele. 2023. Zeta diversity patterns in metabarcoded lotic algal assemblages as a tool for bioassessment. *Ecological Applications* DOI:10.1002/eap.2812

SCCWRP Journal Article #1319
Full text available online: www.sccwrp.org/publications

Using zeta diversity in describing the health of soft sediment benthic macroinvertebrates in the Southern California Bight

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ABSTRACT

Ecological assessments of marine sediments have often focused on measures derived from the taxonomic, and sometimes functional, diversity of individual assemblages of benthic macroinvertebrates (BMIs). These assemblages are linked by a variety of ecological processes, demonstrating a need to describe groupings of generalization of diversity measures, in assessing the health of regional groupings of them using regional measures of diversity. Here the use of zeta diversity is demonstrated, as a novel generalization of diversity measures, in assessing the health of regional groupings of BMI assemblages in the sediments of nearshore habitats such as estuaries and embayments. Using 1203 samples of BMI assemblages found in Southern California Bight (SCB), a model was constructed using three orders of zeta described by the Benthic Response Index. Also investigated was the use of zeta diversity in assessing the relative likelihood of models of community assembly for regional groupings of BMIs, with niche assembly found to be likelier in both nearshore and offshore habitats.

CITATION

Simons, A.L., N. Aulerich, H. Carlson, I. Chandra, J. Chancellor, G. Gemayel, D.J. Gillett, D. Levene, J. Lin, G. Nichol, H. Patel, S. Zhu. 2023. Using Zeta Diversity in Describing the Health of Soft Sediment Benthic Macroinvertebrates in the Southern California Bight. *Journal of Coastal Research* 39:418-430.

SCCWRP Journal Article #1320
Full text available by request: pubrequest@sccwrp.org

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Critical considerations for communicating environmental DNA science

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Abstract

The economic and methodological efficiencies of environmental DNA (eDNA) based survey approaches provide an unprecedented opportunity to assess and monitor aquatic environments. However, instances of inadequate communication from the scientific community about confidence levels, knowledge gaps, reliability, and appropriate parameters of eDNA-based methods have hindered their uptake in environmental monitoring programs and, in some cases, has created misperceptions or doubts in the management community. To help remedy this situation, scientists convened a session at the Second National Marine eDNA Workshop to discuss strategies for improving communications with managers. These include articulating the readiness of different eDNA applications, highlighting the strengths and limitations of eDNA tools for various applications or use cases, communicating uncertainties associated with specified uses transparently, and avoiding the exaggeration of exploratory and preliminary findings. Several key messages regarding implementation, limitations, and relationship to existing methods were prioritized. To be inclusive of the diverse managers, practitioners, and researchers, we and the other workshop participants propose the development of communication workflow plans, using RACI (Responsible, Accountable, Consulted, Informed) charts to clarify the roles of all pertinent individuals and parties and to minimize the chance for miscommunications. We also propose developing decision support tools such as Structured Decision-Making (SDM) to help balance the benefits of eDNA sampling with the inherent uncertainty, and developing an eDNA readiness scale to articulate the technological readiness of eDNA approaches for specific applications. These strategies will increase clarity and consistency regarding our understanding of the utility of eDNA-based methods, improve transparency, foster a commonvision for confidently applying eDNA approaches, and enhance their benefit to the monitoring and assessment community.

Citation

Stein, E.D., C.L. Jerde, E. Andruszkiewicz Allan, A.J. Sepulveda, C.L. Abbott, M.R. Baerwald, J. Darling, K.D. Goodwin, R.S. Meyer, M.A. Timmers, P.M. Thielen. 2023. Critical considerations for communicating environmental DNA science. *Environmental DNA* DOI:10.1002/edn3.472.

SCCWRP Journal Article #1339
Full text available online: www.sccwrp.org/publications

Toward a national eDNA strategy for the United States

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[13]*Division of Integrated Science and Engineering, California Department of Water Resources, Sacramento, CA, USA*
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Abstract

Environmental DNA (eDNA) data make it possible to measure and monitor biodiversity at unprecedented resolution and scale. As use-cases multiply and scientific consensus grows regarding the value of eDNA analysis, public agencies have an opportunity to decide how and where eDNA data fit into their mandates. Within the United States, many federal and state agencies are individually using eDNA data in various applications and developing relevant scientific expertise. A national strategy for eDNA implementation would capitalize on recent developments, providing a common set of next-generation tools for natural resource management and public health protection. Such a strategy would avoid patchwork and possibly inconsistent guidelines in different agencies, smoothing the way for efficient uptake of eDNA data in management. Because eDNA analysis is already in widespread use in both ocean and freshwater settings, we focus here on applications in these environments. However, we forsee the broad adoption of eDNA analysis to meet many resource management issues across the nation because the same tools have immediate terrestrial and aerial applications.

Citation

Kelly, R.P., D.M. Lodge, K.N. Lee, S. Theroux, A.J. Sepulveda, C.A. Scholin, J.M. Craine, E.A. Allan, K.M. Nichols, K.M. Parsons, K.D. Goodwin, Z. Gold, F.P. Chavez, R.T. Noble, C.L. Abbott, M.R. Baerwald, A.M. Naaum, P.M. Thielen, A.L. Simons, C.L. Jerde, J.J. Duda, M.E. Hunter, J.A. Hagan, R.S. Meyer, J.A. Steele, M.Y. Stoeckle, H.M. Bik, C.P. Meyer, E.D. Stein, K.E. James, A.C. Thomas, E. Demir-Hilton, M.A. Timmers, J.F. Griffith, M.J. Weise, S.B. Weisberg. 2023. Toward a national eDNA strategy for the United States. *Environmental DNA* DOI:10.1002/edn3.432.

SCCWRP Journal Article #1336
Full text available online: www.sccwrp.org/publication

When is aquatic resource type conversion appropriate: A framework for cleaning sand out of the gears and a case study for McInnis Marsh

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Abstract

Wetland and stream restoration projects may sometimes involve converting one "type" of aquatic habitat to another "type" (e.g., managed salt ponds into tidal marshes, depressional wetlands into streams, marsh into transition zone habitat). This "type conversion" may be necessary and beneficial in the context of addressing watershed plans or regional restoration goals, or in achieving resiliency to climatic changes (Goals Project 2015). Conversion can also occur through other large-scale, complex actions (e.g., mitigation banking initiatives). Whether driven by habitat restoration goals or compensatory mitigation needs or both, regulatory oversight typically governs the process. Holistically assessing such conversion through the regulatory lens is challenging for permitting programs. The challenge stems from how to accurately determine the overall value of an aquatic resource based on site-specific ecological properties and in the context of larger regional ecosystem management and goals.

Citation

Siu, J., E.D. Stein, J.S. Brown. 2023. When is Aquatic Resource Type Conversion Appropriate: A Framework for Cleaning Sand out of the Gears and a Case Study for McInnis Marsh. *Wetland Science and Practice* 41:70-85.

SCCWRP Journal Article #1318
Full text available by request: pubrequest@sccwrp.org

Options, Impediments, and Supports for the development of an eelgrass (*Zostera marina*) habitat occupancy model in the embayments of Southern California

David J. Gillett[1] and Anne Holt[1]

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

Citation

Gillett, D.J., A. Holt. 2023. Options, Impediments, and Supports for the Development of an Eelgrass (*Zostera marina*) Habitat Occupancy Model in the Embayments of Southern California. Technical Report 1334. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1334
Full text available online: www.sccwrp.org/publications

Instructions for application of the Rapid Screening Causal Assessment (RSCA) tools v 2.0 in California's streams

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

Citation

Gillett, D.J., R.D. Mazor, A.E. Holt, R. Darling, R. Butler. 2023. Instructions for Application of the Rapid Screening Causal Assessment (RSCA) Tools v 2.0 in California's Streams. Technical Report 1310. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1310
Full text available online: www.sccwrp.org/publications

A standard taxonomic effort (STE) for terrestrial arthropods collected from dry streams in California and Arizona

Raphael D. Mazor

Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Mazor, R.D. 2023. A standard taxonomic effort (STE) for terrestrial arthropods collected from dry streams in California and Arizona. Technical Report 1343. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1343
Full text available online: www.sccwrp.org/publications

A standard taxonomic effort (STE) for bryophytes collected from dry streambeds in California and Arizona

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[3]School of Life Sciences at University of Nevada – Las Vegas, Las Vegas, NV

Citation

Mazor, R.D., J. Olson, T. Clark. 2023. A standard taxonomic effort (STE) for bryophytes collected from dry streambeds in California and Arizona. Technical Report 1344. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1344
Full text available online: www.sccwrp.org/publications

Ecological conditions of dry streams in the Los Angeles region

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

Citation

Mazor, R.D., J.S. Brown, R. Darling. 2023. Ecological conditions of dry streams in the Los Angeles region. Technical Report 1333. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1333
Full text available online: www.sccwrp.org/publications

An assessment of the biological condition of streams in the San Francisco Bay

Jeffrey S. Brown[1] and Raphael D. Mazor[1]

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

Citation

Brown, J.S., R.D. Mazor. 2023. An assessment of the biological condition of streams in the San Francisco Bay. Technical Report 1340. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1340
Full text available online: www.sccwrp.org/publications

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Framework developed to assess streams' vulnerability to changes in flow patterns

SCCWRP and its partners have developed a scientific framework that enables watershed managers to systematically evaluate how changes in stream flow patterns in the coming years will adversely affect sensitive aquatic species and habitats.

The risk-decision framework – published in a SCCWRP technical report in 2023 – considers how climate change, future land-use changes and changing water management practices will affect the ecological health of streams across the San Diego region. These insights are intended to help watershed managers make informed decisions about which streams to prioritize protecting and restoring.

The framework was developed by coupling two types of models: hydrologic models that explain how stream flow patterns will change across the San Diego region, and species distribution models that explain how sensitive species like the arroyo toad are affected by stream flow alterations. The framework's outputs will enable managers to determine if future hydrologic change has the potential to adversely affect aquatic life.

The work builds off a similar 2019 environmental flows analysis in the Los Angeles region focusing on climate change impacts.

Researchers have developed a risk-decision framework to systematically evaluate how climate change, future land-use changes and changing water management practices will affect the ecological health of streams across the San Diego region, including Green Valley, above.

Second phase launched to build technical foundation for stream flow diversions

SCCWRP and its partners have begun the second phase of a two-year study to build the technical foundation for a statewide program requiring California cannabis growers to demonstrate that the water they are requesting to divert from nearby streams to support cannabis cultivation does not adversely affect the streams' ecological health.

The second phase, launched in 2023, focuses on applying a draft scientific workflow based on the California Environmental Flows Framework to the North Coast region of California; cannabis growers will be able to use the workflow to assess potential ecological risks from diverting stream flows.

The workflow will help water resources managers determine whether the individual and cumulative effects of cannabis growers' proposed stream flow diversions will adversely affect the flow regimes necessary to support ecological health.

The State Water Resources Control Board is using the project as a test case for how to eventually apply this approach statewide.

The South Fork of the Eel River in Northern California, above, is among the streams that California cannabis growers are requesting to divert water from to support cannabis cultivation. Researchers are building the technical foundation for a statewide program that will require cannabis growers to demonstrate that their diversion requests do not adversely affect the streams' ecological health.

Study launched to probe how water temperature affects stream health

SCCWRP and its partners have launched a study investigating how water temperature affects the health of sensitive aquatic life in Southern California streams where treated wastewater effluent is being discharged – an investigation that is complementing ongoing studies in two other watersheds.

The new study, launched in 2023, focuses on the upper Santa Clara River watershed, adding another study area to a water temperature investigation that already includes the San Gabriel River and Los Angeles River watersheds. Wastewater effluent is typically discharged into streams above the stream's ambient temperature.

Unlike the San Gabriel and L.A. River watersheds, the Santa Clara River watershed receives inputs from groundwater. Groundwater is thought to have a cooling effect on river temperature, meaning the groundwater discharge in the Santa Clara River – in combination with wastewater discharges – has the potential to affect stream temperatures.

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How low can you go? Widespread challenges in measuring low stream discharge and a path forward

Erin C. Seybold[1], Anna Bergstrom[2], C. Nathan Jones[3], Amy J. Burgin[4], Sam Zipper[1], Sarah E. Godsey[5], Walter K. Dodds[6], Margaret A. Zimmer[7,8], Margaret Shanafield[9], Thibault Datry[10], Raphael D. Mazor[11], Mathis L. Messager[10,12], Julian D. Olden[13], Adam Ward[14], Songyan Yu[15], Kendra E. Kaiser[2], Arial Shogren[3], Richard H. Walker[16]

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[15]*Australian Rivers Institute and School of Environment and Science, Griffith University, Nathan, Queensland, Australia*
[16]*Department of Biology and Chemistry, Upper Iowa University, Fayette, IA*

Abstract

Low flows pose unique challenges for accurately quantifying streamflow. Current field methods are not optimized to measure these conditions, which in turn, limits research and management. In this essay, we argue that the lack of methods for measuring low streamflow is a fundamental challenge that must be addressed to ensure sustainable water management now and into the future, particularly as climate change shifts more streams to increasingly frequent low flows. We demonstrate the pervasive challenge of measuring low flows, present a decision support tool (DST) for navigating best practices in measuring low flows, and highlight important method developmental needs.

Citation

Seybold, E.C., A. Bergstrom, C. Nathan Jones, A.J. Burgin, S. Zipper, S.E. Godsey, W.K. Dodds, M.A. Zimmer, M. Shanafield, T. Datry, R.D. Mazor, M.L. Messager, J.D. Olden, A. Ward, S. Yu, K.E. Kaiser, A. Shogren, R.H. Walker. 2023. How low can you go? Widespread challenges in measuring low stream discharge and a path forward. *Limnology and Oceanography Letters* DOI:10.1002/lol2.10356.

SCCWRP Journal Article #1342
Full text available online: www.sccwrp.org/publications

Impact of wastewater reuse on contaminants of emerging concern in an effluent-dominated river

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Abstract

Contaminants of emerging concern such as pharmaceuticals, personal care products, per- and polyfluoroalkyl substances, and plasticizers, are ubiquitous in effluent-dominated rivers and have potential adverse effects on humans and aquatic life. Demands on water supply have prompted conservation and water reuse measures, impacting the discharge in these rivers, yet the effects of these management decisions on water quality are largely intuited and not quantified. This research examines how changes in water reuse practices will impact concentrations of contaminants of emerging concern, specifically carbamazepine, diclofenac, galaxolide, gemfibrozil, 4-nonylphenol, and perfluorooctane sulfonic acid (PFOS), in the effluent-dominated Los Angeles River (Los Angeles County, California). A water quality module was added to a calibrated hydrologic model of the system and parametrized with observed water quality monitoring data in EPA SWMM. Results indicate that water reuse (i.e., reduced effluent flow) will consistently improve in-stream water quality for all compounds studied except PFOS. However, the improvements are often not substantial enough to mitigate high concentrations directly downstream of treated effluent discharge points. Concentrations of these pharmaceuticals are substantially reduced through attenuation as dilution and degradation occur downstream, though the rate of this attenuation is variable and based on the contaminant. In contrast, concentrations of PFOS increase under some wastewater reuse scenarios and decrease under others but remain below the recommended environmental screening levels. Our work also highlights that management decisions regarding water quantity should integrate water quality modeling to help identify priority monitoring locations and constituents.

Citation

Wolfand, J.M., A. Sytsma, K.T. Taniguchi-Quan, E.D. Stein, T.S. Hogue. 2023. Impact of wastewater reuse on contaminants of emerging concern in an effluent-dominated river. *Frontiers in Environmental Science* DOI:10.3389/fenvs.2023.1091229.

SCCWRP Journal Article #1349
Full text available by request: pubrequest@sccwrp.org

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Development and evaluation of the beta streamflow duration assessment methods for the Northeast and Southeast

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Citation

Gross, S., K.M. Fritz, T.L. Nadeau, R.D. Mazor, M. Eddy, B. Topping, R.F. Edgerton, K. Nicholas. 2023. Development and Evaluation of the Beta Streamflow Duration Assessment Methods for the Northeast and Southeast. Technical Report 1321. U.S. Environmental Protection Agency. Washington, D.C.

SCCWRP Technical Report #1321
Full text available online: www.sccwrp.org/publications

Risk-decision framework for evaluating vulnerability of streams to hydrologic alteration

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[2]*Department of Geography, San Diego State University, San Diego, CA*

Citation

Taniguchi-Quan, K.T., K. Irving, R. Darling, D. Kim, H. McMillan, E.D. Stein. 2023. Risk-Decision Framework for Evaluating Vulnerability of Streams to Hydrologic Alteration. Technical Report 1322. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1322
Full text available online: www.sccwrp.org/publications

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OAH model used to investigate effects of nutrient discharges

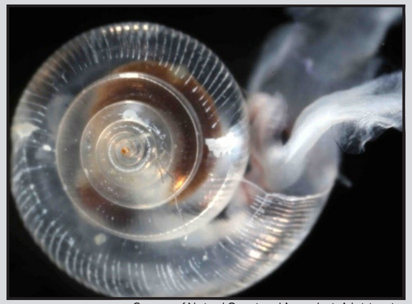
A research team that has been modeling how land-based nutrient discharges into California coastal waters influences ocean acidification and hypoxia (OAH) has demonstrated how to use the model for predicting how coastal OAH conditions would be affected if these discharges were reduced.

The modeling effort, described in a 2023 journal article co-authored by SCCWRP, tested multiple hypothetical management scenarios that involve reducing nitrogen discharges by 0%, 50% and 85% across 19 Southern California wastewater outfalls.

The modeling work predicted that nitrogen reductions would result in a reversal of subsurface oxygen and pH losses, an expansion of simulated habitat volume for shelled organisms that are sensitive to pH losses, and an expansion of aerobic habitat for fish.

The findings mark a key first step toward answering management questions about the role of land-based nutrient discharges, if any, in exacerbating coastal OAH conditions.

In 2023, a panel of scientific experts launched a comprehensive independent review of OAH modeling work to date, including this study's findings.



Courtesy of National Oceanic and Atmospheric Administration

A pteropod, or sea snail, with pit marks on its shell, shows signs of shell dissolution in response to ocean acidification. Researchers are studying how seawater chemistry conditions could be altered if land-based nutrient discharges into California coastal waters are reduced.

The next step is to run modeling simulations with more realistic nutrient-reduction scenarios – scenarios informed by changes that managers at each outfall could realistically make to their water recycling and nutrient management practices.

Researchers also need to run scenarios that will help managers weigh the potential benefits of taking short-term actions to reduce nutrients against the pace with which OAH is intensifying in Southern California coastal waters.

Tools developed to predict risk of mass strandings caused by HAB toxin

SCCWRP and its partners have developed a set of tools for predicting the likelihood of marine mammals becoming stranded on Southern California beaches based on exposure to elevated levels of domoic acid, a toxin produced by a harmful algal bloom (HAB) known as *Pseudo-nitzschia*.

The predictive tools, described in a journal article published in 2023, are intended to provide environmental managers and marine mammal rescue centers with critical early warnings about anticipated mass strandings of sea lions and other animals as a result of domoic acid poisoning, such as an event in 2023 that sickened or killed hundreds of marine mammals.

The predictive tools leverage HABs monitoring data collected at ocean piers via California's Harmful Algal Bloom Monitoring and Alert Program (HABMAP), plus data collected further offshore via rapid-response HABs monitoring efforts.

Rapid-response HABs monitoring effort helps illuminate how toxic blooms affect marine mammals

SCCWRP and its partners helped mobilize and coordinate a rapid-response effort in 2023 to collect offshore field sampling data on toxin-producing harmful algal blooms (HABs) in Southern California coastal waters, following a massive bloom event that sickened or killed more than 500 marine mammals.

The new data set is helping researchers build modeling tools for predicting when and where these disruptive events will occur, and for estimating how sea lions, dolphins and other marine animals will be affected.

The rapid-response HABs monitoring effort nearly doubled in size an offshore data set that was collected in 2022 during a similarly disruptive bloom event.

Researchers will pair the bloom data sets with data collected by Southern California marine mammal centers. The paired data sets will be used to refine a set of prototype modeling tools designed to predict the locations and severity of toxin-producing bloom events at the earliest possible stages.

Courtesy of Channel Islands Marine & Wildlife Institute

A rescue crew prepares to transport a sea lion stranded on the beach as a result of domoic acid exposure to a rehabilitation center for treatment. SCCWRP helped mobilize and coordinate a rapid-response effort to collect offshore field sampling data on toxin-producing HABs, which are believed to be responsible for seasonal marine mammal strandings.

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Environmental and ecological drivers of harmful algal blooms revealed by automated underwater microscopy

Kasia M. Kenitz[1], Clarissa R. Anderson[2], Melissa L. Carter[2], Emily Eggleston[3], Kristi Seech[2], Rebecca Shipe[4], Jayme Smith[5], Eric C. Orenstein[1,6], Peter J.S. Ranks[1], Jules S. Jaffe[1], Andrew D. Barton[1,7]

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Abstract

In recent years, harmful algal blooms (HABs) have increased in their severity and extent in many parts of the world and pose serious threats to local aquaculture, fisheries, and public health. In many cases, the mechanisms triggering and regulating HAB events remain poorly understood. Using underwater microscopy and Residual Neural Network (ResNet-18) to taxonomically classify imaged organisms, we developed a daily abundance record of four potentially harmful algae (*Akashiwo sanguinea*, *Chattonella spp.*, *Dinophysis spp.*, and *Lingulodinium polyedra*) and major grazer groups (ciliates, copepod nauplii, and copepods) from August 2017 to November 2020 at Scripps Institution of Oceanography pier, a coastal location in the Southern California Bight. Random Forest algorithms were used to identify the optimal combination of environmental and ecological variables that produced the most accurate abundance predictions for each taxon. We developed models with high prediction accuracy for *A. sanguinea* (R2 ¼0:79_0:06), *Chattonella spp.* (R2 ¼0:63_0:06), and *L. polyedra* (R2 ¼0:72_0:08), whereas models for *Dinophysis spp.* showed lower prediction accuracy (R2 ¼0:24_0:07). Offshore nutricline depth and indices describing climate variability, including El Niño Southern Oscillation, Pacific Decadal Oscillation, and North Pacific Gyre Oscillation, that influence regional-scale ocean circulation patterns and environmental conditions, were key predictor variables for these HAB taxa. These metrics of regional-scale processes were generally better predictors of HAB taxa abundances at this coastal location than the *in situ* environmental measurements. Ciliate abundance was an important predictor of *Chattonella* and *Dinophysis spp.*, but not of *A. sanguinea* and *L. polyedra*. Our findings indicate that combining regional and local environmental factors with microzooplankton populations dynamics can improve real-time HAB abundance forecasts.

Citation

Kenitz, K.M., C.R. Anderson, M.L. Carter, E. Eggleston, K. Seech, R. Shipe, J. Smith, E.C. Orenstein, P.J.S. Franks, J.S. Jaffe, A.D. Barton . 2023. Environmental and ecological drivers of harmful algal blooms revealed by automated underwater microscopy. *Limnology and Oceanography* 9999:1-18.

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A cross-regional examination of patterns and environmental drivers of *Pseudo-nitzschia* harmful algal blooms along the California coast

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Abstract

Pseudo-nitzschia species with the ability to produce the neurotoxin domoic acid (DA) are the main cause of harmful algal blooms (HABs) along the U.S. West Coast, with major impacts on ecosystems, fisheries, and human health. While most *Pseudo-nitzschia* (PN) HAB studies to date have focused on their characteristics at specific sites, few cross-regional comparisons exist, and mechanistic understanding of large-scale HAB drivers remains incomplete. To close these gaps, we compiled a nearly 20-year time series of *in situ* particulate DA and environmental observations to characterize similarities and differences in PN HAB drivers along the California coast. We focus on three DA hotspots with the greatest data density: Monterey Bay, the Santa Barbara Channel, and the San Pedro Channel. Coastwise, DA outbreaks are strongly correlated with upwelling, chlorophyll-a, and silicic acid limitation relative to other nutrients. Clear differences also exist across the three regions, with contrasting responses to climate regimes across a north to south gradient. In Monterey Bay, PN HAB frequency and intensity increase under relatively nutrient-poor conditions during anomalously low upwelling intensities. In contrast, in the Santa Barbara and San Pedro Channels, PN HABs are favored under cold, nitrogen-rich conditions during more intense upwelling. These emerging patterns provide insights on ecological drivers of PN HABs that are consistent across regions and support the development of predictive capabilities for DA outbreaks along the California coast and beyond.

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Citation

Sandoval-Belmar, M., J. Smith, A.R. Moreno, C. Anderson, R.M. Kudela, M. Sutula, F. Kessouri, D.A. Caron, F.P. Chavez, D. Bianchi. 2023. A cross-regional examination of patterns and environmental drivers of *Pseudo-nitzschia* harmful algal blooms along the California coast. *Harmful Algae* 126:102435.

SCCWRP Journal Article #1323
Full text available online: www.sccwrp.org/publications

Quantifying the linkages between California sea lion (*Zalophus californianus*) strandings and particulate domoic acid concentrations at piers across Southern California

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Abstract

Domoic acid-producing blooms of the diatom genus Pseudo-nitzschia are pervasive in coastal environments globally. Domoic acid, a neurotoxin, accumulates via trophic transfer into marine food webs and is often associated with mass marine mammal mortality and stranding events. In Southern California, California sea lions (*Zalophus californianus*) are an indicator species for food web impacts of domoic acid because they are abundant secondary consumers, sensitive to domoic acid intoxication, and are actively monitored by stranding networks. However, domoic acid exposure may occur a distance from where a sea lion ultimately strands. This spatiotemporal variation complicates coupling domoic acid observations in water to strandings. Therefore, we sought to quantify whether monitoring data from four pier sites across the region, covering nearly 700 km of coastline from 2015-2019, could be used to predict adult and subadult sea lion strandings along the 68 km Orange County coastline surveyed by the Pacific Marine Mammal Center. We found that increased sea lion strandings were often observed just prior to an increase in particulate domoic acid at the piers, confirming that clusters of subadult and adult sea lion strandings with clinical signs of domoic acid intoxication serve as indicators of bloom events. In addition, domoic acid concentrations at Stearns Wharf, nearly 200 km from stranding locations, best predicted increased total sea lion strandings, and strandings of sea lions with domoic acid intoxication symptoms. Particulate domoic acid concentrations greater than 0.05 mg/L at Stearns Wharf were linked to stranding probabilities in Orange County ranging from 2.2% to 55% per week, and concentrations of 0.25 mg/L resulted in weekly stranding probabilities ranging from 16% to 81% depending on the stranding scenario modeled.

Citation

Smith, J., J.A. Cram, M.P. Berndt, V. Hoard, D. Shultz, A.C. Deming. 2023. Quantifying the linkages between California sea lion (Zalophus californianus) strandings and particulate domoic acid concentrations at piers across Southern California. *Frontiers in Marine Science* 10:1278293.

SCCWRP Journal Article #1359
Full text available online: www.sccwrp.org/publications

Convening expert taxonomists to build image libraries for training automated classifiers

Kasia M. Kenitz[1], Eric C. Orenstein[1], Clarissa R. Anderson[1], Alexander J. Barth[2,3], Christian Briseño-Avena[4], David A. Caron[5], Melissa L. Carter[1], Emily Eggleston[5], Peter J. S. Franks[1], James T. Fumo[1,6], Jules S. Jaffe[1], Kelsey A. McBeain[6], Anthony Odell[7], Kristi Seech[1], Rebecca Shipe[8], Jayme Smith[9], Darcy A. A. Taniguchi[10], Elizabeth L. Venrick[1], and Andrew D. Barton[1,11]

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Abstract

Digital imaging technologies are increasingly used to study life in the ocean. To deal with the large volume of image data collected over space and time, scientists employ various machine learning and deep learning algorithms to perform automated image classification. Training of classifiers requires a large number of expertly curated sets of images, a time-consuming process that requires a large number of expertly curated sets of images, a time-consuming process that requires taxonomic knowledge and understanding of the local ecosystem. The creation of these labeled training sets is the critical bottleneck for building skillful automated classifiers. Here, we discuss how we overcame this barrier by leveraging taxonomic knowledge from a group of specialists in a workshop setting and suggest best practices for effectively organizing image annotation efforts. In our experience, this 2 day workshop proved very insightful and facilitated classification of over 4 years of plankton images obtained at Scripps Pier (La Jolla, CA), focusing on diatoms and dinoflagellates. We highlight the importance of facilitating a dialog between taxonomists and engineers to better integrate ecological goals with computational constraints, and encourage continuous involvement of taxonomic experts for successful implementation of automated classifiers.

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Citation

Kenitz, K.M., E.C. Orenstein, C.R. Anderson, A.J. Barth, C. Briseno-Avena, D.A. Caron, M.L. Carter, E. Eggleston, P.J.S. Franks, J.T. Fumo, J.S. Jaffe, K.A. McBeain, A. Odell, K. Seech, R. Shipe, J. Smith, D.A.A. Taniguchi, E.L. Venrick, A.D. Barton. 2023. Convening Expert Taxonomists to Build Image Libraries for Training Automated Classifiers. *Limnology and Oceanography Bulletin* DOI:10.1002/lob.10584.

SCCWRP Journal Article #1326
Full text available online: www.sccwrp.org/publications

Historic and recent trends of cyanobacterial harmful algal blooms and environmental conditions in Clear Lake, California: A 70-year perspective

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Abstract

Clear Lake is a large, natural lake in northern California, USA, with many beneficial uses but also substantive environmental issues. The lake has a long history of water quality problems including mercury contamination, pesticide usage, invasive species, and high rates of primary production. In recent years, an increase in cyanobacterial harmful algal blooms (cyanoHABs) has been documented in the lake, adding to the environmental issues faced by aquatic species present in the lake and the local community. Extensive observations of various physical, chemical, and biological parameters in Clear Lake began in the mid-1900s. The most pertinent of these data sets and findings have been reviewed and analyzed with the intent of improving our understanding of the causes and drivers of cyanoHABs, toxin production, and identifying data gaps. Several parameters including average annual water temperature have remained relatively constant over the past 70 years, although the seasonally averaged water temperatures have shifted in a manner that may now favor cyanobacterial dominance. Clear Lake has also witnessed recent changes in several environmental variables such as total phosphorus concentrations that might contribute to blooms. An analysis of lake conditions prior to and following the enactment of a total maximum daily load (TMDL) for phosphorus in 2007 indicates little measurable influence on total phosphorus concentrations in Clear Lake. The present trajectory of lake chemistry suggests that additional research and management efforts will be needed to address the recurrence of cyanoHABs in the future. Future lake management strategies should include consideration of the role of internal nutrient loads to lessen cyanoHABs. Furthermore, a better understanding of cyanobacterial community interactions and top-down effects on bloom formation within the lake can help guide future cyanoHAB management strategies.

Citation

Smith, J., E. Eggleston, M.D.A. Howard, S. Ryan, J. Gichuki, K. Kennedy, A. Tyler, M. Beck, S. Huie, D.A. Caron. 2023. Historic and recent trends of cyanobacterial harmful algal blooms and environmental conditions in Clear Lake, California: A 70-year perspective. *Elementa: Science of the Anthropocene* DOI:10.1525/elementa.2022.00115.

SCCWRP Journal Article #1348
Full text available online: www.sccwrp.org/publications

Modeling the dispersal of the San Francisco Bay plume over the northern and central California shelf

Jian Zhou[1,2,3], Jonathan G. Izett[2], Christopher A. Edwards[2], Pierre Damien[3], Fayçal Kessouri[3,4], and James C. McWilliams[3]

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[2]*Department of Ocean Sciences, University of California, Santa Cruz, CA*
[3]*Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, CA*
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Abstract

High-resolution simulations by the Regional Ocean Modeling System (ROMS) were used to investigate the dispersal of the San Francisco Bay (SFB) plume over the northern-central California continental shelf during the period of 2011 to 2012. The modeled bulk dynamics of surface currents and state variables showed many similarities to corresponding observations. After entering the Pacific Ocean through the Golden Gate, the SFB plume is dispersed across the shelf via three pathways: (i) along the southern coast towards Monterey Bay, (ii) along the northern coast towards Point Arena, and (iii) an offshore pathway restricted within the shelf break. On the two-year mean timescale, the along-shore zone of impact of the northward-dispersed plume is about 1.5 times longer than that of the southern branch. Due to the opposite surface Ekman transports induced by the northerly or southerly winds, the southern plume branch occupies a broader cross-shore extent, roughly twice as wide as the northern branch which extends roughly two times deeper due to coastal downwelling. Besides these mean characteristics, the SFB plume dispersal also shows considerable temporal variability in response to various forcings, with wind and surface-current forcing most strongly related to the dispersing direction. Applying constituent-oriented age theory, we determine that it can be as long as 50 days since the SFB plume was last in contact with SFB before being flushed away from the Gulf of the Farallones. This study sheds light on the transport and fate of SFB plume and its impact zone with implications for California's marine ecosystems.

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Citation

Zhou, J., J.G. Izett, C.A. Edwards, P. Damien, F. Kessouri, J.C. McWilliams. 2023. Modeling the dispersal of the San Francisco Bay plume over the northern and central California shelf. *Estuarine, Coastal and Shelf Science* 287:108336.

SCCWRP Journal Article #1350
Full text available by request: pubrequest@sccwrp.org

Modulation of phytoplankton uptake by mesoscale and submesoscale eddies in the California Current System

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Abstract

Eddies play a crucial role in shaping ocean dynamics by affecting material transport, and generating spatiotemporal heterogeneity. However, how eddies at different scales modulate biogeochemical transformation rates remains an open question. Applying a multi-scale decomposition to a numerical simulation, we investigate the respective impact of mesoscale and submesoscale eddies on nutrient transport and biogeochemical cycling in the California Current System. First, the non-linear nature of nutrient uptake by phytoplankton results in a 50% reduction in primary production in the presence of eddies. Second, eddies shape the vertical transport of nutrients with a strong compensation between mesoscale and submesoscale. Third, the eddy effect on nutrient uptake is controlled by the covariance of temperature, nutrient and phytoplankton fluctuations caused by eddies. Our results shed new light on the tight interaction between nonlinear fluid dynamics and ecosystem processes in realistic eddy regimes, which remain largely underresolved by global Earth system models.

Citation

Damien, P., D. Bianchi, F. Kessouri, J.C. McWilliams. 2023. Modulation of Phytoplankton Uptake by Mesoscale and Submesoscale Eddies in the California Current System. *Geophysical Research Letters* DOI:10.1029/2023GL104853.

SCCWRP Journal Article #1346
Full text available online: www.sccwrp.org/publications

Effect of ocean outfall discharge volume and dissolved inorganic nitrogen load on urban eutrophication outcomes in the Southern California Bight

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Abstract

Climate change is increasing drought severity worldwide. Ocean discharges of municipal wastewater are a target for potable water recycling. Potable water recycling would reduce wastewater volume; however, the effect on mass nitrogen loading is dependent on treatment. In cases where nitrogen mass loading is not altered or altered minimally, this practice has the potential to influence spatial patterns in coastal eutrophication. We apply a physical-biogeochemical numerical ocean model to understand the influence of nitrogen management and potable wastewater recycling on net primary productivity (NPP), pH, and oxygen. We model several theoretical management scenarios by combining dissolved inorganic nitrogen (DIN) reductions from 50 to 85% and recycling from 0 to 90%, applied to 19 generalized wastewater outfalls in the Southern California Bight. Under no recycling, NPP, acidification, and oxygen loss decline with DIN reductions, which simulated habitat volume expansion for pelagic calcifiers and aerobic taxa. Recycling scenarios under intermediate DIN reduction show patchier areas of pH and oxygen loss with steeper vertical declines relative to a "no recycling" scenario. These patches are diminished under 85% DIN reduction across all recycling levels, suggesting nitrogen management lowers eutrophication risk even with concentrated discharges. These findings represent a novel application of ocean numerical models to investigate the regional effects of idealized outfall management on eutrophication. Additional work is needed to investigate more realistic outfall-specific water recycling and nutrient management scenarios and to contextualize the benefit of these management actions, given accelerating acidification and hypoxia from climate change.

Citation

Ho, M., F. Kessouri, C.A. Frieder, M. Sutula, D. Bianchi, J.C. McWilliams. 2023. Effect of ocean outfall discharge volume and dissolved inorganic nitrogen load on urban eutrophication outcomes in the Southern California Bight. *Scientific Reports* 13:22148.

SCCWRP Journal Article #1356
Full text available online: www.sccwrp.org/publications

Enhanced biogeochemical cycling along the U.S. West Coast shelf

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Abstract

Continental margins play an essential role in global ocean biogeochemistry and the carbon cycle; however, global assessments of this role remain highly uncertain. This uncertainty arises from the large variability over a broad range of temporal and spatial scales of the processes that characterize these environments. High-resolution simulations with ocean biogeochemical models have emerged as essential tools to advance biogeochemical assessments at regional scales. Here, we examine the processes and balances for carbon, oxygen, and nitrogen cycles along the U.S. West Coast in an 11-year hindcast simulation with a submesoscale-permitting oceanic circulation coupled to a biogeochemical model. We describe and quantify the biogeochemical cycles on the continental shelf, and their connection to the broader regional context encompassing the California Current System. On the shelf, coastal and wind stress curl upwelling drive a vigorous overturning circulation that supports biogeochemical rates and fluxes that are approximately twice as large as offshore. Exchanges with the proximate sediments, submesoscale shelf currents, bottom boundary layer transport, and intensified cross-shelf export of shelf-produced materials further impact coastal and open-ocean balances. While regional variability prevents extrapolation of our results to global margins, our approach provides a powerful tool to identify the dominant dynamics in different shelf setting and quantify their large-scale consequences.

Citation

Damien, P., D. Bianchi, J.C. McWilliams, F. Kessouri, C. Deutsch, R. Chen, L. Renault. 2023. Enhanced Biogeochemical Cycling Along the U.S. West Coast Shelf. *Global Biogeochemical Cycles* DOI:10.1029/2022GB007572.

SCCWRP Journal Article #1354
Full text available by request: pubrequest@sccwrp.org

A Macroalgal Cultivation Modeling System (MACMODS): Evaluating the role of physical-biological coupling on nutrients and farm yield

Christina A. Frieder[1], Chao Yan[2], Marcelo Chamecki[2], Daniel Dauhajre[2], James C. McWilliams[2], Javier Infante[3], Meredith L. McPherson[4], Raphael M. Kudela[4], Fayçal Kessouri[5], Martha Sutula[5], Isabella B. Arzeno-Soltero[1], and Kristen A. Davis[1,6]

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[2]*Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA*
[3]*Patagonia Seaweeds, Puerto Varas, Chile*
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Abstract

Offshore aquaculture has the potential to expand the macroalgal industry. However, moving into deeper waters requires suspended structures that will present novel farm-environment interactions. Here, we present a computational modeling framework, the Macroalgal Cultivation Modeling System (MACMODS), to explore within-farm modifications to light, seawater flow, and nutrient fields across time and space scales relevant to macroalgae. A regional ocean model informs the site-specific setting, the Santa Barbara Channel in the Southern California Bight. A fine-scale hydrodynamic model predicts modified flows and turbulent mixing within the farm. A spatially resolved macroalgal growth model, parameterized for giant kelp, Macrocystis pyrifera, predicts kelp biomass. Key findings from model integration are that regional ocean conditions set overall farm performance, while fine-scale within-farm circulation and nutrient delivery are important to resolve variation in within-farm macroalgal performance. Therefore, we conclude that models resolving within-farm dynamics can provide benefit to farmers with insight on how farm design and regional ocean conditions interact to influence overall yield. Here, the presence of repeating longlines aligned with the mean current generate flow diversions around the farm as well as attached Langmuir circulations and increased turbulence intensity. These flow-induced phenomena lead to less biomass in the interior portion of the farm relative to the edges. We also find that there is an effluent "footprint" that extends as much as 20 km beyond the farm. In this regard, MACMODS can be used to not only evaluate farm design and cultivation practices that maximize yield but also explore interactions between the farm and ecosystem in order to minimize impacts.

Citation

Frieder, C.A., C. Yan, M. Chamecki, D. Dauhajre, J.C. McWilliams, J. Infante, M.L. McPherson, R.M. Kudela, F. Kessouri, M. Sutula, I.B. Arzeno-Soltero, K.A. Davis. 2022. A Macroalgal Cultivation Modeling System (MACMODS): Evaluating the Role of Physical-Biological Coupling on Nutrients and Farm Yield. *Frontiers in Marine Science* DOI:10.3389/fmars.2022.752951.

SCCWRP Journal Article #1347
Full text available online: www.sccwrp.org/publications

Seasonal dynamics and annual budget of dissolved inorganic carbon in the northwestern Mediterranean deep-convection region

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[2]*The Royal Netherlands Institute for Sea Research (NIOZ), Department of Estuarine and Delta Systems, Yerseke, The Netherlands*
[3]*Sorbonne Université, CNRS, Laboratoire d'Océanographie de Villefranche (LOV), Villefranche-sur-Mer, France*
[4]*Sorbonne Université, CNRS, OSU STAMAR, Paris, France*
[5]*Mediterranean Institute of Oceanography – MIO, Aix Marseille Université, Université de Toulon, Marseille, France*
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Abstract

Deep convection plays a key role in the circulation, thermodynamics, and biogeochemical cycles in the Mediterranean Sea, which is considered to be a hotspot of

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biodiversity and climate change. In the framework of the DEWEX (Dense Water Experiment) project, the seasonal and annual budgets of dissolved inorganic carbon in the deep-convection area of the northwestern Mediterranean Sea are investigated over the period September 2012–September 2013 using a 3D coupled physical–biogeochemical–chemical modeling approach. At the annual scale, we estimate that the northwestern Mediterranean Sea's deep-convection region was a moderate sink of 0.5 $molCm^{-2}yr^{-1}$ of CO_2 for the atmosphere. The model results show the reduction of oceanic CO_2 uptake during deep convection and its increase during the abrupt spring phytoplankton bloom following the deep-convection events. We highlight the major roles in the annual dissolved inorganic carbon budget of both the biogeochemical and physical fluxes, which amount to –3:7 and 3.3 $molCm^{-2}yr^{-1}$, respectively, and are 1 order of magnitude higher than the air–sea CO_2 flux. The upper layer (from the surface to 150m depth) of the northwestern deep-convection region gained dissolved inorganic carbon through vertical physical transport and, to a lesser extent, oceanic CO_2 uptake, and it lost dissolved inorganic carbon through lateral transport and biogeochemical fluxes. The region, covering 2.5% of the Mediterranean, acted as a source of dissolved inorganic carbon for the surface and intermediate water masses of the Balearic Sea and southwestern Mediterranean Sea and could represent up to 22% and 11 %, respectively, of the CO_2 exchanges with the Atlantic Ocean at the Strait of Gibraltar.

CITATION

Ulses, C., C. Estournel, P. Marsaleix, K. Soetaert, M. Fourrier, L. Coppola, D. Lefevre, F. Touratier, C. Goyet, V. Guglielmi, F. Kessouri, P. Testor, X. Durrieu de Madron. 2023. Seasonal dynamics and annual budget of dissolved inorganic carbon in the northwestern Mediterranean deep-convection region. *Biogeosciences* 20:4683-4710.

SCCWRP Journal Article #1355
Full text available online: www.sccwrp.org/publications

Diversity and prevalence of cyanobacteria and cyanotoxins in Los Angeles region recreational lakes and reservoirs

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

CITATION

Smith, J., D. Shultz, A. Lie, S. Theroux. 2023. Diversity and Prevalence of Cyanobacteria and Cyanotoxins in Los Angeles Region Recreational Lakes and Reservoirs. Technical Report 1309. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1309
Full text available online: www.sccwrp.org/publications

Experts help shape Oregon's approach to assessing OAH

A West Coast technical advisory workgroup that was convened to guide the State of Oregon in developing a standardized approach for assessing the effects of ocean acidification and hypoxia (OAH) on coastal marine life has successfully helped Oregon to develop this assessment methodology.

The OAH assessment methodology, which Oregon developed in 2023 based on the workgroup's guidance, utilizes a combination of biological indicators and chemical measures to evaluate the health of marine aquatic life. SCCWRP was among the advisory workgroup's members.

The workgroup helped Oregon synthesize the science and provided technical review of Oregon's work. Oregon is planning to begin using the methodology in 2024 to assess OAH conditions in its coastal waters.

OAH conditions are intensifying along the West Coast, with coastal marine life in the Pacific Northwest disproportionately affected by changing seawater chemistry conditions.

Shell-forming organisms are having a tougher time building their shells as changing seawater chemistry lessens the availability of minerals that these organisms depend on.

Although the consequences of OAH for Southern California marine life have been relatively muted compared to more northern waters, these unfavorable conditions are expected to intensify across coastal Southern California in the coming years.

Tiny sea snails known as pteropods, which are collected using a plankton tow net, have provided some of the earliest signs of the ecological effects of ocean acidification and hypoxia in California coastal waters. A technical workgroup helped guide the State of Oregon in developing a standardized approach for assessing OAH effects on coastal marine life.

Evaluation of CO_2 removal technology to shed light on possible solution for climate change

SCCWRP and its partners have begun working to evaluate the effectiveness of a technology designed to remove dissolved carbon dioxide directly from coastal waters – an investigation that will shed light on whether this potential management solution could help combat global climate change as well as alleviate the effects of intensifying West Coast ocean acidification.

SCCWRP began working with startup company Captura in 2023 to examine if the company's electro-dialysis technology has the potential to draw down carbon dioxide in the atmosphere by removing carbon dioxide from coastal waters.

Captura's working hypothesis is that carbon dioxide removal will increase the waters' capacity to absorb carbon dioxide from the atmosphere.

SCCWRP will explore whether this technology also has the potential to offset the ecological effects of ocean acidification in Southern California coastal waters.

Electrodialysis is one of multiple marine carbon dioxide removal (mCDR) technologies being investigated as potential solutions for the effects of climate change and coastal OAH.

Courtesy of Captura Corporation

Researchers are working with Captura to investigate whether its electrodialysis technology, pictured above on a pier in Newport Beach, has the potential to help combat global climate change as well as alleviate the effects of intensifying West Coast ocean acidification.

Experts on HABs, kelp convened to support development of ocean health report cards

SCCWRP has convened two groups of experts to develop consensus on how to assess the state of harmful algal blooms (HABs) and kelp, respectively, in California and West Coast marine waters – part of an ongoing effort to develop multi-indicator report cards for tracking coastal ocean health.

The two groups, which began meeting in 2023, have been tasked with developing scientific consensus on what data sets should be used to assess HABs and kelp, respectively, as well as what thresholds should be used as the basis for assessing condition, and what level of uncertainty is acceptable.

HABs and kelp are two of 18 indicators under development that will feed into ocean health report cards being built for both California and the U.S. West Coast. The pair of report cards will be released in 2025.

Large global variation in the carbon dioxide removal potential of seaweed farming due to biophysical constraints

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Abstract

Estimates suggest that over 4 gigatons per year of carbon dioxide (Gt-CO_2 year^{-1}) be removed from the atmosphere by 2050 to meet international climate goals. One strategy for carbon dioxide removal is seaweed farming; however its global potential remains highly uncertain. Here, we apply a dynamic seaweed growth model that includes growth-limiting mechanisms, such as nitrate supply, to estimate the global potential yield of four types of seaweed. We estimate that harvesting 1 Gt year^{-1} of seaweed carbon would require farming over 1 million km^2 of the most productive exclusive economic zones, located in the equatorial Pacific; the cultivation area would need to be tripled to attain an additional 1 Gt year^{-1} of harvested carbon, indicating dramatic reductions in carbon harvest efficiency beyond the most productive waters. Improving the accuracy of annual harvest yield estimates requires better understanding of biophysical constraints such as seaweed loss rates (e.g., infestation, disease, grazing, wave erosion).

Citation

Arzeno-Soltero, I.B., B.T. Saenz, C.A. Frieder, M.C. Long, J. DeAngelo, S.J. Davis, K.A. Davis. 2023. Large global variations in the carbon dioxide removal potential of seaweed farming due to biophysical constraints. *Communications Earth and Environment* 4:185.

SCCWRP Journal Article #1337
Full text available online: www.sccwrp.org/publications

Economic and biophysical limits to seaweed farming for climate change mitigation

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Abstract

Net-zero greenhouse gas (GHG) emissions targets are driving interest in opportunities for biomass-based negative emissions and bioenergy, including from marine sources such as seaweed. Yet the biophysical and economic limits to farming seaweed at scales relevant to the global carbon budget have not been assessed in detail. We use coupled seaweed growth and technoeconomic models to estimate the costs of global seaweed production and related climate benefits, systematically testing the relative importance of model parameters. Under our most optimistic assumptions, sinking farmed seaweed to the deep sea to sequester a gigaton of CO_2 per year costs as little as US$480 per t$CO_2$ on average, while using farmed seaweed for products that avoid a gigaton of CO_2-equivalent GHG emissions annually could return a profit of $50 per t$CO_2$-eq. However, these costs depend on low farming costs, high seaweed yields, and assumptions that almost all carbon in seaweed is removed from the atmosphere (that is, competition between phytoplankton and seaweed is negligible) and that seaweed products can displace products with substantial embodied non-CO_2 GHG emissions. Moreover, the gigaton-scale climate benefits we model would require farming very large areas (>90,000 km^2)—a >30-fold increase in the area currently farmed. Our results therefore suggest that seaweed-based climate benefits may be feasible, but targeted research and demonstrations are needed to further reduce economic and biophysical uncertainties.

Citation

DeAngelo, J., B.T. Saenz, I.B. Arzeno-Soltero, C.A. Frieder, M.C. Long, J. Hamman, K.A. Davis, S.J. Davis. 2023. Economic and biophysical limits to seaweed farming for climate change mitigation. *Natural Plants* 9:45-57.

SCCWRP Journal Article #1311
Full text available online: www.sccwrp.org/publications

Changes in the macrobenthic infaunal community of the Southern California continental margin over five decades in relation to oceanographic factors

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Abstract

Climate change has altered the physiochemical conditions of the coastal ocean but effects on infaunal communities have not been well assessed. Here, we used multivariate ordination to examine temporal patterns in benthic community composition from 4 southern California continental shelf monitoring programs that range in duration from 30 to 50 yr. Temporal changes were compared to variations in temperature, oxygen, and acidification using single-taxon random forest models. Species richness increased over time, coupled with a decline in overall abundance. Continental shelf macrobenthic communities from the 2010s comprised a broader array of feeding guilds and life history strategies than in the 1970s. Changing water temperature was associated with northward shifts in geographic distribution and increases in species abundance, while acidification was associated with southward shifts and declines in abundance of other species. Acidification was also associated with changes in depth distribution of benthic fauna, with shelled molluscs declining in abundance at depths most associated with increasing exposure to acidification. This broad-scale community-level analysis establishes causal hypotheses that set the stage for more targeted studies investigating shifts in abundance or distribution for taxa that appear to be responding to climate change-related disturbances.

Citation

Gillett, D.J., S.B. Weisberg, S.R. Alin, D. Cadien, R. Velarde, K. Barwick, C. Larsen, A. Latker. 2023. Changes in the macrobenthic infaunal community of the Southern California continental margin over five decades in relation to oceanographic factors. *Marine Ecology Progress Series* 722:65-88.

SCCWRP Journal Article #1351
Full text available by request: pubrequest@sccwrp.org

Toward improved sediment management and coastal resilience through efficient permitting in California

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Abstract

The value of sediment for helping coastal habitats and infrastructure respond to sea level rise is widely recognized. Across the country, coastal managers are seeking ways to beneficially use sediment sourced from dredging and other projects to counter coastal erosion and protect coastal resources. However, these projects are difficult to permit and have been slow to actualize. This paper draws on interviews with sediment managers and regulators in California to explore the challenges and opportunities for habitat restoration and beach nourishment within the current permitting regime. We find that permits are costly, difficult to obtain, and sometimes stand as a barrier to more sustainable and adaptive sediment management. We next characterize streamlining approaches and describe entities and ongoing efforts within California that apply them. Finally, we conclude that to keep pace with coastal losses due to climate change impacts, efforts toward efficient permitting must be accelerated and approaches diversified to support coastal resilience practices state-wide, in a timeframe that will allow coastal managers to innovate and adapt.

Citation

Goodrich, K.A., N. Ulibarri, R. Matthew, E.D. Stein, M. Brand, B.F. Sanders. 2023. Toward improved sediment management and coastal resilience through efficient permitting in California. *Environmental Management* 72:558–567.

SCCWRP Journal Article #1353
Full text available by request: pubrequest@sccwrp.org

Expert panel affirms State's CEC strategy is working

An advisory panel of international scientific experts that was tasked with reviewing California's management strategy for monitoring CECs (contaminants of emerging concern) in aquatic environments has concluded that California has successfully implemented the strategy as conceptualized and that these investments have been effective.

The seven-member panel, which completed its review in 2023, found that the risk-based management framework that California has been using for deciding which CECs to prioritize and monitor is fundamentally sound.

The CEC Ecosystems Panel was originally convened in 2009 to conceptualize a proposed CEC monitoring strategy for California; this present-day framework was published in 2012.

Since then, California has largely implemented the original panel's recommendations, including generating more CEC monitoring data for assessing exposure in aquatic environments.

The reconvened panel reviewed the monitoring data and developed a prescriptive workflow that California can use to analyze and complete quality-control steps for the data – and ultimately use the data to produce updated lists of CECs that should be monitoring priorities for California.

A panel of scientific experts has found that the risk-based management framework that California uses for monitoring CECs is fundamentally sound. Multiple types of pharmaceuticals, above, are among the CECs that California has identified as potential monitoring priorities in aquatic environments.

Size of microplastics toxicity database nearly doubled

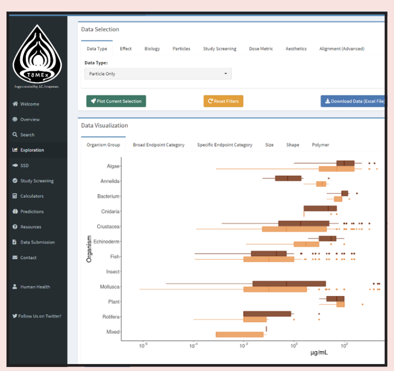
SCCWRP and its partners have nearly doubled the size of a public, web-based repository of toxicity data that summarizes the health effects of microplastics exposure on humans and aquatic life – a major expansion that reflects the key role the Toxicity of Microplastics Explorer (ToMEx) is playing in advancing California's microplastics management strategy.

Microplastics researchers from 14 nations met multiple times in 2023 to evaluate newer microplastics toxicity studies and decide if and how to add the data from these studies to the ToMEx database. Scoring criteria were used to decide which studies are not of sufficient quality.

ToMEx, which will be updated with the new data in 2024, is serving as a key resource for microplastics toxicity experts as they develop health thresholds that define for California managers the exposure levels at which microplastics can be expected to trigger adverse biological effects.

Preliminary thresholds already have been derived for aquatic life; work is ongoing to amass sufficient data to develop human health thresholds.

The 150+ new toxicity studies being added to ToMEx will help researchers refine preliminary aquatic life thresholds that were originally developed in 2021.



Researchers have nearly doubled the size of the Toxicity of Microplastics Explorer (ToMEx) tool, which is a public, web-based repository of toxicity data from published microplastics health effects studies.

Recommendations developed to improve C. dubia toxicity test

An expert science panel has developed best-practice recommendations for improving the quality and consistency of a toxicity test commonly used in California to monitor the water quality of treated wastewater and stormwater discharges.

The recommendations, published as a statewide guidance manual in 2023, were developed following an investigation that examined multiple aspects of lab culturing and testing procedures that could account for variability in results for the *Ceriodaphnia dubia* survival and chronic reproduction test. The toxicity test has been in use since the mid-1980s.

The study found that about half of labs consistently produced high-quality testing data. For the other half, the study concluded that variability was most likely a result of multiple, potentially intermittent causes unique to individual labs.

In response, the panel developed recommendations to help ensure consistent laboratory methods, an optimized accreditation process, and improved training for all parties.

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Bioanalytical and non-targeted mass spectrometric screening for contaminants of emerging concern in Southern California Bight sediments

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Abstract

Assessing the impact of chemical contaminants on aquatic ecosystem health remains challenging due to complex exposure scenarios and the myriad of impact metrics to consider. To expand the breadth of compounds monitored and evaluate the potential hazard of environmental mixtures, cell-based bioassays (estrogen receptor alpha (ERα) and aryl hydrocarbon receptor (AhR)) and non-targeted chemical analyses with high resolution mass spectrometry (NTA-HRMS) were used to assess the quality of ~70 marine sediment samples collected from 5 distinct coastal and offshore habitats of the Southern California Bight. AhR responses (<0.12–4.5 ng TCDD/g dry weight) were more frequently detectable and more variable than for ERα (<0.1–0.5 ng E2/g dry weight). The range of AhR and ERα responses increased by habitat as follows: Channel Islands < Mid-shelf < Marinas < Ports < Estuaries. The narrow range and magnitude of ERα screening response suggested limited potential for estrogenic impacts across sediments from all 5 habitats. The AhR response was positively correlated with total PAH and PCB concentrations and corresponded with a chemical score index representing the severity of metal and organic contamination. NTA-HRMS fingerprints generated in positive electrospray ionization mode were clearly distinguishable among coastal vs. offshore samples, with the greatest chemical complexity (n = 982 features detected) observed in estuarine sediment from a highly urbanized watershed (Los Angeles River). The concordance and complementary nature of bioscreening and NTA-HRMS results indicates their utility as holistic proxies for sediment quality, and when analyzed in conjunction with routine targeted chemical monitoring, show promise in identifying unexpected contaminants and novel toxicants.

Citation

Mehinto, A.C., B. Du, E. Wenger, Z. Tian, E.P. Kolodziej, D. Apeti, K.A. Maruya. 2023. Bioanalytical and non-targeted mass spectrometric screening for contaminants of emerging concern in Southern California bight sediments. *Chemosphere* 331:138789.

SCCWRP Journal Article #1338
Full text available by request: pubrequest@sccwrp.org

Assessing bioaccumulation potential of sediment associated fipronil degradates in oligochaete *Lumbriculus variegatus* based on passive sampler measured bioavailable concentration

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Abstract

The degradates of fipronil have equivalent or even more toxicity to non-target aquatic invertebrates. To assess their environmental risks, information of bioaccumulation is required. Currently, little is known about the bioaccumulative property of fipronil degradates in sediment, while it is well known that passive sampler may measure bioavailable concentration (Cfree) which links with the environmental effect more tightly than the total environment concentration. The goal of the present study was to characterize bioaccumulation potential in oligochaete Lumbriculus variegatus for a fipronil degradate sulfide. The sediment organic carbon-water partition coefficient (KOC) was measured with polymethyl methacrylate (PMMA) film passive sampler, and KOC was used to bridge the gap between biota-sediment accumulation factor (BSAF) and bioconcentration factor (BCF). The bioavailable concentration (Cfree)-based KOC values were 5371 ± 152 and 5013 ± 152 (mL/g OC) for fipronil sulfide (FSI) and sulfone (FSO), respectively. Since the two fipronil degradates were produced continuously in sediment by the parent compound, the time-weighted-average (TWA) concentration of FSI in the sediment was estimated from a bioassay with L. variegatus to calculate BSAF value (0.581±0.211 g OC/g lipid) and BCF (3046±1103 or log 3.48±0.16mL/g). This approach is able to estimate the Cfree-based KOC and BCF values of fipronil degradate in sediment with ongoing degradation of the parent compound.

Citation

Wang, S., W. Lao, H. Li, L. Guo, J. You. 2023. Assessing bioaccumulation potential of sediment associated fipronil degradates in oligochaete Lumbriculus variegatus based on passive sampler measured bioavailable concentration. *Science of the Total Environment* 863:1-7.

SCCWRP Journal Article #1306
Full text available by request: pubrequest@sccwrp.org

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Incorporating performance reference compounds in retractable/reusable solid phase microextraction fiber for passive sampling of hydrophobic organic contaminants in water

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Abstract

Solid phase microextraction (SPME) has been used to measure aqueous-phase hydrophobic organic chemicals (HOCs) in equilibrium passive sampling mode for over two decades. However, determination of the extent of equilibrium has not been well-established for the retractable/reusable SPME sampler (RR-SPME), especially in the field applications. The goal of this study was to establish a method regarding to sampler preparation and data processing to characterize the extent of equilibrium of HOCs on the RR-SPME (100-µm thickness of polydimethylsiloxane (PDMS) coating) by incorporating performance reference compounds (PRCs). A fast (4 h) PRC loading protocol was identified with using a ternary solvent mixture (i.e., acetone-methanol-water mixture (4:4:2, v/v)) to accommodate diverse carrier solvents of the PRCs. The isotropy of the RR-SPME was validated by a paired, co-exposure approach with 12 different PRCs. The aging factors measured with the co-exposure method approximately equal to one, indicating the isotropic behavior was not changed after storage at 15 °C and −20 °C for 28 days. As a method demonstration, the PRC-loaded RR-SPME samplers were deployed in the ocean off Santa Barbara, CA (USA) for 35 days. The PRCs approaching the extents of equilibrium ranged from 20 ± 15.5 % to 96.5 ± 1.5 % and showed a declining trend along with log KOW increase. A generic equation relationship was deduced based on a correlation relationship of desorption rate constant (k2) and log KOW to extrapolate non-equilibrium correction factor from the PRCs to the HOCs. The merit of the present study is manifested by its theory and implement to enable the RR-SPME passive sampler to be utilized in environmental monitoring.

Citation

Lao, W. 2023. Incorporating performance reference compounds in retractable/reusable solid phase microextraction fiber for passive sampling of hydrophobic organic contaminants in water. *Science of the Total Environment* DOI:10.1016/j.scitotenv.2023.162252.

SCCWRP Journal Article #1313
Full text available by request: pubrequest@sccwrp.org

Passive-sampler-derived PCB and OCP concentrations in the waters of the world—First results from the AQUA-GAPS/MONET Network

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Abstract

Persistent organic pollutants (POPs) are recognized as pollutants of global concern, but so far, information on the trends of legacy POPs in the waters of the world has been missing due to logistical, analytical, and financial reasons. Passive samplers have emerged as an attractive alternative to active water sampling methods as they accumulate POPs, represent time-weighted average concentrations, and can easily be shipped and deployed. As part of the AQUA-GAPS/MONET, passive samplers were deployed at 40 globally distributed sites between 2016 and 2020, for a total of 21 freshwater and 40 marine deployments. Results from silicone passive samplers showed α-hexachlorocyclohexane (HCH) and γ-HCH displaying the greatest concentrations in the northern latitudes/Arctic Ocean, in stark contrast to the more persistent penta (PeCB)- and hexachlorobenzene (HCB), which approached equilibrium across sampling sites. Geospatial patterns of polychlorinated biphenyl (PCB) aqueous concentrations closely matched original estimates of production and use, implying limited global transport. Positive correlations between log-transformed concentrations of Σ7PCB, ΣDDTs, Σendosulfan, and Σchlordane, but not ΣHCH, and the log of population density ($p < 0.05$) within 5 and 10 km of the sampling sites also supported limited transport from used sites. These results help to understand the extent of global distribution, and eventually time-trends, of organic pollutants in aquatic systems, such as across freshwaters and oceans. Future deployments will aim to establish time-trends at selected sites while adding to the geographical coverage.

Citation

Lohmann, R., B. Vrana, D. Muir, F. Smedes, J. Sobotka, E.Y. Zeng, L. Bao, I.J. Allan, P. Astrahan, R.O. Barra, T. Bidleman, E. Dykyi, N. Estoppey, G. Fillmann, N. Greenwood, P.A. Helm, L. Jantunen, S. Kaserzon, J.V. Macias, K.A. Maruya, F. Molina, B. Newman, R.M. Prats, M. Tsapakis, M. Tysklind, B.L. van Drooge, C.J. Veal, C.S. Wong. 2023. Passive-Sampler-Derived PCB and OCP Concentrations in the Waters of the World—First Results from the AQUA-GAPS/MONET Network. *Environmental Science and Technology* 57:9342-9352.

SCCWRP Journal Article #1331
Full text available by request: pubrequest@sccwrp.org

Comparison of two procedures for microplastics analysis in sediments based on interlaboratory exercise

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Abstract

Microplastics (MP) are distributed throughout ecosystems and settle into sediments where they may threaten benthic communities; however, methods for quantifying MP in sediments have not been standardized. This study compares two methods for analyzing MP in sediments, including extraction and identification, and provides recommendations for improvement. Two laboratories processed sediment samples using two methods, referred to as “core” and “augmentation”, and identified particles with visual microscopy and spectroscopy. Using visual microscopy, the augmentation method yielded mean recoveries (78%) significantly greater than the core (47%) ($p = 0.03$), likely due to the use of separatory funnels in the former. Spectroscopic recovery of particles was lower at 42 and 54% for the core and augmentation methods, respectively. We suspect the visual identification recoveries are overestimations from erroneous identification of non-plastic materials persisting post-extraction, indicating visual identification alone is not an accurate method to identify MP, particularly in complex matrices like sediment. However, both Raman and FTIR proved highly accurate at identifying recovered MP, with 96.7% and 99.8% accuracy, respectively. Low spectroscopic recovery of spiked particles indicates that MP recovery from sediments is lower than previously assumed, and MP may be more abundant in sediments than current analyses suggest. To our knowledge, likely due to the excessive time/labor-intensity associated with MP analyses, this is the first interlaboratory study to quantify complete method performance (extraction, identification) for sediments, with regards to capabilities and limitations. This is essential as regulatory bodies move toward long-term environmental MP monitoring.

Citation

Langknecht, T., W. Lao, C.S. Wong, S. Kotar, D.E. Khatib, S. Robinson, R.M. Burgess, K.T. Ho. 2023. Comparison of two procedures for microplastics analysis in sediments based on an interlaboratory exercise. *Chemosphere* DOI:10.1016/j.chemosphere.2022.137479.

SCCWRP Journal Article #1308
Full text available by request: pubrequest@sccwrp.org

How to establish detection limits for environmental microplastics analysis

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Abstract

Establishing analytical detection limits is crucial. Common methods to do so are suitable only for variables with continuous distributions. Because count data for microplastic particles is a discrete variable following the Poisson distribution, currently-used approaches for estimating the detection limit in microplastics analysis are inadequate. Here we evaluate the minimum detectable amount (MDA) in microplastic particle analysis, using blank sample data from an interlaboratory calibration exercise for clean water (representing drinking water), dirty water (ambient water), sediment (porous media) and fish tissue (biotic tissues). Two MDAs are applicable: MDA_A to evaluate analytical methods, estimated with replicate blank data; and MDA_B for individual sample batches, calculated with a single blank count. For illustrative purposes, this dataset’s overall MDA_A values were 164 counts (clean water), 88 (dirty water), 192 (sediment), and 379 (tissue). MDA values should be reported on a laboratory-specific basis and for individual size fractions, as this provides more useful information about capabilities of individual laboratories. This is due to wide variation in blank levels, as noted by MDAB values (i.e., among different laboratories) from 14 to 158 (clean water), 9 to 86 (dirty water, 9 to 186 (sediment), and 9 to 247 (tissue). MDA values for fibers were considerably greater than for non-fibers, suggesting that separate MDA values should be reported. This study provides a guideline for estimation and application of microplastics MDA for more robust data to support research activities and environmental management decisions.

Citation

Lao, W., C.S. Wong. 2023. How to establish detection limits for environmental microplastics analysis. *Chemosphere* 327:138456.

SCCWRP Journal Article #1317
Full text available by request: pubrequest@sccwrp.org

What determines accuracy of chemical identification when using micro spectroscopy for the analysis of microplastics?

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Abstract

Fourier transform infrared (FTIR) and Raman microspectroscopy are methods applied in microplastics research to determine the chemical identity of microplastics. These techniques enable quantification of microplastic particles across various matrices. Previous work has highlighted the benefits and limitations of each method and found these to be complimentary. Within this work, metadata collected within an interlaboratory method validation study was used to determine which variables most influenced successful chemical identification of un-weathered microplastics in simulated drinking water samples using FTIR and Raman microspectroscopy. No variables tested had a strong correlation with the accuracy of chemical identification ($r = \leq 0.63$). The variables most correlated with accuracy differed between the two methods, and include both physical characteristics of particles (color, morphology, size, polymer type), and instrumental parameters (spectral collection mode, spectral range). Based on these results, we provide technical recommendations to improve capabilities of both methods for measuring microplastics in drinking water and highlight priorities for further research. For FTIR microspectroscopy, recommendations include considering the type of particle in question to inform sample presentation and spectral collection mode for sample analysis. Instrumental parameters should be adjusted for certain particle types when using Raman microspectroscopy. For both instruments, the study highlighted the need for harmonization of spectral reference libraries among research groups, including the use of libraries containing reference materials of both weathered plastic and natural materials that are commonly found in environmental samples.

Citation

De Frond, H., W. Cowger, V. Renick, S. Brander, S. Primpke, S. Sukumaran, D. Elkhatib, S. Barnett, M. Navas-Moreno, K. Rickabaugh, F. Vollnhals, B. O'Donnell, A. Lusher, E. Lee, W. Lao, G. Amarpuri, G. Sarau, S. Christiansen. 2023. What determines accuracy of chemical identification when using microspectroscopy for the analysis of microplastics? *Chemosphere* DOI:10.1016/j.chemosphere.2022.137300.

SCCWRP Journal Article #1312
Full text available by request: pubrequest@sccwrp.org

Patterns of microplastics in blank samples: a study to inform best practices for microplastic analysis

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Abstract

Quality assurance and quality control (QA/QC) techniques are critical to analytical chemistry, and thus the analysis of microplastics. Procedural blanks are a key component of QA/QC for quantifying and characterizing background contamination. Although procedural blanks are becoming increasingly common in microplastics research, how researchers acquire a blank and report and/or use blank contamination data varies. Here, we use the results of laboratory procedural blanks from a method evaluation study to inform QA/QC procedures for microplastics quantification and characterization. Suspected microplastic contamination in the procedural blanks, collected by 12 participating laboratories, had between 7 and 511 particles, with a mean of 80 particles per sample (±SD 134). The most common color and morphology reported were black fibers, and the most common size fraction reported was 20–212 µm. The lack of even smaller particles is likely due to limits of detection versus lack of contamination, as very few labs reported particles <20 µm. Participating labs used a range of QA/QC techniques, including air filtration, filtered water, and working in contained/'enclosed' environments. Our analyses showed that these procedures did not significantly affect blank contamination. To inform blank subtraction, several subtraction methods were tested. No clear pattern based on total recovery was observed. Despite our results, we recommend commonly accepted procedures such as thorough training and cleaning procedures, air filtration, filtered water (e.g., MilliQ, deionized or reverse osmosis), non-synthetic clothing policies and 'enclosed' air flow systems (e.g., clean cabinet). We also recommend blank subtracting by a combination of particle characteristics (color, morphology and size fraction), as it likely provides final microplastic particle characteristics that are most representative of the sample. Further work should be done to assess other QA/QC parameters, such as the use of other types of blanks (e.g., field blanks, matrix blanks) and limits of detection and quantification.

Citation

Munno, K., A.L. Lusher, E.C. Minor, A. Gray, K. Ho, J. Hankett, C.T. Lee, S. Primpke, R.E. McNeish, C.S. Wong, C. Rochman. 2023. Patterns of microparticles in blank samples: A study to inform best practices for microplastic analysis. *Chemosphere* 333:138883.

SCCWRP Journal Article #1325
Full text available by request: pubrequest@sccwrp.org

The influence of complex matrices on method performance in extracting and monitoring for microplastics

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Abstract

Previous studies have evaluated method performance for quantifying and characterizing microplastics in clean water, but little is known about the efficacy of procedures used to extract microplastics from complex matrices. Here we provided 15 laboratories with samples representing four matrices (i.e., drinking water, fish tissue, sediment, and surface water) each spiked with a known number of microplastic particles spanning a variety of polymers, morphologies, colors, and sizes. Percent recovery (i.e., accuracy) in complex matrices was depented, with ~60-70% recovery for particles >212 um, but as little as 2% recovery for particles <20 um. Extraction from sediment was most problematic, with recoveries reduced by at least one-third relative to drinking water. Though accuracy was low, the extraction procedures had no observed effect on precision or chemical identification using spectroscopy. Extraction procedures greatly increased sample processing times for all matrices with the extraction of sediment, tissue, and surface water taking approximately 16, 9, and 4 time slonger than drinking water, respectively. Overall, our findings indicate that increasing accuracy and reducing sample processing times present opportunities for method improvement rather than particle identification and characterization.

Citation

Thornton Hampton, L.M., H. De Frond, K. Gesulga, S. Kotar, W. Lao, C. Matuch, S.B. Weisberg, C.S. Wong, S. Brander, S. Christansen, C.R. Cook, F. Du, S. Ghosal, A.B. Gray, J. Hankett, P.A. Helm, K.T. Ho, T. Kefela, G. Lattin, A. Lusher, L. Mai, R.E. McNeish, O. Mina, E.C. Minor, S. Primpke, K. Rickabaugh, V.C. Renick, S. Singh, B.V. Bavel, F. Vollnhals, C.M. Rochman. 2023. The influence of complex matrices on method performance in extracting and monitoring for microplastics. *Chemosphere* 334:138875

SCCWRP Journal Article #1335
Full text available by request: pubrequest@sccwrp.org

Presence of antibiotic resistance genes in the receiving environment of Iqaluit's wastewater treatment plant in water, sediment, and clams sampled from Frobisher Bay, Nunavut: A preliminary study in the Canadian Arctic

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ABSTRACT

Antibiotic resistance (AR) is a growing health concern worldwide and the Arctic represents an understudied region in terms of AR. This study aimed to quantify AR genes (ARGs) from effluent released from a wastewater treatment plant (WWTP) in Iqaluit, Nunavut, Canada, thus creating a baseline reference for future evaluations. Water, sediment, and truncate softshell clam (*Mya truncate*) tissue samples were compared from the wastewater, the receiving environment of Frobisher Bay, and nearby undisturbed freshwaters. The pharmaceuticals and personal care products (PPCPs) atenolol, carbamazepine, metoprolol, naproxen, sulfapyridine, and trimethoprim were found in the wastewater, but the PPCPs were undetectable in the receiving environment. However, the relative abundances of ARGs were significantly higher in wastewater than in the receiving environment or reference sites. Abundances did not significantly differ in Frobisher Bay compared to undisturbed reference sites. ARGs in clams near the WWTP had similar relative abundances as those from pristine areas. The lack of ARG detection is likely due to Frobisher Bay tides flushing inputs to levels below detection. These data suggest that the WWTP infrastructure does not influence the receiving environment based on the measured parameters; more importantly, further research must elucidate the impact and fate of AR and PPCPs in Arctic communities.

CITATION

Starks, M., C.M. Schaefer, K.M. Jeffries, D. Deslauriers, K.H. Luong, C.S. Wong, M.L. Hanson, C.W. Knapp. 2023. Presence of antibiotic resistance genes in the receiving environment of Iqaluit's wastewater treatment plant in water, sediment, and clams sampled from Frobisher Bay, Nunavut: a preliminary study in the Canadian Arctic. *Arctic Science* 9:919-927.

SCCWRP Journal Article #1357
Full text available online: www.sccwrp.org/publications

Monitoring strategies for constituents of emerging concern (CECs) in California's aquatic ecosystems: Recommendations of a Science Advisory Panel

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[4]Environment and Climate Change Canada
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[7]Nanyang Technical University, Singapore

CITATION

Drewes, J.E., P. Anderson, N. Denslow, D.C.G. Muir, A. Olivieri, D. Schlenk, S.A. Snyder. 2023. Monitoring Strategies for Constituents of Emerging Concern (CECs) in California's Aquatic Ecosystems. Technical Report 1302. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1302
Full text available online: www.sccwrp.org/publications

Ceriodaphnia dubia quality assurance guidance recommendations

Robert Brent[1], Howard Bailey[2], Teresa Norberg-King[3], Leana Van der Vliet[4], and A. John Bailer[5]

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[4]Environment and Climate Change Canada, Gatineau, Quebec, Canada
[5]Miami University, Oxford, OH

CITATION

Brent, R., H. Bailey, T. Norberg-King, L. Van der Vliet, A. John Bailer. 2023. Ceriodaphnia dubia Quality Assurance Guidance Recommendations. Technical Report 1341. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1341
Full text available online: www.sccwrp.org/publications

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City of L.A. launches study to use ddPCR to monitor spills

SCCWRP and the City of Los Angeles have begun working to earn regulatory approvals to use a rapid, DNA-based method for detecting fecal contamination at City beaches – an advance that would enhance the City's ability to reopen beaches as soon as safely possible following sewage spills.

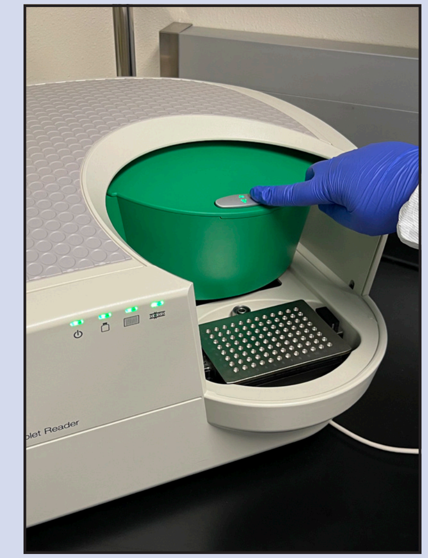
The study, launched in 2023, will compare the performance of the droplet digital polymerase chain reaction (ddPCR) method to traditional bacteria culturing methods and an EPA-approved quantitative PCR method for detecting fecal contamination in beach water.

The ddPCR method, which SCCWRP and its member agencies have spent nearly a decade vetting and optimizing, enables public health agencies to notify beachgoers about contamination on the same day that water samples are collected.

By contrast, results from traditional, culture-based methods are typically not available for 24 to 72 hours after samples reach the laboratory – a reporting delay that can influence how rapidly beaches can be closed and reopened following sewage spills.

Although the City of Los Angeles is not planning to replace culture-based methods with ddPCR for routine testing, the City would be granted this option following successful completion of the method comparison study.

In 2022, San Diego County became the first municipality in the nation to end reliance on culture-based methods altogether in favor of using the ddPCR method across more than 50 beach locations.



The City of Los Angeles is seeking to enhance its ability to reopen beaches as soon as safely possible following sewage spills by gaining regulatory approvals to use the droplet digital polymerase chain reaction (ddPCR) method, above.

Second phase of Newport Bay study revisits shellfish water-quality standard

SCCWRP and its partners have launched the second phase of a study examining whether an existing water-quality standard designed to protect the health of people who consume shellfish from Newport Bay is built on solid scientific footing – a study that could have implications for similar bodies statewide that also have been failing to meet this regulatory standard.

The study's second phase, initiated in 2023, is probing whether California's existing standard for permissible bacterial levels correlates to potentially unsafe levels of pathogens in bivalve shellfish that are harvested from Newport Bay during wet weather.

The study's first phase, which examined this same relationship during dry weather, found no correlation. Bacterial levels, however, tend to be higher during wet weather. The Phase 2 findings will be released in 2024.

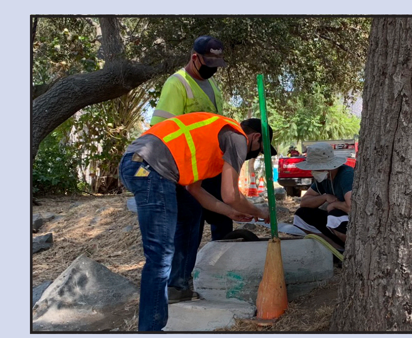
Leak detection method successfully applied to test public sewer pipes across San Diego area

SCCWRP and its partners have successfully tested more than 25 underground sewer pipes in the San Diego area for leaks using a newly developed method that can detect volumetric losses of as little as a one liter out of 4,000 liters – a key milestone in ongoing efforts to estimate what portion of human fecal contamination in the region's waterways can be attributed to raw wastewater exfiltrating from public sewer systems.

Data from the field testing, which was completed in 2023, will enable researchers to extrapolate how much sewage is exfiltrating from sewer pipes across the lower San Diego River watershed. The findings are scheduled to be published in 2024.

The exfiltration method utilizes prototype equipment and methods developed by SCCWRP. It involves pumping a known volume of water at a controlled rate through an isolated section of sewer pipe, then looking for a difference in the volume pumped in vs. recovered.

The sites where the method has been deployed represent a range of different pipe materials and ages.



A field crew recovers water from a sewer manhole in San Diego County as part of an effort to measure exfiltration from underground sewer pipes. Researchers are studying what portion of human fecal contamination in the San Diego River watershed, if any, can be attributed to raw wastewater exfiltrating from public sewer systems.

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Host and water microbiota are differentially linked to potential human pathogen accumulation in oysters

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Abstract

Oysters play an important role in coastal ecology and are a globally popular seafood source. However, their filter-feeding lifestyle enables coastal pathogens, toxins, and pollutants to accumulate in their tissues, potentially endangering human health. While pathogen concentrations in coastal waters are often linked to environmental conditions and runoff events, these do not always correlate with pathogen concentrations in oysters. Additional factors related to the microbial ecology of pathogenic bacteria and their relationship with oyster hosts likely play a role in accumulation but are poorly understood. In this study, we investigated whether microbial communities in water and oysters were linked to accumulation of *Vibrio parahaemolyticus*, *Vibrio vulnificus*, or fecal indicator bacteria. Site-specific environmental conditions significantly influenced microbial communities and potential pathogen concentrations in water. Oyster microbial communities, however, exhibited less variability in microbial community diversity and accumulation of target bacteria overall and were less impacted by environmental differences between sites. Instead, changes in specific microbial taxa in oyster and water samples, particularly in oyster digestive glands, were linked to elevated levels of potential pathogens. For example, increased levels of *V. parahaemolyticus* were associated with higher relative abundances of cyanobacteria, which could represent an environmental vector for *Vibrio spp.* transport, and with decreased relative abundance of Mycoplasma and other key members of the oyster digestive gland microbiota. These findings suggest that host and microbial factors, in addition to environmental variables, may influence pathogen accumulation in oysters.

Citation

Diner, R.E., A.G. Zimmer-Faust, E. Cooksey, S. Allard, S.M. Kodera, E. Kunselman, Y. Garodia, M.P. Verhougstraete, A.E. Allen, J.F. Griffith, J.A. Gilbert. 2023. Host and Water Microbiota Are Differentially Linked to Potential Human Pathogen Accumulation in Oysters. *Applied and Environmental Microbiology* DOI:10.1128/aem.00318-23.

SCCWRP Journal Article #1328
Full text available online: www.sccwrp.org/publications

Relationship between coliphage and *Enterococcus* at Southern California beaches and implications for beach water quality management

Amity G. Zimmer-Faust[1], John F. Griffith[1], Joshua A. Steele[1], Bryan Santos[2], Yiping Cao[3], Laralyn Asato[2], Tania Chiem[4], Samuel Choi[3], Arturo Diaz[3], Joe Guzman[4], David Laak[5], Michele Padilla[6], Jennifer Quach-Cu[6], Victor Ruiz[7], Mary Woo[8], Stephen B. Weisberg[1]

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Abstract

Coliphage have been suggested as an alternative to fecal indicator bacteria for assessing recreational beach water quality, but it is unclear how frequently and at what types of beaches coliphage produces a different management outcome. Here we conducted side-by-side sampling of male-specific and somatic coliphage by the new EPA dead-end hollow fiber ultrafiltration (D-HFUF-SAL) method and Enterococcus at southern California beaches over two years. When samples were combined for all beach sites, somatic and male-specific coliphage both correlated with *Enterococcus*. When examined categorically, *Enterococcus* would have resulted in approximately two times the number of health advisories as somatic coliphage and four times that of male-specific coliphage, using recently proposed thresholds of 60 PFU/100 mL for somatic and 30 PFU/100 mL for male-specific coliphage. Overall, only 12% of total exceedances would have been for coliphage alone. Somatic coliphage exceedances that occurred in the absence of an *Enterococcus* exceedance were limited to a single site during south swell events, when this beach is known to be affected by nearby minimally treated sewage. Thus, somatic coliphage provided additional valuable health protection information, but may be more appropriate as a supplement to FIB measurements rather than as replacement because: (a) EPA-approved PCR methods for *Enterococcus* allow a more rapid response, (b) coliphage is more challenging owing to its greater sampling volume and laboratory time requirements, and (c) *Enterococcus'* long data history has yielded predictive management models that would need to be recreated for coliphage.

Citation

Zimmer-Faust, A.G., J.F. Griffith, J.A. Steele, B. Santos, Y. Cao, L. Asato, T. Chiem, S. Choi, A. Diaz, J. Guzman, D. Laak, M. Padilla, J. Quach-Cu, M. Woo, S.B. Weisberg. 2023. Relationship between coliphage and Enterococcus at southern California beaches and implications for beach water quality management. *Journal of Water Research* 230:119383.

SCCWRP Journal Article #1330
Full text available by request: pubrequest@sccwrp.org

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Dry and wet weather survey for human fecal sources in the San Diego River Watershed

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Abstract

State and federal agencies regulate fecal indicator bacteria (FIB), such as *E. coli* or *Enterococcus*, in order to manage public health risks at swimming beaches. Despite these goals, watershed managers are challenged in terms of how to best clean up sources of FIB because concentrations frequently exceed water quality objectives, and sources—both human and nonhuman sources of FIB—appear to be everywhere. Since most nonhuman fecal sources represent substantially lower public health risks than human sources do, this study utilizes the human fecal source marker HF183 to better define watershed managers' riskiest sites and times in order to prioritize remediation actions. A total of 117 samples were collected and analyzed for both FIB and HF183 from 26 sites during multiple sampling campaigns between 2019 and 2021 along the mainstem in addition to major tributaries in a highly urbanized watershed. The results indicated that the vast majority of samples (96%) quantified HF183 during wet weather, ranging from 99 to 44,768 gene copies/100 mL. Similar to HF183, the FIB results exceeded water quality objectives for 100% of the samples in wet weather; however, HF183 was rarely quantified in dry weather, with 3 of 72 samples (4%) exceeding 500 gene copies/100 mL, while two-thirds of samples (67%) exceeded FIB water quality objectives during dry weather. Where HF183 was detected in dry weather, isolated and unpredictable events explained human fecal pollution. It is more challenging in wet weather to identify and quantify the source(s) of human fecal pollution.

Citation

Schiff, K.C., J.F. Griffith, J.A. Steele, A.G. Zimmer-Faust. 2023. Dry and Wet Weather Survey for Human Fecal Sources in the San Diego River Watershed. *Water* 15:2239.

SCCWRP Journal Article #1327
Full text available online: www.sccwrp.org/publications

Correlation between wastewater and COVID-19 case incidence rates in major California sewersheds across three variant periods

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Abstract

Monitoring for COVID-19 through wastewater has been used for adjunctive public health surveillance, with SARS-CoV-2 viral concentrations in wastewater correlating with incident cases in the same sewershed. However, the generalizability of these findings across sewersheds, laboratory methods, and time periods with changing variants and underlying population immunity has not been well described. The California Department of Public Health partnered with six wastewater treatment plants starting in January 2021 to monitor wastewater for SARS-CoV-2, with analyses performed at four laboratories. Using reported PCR-confirmed COVID-19 cases within each sewershed, the relationship between case incidence rates and wastewater concentrations collected over 14 months was evaluated using Spearman's correlation and linear regression. Strong correlations were observed when wastewater concentrations and incidence rates were averaged (10- and 7-day moving window for wastewater and cases, respectively, $\rho = 0.73–0.98$ for N1 gene target). Correlations remained strong across three time periods with distinct circulating variants and vaccination rates (winter 2020–2021/Alpha, summer 2021/Delta, and winter 2021–2022/Omicron). Linear regression revealed that slopes of associations varied by the dominant variant of concern, sewershed, and laboratory ($\beta = 0.45–1.94$). These findings support wastewater surveillance as an adjunctive public health tool to monitor SARS-CoV-2 community trends.

Citation

Rabe, A., S. Ravuri, E. Burnor, J.A. Steele, R.S. Kantor, S. Choi, S. Forman, R. Batjiaka, S. Jain, T.M. León, D.J. Vugia, A.T. Yu. 2023. Correlation between wastewater and COVID-19 case incidence rates in major California sewersheds across three variant periods. *Journal of Water & Health* 21:1303-1317.

SCCWRP Journal Article #1345
Full text available online: www.sccwrp.org/publications

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Longitudinal metatranscriptomic sequencing of Southern California wastewater representing 16 million people from August 2020-21 reveals widespread transcription of antibiotic resistance genes

Jason A. Rothman[1], Andrew Saghir[1], Seung-Ah Chung[2], Nicholas Boyajian[1], Thao Dinh[1], Jinwoo Kim[1], Jordan Oval[1], Vivek Sharavanan[1], Courtney York[1], Amity G. Zimmer-Faust[3], Kylie Langlois[3], Joshua A. Steele[3], John F. Griffith[3], Katrine L. Whiteson[1]

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Abstract

Municipal wastewater provides a representative sample of human fecal waste across a catchment area and contains a wide diversity of microbes. Sequencing wastewater samples provides information about human-associated and medically important microbial populations and may be useful to assay disease prevalence and antimicrobial resistance (AMR).

Here, we present a study in which we used untargeted metatranscriptomic sequencing on RNA extracted from 275 sewage influent samples obtained from eight wastewater treatment plants (WTPs) representing approximately 16 million people in Southern California between August 2020 – August 2021. We characterized bacterial and viral transcripts, assessed metabolic pathway activity, and identified over 2,000 AMR genes/variants across all samples. Because we did not deplete ribosomal RNA, we have a unique window into AMR carried as ribosomal mutants. We show that AMR diversity varied between WTPs (as measured through PERMANOVA, $P < 0.001$) and that the relative abundance of many individual AMR genes/variants increased over time (as measured with MaAsLin2, $P_{adj} < 0.05$). Similarly, we detected transcripts mapping to human pathogenic bacteria and viruses suggesting RNA sequencing is a powerful tool for wastewater-based epidemiology and that there are geographical signatures to microbial transcription. We captured the transcription of gene pathways common to bacterial cell processes, including central carbon metabolism, nucleotide synthesis/salvage, and amino acid biosynthesis. We also posit that due to the ubiquity of many viruses and bacteria in wastewater, new biological targets for microbial water quality assessment can be developed.

To the best of our knowledge, our study provides the most complete longitudinal metatranscriptomic analysis of a large population's wastewater to date and demonstrates our ability to monitor the presence and activity of microbes in complex samples. By sequencing RNA, we can track the relative abundance of expressed AMR genes/ variants and metabolic pathways, increasing our understanding of AMR activity across large human populations and sewer sheds.

Citation

Rothman, J.A., A. Saghir, S. Chung, N. Boyajian, T. Dinh, J. Kim, J. Oval, V. Sharavanan, C. York, A.G. Zimmer-Faust, K. Langlois, J.A. Steele, J.F. Griffith, K.L. Whiteson. 2023. Longitudinal metatranscriptomic sequencing of Southern California wastewater representing 16 million people from August 2020–21 reveals widespread transcription of antibiotic resistance genes. *Journal of Water Research* 329:119421.

SCCWRP Journal Article #1329
Full text available by request: pubrequest@sccwrp.org

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Mechanistic study to open stormwater BMP 'black box'

SCCWRP and its partners have launched a three-year study to characterize the mechanistic inner processes by which a ubiquitous class of stormwater BMPs (best management practices) removes common types of stormwater pollutants as runoff flows through them – an investigation that has the potential to open the "black box" for how these systems work and how managers can optimize their long-term performance.

The project, which kicked off in 2023, focuses on biofiltration BMPs, an engineered system that is intended to remove metals, nutrients, and persistent organic pollutants as runoff filters gradually through the system.

Researchers routinely measure the properties of runoff entering and exiting BMPs, but do not fully understand what happens to this runoff while it is being treated inside the BMP. Once researchers understand these processes, they'll be able to design and maintain BMPs optimized to treat runoff over the long term – particularly valuable given the significant investments Southern California has been making in implementing structural BMPs over the past decade.

Traditionally, stormwater managers have relied on published BMP design guidance manuals to inform how they design, construct and maintain BMPs. But the guidance in these manuals is based on incomplete mechanistic understanding of BMP performance.

A bioswale that runs along the side of a roadway in Orange County collects and treats stormwater runoff. SCCWRP and its partners have launched a study to characterize the mechanistic inner processes by which biofiltration BMPs remove common contaminants in runoff.

Additional monitoring added to study quantifying benefits of replacing turf lawns

SCCWRP and the County of San Diego have added an additional year of monitoring to a study seeking to quantify the runoff reduction benefits of replacing residential grass with drought-tolerant landscaping, following promising initial results that suggest turf replacement, a type of non-structural stormwater BMP (best management practice), can reduce volumes of dry- and wet-weather runoff by absorbing more irrigation and rainfall on site.

The expanded monitoring phase, which was greenlit in 2023, is using continuous soil moisture sensors and visual observation to quantify if dry- and wet-weather runoff are absorbed on site after turf and traditional spray irrigation are replaced with drought-tolerant landscaping and drip irrigation.

This first-of-its-kind study is exploring if turf replacement projects are effective at soaking up irrigation runoff and rainfall.

Custom-built rainfall generator deployed for first time in street sweeping study

SCCWRP has developed a custom-built, field-deployable rainfall generator capable of creating repeatable, controlled wet-weather conditions to support a study investigating the effectiveness of routine street sweeping in removing contaminants that enter storm drains and contribute to runoff pollution.

Researchers deployed the rainfall generator in 2023 to begin measuring how much bacteria, nutrients, trace heavy metals, microplastics and other common stormwater contaminants are transported from streets into storm drains during wet-weather flows, and if street sweeping is effective in preventing the transport of at least some of this pollution into storm drains.

The instrument, which researchers anticipate having widespread utility beyond the street sweeping study, will enable researchers to eliminate much of the variability that surrounds interpreting water-quality data from real-world rainfall and runoff events.

The rainfall generator can generate rainfall at a controlled rate and duration across 84 square feet of surface area.

A custom-built, field-deployable rainfall generator, pictured above in a Long Beach parking lot, is being used in a study investigating the effectiveness of routine street sweeping in removing contaminants that enter storm drains and contribute to runoff pollution.

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BMP monitoring network completes Year 1 sampling, doubling size for Year 2

The Southern California Stormwater Monitoring Coalition (SMC) has successfully collected monitoring data on the performance of structural stormwater BMPs (best management practices) across Southern California during its first-year sampling effort – and made plans to nearly double the size of its Regional BMP Monitoring Network during Year 2.

During the network's Year 1 wet-weather season, which ended in early 2023, researchers deployed field teams to seven BMPs spread across five sites, with as many as eight storm events sampled per site.

For Year 2, which encompasses the 2023-2024 wet-weather season, researchers set a goal to increase the number of BMPs being monitored to about 10.

The SMC's Regional BMP Monitoring Network, which is being led by SCCWRP, will help address significant, persistent knowledge gaps in managers' understanding of how to optimize the operation, maintenance and performance of structural stormwater BMPs.

Most BMP implementation decisions to date in Southern California have been made based on limited performance effectiveness data and analyses – often from outside the region.

Courtesy of Los Angeles County Public Works

A field crew constructs a bioretention planter in Riverside County. The Southern California Stormwater Monitoring Coalition (SMC) is collecting performance data for bioretention planters and other types of structural stormwater BMPs (best management practices) across Southern California via its new Regional BMP Monitoring Network.

Monitoring framework incorporated into three estuarine assessments

A statewide monitoring framework co-developed by SCCWRP to bring consistency to how California assesses the health of its coastal estuaries has been incorporated into three estuarine monitoring assessment efforts.

The estuary monitoring framework was incorporated in 2023 into a California Ocean Protection Council assessment of the health of California's estuarine Marine Protected Areas (MPAs), the Southern California Bight 2023 Regional Monitoring Program, and monitoring of smaller estuaries via the Santa Monica Bay National Estuary Program's Comprehensive Conservation and Management Plan. SCCWRP and its partners also began working to incorporate the framework into other monitoring efforts, including coastal resiliency monitoring by the U.S. Environmental Protection Agency.

The estuary monitoring framework focuses on evaluating ecological functioning of estuaries – an approach that allows for greater flexibility and comparability across California's highly heterogenous estuaries.

Bight '23 develops 7 study elements probing coastal ocean health

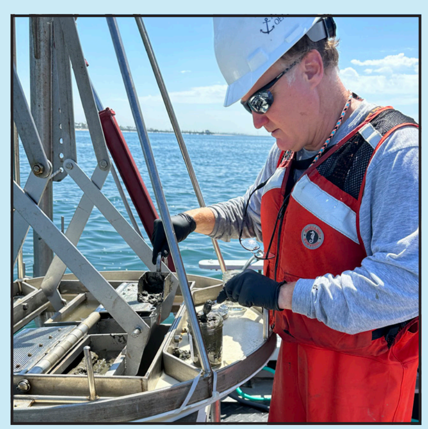
The Southern California Bight Regional Monitoring Program has developed seven study elements for its 2023 monitoring cycle – the largest number of elements to date – reflecting the program's commitment to probing a wide range of issues affecting the health of Southern California's coastal ocean.

Bight '23 kicked off in mid-2023 with field sampling supporting Sediment Quality and multiple other study elements.

Among the contaminants being monitored during the five-year monitoring cycle are CECs (contaminants of emerging concern) recently identified as monitoring priorities via a statewide review panel, including PFAS (per- and polyfluoroalkyl substances) and tire wear compounds.

Bight '23 also is investigating how a range of contaminants can accumulate in shellfish, including toxins produced by harmful algal blooms (HABs), pathogens, PFAS and microplastics.

The seven Bight '23 study elements are Sediment Quality, Water Quality, Microbiology, Trash and Microplastics, Estuaries, Harmful Algal Blooms and Submerged Aquatic Vegetation.



A Southern California Bight 2023 Regional Monitoring Program field crew member places sediment collected from the seafloor into jars. Bight '23 consists of seven study elements – the largest number of elements to date.

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Regional assessment of trash in Southern California coastal watersheds, United States

Karen McLaughlin[1], Raphael Mazor[1], Martha Sutula[1], and Kenneth Schiff[1]

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Abstract

Trash impairment of watersheds has been recognized as a worldwide environmental problem. Trash monitoring in streams and rivers is necessary to enhance our understanding of its effects on freshwater habitats and the role of streams as a conduit for transport to marine environments. Southern California, with a population of over 22 million, is home to nearly 7,400 km of wadeable streams in watersheds spanning a variety of land uses, making it an ideal region to study the extent and magnitude of trash and trash types (plastic, metal, glass, etc.) and identify relationships between land use and the amount of trash. These data can be used to develop mitigation strategies and evaluate management successes. We found that 77% of Southern California's coastal stream kilometers contained trash, with an estimated stock of 7 million pieces of trash. Of the types enumerated, plastic trash was the most ubiquitous, present in 69% of stream kilometers, trash. Of the types enumerated, plastic trash was the most ubiquitous, present in 69% of stream kilometers, and the most abundant, with an estimated stock of over 4.3 million pieces of plastic. The most common items were single-use plastic containers, wrappers, and plastic bags. Urban land use was associated with the greatest extent and magnitude of trash, with levels nearly double those found in open land uses. Trash was strongly associated with indicators of human activity and development in watersheds. Road density and proximity to roads and parking lots were strongly associated with increased trash in watersheds. This survey also suggested that management actions had a positive effect on trash count. After the previous trash survey in Southern California streams in 2011-2013, a statewide ban on plastic bags was implemented in 2016. We found a significant decrease in the number of plastic bags within streams in the present survey compared to the previous survey.

Citation

McLaughlin, K., R.D. Mazor, M. Sutula, K.C. Schiff. 2023. Regional assessment of trash in Southern California coastal watersheds, United States. *Frontiers in Environmental Science* 11:1210201

SCCWRP Journal Article #1332
Full text available online: www.sccwrp.org/publications

Monitoring program to evaluate California's Estuarine Marine Protected Areas – Estuary Marine Protected Area Program overview

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Citation

Stein, E.D., J.B. Walker, K. O'Connor, R. Clark, C. Whitcraft. 2023. Development of a Statewide Estuary Monitoring Program to Evaluate California's Estuarine Marine Protected Areas - Estuary Marine Protected Area Program Overview. Technical Report 1315. California Ocean Protection Council. Sacramento, CA.

SCCWRP Technical Report #1315
Full text available online: www.sccwrp.org/publications

Estuary Marine Protected Area – Monitoring protocol

Jan Walker[1], Eric Stein[1], Kevin O'Connor[2], Ross Clark[2], Christine Whitcraft[3], Sebastian Garcia[3], Brent Hughes[4], Alyssa Cooper[4], David Jacobs[5], Mira Abrecht[5], John Largier[6], Robin Roettger[6], Christina Toms[7]

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Citation

Walker, J.B., E.D. Stein, K. O'Connor, R. Clark, C. Whitcraft, S. Garcia, B. Hughes, A. Cooper, D. Jacobs, M. Abrecht, J. Largier, R. Roettger, C. Toms. 2023. Estuary Marine Protected Area - Monitoring Protocol. Technical Report 1315.A. Ocean Protection Council. Sacramento, CA.

SCCWRP Technical Report #1315.A
Full text available online: www.sccwrp.org/publications

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Estuary Marine Protected Area – 2021 data analysis report

Kevin O'Connor[1], Ross Clark[1], Brooke Fulkerson[1], Jan Walker[2], Eric Stein[2], Christine Whitcraft[3], Sebastian Garcia[3], Sarah Stoner-Duncan[1], Brent Hughes[4], Alyssa Cooper[4], David Jacobs[5], Mira Abrecht[5], John Largier[6], Robin Roettger[6], Christina Toms[7]

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Citation

O'Connor, K., R. Clark, B. Fulkerson, J.B. Walker, E.D. Stein, C. Whitcraft, S. Garcia. 2023. Estuary Marine Protected Area - 2021 Data Analysis Report. Technical Report 1315.B. California Ocean Protection Council. Sacramento, CA.

SCCWRP Technical Report #1315.B
Full text available online: www.sccwrp.org/publications

Estuary Marine Protected Area – Monitoring Program Implementation Blueprint

Eric Stein[1], Jan Walker[1], Kevin O'Connor[2], Christina Toms[3], Ross Clark[2], Christine Whitcraft[4], Brent Hughes[5] Alyssa Cooper[5], David Jacobs[6], Mira Abrecht[6], John Largier[7], Robin Roettger[7]

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Citation

Stein, E.D., J.B. Walker, K. O'Connor, C. Toms. 2023. Estuary Marine Protected Area - Monitoring Program Implementation Blueprint. Technical Report 1315.C. California Ocean Protection Council. Sacramento, CA.

SCCWRP Technical Report #1315.C
Full text available online: www.sccwrp.org/publications

Bioassessment survey of the Stormwater Monitoring Coalition: Workplans for Years 2021 through 2025 Version 3.0 (2023)

Raphael D. Mazor[1]

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

Citation

Mazor, R.D. 2023. Bioassessment Survey of the Stormwater Monitoring Coalition: Workplan for Years 2021 through 2025 Version 3.0 (2023). Technical Report 1174. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1174
Full text available online: www.sccwrp.org/publications

Development of the SMC Regional BMP Monitoring Network

Elizabeth Fassman-Beck, Ken Schiff, and Robert Butler

Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Fassman-Beck, E., K.C. Schiff, R. Butler. 2023. Development of the SMC Regional BMP Monitoring Network 2020-2023. Technical Report 1352. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1352
Full text available online: www.sccwrp.org/publications

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Advisory Committees

National and International

Genome Canada
Dr. **Alvina Mehinto**, Chair, Research Oversight Committee, iTrackDNA: Non-Destructive Precision Genomics for Environmental Impact Tracking in a Global Climate Change Era

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Dr. **Jayme Smith**, Member

Dr. **Jayme Smith**, Organizing Committee Member, US HAB Symposium

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Dr. **Jan Walker**, Member, Science Advisory Panel

Dr. **Martha Sutula**, Member, Science Advisory Panel

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Dr. **Raphael Mazor**, Member, Round Table

Dr. **Eric Stein**, Member, Round Table

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City of Los Angeles
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Ken Schiff, Los Angeles River Zinc Water Quality Criteria Recalculation Technical Committee

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County of San Diego Watershed Protection Program

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Elkhorn Slough Tidal Wetland Project

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Integral Corporation

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Dr. **Jan Walker**, Member, Science Advisory Team, Aliso Creek Estuary Restoration

Los Angeles River Watershed Monitoring Group

Dr. **Raphael Mazor**, Member, Technical Advisory Group

Los Angeles Freshwater Mussel Restoration Project

Dr. **Raphael Mazor**, Member, Technical Advisory Group

Los Cerritos Wetland Conservation Authority

Dr. **Eric Stein**, Member, Los Cerritos Wetland Restoration Technical Advisory Committee

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Malibu Lagoon Restoration

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Massachusetts Institute of Technology Sea Grant

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National Parks Service

Dr. **Raphael Mazor**, Member, Technical Advisory Group, Mediterranean Coast Network Inventory and Monitoring Program

The Nature Conservancy

Dr. **Eric Stein**, Member, Coastal Conservation Assessment Science Panel

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Ormond Beach Wetland Restoration

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Dr. **Martha Sutula**, Member, Technical Advisory Committee

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San Diego Climate Science Alliance

Dr. **Eric Stein**, Member of the Fourth Climate Assessment Workgroup

San Francisco Estuary Institute

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Santa Monica Bay Restoration Commission

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Dr. **Eric Stein**, Vice-Chair, Technical Advisory Committee

Tijuana River National Estuarine Research Reserve

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Dr. **Martha Sutula**, Member, Science Advisory Team, Tidal Restoration Program

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University of Manitoba

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University of New Hampshire Sea Grant

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U.S. Navy Space and Naval Warfare Systems Command

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Vanguard University

Dr. **Jayme Smith**, Member, Science and Pre-Engineering Advisory Council

Water Research Foundation

Dr. **Alvina Mehinto**, Project Advisory Committee Member, Development of Standard Operating Procedures for the Collection, Storage, and Extraction of Aqueous Samples for In Vitro Bioanalytical Screening (4828)

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Journal Editorships

Chemosphere

Dr. **Alvina Mehinto**, Associate Editor, Toxicology and Risk Assessment Section

Dr. **Charles Wong**, Managing Guest Editor, Methods for Detection and Quantification of Microplastics

Critical Reviews in Environmental Science and Technology

Dr. **Charles Wong**, Associate Editor

Elementa: Science of the Anthropocene

Dr. **Martha Sutula**, Associate Editor

Environmental DNA

Dr. **Susanna Theroux**, Guest Editor

Environmental Pollution

Dr. **Charles Wong**, Associate Editor

Environmental Science & Technology Letters

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Dr. **Charles Wong**, Editorial Board Member

Freshwater Biology

Dr. **Eric Stein**, Co-Editor, Special Issue on Environmental Flows

Freshwater Science

Dr. **Raphael Mazor**, Associate Editor

Frontiers in Biogeochemical Dynamics

Dr. **Faycal Kessouri**, Review Editor

Frontiers in Environmental Science

Dr. **Eric Stein**, Associate Editor, Frontiers in Environmental Science: Freshwater Science

Dr. **Eric Stein**, Topic Editor, Environmental Flows in an Uncertain Future Research

Frontiers in Microbiology

Dr. **Joshua Steele**, Associate Editor, Aquatic Microbiology

Dr. **Joshua Steele**, Review Editor, Microbiotechnology

Journal of Marine Science and Engineering

Dr. **John Griffith**, Editorial Board Member

Journal of Sustainable Water in the Built Environment

Dr. **Elizabeth Fassman-Beck**, Associate Editor

Marine Pollution Bulletin

Ken Schiff, Associate Editor

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Dr. **Eric Stein**, Editorial Board Member

Dr. **Eric Stein**, Associate Editor, Hydrology and Hydroecology Section

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Dr. **Joshua Steele**, Councilor, Council on Microbial Sciences

American Society for Photogrammetry and Remote Sensing

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Center for Watershed Protection

Ken Schiff, Planning Committee Member, National Stormwater Conference

Coastal and Estuarine Research Federation

Scott Martindale, Editorial Board Member, Coastal and Estuarine Science News

National Association of Marine Laboratories

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North American Lake Management Society

Dr. **Karen McLaughlin**, Planning Committee Member, National Monitoring Conference

Dr. **Karen McLaughlin**, Program Committee Member, National Monitoring Conference

Pacific Northwest Consortium on Plastics

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Society for Freshwater Science

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Dr. **Raphael Mazor**, Member, Justice, Equity, Diversity, and Inclusion Task Force

Dr. **Katie Irving**, Member, Early Career Committee

Society of Environmental Toxicology and Chemistry

Darrin Greenstein, Steering Committee Member, North America Aquatic Toxicity Testing Interest Group

Ken Schiff, Member, Whole Effluent Testing Advisory Technical Committee and Interest Group

Dr. **Leah Thornton Hampton**, Member, Microplastics Interest Group

Society of Wetland Scientists

Dr. **Eric Stein**, Society's President-Elect

Dr. **Eric Stein**, Past President, Western Chapter

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California State University, Monterey Bay

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California State University, San Diego

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Institut National de la Recherche Scientifique, Canada

Dr. **Alvina Mehinto**, Ph.D. Committee of Julie Robitaille

Instituto Tecnológico de Costa Rica

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Texas Christian University

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University of California, Berkeley

Dr. **Raphael Mazor**, Ph.D. Committee of Melissa Von Mayrhauser

University of California, Irvine

Dr. **Susanna Theroux**, Ph.D. Committee of Ashton Bandy

SCCWRP Commission

and the Commission's Technical Advisory Group (CTAG)

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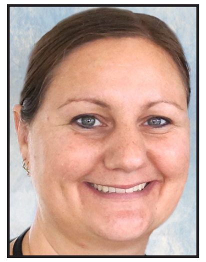
Commissioner


Jim Marchese
Alternate Commissioner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Commissioner


Martha Tremblay
Alternate Commissioner


Joshua Westfall
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CTAG Representative

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Arne Anselm
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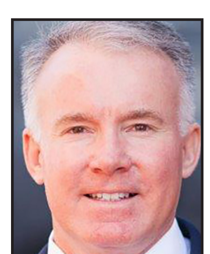
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Dave Laak
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Water-Quality Regulatory Agencies

California State Water Resources Control Board


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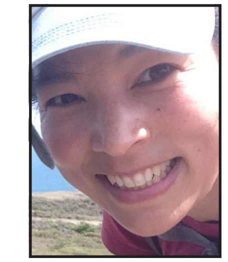
Greg Gearheart
Alternate Commissioner


Lori Webber
CTAG Representative

U.S. Environmental Protection Agency, Region 9


Ellen Blake
Commissioner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California Ocean Protection Council


Jenn Eckerle
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Alternate Commissioner and CTAG Representative

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San Diego Regional Water Quality Control Board


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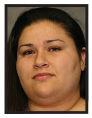
Communications Director



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Maribel Gonzalez
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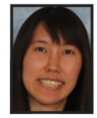
Christina Rivas
Adminstrative Assistant



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Cross-Departmental Technical Support

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Duy Nguyen
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Ayah Halabi
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