SCCWRP

2025 ANNUAL REPORT

Generating public health insights

Science improves understanding of environmental exposure risks, helps managers better protect human health

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
Applying next-generation science to aquatic ecosystems management

Welcome to the interactive version of SCCWRP's 2025 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 2025 Annual Report

Editor
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Cover art
Oysters are prepared for dissection to analyze samples for fecal pathogens in a SCCWRP laboratory.

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A SCCWRP field crew deploys oysters in cages across Newport Bay in Orange County for a study working to improve understanding of the exposure risks associated with consuming recreationally harvested shellfish. **Page 13**

Accomplishments with journal abstracts

People

Snapshot of Success

SCCWRP's progress in 2025 to build a scientific foundation for effective management of aquatic ecosystems

Research excellence

1 Establish scientific credibility

Goal: Pursue ambitious, high-quality investigations that establish and maintain SCCWRP's credibility in the aquatic sciences

The foundation of SCCWRP's success is developing and executing technically rigorous, unbiased investigations that pass scrutiny by scientific peers and become a meaningful contribution to the field. SCCWRP uses two key indicators to track its success at building scientific credibility:

» Publication rate

Virtually all of SCCWRP's work is codified in technical manuscripts and submitted for publication by scientific journals. The journal peer review process helps ensure SCCWRP's work is consistently rigorous and advances scientific understanding in the field.

Accomplishment

SCCWRP scientific staff published an average of **2.7** 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 are expected to achieve when being considered for promotion. **Page 21**

» Citation rate

Whereas publication rate quantifies productivity, citation rate measures the level of influence that SCCWRP's work has had on the fields that SCCWRP is part of. SCCWRP's goal is for other scientists to reference SCCWRP's work when publishing their own.

Accomplishment

SCCWRP journal publications were cited **2,904** times in 2025, according to Web of Science.

2 Build scientific consensus

Goal: Reach agreement with the broader scientific community on the technical soundness of SCCWRP's work for management use

Before SCCWRP advances its work to environmental managers for their consideration, SCCWRP ensures leading researchers in the field have reached agreement that SCCWRP's work is technically sound. SCCWRP facilitates scientific consensus-building through:

» Collaboration

SCCWRP works proactively to co-develop and co-administer projects with other leaders in the field, then co-publish this work in peer-reviewed journals and similar forums.

Accomplishment

SCCWRP published scientific articles and reports with **148** different institutions from **30** countries in 2025. **Page 21**

» Leadership

To optimize SCCWRP's opportunities to build strong working relationships with leaders in the field, SCCWRP staff serve in leadership roles for a range of professional societies, advisory committees and scientific journals.

Accomplishment

SCCWRP scientific staff held **125** leadership roles with professional societies, advisory committees and scientific journals in 2025. **Page 53**

Management influence

3 Assess management readiness

Goal: Engage the stakeholder community in learning about SCCWRP's work and providing feedback on its readiness for management use

Before environmental managers consider using SCCWRP's work in their decision-making processes, they consider the perspectives of a wide range of stakeholders. To ensure these affected parties have opportunities to learn about SCCWRP's work and provide feedback on its readiness for management use, SCCWRP takes a multi-pronged approach to stakeholder outreach and engagement:

» Stakeholder partnerships

SCCWRP does more than just partner on its work with other leading researchers. SCCWRP also proactively fosters project partnerships with stakeholders, creating pathways for them to directly help shape a project's trajectory.

Accomplishments

32 of the **47** projects that SCCWRP completed in 2025 were conducted with one or more stakeholders as full project partners. Of these projects, **24** were conducted in partnership with one or more SCCWRP member agencies.

» Stakeholder interactions

Not every stakeholder that SCCWRP engages with will become a full project partner. At minimum, SCCWRP conducts project briefings for stakeholders. For projects where stakeholder input is essential to success, SCCWRP invites stakeholders to serve as project advisers and consultants – providing more in-depth forums for stakeholders to learn about and review SCCWRP's work, and ultimately assess its readiness for management use.

Accomplishment

44 of the **47** projects that SCCWRP completed in 2025 included stakeholders serving as project advisers and consultants, including via stakeholder advisory committees, to enhance their opportunities to provide feedback.

4 Provide implementation support

Goal: Provide long-term technical support to end users to facilitate expeditious transfer of science to management

Once managers decide to adopt new science, they need long-term support to become comfortable and confident using it. SCCWRP hosts trainings, develops technical resources, and facilitates regional monitoring programs to help ensure successful end-user implementation:

» Trainings

SCCWRP hosted training workshops in 2025 spanning a range of topics, including:

Accomplishments

- Prototype field sensors for detecting illicit pollutant discharges
- Methods for measuring microplastics in drinking water samples
- Laboratory accreditation assessments for *Ceriodaphnia dubia* toxicity testing
- Bioassessment tools and methods for scoring stream health

» Technical resources

End-user resources developed by SCCWRP in 2025 include:

Accomplishments

- A data dashboard for identifying healthy streams that should be priorities for protection
- A case study demonstrating how to quantify uncertainty in modeling tools that predict coastal ocean acidification and hypoxia
- A manual on how to use satellite imaging data to monitor freshwater harmful algal blooms (HABs)

» Regional monitoring facilitation

SCCWRP continued its facilitation of three Southern California regional monitoring programs in 2025 that member agencies have identified as top priorities:

Accomplishments

- Southern California Bight Regional Monitoring Program, started in 1994 and in its seventh cycle (Bight '23)
- Southern California Stormwater Monitoring Coalition (SMC) Regional Watershed Monitoring Program, preparing to launch its fourth cycle
- SMC Regional BMP Monitoring Network, in its initial data analysis phase

Director's Message

Leaning into public health research

SCCWRP is not a public health agency – rather, our primary mission is to understand the effects of contamination on coastal ecosystems. However, we often study contamination through the dual lens of human and ecosystem health, with the hope of enhancing scientific knowledge that informs public health decision-making.

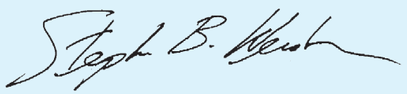
The public health questions we're working to answer have changed over the years, but our commitment to building a scientific foundation for public health decision-making has not. That's why we're using this year's Annual Report to highlight some of the key areas where SCCWRP's work – present, past, and future – intersects with the work of public health agencies.

The highest-profile area of public health we work in focuses on protecting Southern California beachgoers from exposure to viruses and other waterborne pathogens. We are world leaders in advancing the science that drives how fecal contamination gets monitored in beach water and how sources of fecal contamination are identified. We're also regional pioneers in using health risk modeling to estimate illness risks for people exposed to potentially unsafe levels of microbial contamination. *See Page 7 to learn more about SCCWRP's efforts to enable faster, cheaper, more effective fecal contamination monitoring in recreational settings.*

The second area where our work interfaces with public health goes all the way back to where SCCWRP got its start in 1969: assessing the ecological effects of wastewater discharges on coastal ecological health. Early on, we centered our work on how fish, birds and other aquatic life are affected by exposure to chemical contamination from land-based discharges. But over time, we added a public health layer to these investigations, working to evaluate health risks for humans who consume locally harvested seafood. SCCWRP's single most enduring accomplishment on this front has been the development of a pair of scientific frameworks – both subsequently adopted by California – that guide how water-quality managers protect aquatic life and humans, respectively, from contaminated seafloor sediment in enclosed bays and estuaries, where exposure risks tend to be elevated. *See Page 13 to learn more about SCCWRP's work to protect people from contaminated seafood.*

Finally, SCCWRP is part of a national community of researchers that is working to advance the science behind wastewater-based disease monitoring – a rapidly evolving field that uses viruses and other pathogens in wastewater streams to monitor how infectious diseases like COVID-19 spread in communities. *See Page 17 to learn more about our work to advance the science behind wastewater-based epidemiology.*

We are proud of the strong relationships we've developed with the public health community that drive our work and help ensure it's optimally aligned to support public health decision-making. We hope you enjoy learning about the range of ways SCCWRP has contributed to this dynamic, purpose-driven field.



Stephen B. Weisberg, Ph.D.
Executive Director

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GENERATING PUBLIC HEALTH INSIGHTS

Aquatic science researchers don't just study ecosystems from an ecological perspective; they also examine exposure risks for humans

Degradation of aquatic environments has two overarching consequences: It affects ecosystems, and it affects humans.

Aquatic science research focuses on both.

On the ecosystem side, researchers work to better protect diverse plant and animal communities from the many environmental stresses that threaten their health and survival. Researchers identify and prioritize among these stresses, then develop effective strategies for alleviating and preventing them.

On the human side, researchers work to better protect the aquatic environments where people swim, harvest seafood, and source their drinking water. This field – known as environmental public health, or simply environmental health – goes beyond water to encompass air, food and other interfaces that create exposure risks for humans.

The two sides are often interlinked. For example, researchers investigate toxins produced by harmful algal blooms through the dual lens of their potential to harm both wildlife and humans.

The dual nature of this work keeps public health at the center of most aquatic science investigations.

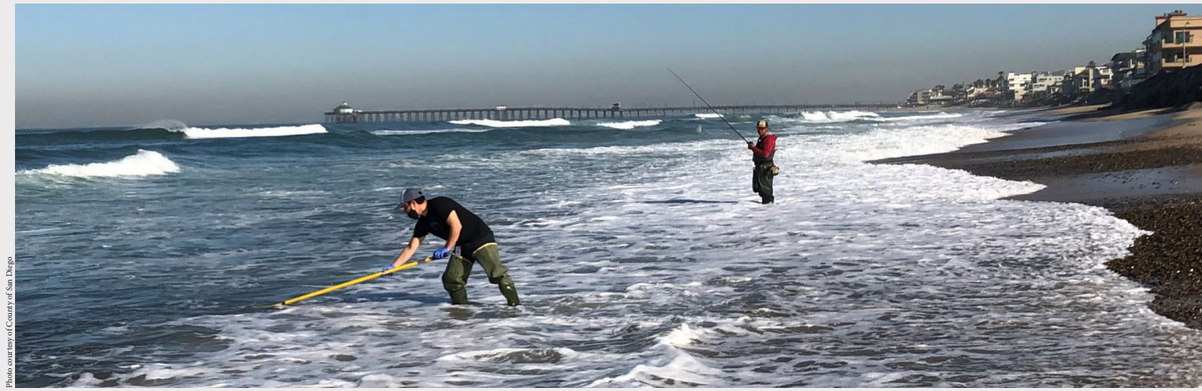

Photo courtesy of County of San Diego

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Indeed, over multiple decades of scientific progress, the environmental management community has built a barrier system to protect people from environmental exposure risks. Even in densely populated regions like Southern California, people are protected from pollutant exposure by a diverse, interconnected range of laws, regulations, policies, management programs and standardized interventions.

Still, problems and knowledge gaps persist, and new public health threats continue to emerge. These remaining challenges are propelling the current generation of public health research.

For SCCWRP and its research partners, public health investigations fall into one of two basic categories:

» Investigations intended to help environmental managers make informed decisions about how to shield the public from exposure risks – either by eliminating access to the risk (such as closing beaches due to fecal contamination), or by notifying people of an elevated public health threat so they can make their own informed decisions (such as posting advisories about consumption of locally caught sportfish)

» Investigations intended to pinpoint the underlying causes and sources of human health risks, as well as to develop a scientific foundation for managers to take informed actions to reduce or eliminate these risks

"SCCWRP's public health research agenda is aligned to support the human health-related beneficial uses for aquatic resources that we as a society have deemed important to protect," said Dr. Stephen Weisberg, SCCWRP's Executive Director. "Whether it's swimming in the ocean or consuming seafood from contaminated water bodies, the basic approach is the same: First, do science that enables managers to implement shorter-term, stop-gap actions that effectively shield the public from risks. Second, identify the root causes of health risks and what managers can do to effectively solve them."

SCCWRP's Dr. John Griffith collects a sample at the end of a storm drain as part of an investigation into sources of fecal contamination in beach water downstream. Aquatic science researchers pursue investigations that are intended to better protect both ecosystems and public health.

The feature articles in this Annual Report chronicle efforts by SCCWRP and its partners to build a scientific foundation for public health decision-making across three main areas. The first two articles examine researchers' work to build a scientific foundation for protecting water quality through two public-health lenses: "Is it safe to swim?" and "Is seafood safe to eat?" The third article shifts to a different area of public health research, explaining how wastewater is used as a public health tool to track the spread of infectious diseases in communities.

1 » **Is it safe to swim? Protecting water recreation**: Researchers are working to extend enhanced protections to people who swim and engage in other water-contact recreational activities, with a focus on reducing health risks associated with exposure to fecal contamination, pathogens that naturally occur in aquatic environments, and toxins produced by harmful algal blooms. **Page 7**

2 » **Is seafood safe? Guarding against consumption risks**: Researchers are working to protect consumers from adverse health outcomes when they eat fish and shellfish harvested recreationally from local water bodies. **Page 13**

3 » **Are diseases spreading? Tracking pathogens via wastewater**: Researchers are working to improve wastewater as a tool for identifying the prevalence and spread of COVID-19 and other infectious diseases through communities in near real time, complementing clinical data that public health agencies have traditionally relied on to track diseases. **Page 17**

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IS IT SAFE TO SWIM? PROTECTING WATER RECREATION

Researchers have made key progress toward better protecting people who swim in contaminated waters

When people swim and engage in other water-contact recreation activities, they may be exposed to multiple contaminants that can cause illness.

Elevated levels of certain contaminants – from sources ranging from isolated sewage spill incidents to toxins that grow naturally in the environment – can result in gastrointestinal illnesses, infect open wounds, and trigger muscle paralysis and seizures.

In Southern California, where beaches alone receive an estimated 129 million visitors each year, environmental managers have implemented rigorous water-quality monitoring and source-control programs to significantly reduce the type of contamination that poses the single biggest threat to public health: human fecal contamination.

Human sources of fecal contamination in the waters where people swim and engage in other water-contact activities are far more likely to cause illness than fecal matter from most other animals.

While human fecal contamination has largely been eliminated in most of these recreational settings during warmer, dry times of the year, human sources of fecal contamination are widespread in Southern California runoff during wet weather, creating exposure pathways for people who swim and surf in water bodies downstream.

Researchers have spent decades advancing the science behind detecting human fecal contamination in recreational waters. They have developed new monitoring methods and tools that are designed to make routine fecal contamination monitoring faster, more cost-effective and more reliable – advances that have helped minimize the risks of exposure to fecal contamination.

Researchers also have developed novel methods for more effectively pinpointing the specific origins of contamination – advances that are paving the way for environmental managers to take

Surfers paddle away from shore at San Diego's Ocean Beach shortly after a storm. Researchers have spent decades working to make fecal contamination monitoring at beaches faster, cheaper and more reliable, paving the way for environmental managers to better protect public health.

increasingly targeted, science-informed actions to prevent major sources of human fecal contamination from reaching recreational waters.

Still, gaps remain in this strong overall barrier of protection. During wet weather, public health agencies routinely issue blanket warnings advising the public not to enter the water at Southern California beaches – a reflection of the fact that elevated levels of fecal contamination are widespread in wet-weather runoff.

Furthermore, fecal contamination isn't the only type of contamination that poses a threat to beachgoers and others. In response to climate change and local human activities on land, Southern California's recreational water bodies are facing new and emerging public health threats, including from certain types of pathogens that are proliferating as local water bodies become more favorable to their growth, and toxins being produced under certain conditions by some types of harmful algal blooms.

Collectively, the remaining public-health challenges associated with protecting water-contact recreational activities are driving the current generation of environmental health research in the aquatic sciences.

First, researchers are focused on strengthening routine fecal contamination monitoring programs – by making collection, processing and analysis methods faster, cheaper and more accurate predictors of health risk. Second, researchers are working to develop methods for improving managers' ability to pinpoint where major sources of fecal contamination that pollute recreational water bodies are coming from – an essential precursor to eliminating this contamination at the source.

Meanwhile, beyond fecal contamination, researchers are working to develop more robust monitoring of naturally occurring pathogens and algal toxins – to understand patterns and trends, to identify causes, and ultimately to work toward science-informed options for reducing the public health risks they present.

The traditional way to measure fecal contamination in recreational waters is to culture bacteria from water samples in a laboratory, as shown above at SCCWRP. Next-generation approaches are emerging that have the potential to replace or complement traditional methods.

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"All of the advances pioneered right here in Southern California have made it better, faster and cheaper to detect and address contamination challenges in the water where people swim and surf," said Larry Honeybourne, a former head of the Orange County Health Care Agency's Environmental Health Division, now retired. "While Southern California's heavily used, world-renowned beaches are the most closely monitored beaches in the country, there's still more work to be done. It's these remaining public health challenges that are driving current and future generations of research."

Improving fecal detection methods

The basic approach that public health agencies use to detect fecal contamination at beaches and other recreational waters has remained unchanged for nearly a century.

Since the 1950s, managers have relied on fecal indicator bacteria as a proxy for estimating the total amount of fecal contamination present in a given water sample.

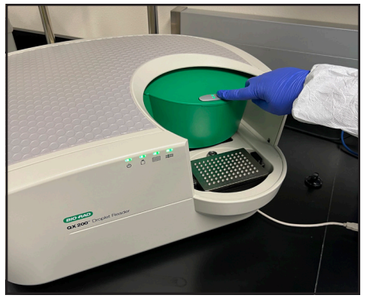
Fecal indicator bacteria – which are abundant in the digestive systems of all warm-blooded animals but are unlikely to cause illness themselves – have historically been far more practical to measure in aquatic environments than the viruses, bacteria and other microbes that sicken people.

Although fecal indicator bacteria remain the primary way that fecal contamination is monitored in Southern California's coastal waters, the methods used to measure fecal indicator bacteria have improved incrementally over the past century.

Scientists originally measured fecal contamination by quantifying all heterotrophic bacteria in a sample; heterotrophic bacteria are a ubiquitous type of bacteria that gain their energy from organic compounds, as opposed to producing this energy themselves.

Then, in the 1950s, water-quality managers switched to measuring the total number of coliform bacteria – a type of bacteria that indicate possible environmental contamination – followed by fecal coliforms, which are more directly linked to fecal contamination from warm-blooded animals. Today, *E. coli* bacteria are commonly measured in fresh water, and *Enterococcus* in marine water. Managers made each of these switches either because the successive type of bacteria served as a better representation of bacteria found in sewage and animal feces, or because of methodological improvements in measurement sensitivity and precision.

These incremental improvements, however, have not fundamentally



One of the DNA-based methods for detecting fecal contamination involves the droplet digital polymerase chain reaction (ddPCR) method.

Evolution of fecal contamination culture methods

The traditional way to measure fecal contamination in recreational waters is to grow, or culture, bacteria from a water sample in a laboratory. This basic culture-based approach is still widely used today for routine water-quality monitoring, although incremental advances, including one pioneered by SCCWRP, have streamlined the approach.

The simplest culture-based method is to plate samples on agar and count the colonies that grow. An alternate method, known as multiple-tube fermentation, is a three-stage test – presumptive, confirmed and completed – that can take up to four days to get results. For decades, multiple-tube fermentation was the gold standard.

In the 1990s, water-quality managers in Southern California transitioned from multiple-tube fermentation to the membrane filtration method, which uses a filter with specific pore sizes to capture bacteria; the filter is then transferred to selective grow media on an agar plate, and the colonies that grow are counted. Membrane filtration is generally more sensitive and precise than multi-tube fermentation for low bacterial concentrations and can handle larger sample volumes.

In the early 2000s, when SCCWRP began working in this space, SCCWRP ushered in a more efficient, less labor-intensive culture-based monitoring method developed and sold by the diagnostic testing company IDEXX; this simple, enzyme-based method quickly replaced membrane filtration across Southern California and beyond, and today remains the dominant method for environmental water-quality testing. The method includes the IDEXX Colilert test, which quantifies *E. coli* and total coliforms, and the IDEXX Enterolert test, which quantifies *Enterococcus*.

SCCWRP's Dr. Kylie Langlois prepares to run a routine fecal contamination detection test developed by the diagnostic testing company IDEXX. In the early 2000s, SCCWRP ushered in use of this simple, enzyme-based test, which has since become the dominant method for testing beach water quality across Southern California.

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Courtesy of Heal the Bay

Warning signs are routinely posted at Southern California beaches during and after rainfall because of elevated health risks from fecal contamination exposure. Researchers have developed tools for distinguishing whether the fecal contamination is from a human source, which is far more likely to sicken people than most non-human sources.

transformed how samples are processed and their fecal indicator bacteria levels quantified.

Methods approved by the U.S. Environmental Protection Agency for measuring fecal indicator bacteria still require a lengthy laboratory incubation period – typically 18 to 72 hours – before the bacteria can be detected and quantified.

Consequently, by the time that public health agencies learn that a beach or other recreational water body is polluted by unsafe levels of fecal contamination, more than 24 hours has typically passed, potentially exposing an entire day's worth of visitors to fecal contamination. Further, in many cases, by the time a health advisory has been posted, the contamination threat has passed. Thus, the lag time associated with established methods for measuring fecal indicator bacteria has two limitations: It allows exposure to contaminated water while waiting for test results, and it can lead to unnecessary advisories and water-body closures when the water is safe.

DNA-based methods for measuring fecal indicator bacteria have ushered in a new era for detecting microbial contamination – one that has the potential to enable public health agencies to be alerted in a matter of hours to the presence of unsafe levels of fecal contamination.

DNA-based measurement methods for beach water quality use specific genetic fragments, or DNA markers, from *E. coli* or *Enterococcus* to quantify fecal indicator bacteria levels in a water sample.

In 2023, San Diego County became the first jurisdiction in the nation to replace culture-based methods for *Enterococcus* with a DNA-based method known as ddPCR (droplet digital polymerase chain reaction) for routine beach water-quality testing.

Following the switch, the County experienced improved ability to rescind health advisories at beaches as soon as the contamination threat has passed – partly due to the fact that DNA-based methods are more sensitive for detecting when fecal contamination falls below levels that can pose a public health risk for beachgoers.

Moreover, this DNA-based approach has reduced the time required to obtain data from 18+ hours to 6-8 hours once a sample arrives at the laboratory. The end result is that public health agencies can identify waterborne threats – and close beaches or warn beachgoers about contamination – with improved speed and accuracy.

"DNA-based methods are a powerful tool that's helping us not just get results faster, but also to detect fecal contamination that culture-based methods may miss or underestimate," said Heather Buonomo, San Diego County's Director of Environmental Health. "That means we're better able to protect public health."

Developing methods to pinpoint fecal sources

Robust fecal contamination monitoring is the first line of defense for protecting public health from exposure at beaches and other water bodies, enabling public health agencies to act quickly to post warning signs and/or close beaches.

But environmental health managers also need tools to investigate where fecal contamination is coming from, especially when contamination persists without an obvious source to target eliminating.

Nowhere is this challenge more acute than with fecal contamination that is introduced to Southern California's coastal zone via wet-weather runoff. Stormwater transports and concentrates high levels of bacteria from land-based sources, even as managers have historically lacked the tools to systematically tease apart specific major sources of this pollution, or to understand each source's relative contribution to overall fecal contamination levels in runoff.

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The first major source-identification breakthrough came in the early 2000s, when a research team that included SCCWRP validated a reliable method for distinguishing human fecal contamination from that of birds, dogs and other warm-blooded animals.

Known as genotypic microbial source tracking, this approach is in widespread use today, enabling managers to determine if fecal contamination is from a human source or from another animal. Human sources of fecal contamination, which are identified using a human-specific DNA marker known as HF183, are far more likely to sicken people than fecal contamination from most other animals because they contain human-specific pathogens.

"Prior to the beginning of the 21st century, DNA-based methods for microbial analyses were largely confined to clinical microbiology," said Dr. Valerie J. Harwood, an environmental microbiologist and Distinguished Professor at the University of South Florida. "SCCWRP and collaborators showed that forensic methods used in hospitals and in law enforcement (DNA fingerprinting) could be adapted for use in the messy milieu of surface waters. Painstaking research resulted in robust, quantitative, PCR-based methods that are now the basis of rapid testing of beach water quality and of the determination of sources of fecal contamination in water."

SCCWRP's Dr. John Griffith uses a peristaltic pump to vacuum contents from an underground sewer pipe in San Diego County. Researchers have developed a novel method for detecting sewage from sewer pipe infrastructure in stormwater runoff; the method involves looking for the unique microbial community that lives on the insides of sewer pipes – known as biofilm – in stormwater runoff. The method has the potential to help investigate fecal contamination in Southern California waterways, which is widespread during wet weather.

Removing fecal contamination from runoff

Runoff is the dominant pathway by which human fecal contamination is transported to the coastal zone during wet weather. While closing beaches or posting warning signs is the default first line of defense for protecting beachgoers from this contamination, it is a Band-Aid solution that does not solve the underlying contamination problem. Researchers, including at SCCWRP, are exploring how to treat runoff using stormwater BMPs (best management practices), such as biofiltration systems, that have the potential to filter and remove fecal contamination as runoff passes through them. Research on BMP effectiveness for removing fecal bacteria and human pathogens is still in its infancy.

Researchers are exploring how stormwater BMPs, such as this biofiltration system that abuts a shoreline in Long Beach, above, could be used to filter and remove fecal contamination as runoff passes through them. Stormwater managers increasingly are investing in BMPs to remove multiple types of contaminants from runoff.

While the ability to distinguish human fecal contamination from nonhuman sources has been a pivotal breakthrough, this science still hasn't provided environmental managers with all the information they need to target and eliminate human fecal sources.

Across highly urbanized Southern California, the high levels of human fecal contamination found in waterways during wet weather have the potential to come from a range of sources – everything from sanitary sewer overflows to private sewer lines that have been illegally connected to storm drains. Thus, to effectively intervene, managers first need to know the specific origins of this contamination.

In 2024, SCCWRP completed an investigation examining how to use the

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microbial biofilm community that grows on the insides of sewer pipes to help distinguish whether fecal contamination in a water body has its origins in sewer pipes vs. another source, such as direct deposition of human sewage into a storm drain.

Sewer pipe biofilm communities have a different biological composition and thus a different genetic signature than the biofilm communities that grow inside storm drain pipes and other types of water conveyance infrastructure.

During the study, which focused on the highly urbanized, lower San Diego River watershed, researchers positively identified the unique genetic signature of sewer pipe biofilm at the watershed's coastal terminus – providing evidence that fecal contamination found in the watershed originated in sewer pipes upstream.

"For years, identifying the sources of fecal contamination in our watersheds has been one of stormwater management's most persistent challenges," said Neil Searing, Water Resources Manager for the San Diego County Watershed Protection Program. "Today, new tools are allowing us to pinpoint those sources, giving us the insight we need to focus resources and address the problem more efficiently."

Addressing other waterborne threats

Fecal contamination isn't the only source of illness-causing microbes in the aquatic environments where humans swim, surf and engage in other water-contact recreational activities.

Some types of microbes that may sicken humans during water-contact recreation are naturally occurring – meaning that instead of being released by humans into the environment, they grow on their own in the environment.

In response to climate change and local human activities, two types of aquatic organisms – *Vibrio* bacteria and toxin-producing harmful algal blooms (HABs) – have emerged in recent years as public health risks for water-contact recreation.

Vibrio, which are now routinely found in coastal environments across Southern California, enter the human body through open wounds, where they can trigger life-threatening infections.

Courtesy of Raphael Kudela, University of California, Santa Cruz

Pinto Lake in Santa Cruz County is tainted a murky greenish color by harmful algal blooms, which can produce toxins that are harmful to swimmers who come into contact with these toxins. Toxin-producing blooms in recreational lakes are among the emerging public health threats that researchers are working to better understand.

Historically, researchers believed that Southern California's aquatic environments were too cold for *Vibrio* to thrive; *Vibrio* are common in warmer, tropical settings.

In recent years, however, scientists have established that *Vibrio* are widespread in warmer brackish waters like enclosed bays and estuaries across Southern California, where they flourish in relatively quiescent waters. Then, during wet weather and wetland tidal exchanges, *Vibrio* can be flushed into the coastal ocean and other water bodies where people swim.

In Southern California, researchers have begun studying how widespread *Vibrio* are, including identifying places and conditions where *Vibrio* may pose a health risk. Routine monitoring programs in Southern California for *Vibrio*, however, have yet to be established.

The other major, naturally growing public-health concern – toxin-producing HABs in freshwater environments – is better studied and better understood.

Under certain conditions, some types of HABs can produce toxins that, upon inadvertent ingestion or even skin contact, can trigger gastrointestinal illness, skin rashes and other illness symptoms.

In recent years, SCCWRP and its research partners have been working to understand the underlying causes of these HABs and which combinations of environmental conditions drive their growth and trigger toxin production and release. Researchers also are beginning to evaluate potential solutions for reducing the frequency and severity of HABs.

Additionally, in response to the health risks associated with swimming in water bodies contaminated with HAB toxins, California has established a public health notification system for freshwater recreational environments. This system, which SCCWRP helped develop more than a decade ago, provides recommended guidelines to help water-body managers decide when and how to notify the public about the presence (or suspected presence) of HAB toxins and/or to close water bodies to recreational activities.

"Increasing natural and anthropogenic pressures are going to continue to compromise the water quality for swimmers and surfers in coastal recreational waters," said Dr. Rachel Noble, Distinguished Professor of Marine Science at the University of North Carolina at Chapel Hill. "However, as researchers, we have made key progress toward tracking and reducing contamination. Work remains to be done to translate our research to improved management strategies across a range of conditions that will ultimately help us continue to protect public health."

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IS SEAFOOD SAFE TO EAT? GUARDING AGAINST CONSUMPTION RISKS

Researchers are working to reduce health risks from consuming recreationally harvested seafood – not just the risks posed by individual contaminants, but also cumulative risks

Most people consume seafood that comes from commercial sources – grocery stores, restaurants and farmers markets.

To prevent these commercial supplies from becoming contaminated, the food safety industry has developed requirements for harvesting, processing, and storing seafood, plus for monitoring seafood and the quality of the water from which the seafood is extracted.

But this same infrastructure does not extend to protect people who harvest fish and shellfish on their own from the coastal ocean, lakes and other water bodies – a practice known as recreational harvesting.

Rather than being able to regulate seafood processors and importers, the environmental management community must focus instead on reducing exposure risks for people who are consuming recreationally harvested seafood.

Recreational harvesting, which

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has complex social, cultural and economic dimensions, can put vulnerable populations at risk of becoming unknowingly exposed to contaminated seafood.

Across Southern California, the research community, including SCCWRP, is focused on improving understanding of consumption risks associated with recreational harvesting practices. Researchers are studying where health risks are elevated, plus identifying effective strategies for reducing exposure risks – both by shielding the public from exposure, and by addressing the underlying causes of seafood contamination.

Historically, much of this research has focused on chemical contamination in Southern California sportfish. Over the years, researchers have conducted extensive monitoring, fishing surveys and source tracking investigations to understand exposure risks associated with chemical contaminants like mercury and PCBs (polychlorinated biphenyls).

But chemical contamination in sportfish isn't the only public health risk facing recreationally harvested seafood. The environmental management community also needs to understand the relative health risks associated with chemical contamination exposure, including exposure to fecal contamination, contaminants of emerging concern (CECs) such as microplastics and PFAS (per- and polyfluoroalkyl substances), and toxins produced by harmful algal blooms (HABs).

Kelp bass, left, and oysters, right, are among the seafood sources that have the potential to be recreationally harvested from Southern California water bodies. Recreational harvesting can put vulnerable populations at risk of becoming unknowingly exposed to contaminated seafood, underscoring the need to reduce exposure risks for these populations.

Many of these other health risks remain understudied and poorly understood, even as environmental managers lack the resources to comprehensively investigate each of these potential risks individually.

That's why SCCWRP and other researchers are shifting their focus to understand the relative significance of multiple risks compared to one another – and the cumulative risks that they collectively represent, both for people who consume recreationally harvested seafood and for overall ecosystem health.

This more integrated approach to risk assessment has the potential to help environmental managers more effectively address the multiple environmental challenges they're simultaneously juggling.

"Environmental managers must make tough decisions every day about how best to address and prioritize among multiple health risks, including seafood consumption risks," said Dr. Wes Smith, Senior Toxicologist for California's Office of Environmental Health Hazard Assessment (OEHHA). "That's why it's so important that scientists don't just take a whack-a-mole approach to studying contamination. Managers need a comprehensive and integrated understanding of the challenges they're up against."

A SCCWRP field crew prepares oysters on the patio of Kerckhoff Marine Laboratory in Orange County for a study examining the degree to which shellfish in Southern California coastal waters can become contaminated by fecal contamination. Researchers are working to improve understanding of the public health risks associated with consuming locally harvested seafood.

Understanding health risks from sportfish chemical contamination

The best-studied type of seafood consumption risk in Southern California is chemical contamination of recreationally harvested sportfish.

Much of this chemical contamination originates with land-based discharges that introduce pollution to coastal water bodies and other aquatic environments. As the chemical contaminants settle into sediment along the water body floor, they create a long-term, direct exposure route for bottom-dwelling aquatic life. Then, as each successive predator consumes its prey, this sediment contamination is transferred via food webs to fish consumed by people.

Exposure to this chemical contamination can increase risks for cancer, reproduction and development disorders, and damage to organs and the central nervous system, among other health problems. Health risks tend to be greatest for people who consume multiple servings of recreationally caught fish per week, and/or who fall into certain risk categories, such as children and women of childbearing age.

SCCWRP have conducted multiple field surveys of anglers at coastal piers and fishing lakes, including Legg Lake in Los Angeles County, above, to understand who is consuming what and how often. These insights can help water-body managers better protect the public from the health risks of consuming recreationally harvested seafood that may be contaminated.

Since SCCWRP's founding in 1969, SCCWRP has been working to comprehensively document the levels and types of chemical contamination found in fish and other aquatic life across a range of popular fishing sites – from the coastal ocean to enclosed bays to freshwater lakes. The most managerially insightful of these efforts have been cyclical monitoring initiatives like the Southern California Bight Regional Monitoring Program, started in 1994, that track conditions over time.

SCCWRP also has conducted extensive field surveys of anglers at coastal piers and fishing lakes to document who is consuming seafood from these water bodies, what types of seafood, and how often. Using these data sets, researchers have then generated quantitative estimates of chemical contamination exposure risks associated with consumption of recreationally caught fish.

Environmental managers, meanwhile, have used these data sets to take faster, better-informed and more targeted actions to shield the public from consumption exposure risks. For example, Southern California consumption risk data get used by environmental health agencies like California's Office of Environmental Health Hazard Assessment to help decide how, when and where to issue seafood consumption advisories that warn the public to limit or stop their consumption of seafood.

"In California, scientists have invested decades of research to establish baseline public-health protections," said Lori Webber, Director of the California Water Quality Monitoring Council. "These protections allow managers to routinely warn the public about consumption risks and minimize the amount of contaminated seafood people eat, even though contamination in sportfish has not been completely eliminated."

To help coastal managers understand where the public health risks associated with sediment contamination are greatest, SCCWRP has focused on developing rigorous, quantitative frameworks that quantify the relationship between sediment contamination and contaminated sportfish.

The most high-profile of these scientific tools is a pair of frameworks known as California's Sediment Quality Objective (SQO) frameworks. These sediment-quality assessment frameworks standardize the process by which coastal managers statewide determine the degree to which sediment contamination poses a health risk for aquatic life and for people who consume seafood, respectively, from California's enclosed bays and estuaries.

A sign posted at Legg Lake warns anglers about the risks of consuming certain quantities of certain species of fish caught at the lake.

The SQO framework for human health, which was adopted by the State Water Resources Control Board in 2018 and is the second of the SQO frameworks, helps managers to identify which coastal water bodies are experiencing the greatest human health risks associated with sediment contamination – and then to set appropriate clean-up goals based on these risks.

"The Human Health SQO framework represents California's most comprehensive effort to date to systematically tease apart the relationship between sediment contamination and contaminated sportfish that people eat," said Chris Beegan, Engineering Geologist for the California State Water Resources Control Board, who led the agency's efforts to develop California's SQO regulatory program. "It's the first of its kind anywhere in the world, and it's helping managers to figure out where the hotspots are and how to go about prioritizing what to clean up where."

Understanding relative, comparative health risks

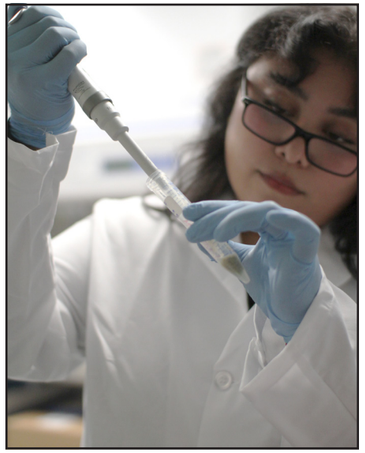
While sportfish have historically been a major focus of Southern California seafood consumption research, the other major class of seafood that researchers increasingly are focusing on is shellfish.

As filter feeders, shellfish can rapidly accumulate elevated levels of multiple types of contaminants in their tissue from the surrounding water column – everything from waterborne fecal pathogens to infectious *Vibrio* bacteria to poisonous toxins produced by some harmful algal blooms.

Although most of these types of contaminants aren't harmful to shellfish and are eventually filtered out of their bodies, contaminated shellfish can pose a health risk when they are harvested during periods where contamination is present in the water column. The risk is particularly elevated if the shellfish are consumed raw or undercooked.

These aspects make shellfish particularly useful as a sentinel organism for investigating the combined effects of multiple types of contaminants and other environmental stresses from both inland and marine areas.

Through an exploratory research area known as ecological risk assessment, SCCWRP is using shellfish to gain integrated insights about both ecological and human health risks – insights that can help Southern California environmental managers make better-informed decisions about how much attention and resources to devote to different environmental challenges.



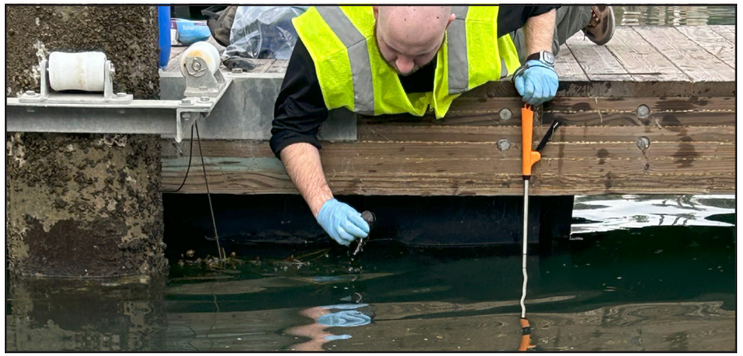
SCCWRP's Shelby Marhoefer-Jess, left, and Andrea Benitez, right, prepare oyster samples to analyze for fecal pathogens as part of an integrated risk assessment for shellfish conducted through the Southern California Bight 2023 Regional Monitoring Program. Shellfish can rapidly accumulate elevated levels of contaminants in their tissue from the surrounding water column.

For example, in one ongoing integrated risk assessment, the 2023 cycle of the Southern California Bight Regional Monitoring Program (Bight '23) is piloting an effort to measure multiple major classes of contaminants – fecal pathogens, HAB toxins and chemical pollutants – in shellfish growing along the Southern California coast. Instead of investigating each contaminant type in a traditional siloed fashion, researchers are working to understand how different risks compare and how they combine to potentially magnify overall risk.

The Bight '23 investigation – expected to be completed in 2026 – is building on a health risk modeling approach developed by the U.S. Environmental Protection Agency to tease apart the relative influence of each of the three classes of contaminants on overall consumption risks, plus the cumulative influence of these contaminants.

The different types of health risk insights that researchers hope to generate through this investigation have the potential to help inform management decision-making in areas like how and when to issue seafood consumption advisories and close water bodies to recreational fishing and harvesting, as well as how to reduce and prevent the biggest threats to ecosystem and human health.

"Traditionally, there's been a siloing effect in terms of how scientists study consumption risks and other types of risks," said Joshua Westfall, Senior Environmental Scientist for Los Angeles County Sanitation Districts. "Through initiatives like the Bight '23 shellfish study, we're on the precipice of developing more integrated understanding of these risks cumulatively. That's going to put more insightful, more relevant information at our fingertips than we've ever had before."



A SCCWRP field crew collects mussels at Cabrillo Beach in Los Angeles County as part of an integrated risk assessment for shellfish conducted through the Southern California Bight 2023 Regional Monitoring Program. The ongoing study is working to understand the relative influence of multiple types of common shellfish contaminants on the integrity of recreationally harvested shellfish, as well as the cumulative health effects of these contaminants on people who eat them.

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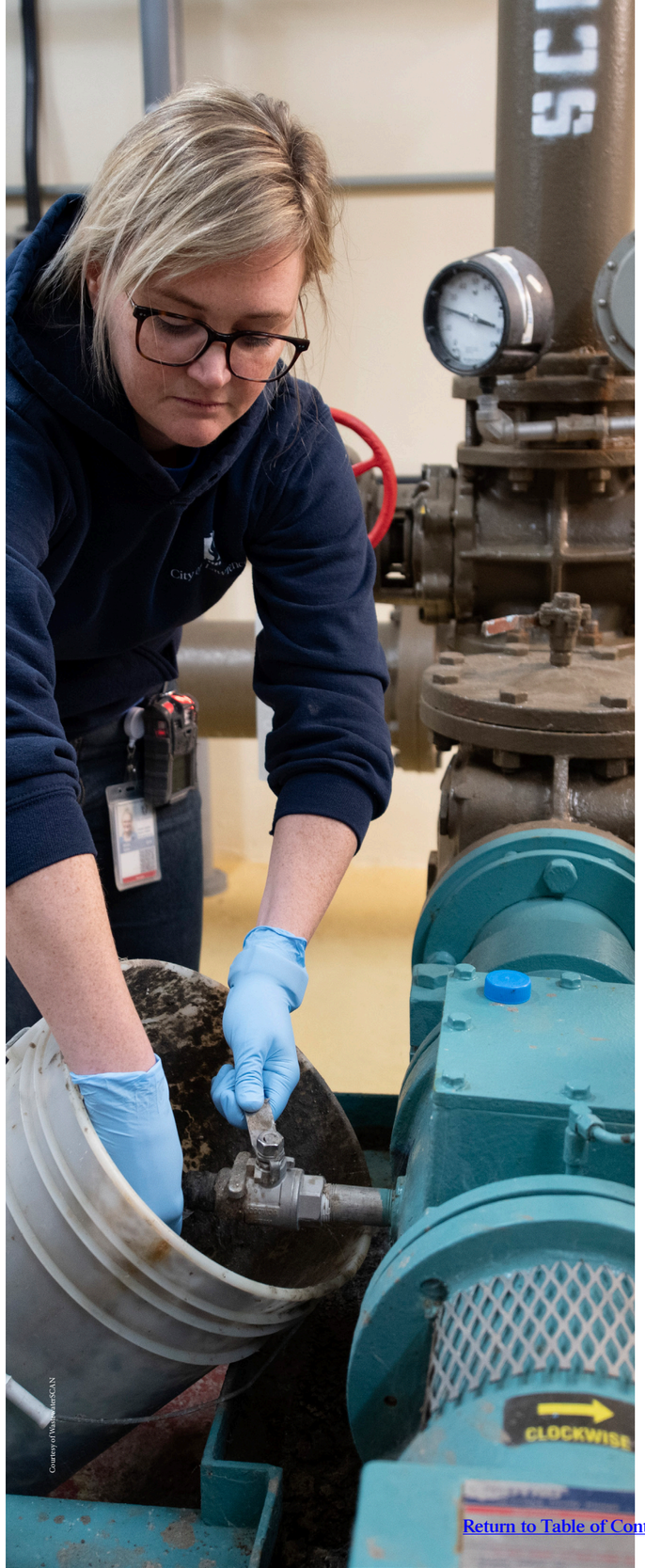

Courtesy of WaterReSCAN

ARE DISEASES SPREADING? TRACKING PATHOGENS VIA WASTEWATER

Raw sewage streams are providing the public health community with insights about infectious disease patterns in communities

Aquatic science researchers have developed robust methods for detecting viruses, bacteria and other pathogens in the water bodies where people swim, surf, and harvest fish and shellfish.

These methods have enabled Southern California's environmental management community to rapidly and

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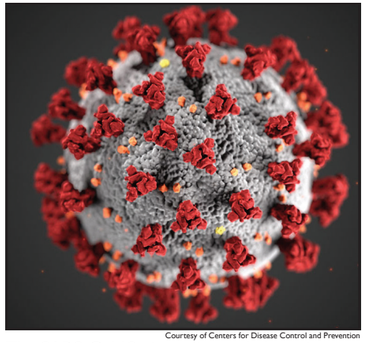


Courtesy of Centers for Disease Control and Prevention

The SARS-CoV-2 virus, pictured above in this artist rendering, can be detected in wastewater streams entering treatment plants. Tracking this information provides researchers with insights about the prevalence and spread of infectious diseases in communities.

Courtesy of Los Angeles County Sanitation Districts

A laboratory technician collects raw sewage samples from the Los Angeles County Sanitation Districts' San Jose Creek Water Reclamation Plant in Whittier to support wastewater-based disease monitoring. As early as the 1970s, the Sanitation Districts was part of the research community that helped advance the science behind wastewater-based epidemiology.

comprehensively identify specific pathogens that are present at levels that pose a risk to human health, as well as to take informed actions that both shield the public from exposure, and eliminate underlying sources of contamination.

The same basic monitoring methods that researchers use to track pathogens in aquatic environments also can be adapted to provide a very different type of public health insight: quantitative information about the prevalence and spread of infectious diseases in communities.

When humans become infected with viruses, bacteria and other pathogens, they often immediately begin excreting these microbes in their feces (and/or their coughing and vomiting). Researchers have learned how to measure individual pathogens in the raw sewage streams entering wastewater treatment plants, then extrapolate these measurements to understand how, when and where diseases are spreading through a community. It's an approach to infectious disease monitoring known as wastewater-based epidemiology.

While this monitoring approach has been in use around the world for decades – including as the foundation for well-established monitoring programs for diseases like polio – wastewater-based epidemiology did not gain traction in the United States until the advent of the COVID-19 pandemic.

Indeed, it was as a direct result of intense public interest in tracking the spread of COVID-19 that the U.S. began building national capacity to do routine wastewater disease monitoring.

Today, communities across the nation are monitoring SARS-CoV-2 – the virus that causes COVID-19 – and more than a dozen other pathogens in raw sewage streams, including influenza, norovirus and RSV (respiratory syncytial virus).

Not only are these wastewater monitoring programs tracking how pathogen levels are rising and falling over time in sewage streams, but researchers also are extrapolating the raw sewage data to estimate the overall portion of a community that is infected with diseases at a given time.

This wastewater testing is helping public health agencies to get ahead of disease outbreaks. Because wastewater can identify diseases as soon as people become infected and begin excreting pathogens in wastewater, wastewater can serve as an early-warning indicator about surges in infections – particularly in areas where there is less clinical data available.

Already, methods for monitoring multiple diseases in wastewater streams have been vetted and transitioned to routine use by public health agencies at the local, state and federal levels.

Among the early adopters is the California Department of Public Health (CDPH), which in 2020 began tracking COVID-19 wastewater data and, two years later, built its own laboratory capacity to routinely analyze wastewater samples – in effect, converting what began as a research-driven pilot project into an ongoing, statewide monitoring program.

"When the pandemic first hit, it felt like the U.S. was playing catch-up with the rest of the world," said Dr. Alexandria Boehm, Professor of Professor of Civil and Environmental Engineering and Oceans at Stanford University. "Now we're leading the world – not only in bringing rigor and standardization to the science behind wastewater-based epidemiology, but also building robust, ongoing disease surveillance programs that connect local monitoring data to state-level and national monitoring programs."

Building a foundation for wastewater disease monitoring

The rapid implementation of COVID-19 wastewater monitoring across the U.S. was enabled by foundational scientific advances that began decades earlier.

In the late 1930s, researchers first detected poliovirus – a highly infectious virus and persistent public health threat – in sewage at multiple locations across the U.S. The presence of poliovirus was confirmed by cell culturing, where animal cells that had been grown in a laboratory were exposed to sewage samples during an incubation period. Then, the cells were examined under a microscope for signs of infection.

In the 1990s, the development of DNA- and RNA-based methods for detecting and measuring pathogens transformed wastewater-based diseased monitoring.

Instead of exposing cell lines to sewage samples, these molecular methods enabled viruses and other pathogens to be isolated from sewage and directly identified and quantified via their genetic signatures.

As the molecular methods matured, they replaced tissue culturing methods, paving the way for robust, routine wastewater-based disease monitoring programs – including international poliovirus monitoring in nations where polio is an endemic or at risk for reimportation.

These international efforts also subsequently served as a template for the U.S. to rapidly build capacity to monitor COVID-19 during the early days of the pandemic.

As early as the 1970s, Southern California's wastewater treatment industry contributed to the science that underlies wastewater-based disease monitoring.

At the time, the wastewater agencies' goal was not to track infection rates in the community, but rather to confirm that existing wastewater treatment processes were consistently rendering viruses inactive – and thus were preventing viable viruses from being released into aquatic environments via treated effluent.

Intrinsic to this work was overcoming a complex technical challenge: how to isolate and measure tiny amounts of viruses in comparatively large sewage samples. Not only are viruses unstable and vulnerable to degradation in the absence of a live host, but raw sewage has highly variable physical, chemical and biological characteristics.

These issues can confound the ability to consistently collect representative samples, as well as to reliably isolate and measure the pathogen content.

The Los Angeles County Sanitation Districts – a Southern California pioneer in this work – built capacity at its Pomona treatment plant in the 1970s to track poliovirus in wastewater. Poliovirus, which is relatively easy to grow in a laboratory, served as a proxy for all enteric viruses, which are viruses commonly excreted in human feces.

A seminal 1977 poliovirus study by the Sanitation Districts was used to set national treatment standards for removing enteric viruses from wastewater and reclaimed water.

"This work pre-dated COVID by decades, but it contributed to the fundamental understanding that when viruses like SARS-CoV-2 make their way into wastewater plants' inbound streams, these influents can become a viable avenue for determining infections in the collective population," said Charles McGee, who established the Sanitation Districts' virus laboratory in the 1970s and later retired from the Orange County Sanitation District.

A SCCWRP laboratory technician prepares sewage samples to analyze for the virus that causes COVID-19 and multiple other human pathogens.

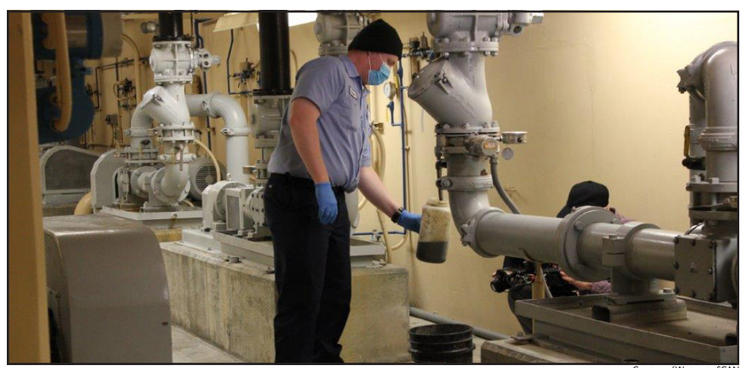
Rapidly building disease monitoring capacity

Almost from the pandemic's outset, wastewater management agencies across Southern California and beyond seized upon raw sewage as a way to track COVID-19 disease outbreaks in communities in near real time – including areas where little clinical patient testing data were available.

Within weeks, all of Southern California's major wastewater treatment agencies began collecting and analyzing samples from their raw sewage streams – an effort coordinated by SCCWRP in partnership with CDPH, Stanford

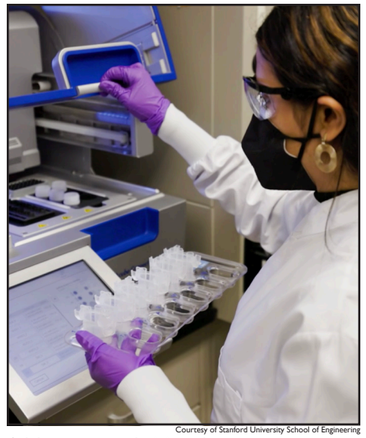
Courtesy of Los Angeles County Sanitation Districts

All of Southern California's major wastewater treatment operators, including the Los Angeles County Sanitation Districts, above, measured the virus that causes COVID-19 in raw sewage streams during the early days of the pandemic. The data have helped public health agencies better understand patterns in how disease spreads through communities.



Courtesy of WastewaterSCAN

A wastewater treatment operator collects sewage from a raw influent stream as it enters a treatment plant in Northern California. Researchers can use raw sewage streams to not only track the prevalence of COVID-19 in communities in near real time, but also to track a range of other infectious diseases.



Courtesy of Stanford University School of Engineering

A laboratory technician places wastewater samples into an instrument for automated DNA extraction at Stanford University. Wastewater-based disease monitoring, which is taking place at treatment plants across the county, is enabling researchers to build national infectious disease monitoring networks, including a Stanford-led program known as WastewaterSCAN that SCCWRP and Southern California wastewater treatment member agencies helped build.

University and others. Importantly, these monitoring efforts took advantage of elements of the best-practices virus monitoring approaches that wastewater treatment agencies had developed and refined decades earlier.

Because different wastewater treatment agencies across Southern California and beyond were using different pathogen measurement methods, the research community – including SCCWRP – helped develop and validate standardize multiple sample collection, processing and analysis methods.

As alternate measurement methods were compared side by side, researchers developed best-practices guidance to enable larger-scale, ongoing COVID-19 monitoring using robust, standardized methods.

Researchers also learned how to combine COVID-19 data that were collected via different measurement methods to form comprehensive data sets reflecting infection patterns across the nation – paving the way for locally collected data to be routinely integrated with larger-scale monitoring programs.

SCCWRP, which served as the regional Southern California coordinator and an expert local resource for this work, helped support the development of two major wastewater disease monitoring programs that remain ongoing to this day:

» WastewaterSCAN, a university-led effort to develop a national disease monitoring network for ongoing tracking of COVID-19 and more than a dozen other diseases; SCCWRP facilitated connecting Southern California wastewater agencies to the network, as well as participated in vetting and standardizing multiple collection, processing and analysis methods

» California Surveillance of Wastewater Systems (Cal-SuWers) Network, a statewide disease monitoring program led by CDPH; SCCWRP served as the lead in transitioning monitoring efforts from research laboratories – where monitoring capacity was initially built – to CDPH laboratories

As more wastewater monitoring data for more diseases have become available, the public health community has begun integrating wastewater disease data into routine planning and decision-making processes.

CDPH, for example, is using the data to help track seasonal infections such as influenza, monitor quick-moving outbreaks such as norovirus, and provide early warnings about the spread of rare infections such as mpox (formerly monkeypox).

Today, public health agencies across the U.S. are increasingly viewing wastewater disease data as an important complement to traditional clinical testing data from hospitals and medical facilities.

Although clinical data remain the public-health gold standard for tracking the spread of infectious diseases, public health agencies recognize that wastewater data reflect infections across the population as a whole – that is, anyone whose fecal waste passes through a public sewer system – enabling wastewater data to offer a more complete picture of overall disease trends in communities. By contrast, clinical data reflect infection trends only among the subset of the population tested for disease in a healthcare setting.

"Wastewater surveillance has added a powerful, population-level signal that complements traditional disease investigation, epidemiology, and clinical testing," said Dr. Alexander Yu, CDPH's Infectious Diseases Branch Chief. "Its rapid adoption alongside clinical data shows just how much value wastewater-based epidemiology provides to public health."

Monitoring pharmaceuticals in wastewater

Wastewater-based epidemiology can do more than monitor the spread of infectious diseases. Researchers have also demonstrated how to monitor specific drugs in wastewater – and the metabolites that people produce when taking drugs – to provide additional insights into community health.

Tracking patterns in pharmaceutical drug use over time can provide information about the prevalence of various health conditions in communities in an anonymous manner – not just infectious outbreaks, but also chronic diseases that are managed with certain medications.

Meanwhile, researchers have learned how to adapt these same basic monitoring methods to track illicit drug use and tobacco and alcohol use in communities, a major application.

Unlike infectious disease monitoring, pharmaceutical and illicit drug monitoring has been limited largely to one-off projects and has not gained widespread traction.

Pharmaceutical drugs and their associated metabolites can be tracked in raw sewage to provide insights about the health of communities – in much the same way that wastewater-based epidemiology can provide insights about the spread of infectious diseases in communities.

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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

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

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

125 Number of leadership roles that SCCWRP scientists hold with professional societies, external advisory committees and editorial boards of scientific journals **Page 53**

Bioassessment

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

Regional Monitoring

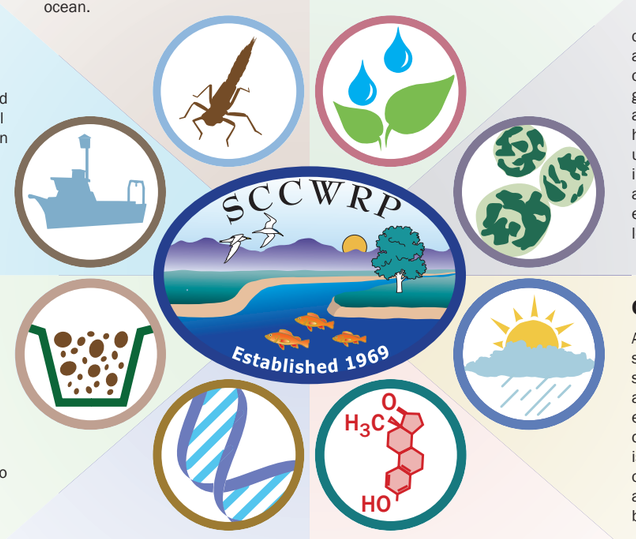
To give environmental managers comprehensive, big-picture snapshots of the condition of aquatic systems and how they are changing over time, SCCWRP facilitates the design and execution of multi-agency regional monitoring – notably, the Southern California Bight Regional Monitoring Program and the Southern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

Ecohydrology

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

Eutrophication

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



Stormwater BMPs

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

Climate Resiliency

As environmental managers seek out next-generation solutions for mitigating and offsetting the local effects 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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Workshop highlights advances in stream biointegrity research

A State Water Board workshop that focused on the appropriateness of taking a biology-based approach to regulating the health of streams in the San Diego region has highlighted the scientific foundation that SCCWRP has built for using bioassessment tools for routine aquatic monitoring – including SCCWRP's work in recent years to address concerns and questions raised by stakeholders.

The workshop, held in Sacramento in 2025, focused on more than a decade of research by SCCWRP and its partners to help managers assess whether policies known as biological objectives are ready to be used to protect the health of California's stream ecosystems.

In 2020, the San Diego Regional Water Quality Control Board established a stream biological objective using a bioassessment scoring tool from SCCWRP to evaluate the health of perennial and intermittently flowing streams across the San Diego region.

This objective, which is undergoing review by the State Water Resources Control Board and has not yet taken effect, has helped bring into focus multiple stakeholder questions and concerns, including whether stream bioassessment tools are applicable statewide and whether streams that have been modified for flood control purposes have the capacity to support healthy biological communities. The answers and insights that SCCWRP has provided on these issues were extensively discussed at the 2025 workshop.

Meanwhile, ongoing SCCWRP research is working to understand the potential impacts of different management actions on stream biological health.

Streams that have been modified for flood control purposes, such as Arroyo Trabuco in southern Orange County, above, tend to receive lower bioassessment scores than other stream types. A State Water Board workshop has highlighted the scientific foundation that SCCWRP has built for using bioassessment tools to monitor the health of different types of streams across California.

Prototype index scoring tool successfully used to assess regional health of eelgrass beds

SCCWRP and its partners have developed and applied a prototype bioassessment index scoring tool to evaluate the health of Southern California eelgrass beds based on their ecological functioning – a proof-of-concept study that paves the way for ongoing monitoring of eelgrass health through programs like the Southern California Bight Regional Monitoring Program.

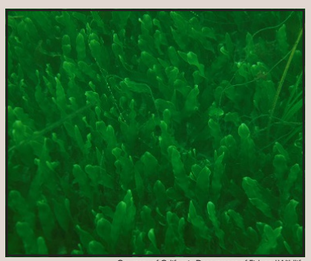
The pilot study, completed in 2025, used a newly developed eelgrass condition assessment index to evaluate the aquatic plants' ability to provide refugia to fish and other animals, as well as other ecosystem services, including attenuating ocean waves and sequestering carbon. The prototype scoring tool is expected to be refined and then applied to assess regional eelgrass health through the Southern California Bight 2023 Regional Monitoring Program. Eelgrass beds are the dominant type of seagrass found in California's coastal embayments.

Pair of novel eDNA monitoring methods used to detect invasive species

SCCWRP and its partners have successfully piloted the use of a pair of novel methods for detecting invasive aquatic species via the DNA they shed into the environment – advances that have demonstrated how to use environmental DNA (eDNA) to provide routine, rapid monitoring for species of interest.

In separate proof-of-concept studies in 2025, researchers tested eDNA methods to detect *Caulerpa* – an invasive green alga – in marine environments and to detect golden mussel – an invasive shellfish – in freshwater environments. eDNA offers a promising, rapid alternative to traditional field collection and identification of species, enabling earlier detection of a range of invasive, threatened and difficult-to-observe species.

While eDNA-based detection methods already existed for *Caulerpa*, researchers in 2025 tested a novel method co-developed by SCCWRP that is about 10 times more sensitive, enabling detection at lower concentrations. Meanwhile, researchers in 2025 also piloted use of a new automated eDNA sampling instrument at Citrus Reservoir in Redlands that is designed to speed up collection of eDNA for golden mussel.



Courtesy of California Department of Fish and Wildlife

Researchers have successfully piloted the use of a pair of novel methods for detecting invasive aquatic species, including *Caulerpa*, above, via the DNA they shed into the environment.

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What is eDNA method standardisation and why do we need it?

Susanna Theroux[1], Adam Sepulveda[2], Cathryn L. Abbott[3], Zachary Gold[4], Alison W. Watts[5], Margaret E. Hunter[6], Katy E. Klymus[7], Shana Lee Hirsch[8], Joseph M. Craine[9], Devin N. Jones[2], Rachel J. Brown[10], Joshua A. Steele[1], Miwa Takahashi[11], Rachel T. Noble[12], John A. Darling[13]

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[8]*University of Washington, Seattle, WA*
[9]*Jonah Ventures, Boulder, CO*
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[11]*Commonwealth Scientific and Industrial Research Organisation, Australia*
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[13]*Center for Ecological Measurement & Modeling, US Environmental Protection Agency, Research Triangle Park, NC*

Abstract

The rapid advancement of environmental DNA (eDNA) science in the past two decades has inspired a concomitant growth in the development of eDNA sampling and analytical methods. However, these methods are often developed by individual laboratories or institutions, which can isolate protocols within programmes, agencies or regions and prevent the beneficial exchange of data and ideas. Recent efforts to advance national and international coordination have resulted in a groundswell of standardisation efforts, but there is still considerable confusion around the role of formal standards for regulatory or research applications. With this commentary, we hope to provide clarity on the terminology used in standardisation discussions, including the differences between formal standards and best practice guidelines. Additionally, we discuss how eDNA method choice may be informed by environmental management scenarios and review examples of formal eDNA method standards being used to inform management action. The eDNA community now has an opportunity to develop a roadmap for method development to help close standardisation gaps, advance eDNA method adoption and accelerate our ability to monitor biological life at the scales our current environmental challenges demand.

Citation

Theroux, S., A. Sepulveda, C.L. Abbott, Z. Gold, A.W. Watts, M.E. Hunter, K.E. Klymus, S.L. Hirsch, J.M. Craine, D.N. Jones, R.J. Brown, J.A. Steele, M. Takahashi, R.T. Noble, J.A. Darling. 2025. What is eDNA method standardisation and why do we need it?. *Metabarcoding and Metagenomics* 9:91-106.

SCCWRP Journal Article #1436
Full text available online: www.sccwrp.org/publications

Proficiency testing and cross-laboratory method comparison to support standardisation of diatom DNA metabarcoding for freshwater biomonitoring

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Abstract

DNA metabarcoding of benthic diatoms has been successfully applied for biomonitoring at the national scale and can now be considered technically ready for routine application. However, protocols and methods still vary between and within countries, limiting their transferability and the comparability of results. In order to overcome this, routine use of DNA metabarcoding for diatom biomonitoring requires knowledge of the sources of variability introduced by the different steps of the procedure. Here, we examine how elements of routine procedures contribute to variability between European laboratories. A set of four experiments were performed focusing on DNA extraction and PCR amplification steps to evaluate their reproducibility between different laboratories and the variability introduced by different protocols currently applied by the scientific community. Under the guidance of a reference laboratory, 17 participants from 14 countries performed DNA

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extraction and PCR amplification in parallel, using the same fixed protocol and their own choice of protocol. Experiments were performed by each participant on a set of standardised DNA and biofilm samples (river, lake and mock community) to investigate potential systematic and random errors. Our results revealed the successful transferability of a protocol amongst labs and a highly similar and consistent ecological assessment outcome obtained regardless of the protocols used by each participant. We propose an "all for one but prove them all" strategy, suggesting that distinct protocols can be used within the scientific community, as long as their consistency is be proven by following minimum standard requirements.

CITATION

Vasselon, V., S.F. Rivera, E. Acs, S.F.P. Almeida, K.B. Andree, L. Apotheloz-Perret-Gentil, B. Bailet, A. Baricevic, K.K. Beentjes, J. Bettig, A. Bouchez, C. Capelli, C. Chardon, M. Duleba, T. Elersek, C. Genthon, M. Jablonska, L. Jacas, M. Kahlert, M.G. Kelly, J.N. Macher, F. Mauri, M. Moletta-Denat, A. Mortagua, J. Pawlowski, J. Perez-Burillo, M. Pfannkuchen, E. Pilgrim, P. Pissaridou, F. Rimet, K. Stanic, K. Tapolczai, S. Theroux, R. Trobajo, B. Van der Hoorn, M.I. Vasquez, M. Vidal, D. Wanless, J. Warren, J. Zimmermann, B. Paix. 2025. Proficiency testing and cross-laboratory method comparison to support standardisation of diatom DNA metabarcoding for freshwater biomonitoring. *Metabarcoding and Metagenomics* 9:35-70.

SCCWRP Journal Article #1416
Full text available online: www.sccwrp.org/publications

Community composition as an overlooked driver of spatial population synchrony

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ABSTRACT

Animal populations often display coherent temporal fluctuations in their abundance, with far-ranging implications for species persistence and ecosystem stability. The key mechanisms driving spatial population synchrony include organismal dispersal, spatially correlated environmental dynamics (Moran effect) and concordant consumer–resource dynamics. Disentangling these mechanisms, however, is notoriously difficult in natural systems, and the extent to which the biotic environment (intensity and types of biotic interactions) mediates metapopulation dynamics remains a largely unanswered question. Here, we test the hypothesis that compositional differences among communities (i.e. beta-diversity), used as a proxy of the differences in biotic interactions experienced by separated populations, reduce population synchrony. Using an extensive dataset of fish population abundance time-series across Europe, we provide evidence that higher beta-diversity is associated with reduced spatial population synchrony within river networks and demonstrate that these effects are independent from geographic separation, environmental dissimilarity, and Moran effects. Although beta-diversity is commonly shown to promote metacommunity stability by reducing spatial synchrony in aggregate community attributes (e.g. total biomass), our study indicates that compositional heterogeneity provides a previously overlooked spatial insurance effect that influences metapopulation dynamics by promoting asynchrony between populations separated in space. These findings illustrate how community assembly across different locations within river networks contributes to metapopulation stability and persistence of individual species and further highlights the implications of the loss in beta-diversity over time via biotic homogenization.

CITATION

Larsen, S., L. Comte, X. Giam, K. Irving, P.A. Tedesco, J.D. Olden. 2025. Community composition as an overlooked driver of spatial population synchrony. *PNAS Nexus* DOI:10.1093/pnasnexus/pgaf272.

SCCWRP Journal Article #1452
Full text available online: www.sccwrp.org/publications

Hydrologic assessment of reference streams in the Los Angeles region

Raphael D. Mazor, Jeff Brown, Lisel Tiefenthaler, Adriana LeCompte Santiago, Garrett Keating

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Mazor, R.D., J.S. Brown, L.L. Tiefenthaler, A. Le Compte Santiago, G. Keating. 2025. Hydrologic assessment of reference streams in the Los Angeles region. Technical Report 1412. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1412
Full text available online: www.sccwrp.org/publications

Improving biointegrity in engineered channels

Raphael D. Mazor, Katie Irving, David J. Gillett, Jeff Brown, Abel Santana

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Mazor, R.D., K. Irving, D.J. Gillett, J.S. Brown, A. Santana. 2025. Improving biointegrity in engineered channels. Technical Report 1437. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1437
Full text available online: www.sccwrp.org/publications

A technical foundation for biointegrity and eutrophication indicators and thresholds for modified channels, intermittent streams, and streams on the Central Valley Floor: 2025 update

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[2]*California Department of Fish and Wildlife, Aquatic Bioassessment Lab, Rancho Cordova, CA*

CITATION

Mazor, R.D., A.C. Rehn, N. Lombardo, M. Sutula. 2025. A Technical Foundation for Biointegrity and Eutrophication Indicators and Thresholds for Modified Channels, Intermittent Streams, and Streams on the Central Valley Floor: 2025 Update. Technical Report 1434. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1434
Full text available online: www.sccwrp.org/publications

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

Raphael D. Mazor, Jeffrey S. Brown

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Mazor, R.D., J.S. Brown. 2025. An assessment of the biological condition of streams in the San Francisco Bay. Technical Report 1419. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1419
Full text available online: www.sccwrp.org/publications

Modeling approach developed for study working to enhance statewide flows framework

SCCWRP and its partners have reached agreement on a conceptual approach for designing modeling tools that account for the relationships between stream flow patterns and water temperature when predicting ecological changes across space and time – the first milestone in an ongoing three-year study seeking to expand the management utility of the California Environmental Flows Framework (CEFF).

The conceptual approach, agreed upon by project stakeholders in 2025, enables researchers to develop regional-scale models that address more integrated management questions about how changes in stream flow patterns and water temperature influence ecosystem health. The existing modeling tools that support CEFF do not adequately consider the relationships between flows and other parameters, including water temperature.

The study builds on CEFF to develop and refine tools, guidance, and strategies that support sustainable water management across a wide range of decisions – from permitting and planning to conservation and flow restoration.

CEFF, co-developed by SCCWRP and unveiled in 2021, provides a rigorous, standardized approach to allocating limited surface flows that balance human and ecosystem needs for flowing water.

Courtesy of U.S. Fish and Wildlife Service

Researchers have reached consensus on a conceptual approach for designing modeling tools that predict how changes in flow patterns in streams like the Eel River in Northern California, above, will influence stream temperature across space and time.

Wastewater discharge study models relationship between stream temperature, ecosystem health

SCCWRP and its partners have successfully used modeling tools to estimate how changes in stream temperature can influence the ecological health of Southern California streams – the latest step in a pair of ongoing studies investigating how changes to the volume of treated wastewater effluent discharges into the Los Angeles and upper Santa Clara Rivers, respectively, affect stream health.

The modeling analyses, completed in 2025, involved developing a series of curves that describe the relationship between stream temperature changes and the biological condition of stream benthic communities, as measured by stream bioassessment index scores. Little field-collected temperature data exist for Southern California stream sites, necessitating using a temperature model.

The study is motivated by new wastewater discharge permits that have lowered the maximum temperature at which receiving water must be maintained from 86 to 80 degrees Fahrenheit; the permits also prohibit effluent discharges that would cause more than a 5-degree increase in water temperature.

The lower allowable temperatures are more difficult to reach because wastewater effluent is typically discharged into streams above the streams' ambient temperature.

Researchers have developed a series of curves that explain the relationship between stream temperature changes and the biological condition of stream benthic communities in watersheds such as the Santa Clara River, above, where treated wastewater effluent is being discharged.

Foundation built to evaluate cannabis growers' requests for stream flow diversions

SCCWRP and its partners have developed a standardized risk-based assessment framework that enables California to determine whether the water that cannabis growers request to divert from nearby streams to support cultivation will adversely affect the streams' ecological health.

The framework, unveiled in 2025, uses a rigorous scientific approach that enables managers to establish flow targets by assessing potential ecological risks to stream health from proposed flow diversions. The framework expands on the California Environmental Flows Framework, which was co-developed by SCCWRP to bring consistency and standardization to how flow targets get set statewide.

While the framework was initially piloted in the North Coast region of California, researchers are exploring how to adapt it to support statewide decision-making on flow diversion requests beyond cannabis growers.

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Vulnerability of an endangered amphibian to climate-change induced hydrologic change

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ABSTRACT

Climate change significantly affects precipitation patterns at multiple scales, which influences river and other hydrologic flow regimes. However, the impacts of climate-driven changes to hydrologic regimes on the vulnerability of species associated with riparian areas remain largely unexplored. Not considering the effect of flow alteration compromises the ability to identify and protect critical habitat areas. We developed a species distribution model to predict the distribution of an endangered amphibian (arroyo toad, *Anaxyrus californicus*) under current and future climate-impacted flow scenarios to better understand its vulnerability to altered conditions. The current modeled distribution of the arroyo toad was compared to models that estimated flows altered through stochastic changes in air temperature and precipitation associated with climate change. To analyze vulnerability, we investigated disparities in elevation, range size, range overlap, protected range, and predicted probability of occurrence. The study identified key flow metrics associated with toad habitats, emphasizing a negative relationship with most, aligning with arroyo toad breeding requirements. Vulnerability assessments demonstrated a potential reduction in toad range and shifts in elevational range potentially due to climate-induced flow alterations. Our study underscores the importance of managing altered flow to support freshwater ecosystems, allowing managers to prioritize conservation efforts, protect vulnerable streams, and address problematic areas. However, additional factors like geomorphology and human activities also play significant roles, suggesting the need for diverse management strategies.

CITATION

Irving, K., K.T. Taniguchi-Quan, A. Santana, M.L. Treglia, R.N. Fisher, J. Haas, C. Loflen, C. Brown, E.D. Stein. 2025. Vulnerability of an Endangered Amphibian to Climate-Change Induced Hydrologic Change. *River Research and Applications* 41:1438-1455.

SCCWRP Journal Article #1441
Full text available online: www.sccwrp.org/publications

Application of nature-based solutions for temperature management Santa Clara River case study: Summary of expert panel workshop May 5-8, 2024

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[3]*University of Tennessee, Knoxville, TN*
[4]*National Renewable Energy Laboratory, Golden, CO*

CITATION

Stein, E.D., B. Bledsoe, E. Fassman-Beck, J. Hathaway, S. Struck. 2025. Application of Nature-Based Solutions for Temperature Management Santa Clara River Case Study: Summary of Expert Panel Workshop May 5-8, 2024. Technical Report 1418. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1418
Full text available online: www.sccwrp.org/publications

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Study demonstrates how to quantify uncertainty in model

A research team that has been modeling how land-based nutrient discharges into Southern California coastal waters influence ocean acidification and hypoxia (OAH) has completed a case study demonstrating how to quantify uncertainty, or error, in the modeling tools' predictions.

The case study, completed in 2025, has helped engage a technical subcommittee of the SCCWRP Commission's Technical Advisory Group (CTAG) in focused discussions about what additional work is needed to improve existing methods for quantifying modeling uncertainty.

These consensus-building conversations are critical as coastal ocean managers weigh how much confidence to place in the OAH modeling tools' predictions, as well as decide if and how to use the predictions as a basis for taking management actions in response to intensifying coastal OAH.

In parallel, the modeling team has expanded its quality assurance documentation for the modeling tools. This new documentation, published in 2025 as a SCCWRP technical report, is intended to enhance transparency and understanding of how the tools are being used; it also is expected to serve as the basis for a modeling Quality Assurance Project Plan (QAPP) that the State Water Board is planning to develop.

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 changing seawater chemistry. A research team that has been modeling how land-based nutrient discharges into Southern California coastal waters influence ocean acidification and hypoxia (OAH) has completed a case study demonstrating how to quantify uncertainty in the modeling tools' predictions.

Best practices developed for using satellite imagery to monitor inland HABs

SCCWRP and its partners have published best-practices guidance for using satellite imagery data as a routine management tool to detect and monitor harmful algal blooms (HABs) in California's large lakes and reservoirs.

The guidance, developed in 2025, provides quality-assurance safeguards to help improve management confidence in satellite imaging data as a tool for assessing HABs status and trends.

Because routine field-based monitoring is rare for many large lakes and reservoirs, water-body managers commonly rely on satellite imagery data for tracking HABs.

Satellite remote sensing data have the potential to provide a viable, cost-effective way to generate a continuous stream of real-time HABs monitoring data.

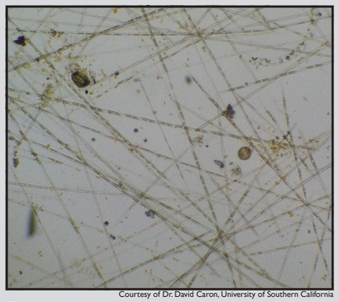
In 2022, SCCWRP and its partners demonstrated how to use satellite imaging data to build a comprehensive, five-year portrait of when and where ecologically disruptive HABs have been occurring in California's large lakes and reservoirs.

Modeling analysis predicts how nutrients affect when, where HABs will occur

SCCWRP and its partners have completed a study using a computer model to predict how land-based nutrients influence the expected frequency and extent of toxins produced by a common type of harmful algal bloom in Southern California coastal waters.

The study, completed in 2025, involved comparing modeling predictions for domoic acid – a toxin produced by a type of HAB known as *Pseudo-nitzschia* – to field data on when and where blooms actually occurred. The model predicted that land-based nutrients are amplifying domoic acid production by a non-trivial amount when compared to the natural susceptibility of the coastal ocean due to ocean processes like natural upwelling events.

The modeling work is helping managers understand the extent to which local, land-based nutrient sources are exacerbating coastal conditions. The model makes use of a coupled physical-biogeochemical ocean model that predicts how land-based discharges affect coastal acidification and hypoxia.



Courtesy of Dr. David Caron, University of Southern California

Toxin-producing *Pseudo-nitzschia* cells, which appear as long needle-like chains under a microscope, above, can dominate marine phytoplankton communities in Southern California coastal waters. Researchers have used a computer model to predict how land-based nutrients influence the frequency and extent of domoic acid, which is the toxin produced by *Pseudo-nitzschia*.

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California's approach to standardizing cyanobacterial bloom metrics derived from satellite imagery

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ABSTRACT

Freshwater harmful algal blooms (FHABs) are increasing globally, with implications for public health, ecosystems, and water resource management. Satellite remote sensing complements field-based efforts and has been used to develop large-scale indicators for FHAB monitoring. However, these indicators can be sensitive to processing choices, which may impact regional assessments and management. This study of 83 California waterbodies uses the Cyanobacteria Index (Clcyano) derived from Sentinel-3's Ocean and Land Colour Instrument (OLCI) to systematically evaluate how three common processing decisions (temporal compositing interval, compositing statistics, and pixel masking strategy) affect four widely used FHAB indicators (annual frequency, spatial extent, occurrence, magnitude). Compositing decisions strongly influenced results, with monthly and maximum-value composites yielding the highest bloom metrics, while shorter 7- and 10-day intervals provided more ecologically relevant resolution. Pixel masking strategies involving nearshore regions and ice- and snow-covered areas affected bloom metrics in different ways. Masking more nearshore pixels generally lowered bloom metric values but eliminated some waterbodies from consideration. Ice and snow masking had spatially localized effects, mostly impacting snow-affected regions. Despite differences in absolute values, trend and status analyses using bloom metrics remained largely consistent across masking approaches. Based on the findings, this study recommends a standardized processing workflow for California FHAB monitoring, which may be applicable to other regions with similar management needs: 7-day composites using maximum Clcyano values, and applying both shoreline and ice masking. This workflow balances ecological relevance, computational efficiency, and indicator consistency, supporting the harmonization of bloom monitoring across satellite products, regions, and management programs.

CITATION

Lie, A.A.Y., M.M. Coffer, M. Van Dyke, C. Nilson, J. Smith. 2026. California's approach to standardizing cyanobacterial bloom metrics derived from satellite imagery. *Ecological Indicators* 182:114492.

SCCWRP Journal Article #1429
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Temporal and spatial dynamics of harmful algal bloom-associated microbial communities in eutrophic Clear Lake, California

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ABSTRACT

Clear Lake is a large, natural eutrophic lake located in northern California, United States. Persistent, toxic cyanobacterial blooms have been reported in the lake since 2011. However, our understanding of the spatiotemporal distribution of toxin-producing genera and their interaction with the biotic and abiotic environment is limited. Moreover, few studies have addressed how the co-occurring microbial communities respond to these toxic cyanobacterial blooms. Using multi-domain 16S/18S rRNA gene amplicon sequencing, a strong seasonal succession within the cyanobacterial and co-occurring eukaryotic assemblage was identified, which was primarily explained by variation in total phosphorus (~30%, $P < 0.001$) and temperature (~15%, $P < 0.01$). Cyanobacterial seasonal succession was often initiated by proliferation of diazotrophs (*Dolichospermum*and *Nodularia*) with concomitant increases in total nitrogen, followed by blooms of non-diazotrophs, such as *Microcystis*, *Limnothrix*, and *Planktothrix*. The picocyanobacterium *Cyanobium*, previously undocumented in the lake, was a dominant summer taxon in the western part of Clear Lake, accounting for ~45%–80% relative abundance of the cyanobacterial reads. Seasonal succession within the eukaryotic assemblage was influenced by photosynthetic chlorophytes and diatoms, as well as mixotrophic ciliates and cryptophytes. Among all toxin-producing cyanobacterial genera, *Microcystis* abundance was most strongly correlated with microcystin concentrations ($P < 0.001$), both of which appeared to influence co-occurring eukaryotes. Finally, using putative relationships based on correlation of sequence abundance and environmental variables, several potential grazers of *Microcystis* were identified, including cyclopoid copepods and *Cryptomonas*. These correlations need further confirmation and experimental work to validate the nature of the relationships.

CITATION

Kalra, I., B.P. Stewart, K.M. Florea, J. Smith, E.A. Webb, D.A. Caron. 2025. Temporal and spatial dynamics of harmful algal bloom-associated microbial communities in eutrophic Clear Lake, California. *Applied and Environmental Microbiology* DOI:10.1128/aem.00011-25.

SCCWRP Journal Article #1428
Full text available online: www.sccwrp.org/publications

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Spatial structure and temporal dynamics in Clear Lake, CA: The role of wind in promoting and sustaining harmful cyanobacterial blooms

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[3]*In-Situ Environmental, Fort Collins, CO*
[4]*Badger Meter, Seaside, CA*
[5]*Xylem Water Solutions, Washington, DC*
[6]*Sacramento-San Joaquin Delta Conservancy, West Sacramento, CA*

Abstract

Clear Lake in Lake County, CA, USA has experienced highly toxic cyanobacterial blooms for more than a decade, with multiple cyanobacterial taxa and cyanotoxins appearing sporadically, typically throughout much of the early-spring to late-fall seasons. Recurring blooms have been attributed to high internal nutrient loads within the lake, with hydrography and hydrology playing important but still poorly documented roles in controlling the availability of growth-limiting elements to the phytoplankton community. The lake is approximately 180 km^2 in areal extent and composed of three somewhat disjointed lobes, or 'Arms'. The large size of the lake presents a formidable task for synoptic lakewide surveys and for understanding the specific features that stimulate the development and magnitude of harmful blooms. We conducted a study in August of 2020 that involved the use of an autonomous underwater vehicle and deployment of a hand-held water column profiler to describe the lakewide status of various biological, chemical, and physical features. Discrete water samples were also collected from ten stations located throughout the lake to produce a near-synoptic depiction of lake status. Additionally, a mechanically driven, continuously monitoring water-column profiler was deployed at a central lake location to document short-term temporal (minutes to months) changes in water-column structure and chemistry. Wind was a dominant feature affecting the lake's chemistry and biology during the study, resulting in massive concentrations and dramatic spatial heterogeneity of phytoplankton biomass and cyanotoxins in the eastern and southeastern Arms of the lake, and confirmed by the analysis of discrete water samples. Unique insight into the processes leading to or prolonging blooms was revealed by the water column profiler, which demonstrated rapid development (within a few hours) of suboxic conditions during periods of calm winds. We speculate that these quiescent periods are fundamental events in the lake's ecology, resulting in episodic 'pulses' of nutrient release from the sediments, which can stimulate or refuel blooms of cyanobacteria in the water column.

Citation

Caron, D.A., A.A.Y. Lie, B. Stewart, A. Tinoco, I. Kalra, S. Smith, A.L. Willingham, S. Sneddon, J. Smith, E. Webb, K. Florea, M.D.A. Howard. 2025. Spatial Structure and Temporal Dynamics in Clear Lake, CA: The Role of Wind in Promoting and Sustaining Harmful Cyanobacterial Blooms. *Water* 17:3265.

SCCWRP Journal Article #1458
Full text available online: www.sccwrp.org/publications

Influence of anthropogenic nutrient sources on kelp canopies during a marine heat wave

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

Abstract

Giant kelp (*Macrocystis pyrifera*), a keystone species in many temperate coastal oceans, is increasingly threatened by global change and local stressors including increased temperature, reduced nutrients, and decreased water clarity. In the Southern California Bight (SCB), a coastal region with enriched nitrogen input from of 23 million, understanding the factors that contribute to the stability of kelp habitat demands comprehensive research to protect this species and its critical ecosystem roles. During the 2014–2016 marine heat wave (MHW), giant kelp exhibited variability in its response across the SCB despite region-wide temperature increases, leading to questions about what might be conferring resilience to thermal stress. To better understand this variation, we spatially analyze kelp forest canopy area before and during the 2014–2016 MHW. We use spatial statistics to determine the correlation between these observations and estimates of anthropogenic dissolved inorganic nitrogen (DIN) derived from a regional physical-biogeochemical model. We find there are regions within the SCB where anthropogenic sources could elevate dissolved inorganic nitrogen to concentrations adequate for kelp growth during periods in which natural supplies would fall below growth thresholds. We also find kelp forests with greater days of anthropogenic influence during the MHW sustained a greater percentage of pre-MHW normalized canopy area. These results suggest possible contribution of anthropogenic nitrogen to kelp nutrient requirements during climate-driven nutrient stress. More work remains to tease apart anthropogenic nutrients from other eutrophication impacts, such as changes to water clarity from increased productivity, as well as other potential environmental and biological factors during MHW and non-MHW periods.

Citation

Hoel, P., D. Bianchi, K.C. Cavanaugh, C.A. Frieder, F. Kessouri. 2025. Influence of anthropogenic nutrient sources on kelp canopies during a marine heat wave. *Marine Pollution Bulletin* 216:117788.

SCCWRP Journal Article #1439
Full text available by request: pubrequest@sccwrp.org

Shifts in bacterioplankton during cyanobacterial blooms reflect bloom toxicity and lake trophic state

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Abstract

Harmful cyanobacterial blooms (cyanoHABs) typically occur in human-impacted eutrophic lakes suffering from nutrient pollution, but they also occur in pristine lakes spanning the trophic gradient. The drivers and dynamics of blooms in these oligotrophic lakes remain understudied. CyanoHABs alter the composition of bacterioplankton with increases in specific cyanobacteria strains, as well as shifts in heterotrophic taxa. Bacterioplankton community shifts during cyanoHABs can be somewhat predictable but have been only studied in a limited number of lakes, mostly eutrophic and impacted by development. The Cascade Mountains (USA) offer a novel setting to examine microcystin variation and shifts in bacterioplankton communities across trophic in relatively undeveloped lakes with documented cyanoHABs. Using physicochemical measurements, time-integrated toxin monitoring, and 16S rRNA gene sequencing, we explored associations of bacterioplankton communities with cyanoHABs and toxins within a season, as well as across lakes and years. In Cascade Mountain lakes, bacterioplankton communities and cyanoHABs varied spatially, reflecting differences in trophic state, among other factors. The cyanotoxin microcystin exceeded the drinking water chronic exposure level (1 ppb) in two lakes, during which cyanobacteria exceeded 20 % of the bacterioplankton community. Bacterioplankton composition changed notably during the cyanoHAB events, varying with bloom toxicity and lake trophic state. These compositional differences were not only driven by increases in cyanobacteria, specifically from the order Nostocales, but also heterotrophic bacteria such as from the orders Burkholderiales and Cytophagales. Therefore, bacterioplankton composition can potentially be consistent indicators of cyanoHABs and toxicity, more so than climatic factors across lakes that span substantial trophic gradients.

Citation

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SCCWRP Journal Article #1451
Full text available by request: pubrequest@sccwrp.org

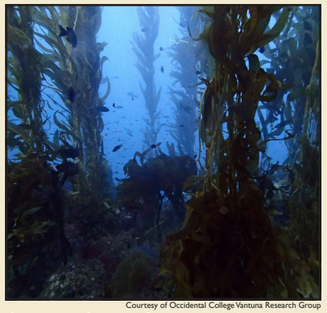
Framework developed to assess kelp forests for ocean health report card

A group of scientific experts convened by SCCWRP has developed a novel framework that uses satellite remote sensing data to assess the health of California's kelp forests across space and time – a standardized approach that paves the way for researchers to develop an ocean health report card for tracking the health of West Coast kelp.

The kelp assessment framework, completed in 2025, integrates high-resolution remote sensing data with standardized analytical methods to map and quantify the extent of kelp forests, as measured by canopy cover. Managers can use the framework to track how coastal kelp ecosystems respond to different factors, including climate change, marine heatwaves and changes in nutrient levels.

Kelp is one of 18 indicators under development to support routine assessments of coastal ocean health via both a California version and a West Coast version of ocean health report cards. The report cards are designed to provide managers and policymakers with comprehensive, executive-level snapshots reflecting the health of the coastal ocean.

The new kelp framework helps overcome a lack of consistency and standardization in how California assesses status and trends for a broad suite of ocean health indicators that have limited the management utility of this information. Kelp forests are key coastal marine ecosystems that support rich biological diversity and can help mitigate the adverse effects of human activities on coastal ocean health, including by drawing down dissolved carbon dioxide levels in the water column through their natural photosynthetic processes.



Courtesy of Occidental College Vantuna Research Group

A group of scientific experts that was convened by SCCWRP has developed a framework that uses satellite remote sensing data to map and quantify the extent of kelp forests – a standardized approach that paves the way for researchers to develop an ocean health report card for tracking the condition of West Coast kelp.

Panels develop recommendations to streamline coastal habitat mapping

A series of expert advisory panels convened by SCCWRP and its partners has developed recommendations for how California can streamline and standardize the process by which coastal habitats get mapped statewide – part of an effort to develop a more continuous, parsimonious process for keeping maps of coastal habitats up to date and relevant for supporting management decisions.

The recommendations, finalized in 2025, are intended to improve California's ability to do routine, consistent, sustainable mapping of rocky intertidal areas, coastal wetlands/estuaries, eelgrass beds, and beaches and dunes. The recommendations cover how to define habitat boundaries, collect and analyze data, and produce annual map updates in a routine and cost-effective manner.

The maps are foundational in building California's capacity to monitor the long-term resilience of coastal habitats to sea level rise and climate change.

Courtesy of Central Coast Wetlands Group, Moss Landing Marine Labs

Researchers have developed recommendations for standardizing how four types of coastal habitats get mapped across California, including for sites like Morro Bay Estuary, above. This work supports California's efforts to develop a statewide program for routinely generating high-quality maps that can support assessments of the health of coastal habitats statewide.

Workshop helps standardize eDNA-based method for monitoring OA effects

A group of scientific experts has developed a coordinated West Coast plan for using environmental DNA (eDNA) to track the effects of ocean acidification (OA) on vulnerable shell-forming organisms – an approach that has the potential to generate different types of insights than manually inspecting for signs of shell dissolution.

During a two-day workshop held in 2025 and hosted by SCCWRP, experts on eDNA and West Coast OA monitoring agreed that analyzing the DNA from pteropods, crab larvae and other tiny shell-forming organisms could serve as a valuable line of evidence for tracking OA's ecological effects along the West Coast; these organisms are having a tougher time building and maintaining their shells as a result of OA.

Workshop participants also developed a framework for standardizing an eDNA-based monitoring method to track OA's effects along the West Coast.

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Setting the limit: Cold rather than hot temperatures limit intertidal distribution of a coastal foundation species

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ABSTRACT

Long-lasting restoration success of foundation species requires understanding their responses to climate change. For species with broad distributions, lower latitudes may serve as a proxy for future warming at higher latitudes. Such space-for-time substitutions are a powerful tool for developing climate change predictions for species distributed along steep elevational gradients. To understand climate resilience of a key coastal foundation species, we examined the upper elevational limit of the native Olympia oyster (*Ostrea lurida*) along its entire range at 26 sites spanning 21° latitude, from British Columbia to Baja California. Counter to our expectations, high air temperatures did not affect variation in the upper limit of Olympia oysters. Indeed, Olympia oysters extended high into the intertidal zone at the warmer southern sites, and shading did not influence the upper limit. Our models indicated instead that extreme low temperatures set the upper limit for Olympia oysters at higher latitudes. In contrast, neither the Pacific oyster (*Magallana gigas*), a co-occurring global invader, nor barnacles exhibited clear latitudinal patterns. These findings suggest that Olympia oysters and restoration projects aimed at supporting their recovery will be resilient to increased temperatures projected by climate change models. Our results also illustrate the importance of testing the assumption that species on steep elevational gradients are living close to their upper thermal limits and will be negatively impacted by warming; for this foundation species, the assumption was false. Latitudinal studies enhance understanding of species response to climate stressors and are key to the design of climate-resilient conservation strategies.

CITATION

Wasson, K., K. Cressman, K. Beheshti, E.C. Herder, C. Endris, C.D.G. Harley, A. Abadia-Cardoso, R. Beas-Luna, J. Carolsfeld, A.L. Chang, J.A. Crooks, M.C. Ferner, E.D. Grosholz, N. Harrington, J. Harris, H. Hayford, A.R. Helms, J. Lorda, J.L. Ruesink, A. Ruiz de Alegria-Arzaburu, S.S. Rumrill, J. Schmitt, R.S. Smith, J.B. Walker, C.R. Whitcraft, S. Yang, D. Zacherl, C.J. Zabin. 2025. Setting the limit: cold rather than hot temperatures limit intertidal distribution of a coastal foundation species. *Marine Environmental Research* 208:107149.

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Full text available online: www.sccwrp.org/publications

Developing a status and trends assessment for floating kelp canopies across large geographic areas

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ABSTRACT

Effective kelp forest stewardship and management requires understanding of status and trends, but most kelp monitoring data streams on the U.S. West Coast are focused on subregional scales with outputs targeted toward a scientific audience. Here, we developed an index of kelp status and trend that integrates across thousands of kilometers and is presented as a simple, informative gauge that can be easily communicated to multiple audiences, including high-level policymakers. The indicator has three main features: (1) it is based on floating kelps as they create canopies, and managers indicated their interest in whether the quantity of kelp surface canopy had changed relative to historical levels. (2) Kelp canopy is assessed within segments along the coastline, rather than as a single coast-wide, cumulative amount. This approach retains local-level information allowing the indicator to be calculated at multiple scales, which accommodates the multigovernance landscape of the U.S. West Coast. (3) Status

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of kelp is expressed as a comparison to a reference period, established using all data prior to a marine heat wave in 2014 that led to substantial kelp losses. When applied to data from recent years, we found that the kelp canopies continue to be below their historical baseline. Since 2014, there has been no coast-wide recovery to reference levels. Still, despite 2023 being among the worst years on record, there was substantial improvement in kelp canopies in 2024 and recent downward trends have stalled. This Kelp Indicator provides a tool to inform resource management, improve policy, and prioritize scientific research, recovery efforts, and monitoring.

CITATION

Frieder, C.A., T.W. Bell, H. Berry, K. Cavanaugh, D.C. Claar, J. Freiwald, B. Grime, S. Hamilton, H.F. Houskeeper, N. Lombardo, S. Marion, T.A. McHugh, G. McKenna, P.E. Parnell, P. Spector, S.B. Weisberg. 2025. Developing a Status and Trends Assessment for Floating Kelp Canopies across Large Geographic Areas. *Environmental Science & Technology* DOI:10.1021/acs.est.5c07501.

SCCWRP Journal Article #1456
Full text available online: www.sccwrp.org/publications

A new climate impact of wildfire chars: Suppression of biogenic methane production over repeated redox cycles

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ABSTRACT

The warming climate has increased the frequency and intensity of wildfires, which can further exacerbate climate change. Here we report the suppression of biogenic methane (CH4) by wildfire chars, a previously unrecognized, potentially beneficial impact of wildfires on global climate. We hypothesized that char derived from wildfires possess an electron storage capacity (ESC) that can support char-respiring microbes, enabling them to outcompete methanogens. A total of 18 chars from fires that occurred between March and October 2023 were collected from across the U.S. All chars possessed sizable ESC, from 0.54 to 2.85 mmol e−/g in the E_H range of −0.36 to +0.81 V. Without char, singly ^{13}C-labeled acetate ($^{13}CH_3{}^{12}COO-$) was converted by a wastewater culture into equimolar $^{13}CH_4$ and $^{12}CO_2$. In the presence of an air-oxidized char, $^{13}CO_2$ was produced at the expense of $^{13}CH_4$, as anaerobic char respirers outcompeted acetoclastic methanogens. Char electron contents measured before and after acetate degradation showed that, electrons that would otherwise end up in CH_4 were deposited into char instead. On average, 28.4 ± 2.2% of the wildfire chars' ESC was utilized to divert electrons away from CH_4. Aeration of microbially utilized chars restored the chars' capacity to suppress CH_4, confirming the redox-reversible nature of ESC. These results improve our understanding of, and ability to assess, the full climate impacts of wildfires and deforestation. This study provides the first significant data set of wildfire char ESC, and the first quantitative demonstration of CH4 suppression by wildfire chars.

CITATION

Choi, J., D. Xin, P.C. Chiu. 2025. A New Climate Impact of Wildfire Chars: Suppression of Biogenic Methane Production Over Repeated Redox Cycles. *Environmental Science & Technology* 59:16443-16451.

SCCWRP Journal Article #1447
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Tracking coastal habitat change over time: Considerations for a statewide mapping program

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CITATION

San Francisco Estuary Institute, Southern California Coastal Water Research Project. 2025. Tracking Coastal Habitat Change Over Time: Considerations for a Statewide Mapping Program. Technical Report 1438. California Ocean Protection Council. Sacramento, CA.

SCCWRP Technical Report #1438
Full text available online: www.sccwrp.org/publications

Monitoring for management: A monitoring strategy for Southern California coastal wetlands

Southern California Wetlands Recovery Project

Southern California Wetlands Recovery Project, Oakland, CA

CITATION

Southern California Wetlands Recovery Project. 2025. Monitoring for Management: A Monitoring Strategy for Southern California Coastal Wetlands. Technical Report 1393.B. Southern California Wetlands Recovery Project. Oakland, CA.

SCCWRP Technical Report #1393.B
Full text available online: www.sccwrp.org/publications

Applicability of regional monitoring for agencies: Guidelines for incorporating the WRP Regional Monitoring Program into agency programs

Southern California Wetlands Recovery Project

Southern California Wetlands Recovery Project, Oakland, CA

CITATION

Southern California Wetlands Recovery Project. 2025. Applicability of Regional Monitoring for Agencies: Guidelines for Incorporating the WRP Regional Monitoring Program into Agency Programs. Technical Report 1393.C. Southern California Wetlands Recovery Project. Oakland, CA.

SCCWRP Technical Report #1393.C
Full text available online: www.sccwrp.org/publications

Implementation strategy for the Wetland Recovery Project Regional Monitoring Program: Provides recommendations for identifying the administrative structure and programmatic needs for long-term implementation of the WRP RMP program

Southern California Wetlands Recovery Project

Southern California Wetlands Recovery Project, Oakland, CA

CITATION

Southern California Wetlands Recovery Project. 2025. Implementation Strategy for the Wetland Recovery Project Regional Monitoring Program: Provides recommendations for identifying the administrative structure and programmatic needs for long-term implementation of the WRP RMP program. Technical Report 1393.D. Southern California Wetlands Recovery Project. Oakland, CA.

SCCWRP Technical Report #1393.D
Full text available online: www.sccwrp.org/publications

Passive samplers used to measure DDT at dump sites

SCCWRP and the Scripps Institution of Oceanography have successfully used passive sampling technology to measure the concentrations of the pesticide DDT and other legacy contaminants that are diffusing from seafloor sediment into the water column at a former industrial waste dump site in the San Pedro Basin.

The analysis, completed in 2025, has provided researchers with the data needed to develop models that estimate how much of this chemical contamination, which became attached to sediment decades ago, is re-entering the water column over time and the exposure risks it poses to aquatic life.

The deployment at the dump site – located between the mainland and Catalina Island – was the first such attempt to deploy passive samplers at this site following its rediscovery about five years ago.

The site received thousands of barrels and bulk waste from the former Montrose Chemical Corporation in Los Angeles County, which at the time was the nation's largest DDT manufacturer.

Passive sampling devices consist of thin membrane films that can detect low levels of contaminants in surface layers of sediment that dissolve into the water column. Researchers may return to the site in the future to deploy additional passive samplers.

A field crew deploys passive sampling devices at an offshore site where thousands of barrels and bulk waste from production of the pesticide DDT were dumped. Researchers are developing models to estimate how much of this chemical contamination in the sediment is re-entering the water column in the San Pedro Basin.

Biofiltration BMPs found to remove microplastic particles

A study examining whether biofiltration BMPs (best management practices) can efficiently remove microplastics from Southern California runoff has found that these stormwater control measures are effective as a treatment solution – an important finding given that runoff is a major contributor to microplastics pollution in aquatic environments.

The regional SCCWRP-led study, completed in 2025, found that biofiltration BMPs successfully reduced microplastics concentrations by a median of 72% across all storm events. Moreover, the study found that the engineered media in biofiltration systems is uniformly efficient at microplastics removal, regardless of the measured size of microplastics and regardless of the type of media installed in the existing BMPs.

The study also found that microplastic particles become trapped within the pore spaces between engineered media particles. Thus, media pore size could be a useful design consideration for optimizing BMP performance in the future.

Researchers estimate that trillions of microplastic particles are discharged annually into California coastal waters via runoff. Thus, the study provides encouraging news for water-quality managers across California and beyond that are seeking solutions to better control and manage the ubiquitous problem of microplastics pollution.

SCCWRP's Jerod Gray, left, and Liesl Tiefenthaler collect media samples from a biofiltration BMP in Orange County for microplastics analysis. Researchers have found that biofiltration BMPs offer an efficient solution for removing microplastics from runoff in Southern California.

Method for screening pesticides in water bodies validated for statewide accreditation

SCCWRP and its partners have successfully validated a new statewide method for detecting and measuring up to 140 pesticides simultaneously using an integrated set of processing and analysis steps – an effort that paves the way for statewide accreditation of the method.

The method validation work, completed in 2025, will serve as the scientific foundation for California's Environmental Laboratory Accreditation Program (ELAP) to consider accrediting laboratories to use the method to generate environmental data.

The method, which is designed for use with both grab water samples and passive sampling devices that sorb contaminants in water bodies, eliminates the need for managers to turn to a diverse range of siloed processing and analysis methods to measure a broad array of current-use pesticides. California has historically lacked a single, streamlined method for screening water bodies for a broad suite of current-use pesticides.

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The Toxicity of Microplastics Explorer (ToMEx) 2.0

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ABSTRACT

In 2021, the Toxicity of Microplastics Explorer (ToMEx, https://microplastics.sccwrp.org) was released as an open source, open access database and web application for microplastics toxicity. Since then, it has been utilized by the microplastic research community for the exploration, visualization, and analysis of toxicity data for both hazard characterization and risk assessment. The peer-reviewed literature has continued to grow exponentially, making ToMEx out-of-date. To ensure the continued utility of ToMEx, an international crowd-sourcing approach was utilized to update ToMEx by extracting data from additional studies published since the original release. Through this process, both the aquatic and human health ToMEx databases roughly doubled in size, and modest increases in data diversity (e.g., number of species represented, types of test particles) were observed in the aquatic organisms database. However, most trends (e.g., greater toxicities observed with smaller particle sizes, lack of dose–response data etc.) observed in the first iteration of ToMEx remained constant. A previously developed framework for deriving ecological health-based microplastic thresholds using species sensitivity distributions was reapplied to determine how thresholds and their associated uncertainty intervals would change following the database update. Twelve new studies passed minimum screening criteria and were deemed fit for the purpose of threshold derivation. The addition of new data allowed for the separation of freshwater and marine compartments which had previously been combined due to a lack of applicable toxicity data for freshwater species. When molecular and cellular level endpoints were included, freshwater thresholds were comparable or increased from values calculated using previous data (-5 to 2.5-fold change) whereas marine thresholds dramatically decreased (-5000 to -29-fold change). However, when endpoints were restricted to organism and above, marine and freshwater thresholds were comparable to those calculated previously (-20 to 14-fold change). Confidence intervals for both marine and freshwater thresholds remained wide. The doubling of the database increases the value of ToMEx for researchers, particularly those focused on characterizing hazards associated with microplastics. Its utility remains limited for environmental managers as 89% of studies in ToMEx 2.0 failed to meet minimum screening criteria for threshold derivation, highlighting the need to generate fit-for-purpose toxicity data for threshold development. However, ToMEx continues to be a useful research tool, and future iterations could become even

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more powerful through novel artificial intelligence applications to streamline data curation and even predict toxicological outcomes.

CITATION

Thornton Hampton, L.M., D.B. Wyler, B.C. Almroth, S. Coffin, W. Cowger, D. Doyle, E.D. Hataley, S.J. Hutton, M.M. Mair, E.L. Miller, L. Monclus, E.E. Sharpe, S. Samreen, K.T. Ahmed, Q.P.V. Allamby, A.L. Antonio Vital, D. Asnicar, J.L. Bare, A. Barrick, K. Berreman, L. Bertrand, V. Boone, A. Bour, J. Brehm, V. Carrasco-Navarro, T. Cook, G.A. Covernton, P. Cubanski, P.M.C. Da Silva, L. de Souza Leite, S.M. Gene, L. Hermabessiere, A. Hooge, Y. Iwasaki, N. Klasios, C.M. Knauss, A.K. Kardgar, P. Kropf, I.B. Kudu, A. Kukkola, C. Laforsch, S.B. Kennedy, F.D.L. Leusch, L.W. Li, H.C. Lu, J. Mahan, U.D. Saif, S. Mondellini, J.P. Norman, Z. Pandelides, T. Petersson, D.A. Philibert, E. Kvist, A.F.R.M. Ramsperger, G. Rigutto, S. Ritschar, M.H. Sandgaard, J. Schmitt, M. Schott, M. Schwarzer, K.J. Seabrook, T.M. Seifried, R. Sepahi, M. Sina, A.N. Testoff, M. Vercauteren, C.M. Wardlaw, A. Yeh, M. Zajac-Fay, A.C. Mehinto. 2025. The Toxicity of Microplastics Explorer (ToMEx) 2.0. *Microplastics and Nanoplastics* DOI:10.1186/s43591-025-00145-6.

SCCWRP Journal Article #1454
Full text available online: www.sccwrp.org/publications

Microplastic pollution in the water column and benthic sediment of the San Pedro Bay, California, USA

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ABSTRACT

The concentration, character, and distribution of microplastics in coastal marine environments remain poorly understood, with most research focusing on the abundance of microplastics at the sea surface. To address this gap, we conducted one of the first comprehensive assessments of microplastic distribution through the marine water column and benthic sediment during the wet and dry season in the coastal waters of the San Pedro Bay Southern California, USA. Microplastic concentrations in the water column did not vary significantly across season but were significantly higher in nearshore environments and at the surface of the water column. Sediment samples contained significantly more microplastics in the wet season and in offshore environments. Black particles were the most dominant color, while fibers were the most abundant morphology, accounting for over 50% of both water column and sediment microplastics. Polyethylene and polypropylene were identified as the most abundant polymers in the water column regardless of morphology type. Tire and road wear particles were found through the study domain. Average microplastic concentrations in the San Pedro Bay were estimated to be $8.65 \times 10^5 \pm 7.60 \times 10^5$ particles/km^2 and 3.19 ± 2.96 particles/m^3. This study highlights the complexity of microplastic concentration, character, and distribution in marine environments and demonstrates that surface only sampling strategies significantly underestimate microplastic concentrations. Our findings underscore the need for continued and expanded research into microplastic distribution and transport dynamics across the marine environment to aid in understanding, managing, and mitigating plastic pollution in coastal marine systems.

CITATION

Singh, S., A.B. Gray, C. Murphy-Hagan, H. Hapich, W. Cowger, J. Perna, T. Le, H. Nogi, B. Badwal, K. McLaughlin, F. Kessouri, C. Moore, G. Lattin, L.M. Thornton Hampton, C.S. Wong, M. Sutula. 2025. Microplastic pollution in the water column and benthic sediment of the San Pedro Bay, California, USA. *Environmental Research* 269:120866.

SCCWRP Journal Article #1432
Full text available online: www.sccwrp.org/publications

Postprocessing methods based on minimum detectable amount and method blank for data reporting of particle count and refining estimation of matrix spike recovery in environmental microplastics analysis

Wenjian Lao

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ABSTRACT

Data handling that converts the raw data into a deliverable dataset is a necessary step in any analytical work. This procedure involves applying detection limits to shaping the raw data to form a deliverable dataset. The detection limit for microplastics analysis is the minimum detectable amount (MDA) that can be calculated from the particle counts of procedural blank samples following the rules of the Poisson distribution. Currently, there is a lack of adequate data reporting guidance encompassing the MDA for microplastics analysis. The goal of this study was to establish a robust protocol for processing count-based raw data using the particle counts of the MDA and the procedural blank. Utilizing the dataset of an interlaboratory comparison exercise, effectiveness of the protocol was elaborated to generate a deliverable dataset and to accurately define the matrix spiking recoveries. The guidance was applied to the raw data of all size fractions (1 - >500 µm), four individual size fractions (>500, 212–500, 20–212, 1–20 µm), and two morphologies (fiber and non-fiber). Six possible data reporting scenarios were identified, with the raw data ranging well above the MDA to below the critical value. One-third (12 of 34) of the raw data for all size fractions needed blank-MDA corrections. The mean values of the spiking recoveries decreased by up to 10% after performing the data reporting guidance. Application of this suggested data reporting guidance may be beneficial for high quality data for microplastics analysis.

CITATION

Lao, W. 2025. Postprocessing methods based on minimum detectable amount and method blank for data reporting of particle count and refining estimation of matrix spike recovery in environmental microplastics analysis. *Chemosphere* 377:144325.

SCCWRP Journal Article #1425
Full text available by request: pubrequest@sccwrp.org

Characterization and potential influence of laboratory airborne particle fallout on microplastics analysis

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ABSTRACT

Attenuating background contamination is essential in analytical methods, particularly for analysis of microplastics (MPs). While measures to mitigate airborne particle interference exist, long-term laboratory fallout remains understudied. We conducted a 28-month monitoring study in a trace organics laboratory where a background contamination control protocol was implemented at the outset. Airborne particles were passively collected on polycarbonate track etch (PCTE) membrane filters at six locations over periods ranging from one to several months. Deposition rates decreased significantly from 82.3 ± 47.6–6.2 ± 5.5 (count / h / 8-inch sieve) within the first eight months and stabilized at a low level (4.21 ± 3.74) with sustained protocol adherence. Estimated intrusion of airborne particles into sample containers during MP sample preparation ranged from 14.1 to 0.2 particles, representing only 2–8 % of the lowest procedural blank, indicating minimal contamination potential. Polyvinyl chloride (PVC) and polytetrafluoroethylene (PTFE) were the most frequently detected MPs. The particle size ≥ 6 µm (counts ≥ 2) was well characterized by log-normal and linear log-log distributions. These findings demonstrate effective contamination control, providing a robust framework for laboratories engaged in MP analysis.

CITATION

Lao, W., S. Sauers, C.S. Wong. 2025. Characterization and potential influence of laboratory airborne particle fallout on microplastics analysis. *Journal of Hazardous Materials* 499:140309.

SCCWRP Journal Article #1455
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Evaluation of multilayer co-extrusion film and other three plastic membranes as passive samplers for determination of polyhalogenated carbazoles in water

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ABSTRACT

Passive sampling methods can provide valuable insights for monitoring hydrophobic organic compounds (HOCs) in aquatic environments. As the list of target HOCs expands, there is an increasing demand for passive samplers that can detect a broader range of these compounds. This study aimed to assess the efficacy of a three-layer co-extruded polyethylene/ethylene vinyl acetate (TLC-EVA) film alongside three existing materials (polyethylene (PE), polydimethylsiloxane (PDMS), and poly(methyl methacrylate) (PMMA)) for passive sampling of carbazole and five halogenated carbazoles (PHCZs), a group of dioxin-like chemicals, in water. The films were calibrated through batch experiments to determine the partition coefficients between the polymer and water (K_{PW}). The performance of the samplers and the presence of PHCZs were evaluated through 7- and 14-day exposures in the Xiaoyi River, which flows through Qufu City, China. The logK_{PW} values varied significantly among the compounds and were generally consistent across the four films, ranging from 2.73 to 4.14 for EVA, 2.65 to 4.21 for PE, 2.85 to 3.98 for PMMA, and 2.62 to 4.22 for PDMS. These findings indicate that the films can effectively function as passive samplers for PHCZs. Additionally, a comparison of logK_{PW} results with physicochemical parameters (logK_{OW} and logK_{OC}) highlighted the negative impact of halogen substituents and steric hindrance on sorption, particularly for 1,3,6,8-tetrabromocarbazole. The passive sampling reached equilibrium within the 7-day exposure period, with all PHCZs detected in the river water. Increased concentrations at urban and wastewater treatment plant outlet sampling sites suggested specific sources of PHCZs. Our results advocate for the application of multilayer co-extrusion films as a novel material for passive sampling of HOCs.

CITATION

Lao, W., X. Shang, S. Yu, H. Xiao, Y. Lou, C. Song, J. You. 2025. Evaluation of multilayer co-extrusion film and other three plastic membranes as passive samplers for determination of polyhalogenated carbazoles in water. *Water Research* DOI:10.1016/j.watres.2025.123266.

SCCWRP Journal Article #1421
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Optimizing Fenton process for efficient destruction of energetic compounds in insensitive munitions explosives (IMX) wastewater

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

ABSTRACT

IMX-104 is a new insensitive munitions explosives (IMX) formulation consisting of three main munitions compounds (MCs), 3-nitro-1,2,4-triazol-5-one (NTO), 2,4-dinitroanisole (DNAN), and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX). The high water solubility and acidity of NTO render existing wastewater treatment technologies, such as granular activated carbon adsorption, ineffective for IMX-104 wastewater. We investigated Fenton oxidation as a potential alternative treatment technology for IMX-104 wastewater, using an aqueous solution saturated with DNAN, NTO, and RDX as a surrogate. For a given quantity of Fenton reagent, the extents of NTO and DNAN destruction and mineralization were strongly influenced by the order of Fe^{2+} and H_2O_2 addition and the Fe^{2+} dosing rate. Optimal results were achieved by (1) adding H_2O_2 prior to Fe^{2+} and (2) decreasing Fe^{2+} dosing rate. These adjustments improved NTO destruction efficiency from 48 % to 95 % and from 95 % to 100 %, respectively. Both beneficial effects were attributed to the greater utilization efficiency of hydroxyl radical (.OH), which was achieved by minimizing non-productive .OH consumption by Fe^{2+}. Through process optimization, complete degradation of all three MCs and >90 % removal of total organic carbon were achieved within 15 minutes. This study demonstrates that the Fenton treatment efficiency for IMX wastewater is highly variable and tunable, and that the dosing sequence and dosing rate can greatly impact treatment outcome. Our findings suggest a general strategy to improve the efficiency of Fenton oxidation – a strategy that is likely applicable to other, non-IMX wastewaters.

CITATION

Xin, D., J. Choi, D.K. Cha, B.P. Hubbard, S.M. Sheets, P.C. Chiu. 2025. Optimizing Fenton process for efficient destruction of energetic compounds in insensitive munitions explosives (IMX) wastewater. *Journal of Environmental Chemical Engineering* 13:116329.

SCCWRP Journal Article #1426
Full text available by request: pubrequest@sccwrp.org

Standard operating procedures for the collection of samples for microplastics analysis part 1: Surface sediment and aquatic biota

Leah M. Thornton Hampton, Alvine C. Mehinto, Stephen B. Weisberg

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Thornton Hampton, L.M., A.C. Mehinto, S.B. Weisberg. 2025. Standard Operating Procedures for the Collection of Samples for Microplastics Analysis Part 1: Surface Sediment and Aquatic Biota. Technical Report 1410.A. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1410.A
Full text available online: www.sccwrp.org/publications

Study links HF183 fecal marker in runoff to illness risks

SCCWRP and its partners have completed a study establishing the inflection point, or threshold, at which levels of the fecal contamination marker HF183 in wet-weather runoff correspond to an elevated illness risk for people swimming in contaminated receiving waters – a finding that paves the way for a follow-up investigation examining what actions are appropriate for managers to take based on the level of HF183 measured.

The three-year study, conducted in partnership with the Southern California Stormwater Monitoring Coalition (SMC) and described in a pair of journal manuscripts published in 2025, found that 100 gene copies of HF183 in a 100-mL sample is the threshold at which a water body with contaminated stormwater is deemed unsafe to swim in.

By contrast, an average of 557 gene copies per 100 mL are present during wet weather in Southern California coastal watersheds. This means that, on average, wet-weather runoff in Southern California would need to be diluted about 5.5-fold to fall within the safe-to-swim range established by the U.S. Environmental Protection Agency.

Translated into illness risks, the fecal contamination levels that researchers measured in Southern California runoff correspond to a predicted average of 190 gastrointestinal illnesses per 1,000 swimmers. The EPA-approved health risk threshold is 32 illnesses per 1,000.

These insights have helped close a critical knowledge gap regarding the illness risks associated with beachgoers and others who inadvertently ingest fecal-contaminated water.

Surfers paddle away from shore at San Diego's Ocean Beach shortly after a storm. SCCWRP and its partners have completed a study establishing the threshold at which levels of the HF183 fecal marker in wet-weather runoff correspond to an elevated illness risk for people swimming in contaminated receiving waters.

Method developed to detect exfiltration from sewer pipes

SCCWRP and its partners have developed a novel method for detecting exfiltration from underground sewer pipes that can detect volumetric losses of as little as one liter out of 4,200 liters – an approach that already has been used to estimate how much sewer exfiltration is contributing to human fecal pollution in the lower San Diego River watershed.

The method, described in a pair of journal manuscripts published in 2025, involves pumping a known volume of water at a controlled rate through an isolated section of sewer pipe, then measuring the difference between the volume pumped in and the volume recovered. The method was developed to mimic typical flow conditions in sewer pipes.

Initially, the method was applied to measure exfiltration from sewer pipes of different types and ages in the lower San Diego River watershed. Then, researchers used the data in combination with modeling tools and other data sources to estimate that public sewer exfiltration may be a significant contributor to human fecal contamination at the coastal terminus of the San Diego River watershed.

More work is needed to refine the method, apply it in other watersheds, and understand how exfiltrated sewage may be reaching receiving waters.

A field crew recovers water from a sewer manhole in San Diego County as part of an effort to measure potential exfiltration from underground sewer pipes. Researchers have used a new method to estimate how much sewer exfiltration is contributing to human fecal pollution in the lower San Diego River watershed.

Towards quantifying exfiltration from *in situ* sanitary sewer pipes

John F. Griffith, Joshua A. Steele, Adriana Gonzalez-Fernández, Kenneth C. Schiff

Southern California Coastal Water Research Project, Costa Mesa, CA

Abstract

Exfiltration from sanitary sewers has been researched for many years because of its potential impact on shallow groundwater or surface water, but measurements of exfiltration *in situ* are rare. Most previous measurements of sanitary sewer exfiltration have been done in the laboratory, in the field using natural, chemical or pharmaceutical tracers or modeled. Relatively few studies have employed physical measurements of volume loss in field settings. Here, we design, test, and apply at a watershed scale, a new methodology for measuring volume loss from sanitary sewer pipes that are currently in use and under typical operating conditions (i.e., not pressurized). The measurement system works by: (1) isolating a section of sanitary sewer between maintenance holes using a sewer bypass or equivalent, (2) introducing roughly 4,200 L of water at a controlled rate into the upstream inspection hole so that pipes remain one-third to one-half full, (3) using vacuum pumps to recover the introduced water at the downstream inspection hole, then (4) measuring differences in the volume from what was pumped into the inspection hole to what was recovered. This process is repeated up to six times to achieve a sensitivity of 0.95 L per experimental pipe segment. This technique was applied to 23 pipe segments of various ages and materials of construction that were selected to be a representative sample of the pipes throughout San Diego. Collectively, these pipes averaged 3.78×10^{-2} L/s-km exfiltration rates (95%CI: 4.96×10^{-2}, 2.60×10^{-2}). Two of the pipe segments were infiltrating groundwater. Six pipe segments were not statistically different from zero (i.e., no exfiltration). There was no statistical difference between pipe segments of differing ages (<i>p<i> = 0.5) or materials of construction ($p = 0.3$). This study represents an initial effort at measuring exfiltration from *in situ* sanitary pipes. Future applications of this methodology should focus on method optimization, measurements at additional locations, and expanding measurements to collect data from additional types of pipe to better understand the geographic portability of the method and the relationship between exfiltration rates, pipe material, and pipe age.

Citation

Griffith, J.F., J.A. Steele, A. Gonzalez-Fernandez, K.C. Schiff. 2025. Towards quantifying exfiltration from *in situ* sanitary sewer pipes. *Frontiers in Environmental Science* DOI:10.3389/fenvs.2024.1458146.

SCCWRP Journal Article #1413
Full text available online: www.sccwrp.org/publications

Extrapolating empirical measurements of wastewater exfiltration from sanitary sewers to estimate watershed-scale fecal pollution loading in urban stormwater runoff

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[2]*WSP, San Diego, CA*

Abstract

Inflow and infiltration are well-known issues for sanitary sewer collection systems, but exfiltration is understudied and rarely empirically quantified. The goal of this study is to estimate the potential human fecal contribution from wastewater exfiltration from sanitary sewers to stormwater in an urban watershed with separate sanitary sewer and storm sewer systems. This study uses newly developed techniques to empirically measure sanitary sewage exfiltration, then compares these exfiltration rates to human fecal pollutant loading in stormwater runoff from multiple urban catchments without other sources of human inputs (i.e., no septic systems, no homeless encampments, no reported sanitary sewer overflows) to estimate the amount of exfiltrated sewage that reaches stormwater. The human-specific genetic marker HF183, which is highly concentrated in raw sewage, was used as a surrogate for human fecal pollution and was measured in nearly every stormwater sample collected. We extrapolated measured exfiltration to the entire 419 km^2 watershed and estimated up to 4.25×10^6 L exfiltrate each day. This is 0.6% of the average daily volume of sewage treated in this sewer collection system and is similar in scale to exfiltration allowed by design standards. Based on ratios of exfiltration loading predictions vs. stormwater loading measurements, the proportion of exfiltrated human fecal load that is estimated to be transported via subsurface pathways (i.e., the subsurface transfer coefficient, STC) to stormwater in the studied catchments is 8.27×10^{-5} (95% CI: 6.30×10^{-5} to 1.37×10^{-4}). Human fecal pollution loads from exfiltration via subsurface transfer during a storm event were calculated to be 1.5×10^{13} (95% CI: 1.79×10^{12} to 3.59×10^{13}) HF183 gene copies per storm. This estimate is similar in scale to the measured mass loading estimates in stormwater for the studied watershed and comparable to independently-measured tracers of sewage. Future work is needed to better understand subsurface transport mechanisms of exfiltrated sewage and to test this approach, and the assumptions used, in other watersheds and sewer systems.

Citation

Steele, J.A., A. Gonzalez-Fernandez, J.F. Griffith, D. Ebentier McCargar, S. Wallace, K.C. Schiff. 2025. Extrapolating empirical measurements of wastewater exfiltration from sanitary sewers to estimate watershed-scale fecal pollution loading in urban stormwater runoff. *Frontiers in Environmental Science* DOI:10.3389/fenvs.2024.1458153.

SCCWRP Journal Article #1414

Full text available online: www.sccwrp.org/publications

Simulated gastrointestinal risk from recreational exposure to Southern California stormwater and relationship to human-associated Bacteroidales marker HF183

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

Abstract

Stormwater may contain pathogens that pose a health risk to recreators. In this study, we use quantitative microbial risk assessment (QMRA) to simulate the human health risk associated with recreational exposure to stormwater using a regional dataset of pathogen concentrations measured over two wet seasons during wet weather events in Southern California, USA, a location where stormwater and sewage systems are separate. We model risk using a Monte Carlo simulation using *Salmonella*, *Campylobacter*, adenovirus, and norovirus concentrations in stormwater, the volume of water ingested during a recreational swimming event, and pathogen-specific dose–response functions. We estimated the median probability of illness from recreational exposure to stormwater to be approximately 190 illnesses per 1000 swimmers (19%). However, stormwater sampling sites are not always designated for recreational use, so we simulated exposures to diluted stormwater, which may be encountered in downstream receiving waters designated for swimming. We determined that if stormwater is diluted 18% into receiving, pathogen-free, ambient waters, the median health risk meets the US EPA's threshold of 32 illnesses per 1000 swimmers. At this dilution, the concentration of HF183, a human-associated fecal marker, is expected to be 100 copies per 100 milliliters. This study provides a risk-based threshold for HF183 concentrations in stormwater-impacted ambient waters from pathogen and indicator concentrations measured in stormwater. Implementing this risk-based threshold will require many policy considerations.

Citation

Lowry, S.A., J.A. Steele, J.F. Griffith, K.C. Schiff, A.B. Boehm. 2025. Simulated gastrointestinal risk from recreational exposure to Southern California stormwater and relationship to human-associated Bacteroidales marker HF183. *Environmental Science: Processes & Impacts* DOI:10.1039/d4em00577e.

SCCWRP Journal Article #1435
Full text available by request: pubrequest@sccwrp.org

Survey of pathogens and human fecal markers in stormwater across a highly populated urban region

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Abstract

Microbial contamination of urban stormwater, rivers, and creeks during rainstorms is a persistent and widespread problem. Remediation of these waters has proven to be challenging since there are many potential sources for the fecal indicator bacteria on which water quality is regulated. Microbial source tracking markers have allowed for improved identification and quantification of the sources of contamination, but the majority of the source-attributed microbial targets are not responsible for causing the illnesses associated with waterborne human fecal contamination. Thus there is a need to better understand the relationships of human pathogens and human fecal markers in stormwater. In this study, we used a spatially-intensive sampling approach (31 sites) across southern California for the analysis of stormwater. During three storms from 2021–2023, we used droplet digital PCR to quantify the human fecal markers HF183 and Lachno3 along with human adenovirus, human norovirus, *Campylobacter* spp., and *Salmonella* spp. This spatially intensive sampling design captures information from a 5900 km^2 area with ~22 million people. We detected human markers HF183 and Lachno3 genes at 90% and 97% of the sites; concentrations ranged from below detection to 10^4 and 10^5 gene copies per 100 mL, respectively. We found variable concentrations of human bacterial and viral pathogen genes. HF183 was significantly correlated to human adenovirus and Lachno3. Lachno3 was also significantly correlated with *Salmonella*. We reported PCR inhibition in 83–90% of the samples but found that separating sediment and adding proteinase K during lysis improved DNA/RNA extraction efficiency and reduced inhibition.

Citation

Steele, J.A., A.G. Zimmer-Faust, T.J. Clerkin, A. Gonzalez-Fernandez, S.A. Lowry, A.D. Blackwood, K. Raygoza, K. Langlois, A.B. Boehm, R.T. Noble, J.F. Griffith, K.C. Schiff. 2025. Survey of pathogens and human fecal markers in stormwater across a highly populated urban region. *Environmental Science: Processes & Impacts* 27:1354-1367.

SCCWRP Journal Article #1440
Full text available by request: pubrequest@sccwrp.org

Evaluation of a modified IDEXX method for antimicrobial resistance monitoring of extended Beta-lactamases-producing *Escherichia coli* in impacted waters near the U.S.-Mexico border

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Abstract

As part of a One Health approach, the World Health Organization (WHO) has deemed extended beta-lactamases-producing *Escherichia coli* (ESBL-Ec) as an appropriate proxy for antimicrobial resistance (AMR) in human, animal, and environmental samples. Traditional methods for ESBL-Ec quantification involve a labor-intensive process of membrane filtration, culturing in the presence and absence of antibiotics, and colony confirmation. The emerging modified IDEXX method utilizes IDEXX Colilert-18 test kits, recognized by the USEPA for the enumeration of total coliforms and *E. coli* in water samples, modified with cefotaxime for measurement of ESBL-Ec in environmental samples. However, this method has yet to be validated for ocean or sewage-contaminated water and has not been compared against the plate-based method with mTEC for surface water. In this study, ESBL-Ec in ocean and river waters of the Tijuana River Estuary were analyzed by three methods: membrane filtration using mTEC plates (as outlined in USEPA Method 1603), membrane filtration using TBX plates (as outlined in the WHO Tricycle Protocol), and Colilert-18 spiked with cefotaxime (Hornsby et al. 2023). Levels of ESBL-Ec were elevated in the Tijuana River Estuary and nearby ocean samples, as high as 2.2×10^6 CFU/100 mL. The modified IDEXX method correlated with membrane filtration methods using selective mTEC ($r = 0.967$, $p < 0.001$, $n = 14$) and TBX (</i>r</i> = 0.95, $p < 0.001$, $n = 14$) agars. These results indicate that the modified IDEXX method can be used as a more accessible alternative to the traditional culturing methods as a screening tool for antibiotic resistance in urban aquatic environments. Advantages of the IDEXX-based method including portability, lower Biosafety Level requirements, fewer dilutions to stay within the dynamic range, greater ease of maintaining sterility during analysis, and less required staff training are discussed. Future studies into the validity of the modified IDEXX method compared to qPCR and metagenomic sequencing are needed.

Citation

Jimenez, K., Y. Kong, Y. Zhang, D. Ferketic, S.K. Nagori, J. Yang, A.A. Yulo, B. Kramer, O.G. Prado, T. Cason, R. Chowdhry, A. Kemsley, L.M. Espinosa, J.A. Steele, J.F. Griffith, J.A. Jay. 2025. Evaluation of a modified IDEXX method for antimicrobial resistance monitoring of extended Beta-lactamases-producing Escherichia coli in impacted waters near the U.S.-Mexico border. *One Health* 20:100997.

SCCWRP Journal Article #1431
Full text available online: www.sccwrp.org/publications

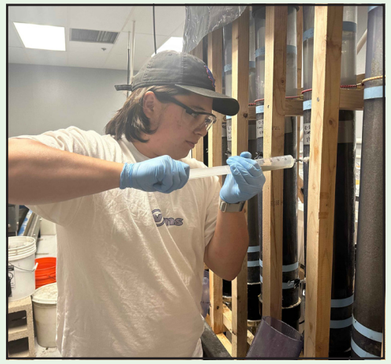
Lab phase completed for BMP mechanistic processes study

SCCWRP and its partners have completed the laboratory phase of an ongoing study working to characterize the mechanistic inner processes by which a ubiquitous class of stormwater BMPs known as biofiltration systems removes pollutants from runoff.

The study's laboratory phase, described in a pair of manuscripts published in 2025, has identified two easily measurable biofiltration media properties – cation exchange capacity and bulk density – that are strong indicators of the media's capacity to remove dissolved copper from stormwater runoff.

The mechanistic inner processes by which structural BMPs like biofiltration systems remove contaminants have historically been a "black box" – with researchers routinely measuring the runoff entering and exiting the BMP, but not focusing on what happens inside the BMP as this runoff is being treated, including understanding the influence that different BMP design specifications have on performance.

Researchers constructed flow-through columns filled with different types of BMP treatment media to mimic how dissolved copper and per- and poly-fluoroalkyl substances (PFAS) are removed as runoff flows through a biofiltration BMP. These studies were designed to simulate real-world BMP conditions, including runoff infiltration rate and pollutant loads.



SCCWRP's Jerod Gray uses a syringe to collect a sample from a set of flow-through columns that have been built in a SCCWRP laboratory to mimic how runoff flows through a biofiltration BMP. Researchers have completed the laboratory phase of an investigation seeking to open the "black box" for how these systems work, providing insights that are expected to help researchers understand the influence that different design specifications have on the BMP's performance.

Tools developed to streamline BMP performance evaluations

SCCWRP has developed a pair of calculator tools intended to streamline the process by which stormwater managers evaluate the performance of structural BMPs (best management practices).

The Multi-Metric BMP Performance Index, which was publicly unveiled in 2025, generates a quantitative BMP performance score to provide insights into whether individual BMPs are performing at levels that contribute to meeting watershed-specific water-quality goals, or whether further management action is needed for the BMP to perform at these levels. The Infiltration Analysis Calculator, which was published online in 2025, determines how quickly runoff is processed across a BMP's soil-water interface – a key indicator of BMP performance. The tools have the potential to enable managers to conduct more insightful, quantitative BMP performance evaluations.

Low-cost sensors for detecting illicit discharges transitioned to end users

SCCWRP and its partners have successfully transitioned a network of low-cost field sensors that play a key role in automating detection of illicit pollutant discharges to a monitoring team at Orange County Public Works, following the completion of a pilot study in Orange County storm drains.

During a workshop held at SCCWRP in 2025, researchers trained end users from Orange County on field deployment, sensor maintenance, and data analysis. The sensors are coupled with an algorithm that automates detection of unusual discharges that can pass rapidly through storm drain systems. The technology was developed by the BoSL Water Monitoring and Control Research Team in Australia.

Historically, researchers have conducted periodic, in-person field sampling during dry weather to detect these discharges – a monitoring approach that can limit managers' chances of detecting transient pollutant discharges. Additionally, processing field samples can take weeks to generate results, further hampering the time managers have to detect an illicit discharge.

By contrast, automated monitoring produces a continuous stream of real-time data that enables the algorithm to alert managers to sudden changes in water quality and flow that can lead to focused source-tracking follow-up work.

A monitoring team from Orange County Public Works explores how to use low-cost field sensors to automate detection of illicit pollutant discharges during a workshop at SCCWRP.

Design of a mobile, field-scale rainfall generator for urban runoff water quality studies

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ABSTRACT

Design principles and construction of a low-cost, portable rainfall generator (RFG) as a tool for field-scale urban runoff water quality studies are presented. The novel RFG (i.e., rainfall simulator) is an adaptation of a classic Norton-Ladder-type RFG that produces and uniformly applies near-natural rainfall to a movable, field-scale footprint. The simulated rainfall mimics the kinetic energy and peak intensity of a significant natural rainfall event in the Mediterranean climate of southern California. Kinetic energy is considered the most important characteristic for mobilizing pollutants. Air-induction nozzles are used to produce a relatively coarse droplet such that the calculated kinetic energy reasonably agrees with kinetic energy modeled by intensity-energy relationships. The 32mm=h intensity of the present RFG matches a 25 year, 60 min return period storm for the Los Angeles region. The design of the RFG system overcomes shortfalls of previous RFGs that underestimated the kinetic energy of low-intensity events, a symptom of small droplets having reduced terminal velocity. The overall system design generates a constant rainfall intensity through eight oscillating nozzles over a uniform area of 6.5 m^2. Pilot testing indicated that pollutant concentrations in runoff created by the RFG are representative of urban runoff. An initial application suggests that the apparatus is useful for measuring the impact of street sweeping on runoff water quality, among other potential comparative assessments.

CITATION

Tiernan, E.D., J. Gray, L.S. Beck, E. Fassman-Beck. 2025. Design of a Mobile, Field-Scale Rainfall Generator for Urban Runoff Water Quality Studies. *Journal of Irrigation and Drainage Engineering* DOI:10.1061/JIDEDH.IRENG-10507.

SCCWRP Journal Article #1443
Full text available by request: pubrequest@sccwrp.org

A data-driven index for evaluating BMP water quality performance

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ABSTRACT

A data-driven stormwater best management practice (BMP) performance index (PI) developed herein provides a simple, unbiased method to interpret the water quality treatment performance of a structural BMP, and provides actionable information for managers in planning, implementing and maintaining BMPs. The PI is derived from field-monitored influent-effluent pollutant event mean concentrations normalized by a user-specified water quality benchmark that may be adapted to reflect watershed-specific objectives. Benchmarking allows performance of any BMP to be investigated regardless of the treatment mechanisms, climate conditions, hydrologic performance, or site-specific pollutant concentrations. Quantitative monitoring data normalized by the benchmark are subsequently binned into performance categories of Success, Excess, Marginal, Insufficient, and Failure, which are indicators of the relative potential to achieve downstream receiving water goals. A single PI score per analyte ($PI_{analyte}$) is derived by compositing the categorical distribution. A simplified analytical hierarchy procedure is adapted to combine multiple $PI_{analyte}$ scores, if/when BMP selection for future applications must address a range of pollutants, e.g., where multiple water quality objectives are present. Data from the International Stormwater BMP Database are used to demonstrate PI applications such as selecting the "right" BMP to address specific water quality concerns, comparing amongst similar types of BMP to identify beneficial design features, and the clear interpretation offered by the score providing actionable information compared to a percent-removal assessment method. An index interpretation guide provides managers, maintenance teams, and designers with a feedback mechanism to refine future project designs, operations, or maintenance needs, and informs progress towards achieving successful watershed management plans.

CITATION

Fassman-Beck, E., E.D. Tiernan, K.L. Cheng, K.C. Schiff. 2025. A data-driven index for evaluating BMP water quality performance. *Water Research* 282:123769.

SCCWRP Journal Article #1442
Full text available online: www.sccwrp.org/publications

Impact of media properties on dissolved copper sorption in stormwater biofiltration

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ABSTRACT

The effectiveness of engineered media in stormwater biofiltration systems depends on their inherent properties that drive contaminant removal mechanisms. Using dissolved copper (Cu), this study identifies the measurable properties of engineered media that determine Cu sorption in batch systems using a representative roadway runoff matrix. An industry standard sand and amendments (regenerated activated carbon, three biochars, and zeolite) were characterized for their physicochemical properties and tested for their sorption affinity (K_d) for dissolved Cu in batch systems. A strong correlation (r = 0.88) was found between cation exchange capacity (CEC), measured by exchangeable cations, and K_d, endorsing the use of CEC as a screening tool for biofiltration materials. Furthermore, the performance of engineered media in column systems was evaluated under high infiltration rates that simulate field conditions. Loading a cumulative rainfall of 275–495 cm to intermittent flow-through column systems demonstrated that volumetric sorption affinity (pK_d) can serve as a comparative metric for assessing the sorption capacity; however, kinetic limitations under high infiltration rates compromised the accuracy of the predictions. Overall, this study identified key measurable properties of engineered media that can predict Cu removal performance in biofiltration systems, bridging the gap between lab-scale experiments and field applications.

CITATION

Xin, D., J. Gray, T. Zabala, A.P. Davis, E. Fassman-Beck. 2025. Impact of Media Properties on Dissolved Copper Sorption in Stormwater Biofiltration. *ACS ES&T Water* DOI:10.1021/acsestwater.5c00680.

SCCWRP Journal Article #1449
Full text available by request: pubrequest@sccwrp.org

Assessment of PFOA and PFOS sorption to engineered media in biofiltration columns

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ABSTRACT

Per- and polyfluoroalkyl substances (PFAS) in stormwater are receiving increasing attention as emerging contaminants of concern. Limited research is available on the performance of engineered media in stormwater best management practices such as biofiltration systems for PFAS removal from runoff. This study evaluated the treatment effectiveness of engineered media mixes for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) using flow-through column experiments designed to closely mimic biofiltration systems. Four different engineered media compositions were tested in duplicate, with each column receiving 230–330-cm simulated rainfall spiked with PFOA and PFOS at around 1,000 and 650 ng/L, respectively, assuming the column surface area is equivalent to 5% of an impervious drainage area. To represent local design guidance, media with particle sizes in the millimeter range were used, resulting in high infiltration rates ranging from 43 to 150 cm/h under a 15-cm ponding depth. Under these conditions, columns containing sand amended with 15% (v/v) regenerated activated carbon (RAC) were effective at PFAS removal, while the other media—sand, sand mixed with 10% biochar, and sand mixed with 10% zeolite—were either ineffective or only effective at the initial stages of treatment. Notably, columns containing 15% RAC reduced the influent concentration to approximately 300 ng/L for PFOA and 200 ng/L for PFOS, after receiving a cumulative rainfall of 307 cm. The RAC in the top 25% of media sorbed 1,910±97 ng/g of PFOA and 1,832±35 ng/g of PFOS, with effluents reaching 92 and 82% exhaustion, respectively. Further analysis of the breakthrough curves estimated that full columns with 45 cm of engineered media are expected to have a lifespan of 35–59 years under Southern California rainfall conditions, highlighting their potential for long-term PFAS removal.

CITATION

Xin, D., A.P. Davis, E. Fassman-Beck. 2025. Assessment of PFOA and PFOS Sorption to Engineered Media in Biofiltration Columns. *Journal of Sustainable Water in the Built Environment* DOI:10.1061/JSWBAY.SWENG-668.

SCCWRP Journal Article #1450
Full text available by request: pubrequest@sccwrp.org

Influence of volumetric water content sensor configuration in evaluating bioretention planter retention and evapotranspiration

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ABSTRACT

Water content reflectometers (reflectometers) are increasingly used to measure volumetric water content in engineered media during green infrastructure monitoring. This paper uses a data-driven analysis to propose guidance on where to install reflectometers and the number of sensors necessary for monitoring runoff retained and evapotranspiration from bioretention planters. Estimates from a planter with 14 reflectometers were compared to alternatives calculated using data from sensor subsets. Data were analyzed from 90 rain events and 69 dry periods from July 2019 through October 2021. Sensors in the middle of the vertical media profile agreed most closely with the average value of all sensors in the planter. Among the four sensors in the middle of the vertical profile, the configuration closest to the average value of all sensors included one sensor near the inlet and one nearest the planter outlet. Observed data suggest that a nonlinear draining/drying vertical profile occurs in the bioretention planters that warrants additional investigation. The results provide initial insights on an alternative approach to the field monitoring of green infrastructure hydrologic performance, particularly where conventional water balance methods of influent-effluent hydrographs are infeasible.

CITATION

Nissen, K., M. Borst, E. Fassman-Beck. 2025. Influence of Volumetric Water Content Sensor Configuration in Evaluating Bioretention Planter Retention and Evapotranspiration. *Journal of Hydrologic Engineering* DOI:10.1061/JHYEFF.HEENG-613.

SCCWRP Journal Article #1448
Full text available by request: pubrequest@sccwrp.org

Development of a method to measure the impacts of street sweeping on wet weather runoff water quality

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Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Fassman-Beck, E., E. Tiernan, D. Xin, A.C. Mehinto, V. McGruer, S. Sauers. 2025. Development of a Method to Measure the Impacts of Street Sweeping on Wet Weather Runoff Water Quality. Technical Report 1411. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1411
Full text available online: www.sccwrp.org/publications

SCCWRP coordinates post-fire aquatic monitoring network

SCCWRP has helped bring together more than two dozen organizations to form a water-quality monitoring network to track how pollution and debris from the Palisades and Eaton fires are spreading through coastal ecosystems and adversely affecting ecological and human health.

The Los Angeles-area Post-Fire Water Quality Monitoring Network – which was formed in 2025 within weeks of two of the most destructive fires in Los Angeles County history – has generated high-quality, comparable data on the levels and types of common post-fire contaminants in aquatic systems, as well as general chemistry measurements such as dissolved oxygen and suspended particles.

SCCWRP rapidly organized a 25-agency workgroup to coordinate monitoring efforts across nearly 200 sampling sites spanning Santa Monica Bay and the Los Angeles River and San Gabriel River watersheds.

SCCWRP also built a publicly accessible data portal that enables managers to assess the overall extent of effects from the fires, including which sites exceed contaminant thresholds for human health and aquatic health.

The monitoring data have the potential to be used to help inform a range of post-fire management decisions, including determining if and for how long to close beaches due to post-fire runoff contamination, whether to issue fish consumption advisories for contaminated fish and shellfish, and how to remediate post-fire pollution in sediment and sand.

Courtesy of the Los Angeles County Fire Department Lifeguard Division

A field crew from Heal the Bay collects a water sample from Santa Monica Bay as part of a multi-agency water-quality monitoring initiative facilitated by SCCWRP that is tracking the effects of pollution and debris from the Palisades and Eaton fires.

First Bight '23 Sediment Quality assessment report published

The Southern California Bight 2023 Regional Monitoring Program has published the first of its Sediment Quality assessment reports summarizing the extent and magnitude of sediment toxicity across Southern California's coastal ocean.

The Bight '23 Sediment Toxicity report, published in 2025, found that sediment toxicity remained low overall, with over 95% of sediment Bight-wide considered low or not toxic – a finding that has remained consistent over the past 15 years.

The sediment toxicity assessment is one of five lines of evidence that the Bight program uses to assess the influence of sediment contamination on the health of Southern California's coastal ecosystems. Assessment reports for the other lines of evidence – as well as the multiple other study elements that make up Bight '23 – will be published over the next few years.

Monitoring program demonstrates how to evaluate estuary health statewide

SCCWRP and its partners have successfully demonstrated how a diverse network of monitoring partners can collaboratively implement a newly developed statewide program for monitoring the health of coastal estuaries – a proof-of-concept milestone that paves the way for California to begin producing comprehensive, routine assessments of wetland health.

The initial implementation of the California Estuarine Marine Protected Areas (EMPA) Monitoring Program, described in a 2025 technical report, demonstrated that seven partners working in geographically disparate settings with varying levels of resources and expertise could produce a unified statewide assessment of coastal estuary health. Once fully developed and implemented in late 2026, the EMPA monitoring program will enable researchers to use standardized, rigorously vetted methods for comprehensively assessing the health of wetlands statewide.

California has spent more than $600 million over the past two decades to protect and preserve wetlands, but these efforts have largely been site-specific and siloed, with managers lacking rigorous assessment tools and a unified monitoring program through which to assess the effectiveness of management interventions.

Courtesy of Central Coast Wetlands Group, Moss Landing Marine Labs

The new California Estuarine Marine Protected Areas (EMPA) Monitoring Program has demonstrated how a diverse network of monitoring partners can collaboratively implement coordinated, statewide wetland monitoring, including at Morro Bay Estuary, above, one of 16 coastal estuary sites to be monitored during the program's initial implementation phase.

Sentinel site networks as a mechanism to evaluate progress toward meeting restoration goals in altered and unaltered landscapes

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Abstract

Establishing appropriate restoration targets, tracking progress toward those targets, and determining appropriate adaptive intervention are some of the greatest challenges to successful ecosystem restoration. Addressing these challenges is often informed by the use of "reference sites" that represent relatively unaltered or historical conditions and conceptually can be used to provide context and comparison for restoration projects. In reality, contemporary "unaltered" sites have often been manipulated by centuries of cultural practices and "pristine" conditions cannot be defined. Moreover, in highly altered landscapes or where stressors are continuing to rapidly reshape ecosystem structure, few or no sites may be unaltered enough to serve as pristine or aspirational reference standard sites for restoration. To address this challenge, we adapted the concept of "reference sites" to a framework for developing sentinel site networks, which consist of sites along a gradient of condition. These sites are selected for long-term monitoring to track ecological conditions through time, to evaluate the effect of regional trends in external conditions or stressors, and to document progress toward site-specific goals and regional objectives. Developing a sentinel site network involves screening sites based on condition, stressors, representativeness, and feasibility for long-term monitoring, informed by input from regional experts and stakeholders. The resultant network includes sites along a gradient of condition, geographical representation, and management that can be customized or regionally based on local constraints. We demonstrate the application of this process through the development of a sentinel site network for coastal wetlands in the highly developed southern California (U.S.A.) region. This process can be readily adapted to other habitats globally and may be particularly useful in habitats that have been highly impacted by human activities.

Citation

Walker, J.B., K. O'Connor, K. Wasson, C. Crain, K.K. Johnston, R.F. Ambrose, C.R. Whitcraft, J. Crooks, K. Beheshti, M. Hall, K. Nichols, M. Clemens, E.D. Stein. 2025. Sentinel site networks as a mechanism to evaluate progress toward meeting restoration goals in altered and unaltered landscapes. *Restoration Ecology* DOI:10.1111/rec.70062.

SCCWRP Journal Article #1427
Full text available online: www.sccwrp.org/publications

Lost on the Pacific Crest Trail: a 4,270 km survey of wilderness waste distribution and characteristics

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Abstract

Mismanaged waste threatens the environment and human health. To better understand waste sources and impacts along recreation trails, we surveyed the entire 4,270 km Pacific Crest Trail, conducting 251 waste surveys (1 km every 16 km). Surveys counted and classified waste within 2 m of the trail. We estimated that there were 53,000 pieces (12,000–130,000) of waste along the trail in 2023, based on a mean count of 12.5 pieces per km. Waste count had a negative log–log linear relationship with distance to the nearest road. Far in the backcountry (survey start 10 km from a road), waste was sparse (0.4 pieces per km), but close to roads (10 m from a road), waste increased to 13 pieces per km. The most common material types were soft plastic (36%), metal (11%), and sanitary waste (10%). The most common morphologies were fragments (47%), package ends (7%), and wipes (6%). Brands visible on waste were rare (48 pieces). We assessed the bias of this survey method, showing that it underestimated waste counts by 50% compared to conducting the survey twice or with twice the number of surveyors. Surveying trail sections with snow cover or at night also reduced observed counts. These findings suggest that cleanup near roads, waste handling education, reduced plastic use, and innovation from outdoor consumer product producers could reduce trail waste. We propose that a baseline value of 0.4 pieces per km should be a waste management target to achieve for all spaces.

Citation

McGruer, V., M. Gustavus, K.Z. Hess, H. Vaquero, K. Moody Wood, E. Israfil, J. Gonzalez-Estrella, V.M. Fulfer, S. Moore, W. Cowger. 2025. Lost on the Pacific Crest Trail: a 4,270 km survey of wilderness waste distribution and characteristics. *Waste Management* 206:115063.

SCCWRP Journal Article #1433
Full text available online: www.sccwrp.org/publications

Southern California Bight 2023 Regional Monitoring Program: Volume I. Sediment Toxicity

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Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Mehinto, A.C., D.J. Greenstein, K.C. Schiff. 2025. Southern California Bight 2023 Regional Monitoring Program: Volume I. Sediment Toxicity. Technical Report 1433. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1433
Full text available online: www.sccwrp.org/publications

Estuary Marine Protected Area: 2023 data analysis report

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Citation

O'Connor, K., B. Fulkerson, J.B. Walker, E.D. Stein, C. Whitcraft, J.S. Huckeba. 2025. Estuary Marine Protected Area - 2023 Data Analysis Report. Technical Report 1430. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1430
Full text available online: www.sccwrp.org/publications

Bioassessment survey of the Stormwater Monitoring Coalition: Workplan for years 2021 through 2025 Version 6.0

Raphael D. Mazor

Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Mazor, R.D. 2025. Bioassessment Survey of the Stormwater Monitoring Coalition: Workplan for Years 2021 through 2025 Version 5.0. Technical Report 1174. Southern California Coastal Water Research Project. Costa Mesa, CA.

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

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Dr. **Kris Taniguchi-Quan**, Member, Technical Advisory Committee, Predicting Actual Flows in California

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

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

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Dr. **Raphael Mazor**, Technical Advisory Team, Bay Area Modified Channels Project

Dr. **Jayme Smith**, Member of the San Francisco Bay Harmful Algae Data Analysis Expert Group

Dr. **Martha Sutula**, Chair, Nutrient Numerical Modeling Expert Review Committee

Dr. **Martha Sutula**, Science Advisor, San Francisco Nutrient Management Strategy Assessment Framework Development

San Gabriel River Temperature Management, Technical Adivsory Committee

Dr. **Eric Stein**, Co-Chair, Facilitator

San Gabriel River Water Reuse Habitat Management Committee

Dr. **Eric Stein**, Co-Chair, Facilitator

San Gabriel River Regional Monitoring Program

Dr. **Raphael Mazor**, Member, Technical Guidance Committee

Santa Clara River Temperature Management Technical Advisory Committee

Dr. **Eric Stein**, Co-Chair, Facilitator

Santa Monica Mountains Resources Conservation District

Dr. **Eric Stein**, Member, Topanga Lagoon Restoration Technical Advisory Committee

Santa Monica Bay Restoration Commission

Dr. **Alvina Mehinto**, Member, Technical Advisory Committee

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

Tijuana River National Estuarine Research Reserve

Dr. **Eric Stein**, Member, Science Advisory Team, Tidal Restoration Program

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

University of Delaware

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University of Manitoba

Dr. **Charles Wong**, Member, Expert Advisory Board, Environmental Science and Environmental Studies Program

U.S. Navy Space and Naval Warfare Systems Command

Dr. **Eric Stein**, Member, Hydrology Technical Advisory Committee

Vanguard University

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

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Journal Editorships

Chemosphere

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

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

Dr. **Alvina Mehinto**, Editorial Board Member

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

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

Kenneth Schiff, Associate Editor

Water

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

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

Professional Societies

American Society for Microbiology

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

Dr. **Joshua Steele**, Division Councilor, General and Applied Microbiology Division

American Society for Photogrammetry and Remote Sensing

Dr. **Kris Taniguchi-Quan**, President, Pacific Southwest Region

California Estuarine Research Society

Minna Ho, Board Member-at-Large

Dr. **Jan Walker**, President-Elect

Center for Watershed Protection

Kenneth Schiff, Planning Committee Member, National Stormwater Conference

Coastal and Estuarine Research Federation

Scott Martindale, Chair, Policy and Advocacy Committee

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

Society for Freshwater Science

Dr. **Raphael Mazor**, Secretary, California Chapter

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

Society of Environmental Toxicology and Chemistry

Kenneth 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

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

Student Thesis/Dissertation Committees

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Dr. **Elizabeth Fassman-Beck**, Ph.D. Committee of Hendrik Rujner

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Dr. **Jan Walker**, Master's Committee of Natalie De Wet

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and the Commission's Technical Advisory Group (CTAG)

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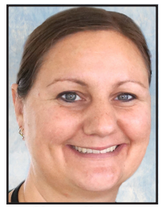

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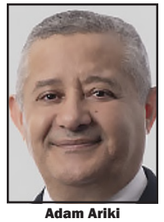

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