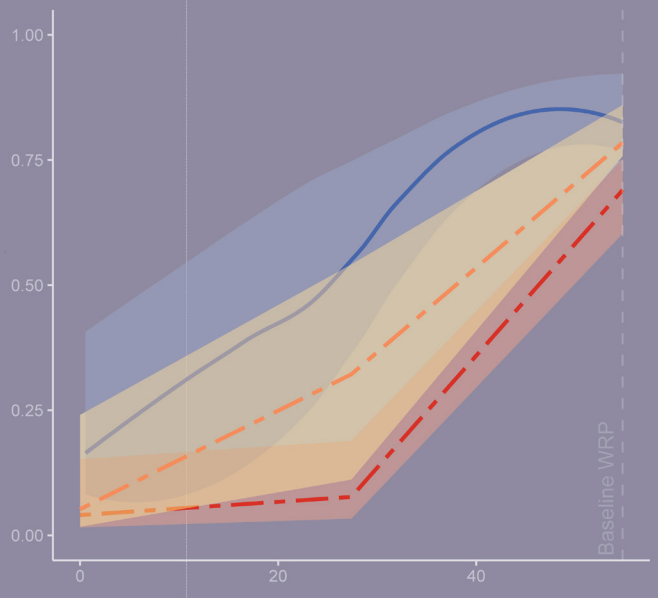
SCCWRP
2024 ANNUAL REPORT



Modeling to understand aquatic health

Scientists turn to simulations and predictions to help answer key questions about ecosystem condition

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT

Applying next-generation science to aquatic ecosystems management

Contents

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Feature Articles

A SCCWRP field crew measures flow rates and other parameters in the Los Angeles River for a modeling study evaluating the flow patterns needed to sustain the river's diverse freshwater ecosystems, plus the recreational benefits provided by these flows. **Page 15**

Accomplishments with journal abstracts

People

Southern California Coastal Water Research Project 2024 Annual Report

Editor
Stephen B. Weisberg, Ph.D.

Managing Editor
Scott Martindale

Cover art
SCCWRP relies on a range of different modeling tools to understand the health of aquatic ecosystems and how they're changing across time and space.

3535 Harbor Blvd.
Costa Mesa, CA 92626
www.sccwrp.org

Snapshot of Success

Steps taken by SCCWRP to improve aquatic science research and water-quality management in 2024

1 Scientific credibility

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

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

» Publication rate

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

Accomplishment

SCCWRP scientific staff published an average of **3.3** journal articles each per year over the past three years. This compares favorably with the **2** publications per year minimum that SCCWRP's partners at academic research institutions generally seek to achieve when being considered for promotion. **Page 25**

» Citation rate

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

Accomplishment

SCCWRP publications were cited **2,571** times in 2024, according to Web of Science statistics.

2 Scientific consensus-building

Goal: Promote consensus-building through scientific collaboration and leadership

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

» Leadership

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

Accomplishment

SCCWRP scientific staff held **126** leadership roles with professional societies, advisory committees and scientific journals in 2024. **Page 59**

» Collaboration

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

Accomplishment

SCCWRP published scientific articles and reports with **153** different institutions in 2024. **Page 25**

What SCCWRP seeks to achieve

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

3 Management influence

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

Scientific credibility and consensus-building are important waypoints along SCCWRP's journey to produce science that positively influences management. The feature articles in this report illustrate how SCCWRP uses modeling to understand how ecosystem condition will change in the future.

» Characterizing condition

SCCWRP helps managers develop and apply modeling tools to better understand the ecological health of aquatic systems and how they're changing over time.

» Understanding human influence

SCCWRP uses modeling to identify and study the influence of various human activities in contributing to ecological stress.

» Assessing effectiveness of potential actions

SCCWRP uses modeling to explore how the trajectory of ecosystem health would change in response to various potential management interventions.

Accomplishment

With the help of modeling, SCCWRP is gaining insights into how seawater chemistry is changing in Southern California coastal waters and which strategies could effectively mitigate ecological effects. **Page 8**

Accomplishment

SCCWRP is developing and applying modeling-based approaches to help managers make decisions about how to allocate limited flows among multiple competing needs. **Page 15**

Accomplishment

SCCWRP is using modeling to help managers design, build and maintain stormwater BMPs (best management practices) that achieve water-quality improvement goals. **Page 21**

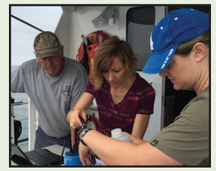
4 Long-term support

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

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

» Training

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



» Intercalibration

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

» Vetting

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

» Outreach

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

SCCWRP prides itself on the long-term support it provides to member agencies.

Accomplishment

SCCWRP staff spent more than **10,900** person-hours in 2024 providing implementation support to member agencies.

Director's Message

The burden is on SCCWRP

SCCWRP invests in modeling because it allows environmental managers to understand the future, including how human intervention could change a predicted future state.

At its most basic, modeling in the aquatic sciences can consist of a single mathematical equation that describes a relationship: If X is true, then Y is predicted to also be true. But supercomputers allow us to extend modeling far beyond basic data analyses, to encompass powerful sets of interconnected models that work in concert to make complex predictions about the condition of aquatic ecosystems across time and space, and how humans are influencing – or have the future potential to influence – this condition.

At the same time, modeling is a prediction, rather than a measurement, which puts an added burden on researchers. It's not enough to build models to answer management questions. SCCWRP also is responsible for building management understanding, confidence and trust in modeling's predictive capabilities.

It's a burden that SCCWRP embraces, as our role is not just to expand scientific knowledge and generate scientific journal articles, but also to provide tools that managers feel confident enough to use. The reality is that modeling is not going to be used as the basis for management decision-making until managers trust that a particular model can reliably predict real-world environmental conditions.

SCCWRP scientists undertake numerous activities to build management confidence. We quantify model uncertainty in several ways, including comparison to empirical measurements. We subject our work to scientific peer review, publishing journal articles about multiple model facets that provide documentation of the modeling tools. Furthermore, our modeling is done with open-source code, so that others have access to the same tools we are using. Once our modeling tools have gained technical acceptance, our effort shifts to developing community consensus about the model scenarios we should be investigating. This engagement is not unique to modeling investigations, but the process tends to be more encompassing with modeling because managers can be more hesitant to buy into insights they cannot directly observe.

The three feature articles in this Annual Report illustrate three of our present modeling efforts in which observational evidence alone is insufficient to answer questions posed by managers: how ocean acidification will unfold in coastal waters (Page 8), how aquatic life will be affected by future alterations to stream flow (Page 15), and how stormwater best management practices should be deployed in watersheds to maximize their effectiveness (Page 21). I hope you enjoy these articles.

Stephen B. Weisberg, Ph.D.
Executive Director

MODELING TO UNDERSTAND AQUATIC HEALTH

When direct observation is infeasible or impractical, researchers rely on modeling analyses to gain insights into ecosystem condition

When it comes to understanding the health of aquatic ecosystems across space and time, researchers typically start with what they can observe.

Environmental researchers have developed a plethora of monitoring programs for collecting data reflecting the condition of the physical environment and how aquatic life – and humans – are affected.

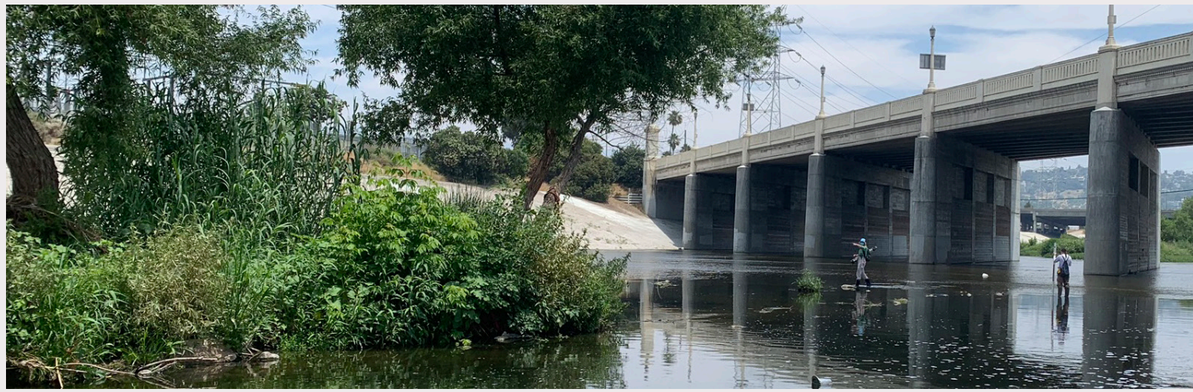
Meanwhile, researchers use laboratory experimentation to intentionally manipulate parameters, and then observe and record what happens.

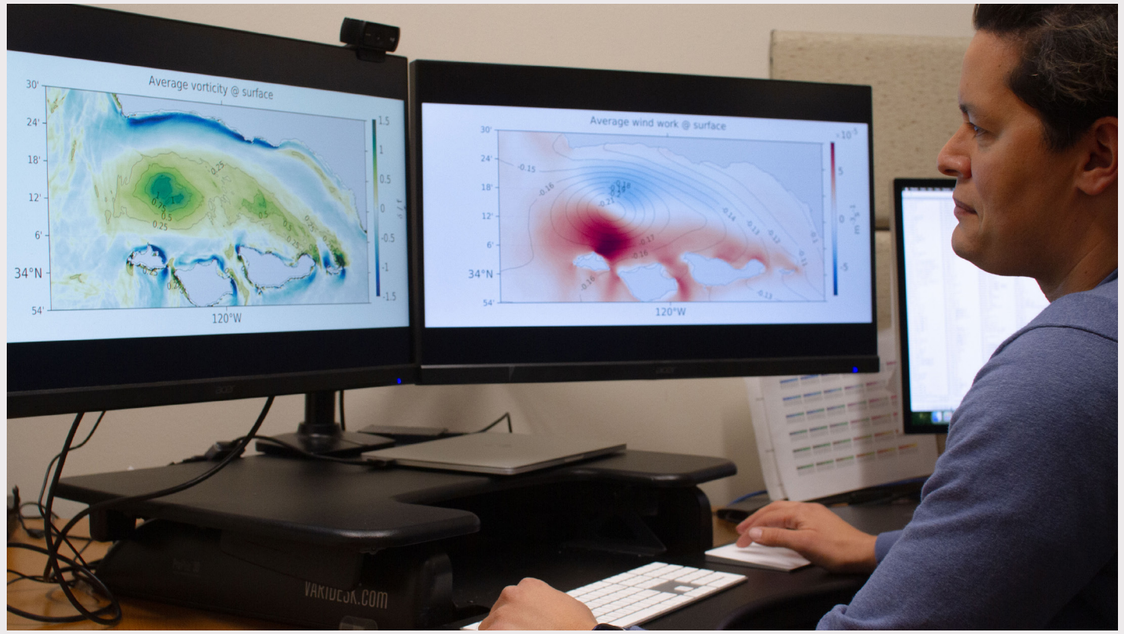
But these types of direct observations – known as empirical evidence – aren't always sufficient to answer the questions being asked about why aquatic ecosystem health is degraded and the influence that humans have on ecosystem health.

For insights that are impractical or infeasible to observe, researchers turn to modeling.

Modeling uses mathematics and computation in combination with observational data to produce insights about the health of the environment – historical, present and potential future conditions.

Whether researchers are investigating how humans have altered ecosystem health over time, or how environmental managers can effectively intervene to offset changes caused by humans,





SCCWRP's Dr. Faycal Kessouri runs a modeling tool on his computer designed to predict the trajectory of ocean acidification in Southern California coastal waters. Modeling tools enable researchers to predict multiple potential future states, before managers are required to make large-scale investments.

modeling can simulate, estimate and predict what is infeasible and impractical to observe.

Researchers routinely use modeling to help bring clarity to historical and present-day observational data, by generating additional insights that interpret, contextualize and fill gaps in what they observe.

But perhaps modeling's most impactful role – and a role that is unique to modeling – is modeling's ability to predict what might happen in the future. Scientists use modeling predictions to understand the trajectory of changing environmental conditions, how aquatic life are expected to be affected, and what is likely to happen as a result of actions that humans may (or may not) take.

Significantly, modeling enables researchers to simulate multiple potential future states – before managers are required to make large-scale investments. That means researchers can model potential actions intended to extend or expand protections for aquatic ecosystem health, as well as potential actions such as development and redevelopment projects that could adversely affect ecosystem health.

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Since the turn of the last century, SCCWRP has increasingly integrated modeling into its work, recognizing that models are pivotal tools – and sometimes the only tools – capable of generating data that help answer the questions that managers are asking.

SCCWRP's use of modeling has evolved alongside advancements in computing power. As technology has enabled more complex calculations to be processed faster, researchers have developed more sophisticated, powerful models.

One of the earliest high-profile manifestations of this more ambitious era of modeling dates back to the early 2000s, when Southern California managers were working to build capacity to develop comprehensive snapshots of the levels and types of contaminants washing off heavily populated landscapes.

With field monitoring not a feasible strategy for collecting data at all of the times and places where managers needed the information, SCCWRP developed a set of modeling tools for estimating what levels and types of contaminants are washing off Southern California landscapes, based on how the land is being used, rainfall depths, and time elapsed since prior rainfall.

Following years of vetting, this modeling approach got incorporated into a wide range of watershed planning initiatives and runoff management programs. Moreover, these models became so accepted that SCCWRP focused on handing them off to consulting firms, which used them for many additional applications.

More recently, SCCWRP has used modeling to predict where in heavily developed watersheds managers are more vs. less likely to find success in improving the biological health of streams, based on surrounding urban and agricultural development; such development is expected to constrain managers' ability to effectively intervene to reverse ecological degradation.

Models also have been at the foundation of multiple SCCWRP-led human health risk modeling assessments, where the goal has been to understand illness risks for humans exposed to fecal contamination in recreational water bodies. Significantly, modeling is one of the few viable options for understanding illness risks, given the ethical and legal considerations that surround studies involving human subjects.

Modeling tools also have been used at SCCWRP to help explain how microplastics suspended in land-based runoff disperses into the coastal ocean, how plumes from coastal wastewater discharges enter and disperse in the coastal ocean, and how low-lying coastal wetland areas will be affected by projected sea level rise and increased storm surges.

Across all of SCCWRP's modeling work, SCCWRP invests in setting guidelines for appropriate and inappropriate use cases for models, quantifying the degree of uncertainty associated with the predictive insights being generated, and transparently communicating assumptions and limitations associated with modeling predictions.

Runoff gradually flows through a bioswale along a roadway in Orange County. Stormwater managers are collecting high-quality data on the performance of multiple BMPs (best management practices) across Southern California to improve BMP performance modeling tools.

Quantifying modeling uncertainty

As with any field or laboratory measurement, the predictions generated through modeling have some degree of error associated with them. Thus, in addition to the time that researchers spend developing models, an equally important focus is quantifying error, or uncertainty, in the model's predictions.

When managers understand modeling uncertainty, they have context for deciding how much confidence to place in what the model is predicting. The more ways that modeling uncertainty gets quantified, the more confidence that managers can have in a model's predictions – and thus the more likely managers are to make informed decisions based on the insights generated through modeling.

The three feature articles in this Annual Report highlight three key use cases for modeling that capture the range of high-profile ways that SCCWRP and its research partners have incorporated modeling into their work – and the transformative effect that modeling has had on SCCWRP's ability to answer complex, pressing management questions about aquatic ecosystem health:

1 » **Ocean acidification modeling**: Modeling serves as a pivotal tool for gaining insights into how seawater chemistry is changing in coastal waters in response to ocean acidification, and how potential management interventions could alter the trajectory of these effects. **Page 8**

2 » **Ecohydrology modeling**: Modeling plays a critical role in understanding how changes in flow patterns have affected and will continue to affect vulnerable aquatic life, especially in the face of climate change, changing water-use practices and changing land-use practices. **Page 15**

3 » **BMP modeling**: Modeling is the engine behind researchers' ability to develop comprehensive understanding of the volumes and types of pollutants running off various landscapes in urbanized environments, and how to more effectively use stormwater BMPs to treat and manage this runoff. **Page 21**

MODELING OCEAN ACIDIFICATION'S TRAJECTORY

Modeling offers key insights into how seawater chemistry is changing in coastal waters – and how Southern California could intervene to protect ocean health

About 15 years ago, ocean acidification emerged as a key issue of concern for Southern California's coastal ocean management community.

This global phenomenon, driven by rising carbon dioxide emissions into the atmosphere, causes seawater to move to an incrementally more acidic state. Ocean circulation patterns make the West Coast particularly vulnerable.

In Southern California, these corrosive conditions are making it tougher for shell-forming organisms to build their shells – albeit the biggest effects thus far have primarily been constrained to deeper coastal waters, and mostly during the spring and early summer months.

But over time, these unfavorable conditions are expected to intensify, altering the habitability of Southern California coastal waters for a wide range of organisms.

To understand how ocean acidification is unfolding in the coastal ocean, researchers initially turned to field monitoring data and laboratory experiments – enabling them to directly measure and record changes to coastal ecosystem condition.

These observational data sets provided foundational insights into how seawater chemistry has been changing across space and time, and how vulnerable marine life are affected by the chemistry changes.

The observational data, however, cannot answer all of the questions being asked about ocean acidification by Southern California's coastal ocean management community.

Observational data cannot paint a comprehensive picture of how acidification will intensify in the coming years, nor explain which areas of the coastal ocean may be disproportionately affected and when.

Moreover, observational data cannot shed light on whether various potential steps that managers are considering taking locally to alleviate acidification's ecological effects in coastal waters could be effective.

That's why researchers also have been building, testing and using multiple sets of interconnected coastal water-quality modeling tools to simulate and predict what is not feasible or practical to observe.

Through modeling, managers are learning how and when conditions will intensify in the coming years, as well as what types of potential management solutions intended to offset acidification conditions are likely to be effective.

To ensure that these modeling tools are robust enough to answer the questions that coastal ocean managers most want answered, researchers are engaging in continuous, iterative dialogue with future end users of the tools and other stakeholders.

This stakeholder community is helping to shape what kinds of predictions the modeling tools should be making, as well as setting guidelines for the types of technical scrutiny that the tools should be subjected to – before managers consider using them to inform decision-making. Ultimately, these insights are helping managers decide how much confidence they should place in the modeling tools' predictions.

"Modeling is serving as a key route through which we're learning about the health of the coastal ocean and how it's changing – and will continue to change – over time," said Dr. Clarissa Anderson, Director of the Southern California Coastal Ocean Observing System (SCCOOS) at the Scripps Institution of Oceanography. "Our coastal ocean modeling tools are getting better all the time, and a big part of the reason is the robust stakeholder community that's invested in getting the modeling right."

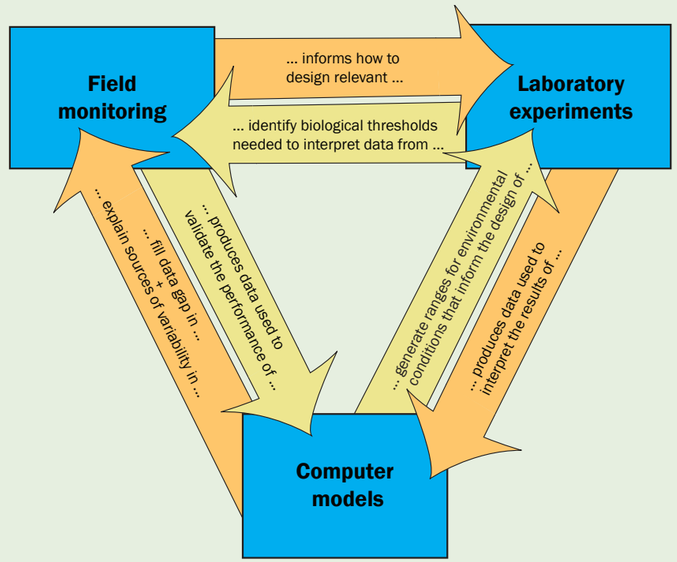
Collecting observational data

Ocean acidification is comprised of a dynamic and complex set of interconnected physical and biogeochemical processes that plays out across time and space.

Tiny shell-forming organisms, which are collected using a plankton tow net, have provided some of the earliest signs of the ecological effects of ocean acidification in Southern California coastal waters.

Three-pronged approach to understanding the trajectory of coastal ocean acidification

Modeling is one of three main lines of evidence that managers use to understand how acidification is unfolding in coastal waters. Each line of evidence generates information and data that benefit the other two lines of evidence.



Background photo courtesy of Occidental College Visiting Research Group

There is no single approach that researchers can use to fully explain these processes. Instead, researchers rely on three main lines of evidence – monitoring data, laboratory experimentation data, and modeling data – that work synergistically to explain acidification's trajectory in coastal waters.

First, to understand environmental condition and variation in relation to coastal acidification, researchers have invested in collecting field monitoring data. For the past decade, the Southern California Bight Regional Monitoring Program has been measuring a property of seawater known as aragonite saturation state across Southern California's coastal ocean. Aragonite saturation state reflects the concentrations of ions available to shell-forming aquatic life, including tiny crustaceans and tiny sea snails that float in the water column and help form the base of marine food webs.

Meanwhile, to track the biological effects of these seasonally corrosive conditions, the Bight program is monitoring for signs of shell dissolution in crab larvae and pteropods. These two types of shell-forming organisms are found in abundance in Southern California's coastal ocean, making them sentinel indicators of acidification's early effects.

The second line of evidence that researchers are using to understand acidification's trajectory is laboratory experimentation – specifically, state-of-the-art dynamic exposure laboratory studies that examine how marine life respond in a controlled setting to fluctuations in pH, dissolved oxygen and other environmental parameters.

SCCWRP is one of only a handful of laboratories worldwide to invest in such a laboratory setup, collecting data that researchers can then use to pinpoint the inflection points, or thresholds, at which different combinations of fluctuating environmental stressors begin to trigger adverse biological consequences for marine life.

The dynamic exposure experiments also are helping researchers understand precisely how sensitive marine life will be affected by different potential combinations

A pair of plankton nets is lowered into Southern California's coastal ocean to collect small, shell-forming marine organisms vulnerable to ocean acidification. The biological data explain how marine life are being affected by seasonally corrosive coastal conditions.

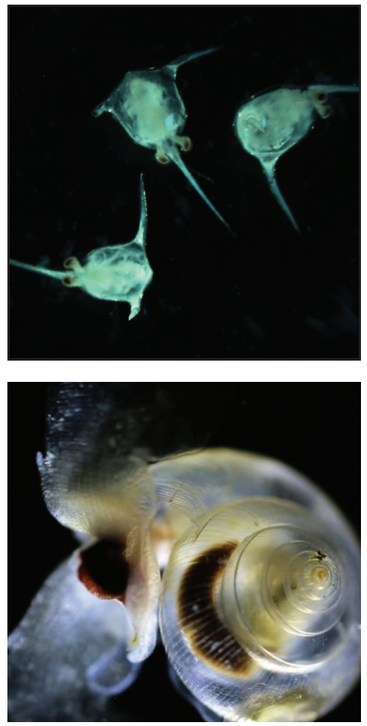
of environmental stress in the future. For example, SCCWRP found that vulnerable marine life begin to experience adverse biological effects sooner when ocean acidification intensifies in combination with rising water temperatures than when temperatures are not also rising.

"Observational data sets have provided foundational insights into how ocean acidification and other co-occurring stressors are affecting coastal ecosystem health," said Dr. Daniele Bianchi, Associate Professor of Atmospheric and Oceanic Sciences at the University of California, Los Angeles. "These same data sets also have been critical in our ability to develop models capable of predicting what's going to happen into the future."

Recognizing the value of modeling

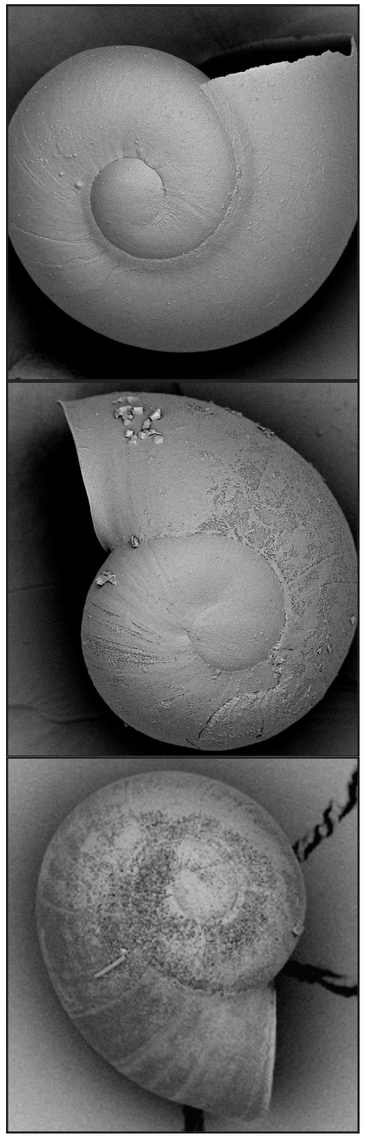
While both monitoring and laboratory data have played key roles in chronicling acidification's trajectory in Southern California, modeling plays a critical complementary role.

Through modeling, researchers can generate data at the times and places necessary to understand patterns and trends. The predictive insights help fill key gaps in monitoring data, predict future conditions, and simulate how potential management interventions would alter acidification's current trajectory.



Crab larvae, top, and pteropods, bottom, are among the marine life vulnerable to ocean acidification in Southern California coastal waters.

Moreover, modeling can explain the underlying mechanisms through which acidification conditions are unfolding in the coastal ocean.



Ocean acidification in Southern California coastal waters is causing tiny sea snails known as pteropods that float in the water column to experience shell dissolution. Scanning electron microscope images, from top to bottom, show a healthy shell, a shell with mild shell dissolution, and a shell with moderate shell dissolution.

In the mid-2010s, an expert science advisory panel that was convened to develop a West Coast strategy for responding to acidification conditions underscored the importance of modeling, calling on West Coast states to invest in developing and applying ocean numerical modeling tools. In 2018, the California Ocean Protection Council captured this same priority in its Ocean Acidification Action Plan.

For the past decade, a modeling research team that includes SCCWRP has been working to develop and apply two main types of ocean acidification modeling tools: a set of models that sheds light on how seawater chemistry is changing in coastal waters, and a complementary set of models explaining how vulnerable marine life are being affected by the seawater chemistry changes.

First, to understand seawater chemistry changes, researchers have integrated a pair of computer models – the Regional Ocean Modeling System (ROMS) and Biogeochemical Elemental Cycling (BEC) – to form the coupled ROMS-BEC modeling tool.

ROMS is a physical ocean model that predicts how seawater circulates – and thereby also predicts how pollution from land, including nutrients, will disperse upon being discharged into coastal waters.

BEC is an ocean biogeochemical model that predicts how nutrients fuel growth of algal blooms in marine waters that, upon their death, are decomposed by bacteria. These decomposition processes, in turn, consume oxygen and lower pH, which has the potential to trigger (or exacerbate) both coastal acidification and hypoxia.

While ROMS and BEC have been used for decades to investigate basic oceanographic science questions, researchers more recently have refined these tools to investigate mitigation strategies for California, including by coupling ROMS and BEC to predict how seawater chemistry will change in Southern California coastal waters.

Second, to understand how vulnerable marine life will be affected by the seawater chemistry changes, researchers have developed a complementary set of biological interpretation tools that translate ROMS-BEC's predictions to biological response data.

These biological interpretation tools enable researchers to predict how biological communities will experience reductions in the amount of available suitable habitat – known as habitat compression – as a result of seawater chemistry changes. The modeling predictions also help managers understand if these changes will be lethal to marine life.

"We have an important window of opportunity to understand how coastal ecosystem health is going to change in the coming years – before we arrive at that future state," said Dr. Justine Kimball, Senior Climate Change Program Manager for the California Ocean Protection Council. "That's why modeling is so important – it's our chance to build a strong scientific foundation that informs coastal ocean management for generations to come."

Using modeling to evaluate solutions

The same modeling being used to understand acidification's coastal trajectory also are being used to evaluate the effectiveness of potential management solutions for alleviating adverse ecological effects.

The largest category of potential management solutions is an umbrella category known as marine carbon dioxide removal (mCDR) that focuses on limiting atmospheric carbon dioxide emissions and removing carbon dioxide from seawater.

Rising levels of atmospheric carbon dioxide emissions are the root cause of both acidification and global climate change; the ocean has been absorbing about one-third of all carbon dioxide emissions in the atmosphere.

mCDR encompasses a wide range of emerging technologies and approaches that have the potential to alleviate intensifying coastal acidification, as well as contribute to offsetting global climate

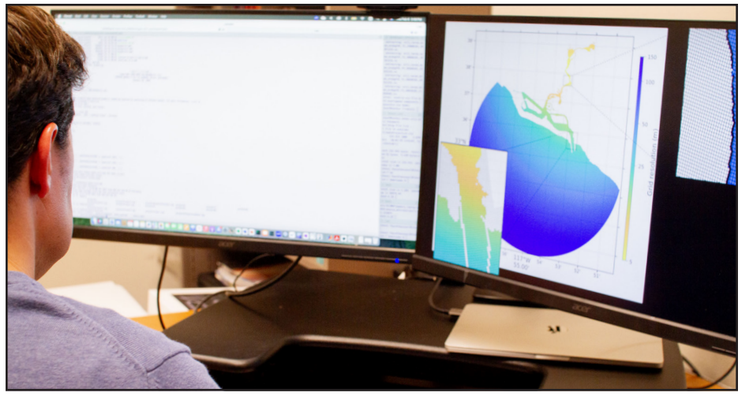
change. Burgeoning mCDR technologies that researchers are exploring for use in Southern California include ocean alkalinity enhancement and direct ocean capture.

In one early mCDR pilot study, SCCWRP is examining the potential of direct ocean capture to meaningfully draw down carbon dioxide in the atmosphere. Direct ocean capture uses electrodialysis technology to isolate and trap dissolved carbon dioxide in seawater; the trapped carbon dioxide can then be either stored or reused. The technology is powered by renewable energy.

Researchers' working hypothesis is that removing this carbon dioxide from the coastal ocean will increase the water's capacity to absorb carbon dioxide from the atmosphere, enabling the water to draw down more carbon dioxide emissions in the atmosphere.

To study what influence the technology could have on coastal acidification and dissolved carbon dioxide levels, researchers are using the ROMS-BEC modeling tool to predict what happens when this technology is deployed at commercial scales in Southern California coastal waters.

If a technology like direct ocean capture – once scaled up – shows promise to meaningfully draw down carbon dioxide levels, the findings from this modeling work could pave the way for conversations with managers about potentially deploying the technology at strategic locations in coastal waters.



SCCWRP's Dr. Faycal Kessouri uses modeling to predict the trajectory of ocean acidification in Southern California coastal waters. Researchers have been building, testing and using interconnected coastal water-quality modeling tools to evaluate the effectiveness of potential management solutions designed to alleviate adverse ecological effects.

Another potential mCDR solution being investigated in Southern California is cultivating underwater kelp farms in specific coastal areas in an effort to alleviate ecological effects on vulnerable marine life.

Known as regenerative aquaculture or macroalgal farming, this mCDR solution would remove carbon dioxide from surrounding waters by tapping into the natural photosynthetic processes of kelp.

Like natural kelp forests, the kelp farms would take up carbon dioxide from water and release oxygen into water during photosynthesis. Unlike natural kelp forests, however, the farmed kelp – which can grow up to two feet a day – would be harvested and removed permanently from coastal waters, ensuring this approach to capturing carbon dioxide is not reversed as the plants die and decompose.

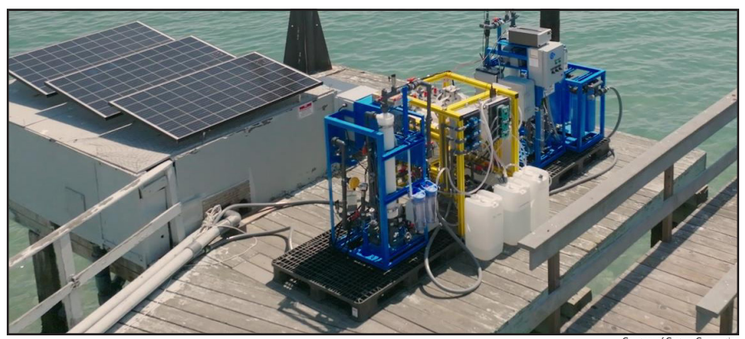
In Southern California, SCCWRP is part of a project co-led by the Universities of California, Irvine and Los Angeles, that is examining how to optimally build underwater kelp farms suspended on underwater ropes.

Researchers are using modeling to not only investigate the carbon sequestration potential of these kelp farms, but also to explore how to optimize the placement and design of these farms in coastal waters to maximize yield and minimize environmental effects.

Similarly, as part of ongoing efforts to restore natural kelp and seagrass beds in shallow coastal environments, researchers are turning to modeling to better understand how to make decisions that optimize the chances of restoration success.

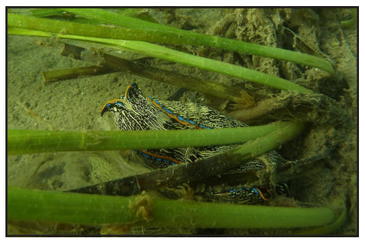
As with macroalgal farming, a key goal of these habitat restoration projects is to maximize their carbon sequestration potential.

"It is unlikely that mCDR solutions by themselves will stop the global phenomenon of ocean acidification, but they could help meaningfully offset the most extreme ecosystem impacts," said Dr. Sophie Chu, Principal Oceanographer and Director of Monitoring, Reporting, and Verification at Captura. "While the scientific community is still in the early stages of exploring mCDR technologies and their potential impacts, ocean modeling is crucial to identify the most promising ideas and areas for the research community to focus on."



Courtesy of Captura Corporation

Electrodialysis technology, deployed on a pier in Newport Beach, is one example of a type of marine carbon dioxide removal (mCDR) technology that may be able to draw down carbon dioxide levels in coastal waters. Researchers are using modeling tools to simulate what would happen if this technology were deployed at commercial scales in Southern California coastal waters.



Modeling can help managers optimize the chances of success when restoring coastal habitats like eelgrass beds, shown above with a sea slug among eelgrass leaves.

Using modeling to investigate coastal nutrient discharges

In addition to mCDR solutions, researchers also are using modeling to explore if intensifying acidification conditions in coastal waters could be offset by reducing nutrient levels in coastal discharges.

Southern California's coastal ocean naturally receives seasonal infusions of nutrients as a result of ocean upwelling – a phenomenon in which strong winds blow surface waters away from shore, propelling deeper, nutrient-rich waters into shallower surface waters closer to shore.

When these natural sources of nutrients combine with nutrients from land-based sources such as wastewater discharges and urban and agricultural runoff, the nutrient levels collectively can exacerbate acidification conditions. Excess nutrients trigger excess growth of algae, known as eutrophication. Then, as the algae die, they are decomposed by bacteria – a process that consumes oxygen and releases carbon dioxide. When too much oxygen gets consumed, the water can become hypoxic to marine life, and when too much carbon dioxide is produced, coastal acidification can be exacerbated.

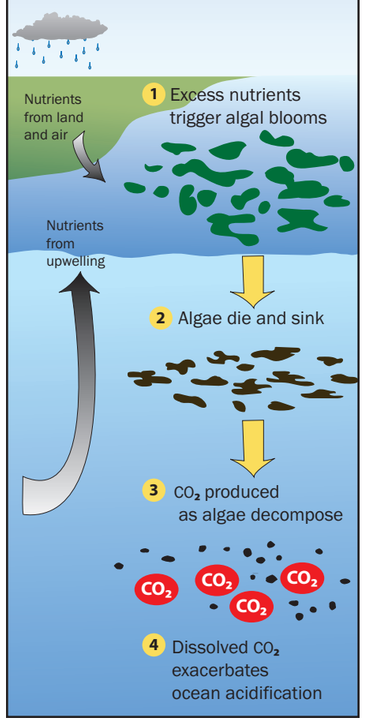
Thus, researchers are using the modeling tools to investigate if land-based nutrient discharges to Southern California's coastal ocean are exacerbating the trajectory of acidification and hypoxia, then to predict if these changes could be offset by reducing nutrient levels in coastal wastewater discharges.

Significantly, these analyses, known as scenario modeling runs, can be completed without requiring managers to invest in potentially costly nutrient removal actions first.

In recent years, researchers have been using scenario modeling to evaluate if Southern California's wastewater treatment industry could alleviate coastal conditions by investing in enhanced nutrient management. Any decision to reduce nutrient levels in coastal wastewater discharges would require upgrades to wastewater treatment processes.

The wastewater-focused modeling scenario runs are helping managers understand how much benefit, if any, could be derived from such investments – particularly as these conditions continue to intensify in the coming years. Moreover,

How nutrients exacerbate ocean acidification along the West Coast



Quantifying modeling uncertainty

As part of developing ocean acidification modeling tools for Southern California, researchers have prioritized estimating the degree of error associated with predictions generated through modeling – an area known as quantifying modeling uncertainty.

When managers understand modeling uncertainty, they have context for deciding how much confidence to place in what the modeling tools are predicting.

The more ways that modeling uncertainty gets quantified, the more confidence that managers can have in modeling predictions – and thus the more likely managers are to use these predictions as a basis for action.

To ensure that coastal ocean modeling tools are capable of making reliable predictions about the trajectory of coastal acidification, researchers have been quantifying modeling uncertainty in multiple ways; each successive approach helps build managers' confidence in the tools' predictions:

- Comparing modeling predictions to field data; any difference represents "uncertainty," which is a combination of error in the model's predictions and error in the field measurements
- Conducting sensitivity analyses, where the data that are fed into the model are intentionally tweaked to determine how vulnerable the model's outputs are to various assumptions that were made during the model's development and vetting process
- Running model comparison analyses, where the model is compared to other models that make similar predictions, with a goal to identify differences among the models

the modeling insights are helping managers quantify the benefits of improved nutrient management relative to the energy costs and/or carbon footprint that would accompany this potential solution.

Engaging with modeling stakeholders

The long-term utility of the acidification modeling tools will be shaped by managers' acceptance and use of the tools for informing coastal ocean planning and decision-making.

That's why the team that developed these modeling tools is investing in continuous, iterative dialogue with managers and other stakeholders.

Researchers are inviting stakeholders to shape the specific management questions that the modeling tools should be answering. Stakeholders also are helping to tailor modeling scenario runs to generate the predictive insights that managers most need.

Additionally, researchers have begun investing in making modeling predictions more transparent and accessible to stakeholders. Plans include creating data visualization products and codifying quality-assurance plans that govern the models' usage in published, publicly available documents.

Finally, researchers are working alongside stakeholders to set expectations about the levels and types of technical scrutiny that the tools should be subjected to – so managers can develop comprehensive understanding of the limitations and uncertainty that surround the modeling tools' predictive capabilities.

In 2023, stakeholders helped convene and oversee an expert panel that independently reviewed the scientific integrity of ROMS-BEC and related modeling tools. To ensure a fair, transparent review, stakeholders established a steering committee made up of water-quality regulatory agencies, regulated agencies, and environmental advocacy groups to establish panel charge questions and vet and select panelists.

The six selected panelists, who are internationally renowned in their areas of expertise, spanned the disciplines of physical and biogeochemical oceanography, ocean numerical modeling, the biological effects of low oxygen and pH levels, and the application of models to support management decisions.

The independent review panel, which found that the tools are built on fundamentally sound science, recommended investing in a series of specific actions to increase stakeholders' confidence and acceptance of the tools' predictive capabilities, including making the modeling outputs and other work more accessible to a broad community of end users, and adapting the modeling tools for use at scales relevant to coastal discharge processes for wastewater.

Through the expert panel review process, managers have gained improved understanding of how the modeling tools can be used to help answer key questions about coastal ocean health, as well as the limits and uncertainty associated with modeling predictions.

"Developing these modeling tools is an ongoing, iterative process that couldn't be done without the support and input of the broader stakeholder community," said Dr. Faycal Kessouri, Senior Scientist at SCCWRP. "Scientists certainly don't have answers yet to all of the questions that managers are asking, but through continued engagement with stakeholders, we're getting closer every day."

Using modeling to predict HABs

ROMS-BEC modeling can do more than predict the trajectory of ocean acidification in coastal waters. The same core modeling capabilities also can be used to help predict the locations and severity of toxin-producing harmful algal blooms (HABs), which are ecologically disruptive events that can result in mass poisoning of sea lions and other marine mammals, as well as trigger fisheries closures.

In 2021, SCCWRP began working with a team of scientists, led by the University of California, Los Angeles, to build a modeling tool that predicts when and where domoic acid – a neurotoxin produced by a ubiquitous type of organism known as *Pseudo-nitzschia* – can be expected to occur along the California coast.

The modeling tool, unveiled in 2023, incorporates ROMS-BEC modeling capabilities to predict when and where nutrients – from both natural sources and land-based discharges – as well as other factors can be expected to widen the window of opportunity for proliferations of toxin-producing *Pseudo-nitzschia* blooms.

The ROMS-BEC HAB modeling component predicts particulate toxin levels in the surface waters. Then, the tool links domoic acid levels to increased probability of severe marine mammal strandings.

Courtesy of Channel Islands Marine & Wildlife Institute

A rescue crew from the Channel Islands Marine & Wildlife Institute prepares to transport a sea lion stranded on the beach. The sea lion likely was poisoned by toxin-producing algal blooms.

MODELING FLOWS TO HELP BALANCE DEMANDS

Southern California faces competing demands on limited flow resources; modeling is helping to identify balanced solutions

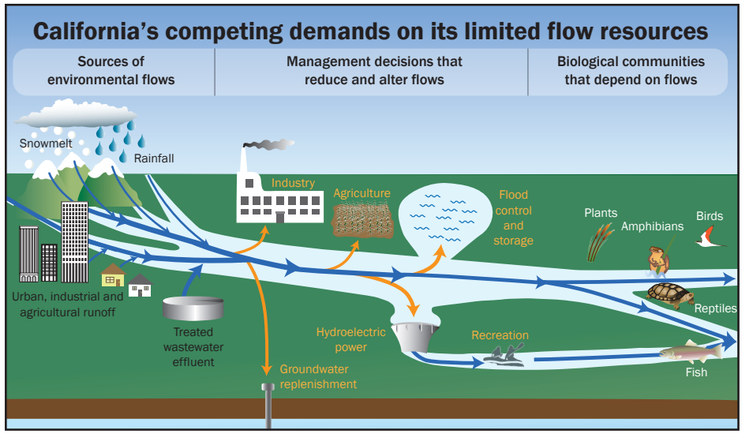
Humans have made dramatic modifications to how water flows through waterways statewide.

That's because across drought-prone California, there's more demand for flowing water than there is supply.

Humans rely on flowing water to bring drinking water to their communities, to sustain agriculture and livestock operations, to power hydroelectric dams, to provide aesthetic, cultural, and recreational benefits.

Cumulatively, however, the wide range of ways that humans have altered how water flows naturally through California has become a major source of ecological stress on waterways – a bigger stressor than common pollutants like heavy metals, pesticides and excess nutrients that degrade water quality.

In fact, altered flows are the No. 1 cause of degradation to aquatic life in Southern California streams, according to foundational work



published in 2015 by the Southern California Stormwater Monitoring Coalition (SMC).

Moreover, the ecological consequences of flow alterations are further intensified when they occur alongside degradation of water quality and human-induced changes in water temperatures.

To understand how flow alterations affect aquatic life, researchers start by making direct observations – monitoring both changes in flow patterns and how aquatic life respond.

But the complex relationship between flow and ecology requires the use of a powerful complementary tool to extend the value of the insights provided by direct observations across space and time. This tool is modeling.

Modeling enables researchers to develop holistic, comprehensive insights into how flow alterations affect aquatic ecosystem health. Instead of managers observing how flow changes affect one species or one human use for flowing water, managers use modeling to understand how flow alterations affect a diverse range of benefits provided by flowing water – and how to balance the many competing demands on this limited resource.

Moreover, modeling can predict what's expected to happen in the future. Through modeling, managers can understand how flow patterns may be affected by future climate change, changing land-use practices, and changing water-use practices – as well as how aquatic life that depend on seasonal flow patterns will respond.

Similarly, modeling can predict how various potential management actions being contemplated – from flow diversions to groundwater replenishment to flood control – can be expected to lessen adverse ecological consequences.

"There are increasing demands on California's flow resources that make the insights provided by modeling critical in helping to protect aquatic ecosystems – not just over the short term, but also over the long term, especially in the face of climate change," said Brionna Drescher, Senior Environmental Scientist in the Instream Flow Program for the California Department of Fish and Wildlife.

Photos courtesy of U.S. Fish and Wildlife Service

The arroyo toad, left, and the arroyo chub and Santa Ana sucker, right, are among the aquatic life vulnerable to changes in stream flow patterns. Researchers use modeling to predict how aquatic life will be affected by changes to flow patterns over the course of a year.

Understanding relationship between flow and ecology

Aquatic ecosystems rely on seasonal patterns in the flow of water through streams to sustain vibrant plant and animal communities – ecosystems that humans also want to see protected.

Even small changes in these flow patterns can have profound, deadly consequences for sensitive plant and animal species.

For example, the survival of the endangered arroyo toad, which lives at the edge of Southern California stream environments, is dependent on characteristic flow patterns over the course of the year to stay alive. Similarly, the Santa Ana sucker fish depends on streambed gravel to lay its eggs – gravel that can be washed away altogether if flows become too fast and too flashy.

At the same time, managers' ability to maintain needed flow patterns for aquatic life is growing more difficult.

As California's population grows, limited flow resources are stretched increasingly thin. For example, as more treated water gets recycled and reused in Southern California, less of this effluent is being discharged into streams; in many cases, these streams would have no flows for much of the year without the effluent discharges.

Likewise, as humans engage in a range of activities that produce runoff – including landscape irrigation and washing cars – the unnatural dry-weather flows in downstream waterways can be equally as ecologically disruptive.

The relationship between flow patterns and ecological health is an area of study known as ecohydrology. This relationship, which is complex and site-specific, is shaped by flow patterns at a given site over the course of the year, local topographic and environmental conditions, and the composition of aquatic life.

Over the past few decades, researchers have been incrementally leveraging improvements in computing power and other technological advances to improve ecohydrology modeling.

California first started using the science of ecohydrology in the early 1980s, to make management decisions about how to allocate limited flows across multiple competing demands.

Many of these early ecohydrology analyses, however, were aimed at identifying a single static minimum flow that would be necessary to protect a single species at a specific life stage, such as salmon during breeding season, or a single beneficial use, such as kayaking.

The problem with these initial analyses was that they led to flow allocation decisions that did not necessarily protect or improve overall ecosystem functioning over the course of the entire year, nor did they promote a holistic, integrated approach to managing limited flow resources.

Courtesy of U.S. Geological Survey

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

Courtesy of Ventura River Watershed Council

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

In other instances, managers used ecohydrology analyses to evaluate how to return flows to a natural, historical state. But they did not consider whether this natural state would translate to enhanced protections for ecosystem health, especially in light of other changes that humans have since made, such as modifying channel size or shape.

"To effectively protect flow-dependent beneficial uses over the long term, it's essential that managers have access to tools that help them make informed decisions in a consistent, standardized fashion," said Jeremy Haas, Healthy Waters Branch Chief for the San Diego Water Quality Control Board. "That's what gives managers the best shot at meeting water supply and community goals while preserving biological integrity of streams."

Protecting environmental flows

Despite the alterations that California has made to natural stream flows, restoring flows to a natural, pre-development state is not necessarily the only option at managers' disposal for protecting vulnerable plant and animal communities, and for conferring the recreational and aesthetic benefits provided by flowing water.

To the contrary, when it comes to managing how water flows through California's heavily urbanized watersheds, managers can instead focus on protecting the key ecological and societal benefits provided by these flow patterns – in other words, protecting what are known as environmental flows.

Under a management paradigm centered around environmental flows, researchers can look at how to protect ecologically significant attributes of the way water flows through the water body over the course of a year – known as functional flow metrics. For example, annual recessional flow patterns are the seasonal flow patterns generated by snow melt in the early spring that support breeding and migration for certain species.

In 2017, recognizing the need to prioritize protecting environmental flows in a consistent manner, SCCWRP partnered with other researchers to unify California's water resources management community around a standardized, modeling-based approach for how limited flows should be allocated among multiple competing needs.

Known as the California Environmental Flows Framework (CEFF), this scientific framework is designed to help managers balance the ecosystem needs of flowing water with human uses, including the recreational, cultural, and aesthetic benefits provided by these flows.

Suite of CEFF models

The California Environmental Flows Framework (CEFF) includes a suite of interconnected modeling tools that help managers make decisions about how to allocate limited flows among multiple competing needs. Not every model is needed for every CEFF application, and models can be tailored for specific systems and management applications. Key models that are foundational to CEFF include:

- Models that predict key attributes of annual flow patterns – known as functional flow metrics – based on landscape, climate, and measured stream flow
- A pair of models that predict flow at sites without flow gages under existing and natural, pre-development conditions, respectively
- Topography and hydraulic models that simulate how flow interacts with channel morphology (e.g., shape, size, slope, and substrate) to create physical habitat conditions needed to support native species' survival, growth, migration and reproduction
- Models that predict the probability of finding a species sensitive to changes in flow patterns at a given site, known as species occurrence models
- Models that predict how sensitive aquatic life will respond to flow alterations, known as biological response modeling
- Scenario models, which predict how future land-use changes, climate change and other human-induced stresses will affect flow patterns and how aquatic life will respond

CEFF is consistent with approaches established under the international Brisbane Declarations, which call for use of a consensus scientific approach for establishing environmental flows, and statewide strategies, including for managing salmon populations and for guiding long-term water resources planning.

Among the key benefits of CEFF is that it gives managers a systematic, structured way to incorporate climate change, changing land-use practices, and changing water-use practices into long-term decision-making about how to allocate limited flows.

"The decisions that managers are faced with making today about how to allocate flows aren't just based on present-day conditions," said Grant Sharp, Manager of the South Orange County Watershed Management Area for Orange County Public Works. "Ecohydrology modeling is allowing managers to look decades into the future – to understand what the future is going to look like, and how management actions may influence it."

Gaining buy-in, support for ecohydrology modeling

Because CEFF is largely based on a suite of models, a big part of gaining management buy-in for CEFF has been working alongside stakeholders to decide how to design, vet and apply these modeling tools.

During the first real-world application of CEFF in 2017, SCCWRP examined if flows in the Los Angeles River can be reduced for water-recycling purposes while simultaneously protecting the ecological and recreational benefits provided by the river's flows – a scenario that is expected to become more commonplace with climate change.

The first step was to bring together dozens of management agencies and other stakeholders to collaboratively decide how to apply a CEFF-based approach to understand the range of flows needed to protect the L.A. River's ecological health and recreational uses, including wastewater agencies that discharge treated effluent into the river, stormwater management agencies that manage wet and dry weather runoff into the river, water-quality regulatory agencies, and environmental advocacy nonprofits.

Significantly, SCCWRP invested in getting the stakeholders who collectively are affected by the conditions in the L.A. River to agree on how to apply and adapt the CEFF-based modeling approach, ensuring they also would buy into the outcomes of the modeling analyses.

Following the L.A. River study, the City of Los Angeles in 2021 used the agreed-upon modeling framework to apply for regulatory approval, under State Water Code Section 1211, to begin recycling more wastewater effluent that has historically been discharged to the Los Angeles River. The application is pending; a supplemental environmental impact report was submitted in 2024.

Treated wastewater effluent is discharged into the Los Angeles River from a nearby water reclamation plant. Researchers have used modeling to understand if some of the river's flows can be diverted for water-recycling purposes without jeopardizing the ecological and recreational benefits that these flows provide.

A SCCWRP field crew measures flow rates and other parameters in the Los Angeles River downstream from where wastewater effluent is discharged into the river. These data get plugged into modeling tools that help researchers evaluate the environmental flow needs of multiple sensitive species and habitats, plus the multiple aesthetic, cultural and recreational benefits provided by these flows.

Also following the L.A. River study, the County of Los Angeles used the CEFF modeling framework to apply for regulatory approval to capture more stormwater in the greater Los Angeles basin via specially designed underground structures – instead of allowing stormwater from these areas to run off into the L.A. River. This stormwater capture program, which also maintains sufficient L.A. River flows to help support ecological and recreational uses, was approved by the Los Angeles Regional Water Quality Control Board in 2023.

Expanding CEFF modeling

The L.A. River study has become the first of multiple proposed and enacted flow management actions that have followed CEFF-based modeling analyses.

In 2022, SCCWRP used the CEFF modeling framework to help managers in southern Orange County optimally balance two competing interests: The elimination of unnatural dry-weather flows in waterways across the area that resulted from irrigation and other discharges, and a recognition that eliminating these dry-weather flows could trigger adverse ecological effects of their own.

SCCWRP generated prioritization maps that helped managers decide where and how to implement flow-capture devices along 23,000 linear feet of degraded stream habitat in southern Orange County. Already, multiple stream restoration and flow diversion projects have been proposed or are underway.

CEFF also is helping to shape more sustainable groundwater management practices statewide.

Because CEFF modeling allows researchers to consider all flow patterns over the course of a year, groundwater management agencies around the state have begun using CEFF modeling to determine if groundwater pumping is adversely affecting the environmental flows that sustain vulnerable aquatic life in surface-level waterways. Groundwater pumping can adversely affect interconnected surface-level flow patterns.

The California Department of Water Resources is exploring the framework for other groundwater management applications, including to inform strategies for implementing flood managed aquifer recharge (Flood-MAR), in which certain areas are deliberately flooded to recharge underground aquifers. The goal is to use the Flood-MAR program to reduce the need for low-flow diversion by diverting high flows for aquifer recharge.

"CEFF is gaining traction because its flexible and science-based structure makes it useful for a variety of water management decisions," said Dr. Bronwen Stanford, Lead River Scientist and Acting Director of Freshwater Science for the Nature Conservancy in California. "CEFF combines a structured process for evaluating flow needs with ecological understanding and sophisticated modeling tools to make environmental flows assessments easier and more transparent."

Investigating co-occurring stressors

Most environmental flows research to date has focused on evaluating patterns in

Diverting flows via 1211 wastewater change petitions

As drought-prone California looks for opportunities to recycle and reuse more water, treated wastewater effluent that's being discharged into the coastal ocean and inland waterways is increasingly viewed as a strategic target. But diverting wastewater discharges from rivers and streams can have ecological consequences for the aquatic life that depend on seasonal flow patterns – especially when this treated water for much of the year is the predominant source of flows. That's why California requires wastewater treatment agencies to seek regulatory approval, under State Water Code Section 1211, to begin recycling this effluent.

Ecohydrology modeling plays a key role in helping managers evaluate how much effluent, if any, can be diverted from streams without jeopardizing the health of aquatic ecosystems that have become dependent on these flows. Through modeling, managers also can understand how other activities that depend on these flows – including fishing and kayaking – will be affected by flow diversions.

A storm drain discharges unnatural dry-weather flows into a tributary of Arroyo Trabuco Creek in southern Orange County. A modeling-based approach known as the California Environmental Flows Framework has helped local watershed managers make decisions about how to reverse these unnatural flow patterns and better protect degraded stream habitat.

the volume, timing and frequency of flows themselves.

But human-caused alterations to flow patterns are part of an interconnected set of stressors affecting watershed health; the most dominant of these co-occurring stressors are water temperature and water quality. Indeed, in the near term, warming temperatures may present an even bigger risk to the ecological health of streams than alterations to flow patterns.

To evaluate the synergistic roles that flow, temperature and water quality play in influencing ecosystem health, researchers are integrating CEFF with models that predict the trajectory of temperature and water-quality changes. These interconnected models relate changes in flow to changes in water quality, then changes in water quality to ecological response.

The goal is to understand the relative risks that each of these multiple environmental stressors presents, so managers can identify and prioritize addressing the most significant risks to ecosystem health first.

In recent years, SCCWRP has been exploring how ecosystem health is affected when wastewater effluent is discharged into Southern California streams at temperatures that are different than the receiving stream. Researchers also are looking at the ecological consequences of these wastewater discharges being warmed by sunlight, especially in shallow urban streams.

Improved understanding of the relationship between water temperature and ecological health has numerous potential management implications, including for setting permissible temperature ranges for stream discharges, deciding how to design stream restoration projects, and determining how groundwater might be used to offset rising surface water temperatures. Groundwater commonly mixes with surface waters at certain times and places, which means it has the potential to lower surface water temperatures.

Meanwhile, as flow patterns continue to change over time – in response to climate change and changing land-use and water-use practices – researchers are working to improve ecohydrology modeling tools to be better predictors of the ecological consequences of multiple environmental stresses.

This work involves shifting from species occurrence models that predict the likelihood of observing a species at a site, to population viability models that predict the long-term sustainability of the entire population at the site. SCCWRP is exploring how to integrate population viability modeling into its ecohydrology investigations, as a complement to species occurrence modeling.

The main advantage of population viability modeling is that it can evaluate longer-term changes in flow patterns due to changing water-use practices, changing land-use practices, and climate change, including rapid swings between extremely wet conditions and dangerously dry conditions, as well as gradual but sustained changes over time, such as those associated with climate change.

"Continued advances in our modeling efforts are increasing our understanding of the interactions among flows in the river, water quality, and temperature," Dr. Mas Dojiri, Assistant General Manager for the City of Los Angeles Sanitation and Environment. "We are confident that, as a result of all of this modeling work, we're getting relevant information to effectively balance the uses of the river, including water recycling, water recreation, and other designated beneficial uses."

A SCCWRP field crew deploys a temperature logger at Bear Creek, a tributary of the San Gabriel River in Los Angeles County, for a study investigating how ecosystem health is affected by wastewater discharges. Wastewater effluent is discharged into this stream above the stream's ambient temperature.

OPTIMIZING BMP PERFORMANCE THROUGH MODELING

Modeling plays an integral role in Southern California's ability to improve the effectiveness of stormwater control measures

Southern California's infrequent but intense storm events trigger massive amounts of water to wash off hundreds of square miles of densely populated landscapes.

This runoff carries a wide range of contaminants that typically flow – untreated – into Southern California's ecologically and economically important inland waterways and coastal waters.

To address this pervasive contamination challenge, one of the key solutions that Southern California's stormwater management community has embraced is a class of pollution control measures known as structural stormwater BMPs (best management practices).

Structural BMPs consist mostly of site-specific engineering solutions designed to control and treat runoff near where the runoff originates using a range of technologies. These technologies commonly capture, infiltrate, divert, detain, or retain runoff while promoting various mechanisms for transforming or sequestering pollutants.

As the pace of BMP implementations has accelerated across Southern California over the past decade, stormwater managers have struggled with how to optimize the performance effectiveness of these costly public infrastructure investments.

Every BMP manages runoff volume and treats water quality differently. Although managers have invested in building capacity to measure the performance of BMPs, BMP performance insights from one site are not readily transferrable to other sites and other types of BMPs.

Moreover, BMPs perform very differently in Southern California than in other parts of the country – a consequence of the region's unique rainfall patterns and other local factors. Thus, BMP performance monitoring data generated outside Southern California cannot automatically be extrapolated to BMPs in Southern California.

That's where modeling is adding important value.

Modeling offers a path forward for stormwater managers to comprehensively understand how BMPs will perform across a region as varied and heavily populated as Southern California.

Through modeling, researchers can extrapolate field monitoring data collected from a limited number of BMPs in Southern California to predict how similar BMPs will perform across broader geographies.

Moreover, modeling has the unique ability to integrate the many factors that influence BMP performance – and then to generate rigorous predictions about the BMP's ability to attain runoff water-quality improvement goals.

Just as importantly, modeling predicts how all of the BMPs being planned for the future – which are expected to be constructed in phases over time – will work as a system to reduce contaminant loading and achieve long-term water-quality improvement goals.

"Modeling is a crucial tool for stormwater managers, allowing us to explore various 'what if' scenarios," said Neil Searing, Water Resources Manager for the San Diego County Watershed Protection Program. "If we capture, divert, and treat runoff on-site, will it meet water-quality objectives? If we build a BMP to reduce pollution now, will it remain effective in 10–20 years, especially with a changing climate? Answering these questions helps managers target their investments in public infrastructure towards solutions designed to achieve maximum benefit."

Turning to BMPs for managing runoff

Structural stormwater BMPs are the centerpiece of Southern California's long-term plans to improve runoff water quality in phases over multiple decades.

These engineered solutions are designed to treat metals, nutrients, sediments, bacteria and other contaminants in runoff, and/or to prevent this pollution from reaching downstream waterways. Examples of common BMPs in Southern California include:

» Extended detention and retention basins that collect runoff and then allow pollutants to settle to the bottom of the basin as water gets slowly discharged to storm drains

» Infiltration galleries and dry wells that divert runoff to large underground holding areas, allowing the runoff to slowly soak into the ground instead of reaching downstream waterways

» Biofiltration and bioretention systems, including vegetated bioswales, that use engineered treatment media in combination with hydrologic and hydraulic controls to remove pollutants from runoff before it either gets discharged into storm drain systems or soaks into the ground

While many BMPs only treat runoff from a relatively small area, such as a parking lot or one stretch of roadway, larger BMPs can treat runoff from an entire neighborhood or larger area.

Using modeling to answer BMP performance questions

Through improved modeling, researchers are working to help stormwater managers improve the performance of structural BMPs – both BMPs already implemented, and those yet to be designed. These BMP modeling insights will help answer key management questions, including:

» What combinations of BMP types should be placed where to get the best outcomes under a range of potential operating conditions?

» What are the specific design factors that will disproportionately influence how a BMP performs over the long term in Southern California?

» What BMP maintenance regimes will support optimal long-term performance effectiveness?

Courtesy of Los Angeles County Department of Public Works

Infiltration galleries like this underground one, above, under construction in Los Angeles County are designed to collect and store runoff from nearby neighborhoods, enabling runoff to soak into the ground.

In Southern California, stormwater managers have spent billions of dollars constructing thousands of structural stormwater BMPs, and are making long-term plans to spend billions more in the coming decades to meet water-quality improvement targets for runoff.

Southern California is one of the first regions of the country to turn to modeling to support regulatory compliance for stormwater discharges. Alternative Compliance, as it is known in California, enables agencies that discharge stormwater to use modeling to plan for BMP and other

Courtesy of Los Angeles County Public Works

A field crew constructs a bioretention system in Riverside County. Researchers use modeling, in combination with field monitoring data collected from a limited number of BMPs in Southern California, including the one above, to predict how similar BMPs will perform across broad geographies.

stormwater investments over multi-decade time scales. If agencies can demonstrate progress implementing the water-quality improvement plans that are identified in the models, then the long-term goal of achieving improved runoff water quality will be achieved.

However, these model-based water-quality improvement plans are only as accurate as the BMP performance models that underlie it.

And as Southern California's stormwater managers have learned, the tools they routinely use for BMP performance modeling tend to have a high degree of uncertainty associated with them.

If these tools overestimate BMP performance, the BMPs may not achieve their intended water-quality improvement targets. Conversely, if the tools underestimate BMP performance, managers may expend excessive and unnecessary resources on BMP design, construction and maintenance.

Most of the BMP modeling tools commonly used in Southern California were developed by making broad assumptions about BMP performance that don't reflect the highly variable, dynamic nature of how individual BMPs perform in the real world.

Some of these performance assumptions are based on limited data, often collected in other climates and geographies. Other performance assumptions are based on rules of thumb and best professional judgment – compiled from one-off research studies, plus practical experience from industry, vendors and manufacturers – and have not been rigorously validated in independent scientific studies.

In relying on all of these assumptions, managers have gravitated to a prescriptive rule-based approach to BMP design, where managers assume that if a specific prescribed set of BMP design rules is followed, the resulting BMP will automatically attain specific prescribed performance standards.

The end result is that the costly investments that Southern California has been making in BMPs may not be optimized to meet long-term water-quality improvement goals.

"Even though these BMPs may look like simple landscape features, they are highly complex engineered devices; we expect a lot of them in helping to improve the quality of our local waterways," said Dr. Allen P. Davis, Professor and Charles A. Irish, Sr. Chair in Civil Engineering at the University of Maryland. "Modeling these systems allow us to evaluate how they perform under the many different conditions to which they may be exposed. Trying to look at all these scenarios by collecting field monitoring data would be extremely time-consuming and cost-prohibitive."

Improving BMP performance modeling

How an individual BMP will perform is shaped by multiple discrete factors – how the BMP is designed, constructed and maintained, where it's placed, and the levels and types of pollutants that the BMP is expected to treat.

All of these factors need to be integrated appropriately to generate accurate, reliable predictions about BMP performance.

In recent years, researchers have focused on improving existing BMP performance modeling tools by eliminating overreliance on broad and unvalidated assumptions – and instead working to develop tools that more accurately reflect the dynamic, real-world operating conditions that shape BMP performance.

At the same time, stormwater managers thus far have struggled to incorporate these improved tools into their routine BMP modeling activities.

The underlying challenge is that better modeling tools require more data to reliably simulate BMP performance – data sets that tend to be very few and far between.

Specifically, these BMP models depend on high-quality, field- and laboratory-collected data that capture the broad range of conditions under which Southern California BMPs operate, as well as that span the range of different

design specifications and maintenance regimes that Southern California managers commonly use to build and operate BMPs.

Researchers ran up against the lack of high-quality BMP performance data during the development of the California BMP Effectiveness Calculator, which was unveiled by SCCWRP in 2019 to estimate the effectiveness of common flow-through BMPs in removing contaminants from runoff. Researchers found that the tool's management utility was constrained by a lack of relevant, Southern California-specific BMP performance data.

To overcome this lack of data, Southern California managers initially used BMP performance insights generated outside the region to improve BMP performance modeling in Southern California.

But BMPs perform very differently in Southern California, where pollution can accumulate on highly developed landscapes during extended dry-weather periods and then wash off all at once during intense storms. Even within the region, the performance of one BMP does not necessarily indicate how a similarly designed or similarly situated BMP will perform.

That's why Southern California stormwater managers have made significant investments in recent years in building capacity to collect high-quality, Southern California-specific BMP performance data.

Through the Southern California Stormwater Monitoring Coalition's 2-year-old Regional BMP Monitoring Network, stormwater managers are using standardized methodologies to collaboratively collect BMP performance data from multiple BMP sites across Southern California.

These rigorous data sets will be essential for managers to fully take advantage of newer, more insightful BMP performance modeling tools.

"Better data is the key to dramatically improving managers' ability to model BMP performance with confidence and accuracy," said James Fortuna, Manager of the North Orange County Watershed Management Area for Orange County Public Works. "Ultimately, our goal is to leverage all of the new data sets to understand how modifying the design of BMPs will affect its pollutant removal capacity – and in the process, lead to potentially more effective, data-driven designs for these BMPs."

Pursuing next-generation BMP modeling

While improving the utility of existing BMP modeling tools is managers' short-term goal, managers simultaneously are exploring how to develop a more powerful next generation of modeling tools over the long term.

The most commonly used BMP performance models are built around simulating what enters the BMP, plus static assumptions about what portion of pollutants will be removed – without focusing on understanding what is happening to runoff pollution as it is being treated inside the BMP.

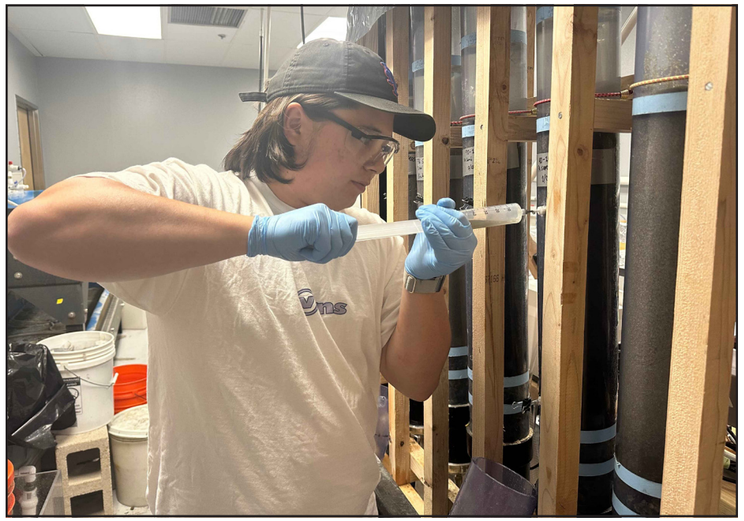
As a result, existing modeling tools for predicting BMP performance do not model the actual processes by which pollution removal occurs inside the BMP.

In 2023, SCCWRP launched a three-year exploratory effort with the State Water Resources Control Board and the SMC to identify and measure the mechanistic inner processes by which a ubiquitous class of BMPs known as biofiltration systems removes common types of stormwater pollutants as runoff flows through them.

Researchers' goal is to open the "black box" that has always surrounded how these systems work – that is, to collect data on the actual processes that are driving pollutant removal inside BMPs.

Researchers hope to use this improved understanding of how BMPs work to develop a fundamentally different class of modeling tools centered around predicting BMP treatment mechanisms.

"We have only scratched the surface in terms of building modeling tools for optimizing BMP performance," said Amanda Magee, Chief of the STORMS (Strategy to Optimize Resource Management of Stormwater) Unit at the California State Water Resources Control Board. "With this next generation of modeling tools, we're going to be able to directly simulate the mechanistic processes that remove pollution from runoff – and that means hopefully more powerful, more accurate predictions about BMP performance."



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 are working to open the "black box" for how these systems work, starting with a laboratory-scale investigation that enables researchers to control and quantify a biofiltration BMP's mechanistic processes.

Accomplishments

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

SCCWRP mission

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

Research themes

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

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

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

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

Bioassessment

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

Ecohydrology

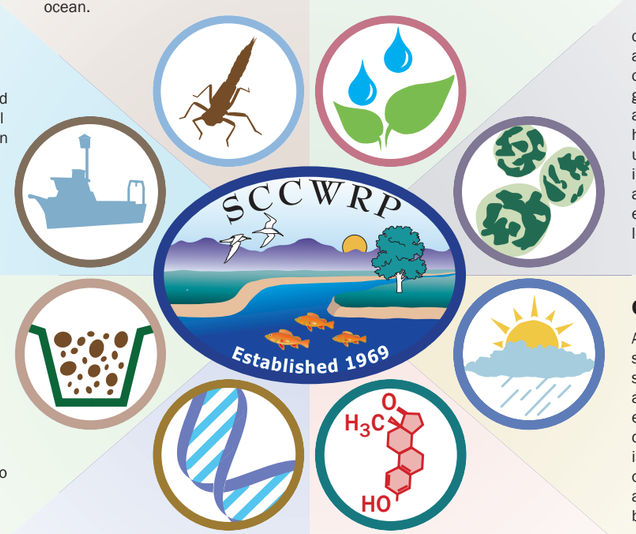
As environmental managers work to protect aquatic systems and the biological communities they support from human-induced alterations to hydrological flow patterns, SCCWRP is working to better understand these ecohydrological relationships and how to develop science-informed best management practices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

Regional Monitoring

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

Eutrophication

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



Stormwater BMPs

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

Climate 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.

SCCWRP helps shape national eDNA monitoring strategy

The White House Office of Science and Technology Policy has unveiled a national strategy intended to bring standardization and consistency to how environmental DNA (eDNA) methods get incorporated into aquatic monitoring programs nationwide – a seminal roadmap document that SCCWRP and its member agencies helped shape.

The National Aquatic eDNA Strategy, unveiled at the 3rd National Workshop on Marine eDNA in 2024, establishes a unified vision and plan for how multiple federal, state and local environmental agencies can work together to expeditiously transition eDNA-based monitoring methods from pilot-scale studies to broadscale adoption by the end-user management community.

SCCWRP played a key role in taking the national eDNA strategy from concept to reality, starting by hosting the 2nd National Workshop on Marine eDNA in 2022 where the idea for a national strategy was first conceptualized.

SCCWRP also co-authored key journal manuscripts and other documents that were incorporated into the strategy. Meanwhile, during a CTAG intersessional meeting, SCCWRP's member agencies provided perspectives on barriers to more widespread adoption and use of eDNA monitoring.

In advance of the national strategy's rollout, SCCWRP's Dr. Susanna Theroux was selected as one of four eDNA experts to give a congressional briefing on eDNA.

The White House Office of Science and Technology Policy in 2024 unveiled the National Aquatic eDNA Strategy to help expeditioiusly transition eDNA-based monitoring methods from pilot-scale studies to broadscale adoption by the end-user management community. eDNA monitoring has the potential to complement traditional monitoring for a range of aquatic life, including kelp bass, above.

Screening-level causal assessment tool successfully applied in San Luis Rey River watershed

SCCWRP and its partners have completed a screening-level causal assessment of the San Luis Rey River watershed in San Diego County using an approach co-developed by SCCWRP that rapidly identifies likely stressors affecting the health of the watershed's biological communities.

The work, completed in 2024 in partnership with the City of Oceanside and the County of San Diego, utilized the Rapid Screening Causal Assessment (RSCA) tool to examine five types of stressors that could be responsible for degraded stream health: altered habitat, elevated conductivity, elevated temperature, eutrophication and altered flows.

Researchers identified altered flow and altered habitats as the most common potential causes for stream degradation.

The RSCA assessment will be followed by a pair of more in-depth causal assessments that provide additional insights and improve management confidence that the stressors responsible for biological degradation have been correctly identified.

SCCWRP and its partners have successfully used a new approach that rapidly identifies likely stressors affecting the health of a watershed's biological communities to complete a screening-level causal assessment of the San Luis Rey River watershed, above.

The MIEM guidelines: Minimum information for reporting of environmental metabarcoding data

Katy E. Klymus[1], Jacoby D. Baker[2], Cathryn L. Abbott[3], Rachel J. Brown[4], Joseph M. Craine[5], Zachary Gold[6], Margaret E. Hunter[7], Mark D. Johnson[8,9], Devin N. Jones[10], Michelle J. Jungbluth[11], Sean P. Jungbluth[11], Yer Lor[12], Aaron Maloy[13], Christopher M. Merkes[12], Rachel Noble[14], Nastassia V. Patin[15,16], Adam J. Sepulveda[10], Stephen F. Spear[12], Joshua A. Steele[16], Miwa Takahashi[17], Alison W. Watts[18], Susanna Theroux[16]

[1]*U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO*
[2]*Monterey Bay Aquarium Research Institute, Moss Landing, CA*
[3]*Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada*
[4]*U.S. Fish and Wildlife, Whitney Genetics Laboratory, Onalaska, WI*
[5]*Jonah Ventures, Boulder, CO*
[6]*NOAA Pacific Marine Environmental Laboratory, Seattle, WA*
[7]*U.S. Geological Survey, Wetland and Aquatic Research Center, Gainesville, FL*
[8]*Engineer Research and Development Center, Champaign, IL*
[9]*Illinois Natural History Survey, University of Illinois at Urbana-Champaign, Champaign, IL*
[10]*U.S. Geological Survey, Northern Rocky Mountain Science Center, Bozeman, MT*
[11]*San Francisco State University, Estuary & Ocean Science Center, Tiburon, CA*
[12]*U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI*
[13]*U.S. Fish and Wildlife Service, Northeast Fishery Center, Lamar, PA*
[14]*University of North Carolina Chapel Hill, Departments of Earth, Marine, and Environmental Sciences and Engineering, Chapel Hill, NC*
[15]*Integrated Oceanography Division, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA*
[16]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[17]*Environomics Future Science Platform, Commonwealth Scientific and Industrial Research Organisation, Indian Oceans Marine Research Centre, Crawley, Western Australia, Australia*
[18]*University of New Hampshire, Department of Civil and Environmental Engineering, Durham, NH*

Abstract

Environmental DNA (eDNA) and RNA (eRNA) metabarcoding has become a popular tool for assessing biodiversity from environmental samples, but inconsistent documentation of methods, data and metadata makes results difficult to reproduce and synthesise. A working group of scientists have collaborated to produce a set of minimum reporting guidelines for the constituent steps of metabarcoding workflows, from the physical layout of laboratories through to data archiving. We emphasise how reporting the suite of data and metadata should adhere to findable, accessible, interoperable and reproducible (FAIR) data standards, thereby providing context for evaluating and understanding study results. An overview of the documentation considerations for each workflow step is presented and then summarised in a checklist that can accompany a published study or report. Ensuring workflows are transparent and documented is critical to reproducible research and should allow for more efficient uptake of metabarcoding data into management decision-making.

Citation

Klymus, K.E., J.D. Baker, C.L. Abbott, R.J. Brown, J.M. Craine, Z. Gold, M.E. Hunter, M.D. Johnson, D.N. Jones, M.J. Jungbluth, S.P. Jungbluth, Y. Lor, A. Maloy, C.M. Merkes, R. Noble, N.V. Patin, A.J. Sepulveda, S.F. Spear, J.A. Steele, M. Takahashi, A.W. Watts, S. Theroux. 2024. The MIEM guidelines: Minimum information for reporting of environmental metabarcoding data. *Metabarcoding and Metagenomics* 8:489-518.

SCCWRP Journal Article #1417
Full text available online: www.sccwrp.org/publications

Critical considerations for communicating environmental DNA science

Eric D. Stein[1], Christopher L. Jerde[2], Elizabeth Andruszkiewicz Allan[3], Adam J. Sepulveda[4], Cathryn L. Abbott[5], Melinda R. Baerwald[6], John Darling[7], Kelly D. Goodwin[8], Rachel S. Meyer[9], Molly A. Timmers[10,11], and Peter M. Thielen[12]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*Marine Science Institute, University of California Santa Barbara, Santa Barbara, CA*
[3]*School of Marine and Environmental Affairs, University of Washington, Seattle, WA*
[4]*U.S. Geological Survey, Northern Rocky Mountain Science Center, Bozeman, MT*
[5]*Fisheries and Oceans Canada, Nanaimo, British Columbia, Canada*
[6]*Division of Integrated Science and Engineering, California Department of Water Resources, West Sacramento, CA*
[7]*U.S. Environmental Protection Agency, Environmental Genomics Branch, Watershed and Ecosystem Characterization Division, Research Triangle Park, NC*
[8]*National Oceanic and Atmospheric Administration, NOAA Ocean Exploration, Stationed at SWFSC/NMFS, La Jolla, CA*
[9]*Department of Ecology and Evolutionary Biology, University of Santa Cruz, Santa Cruz, CA*
[10]*Pristine Seas, National Geographic Society, Washington, DC*
[11]*Hawai'i Institute of Marine Biology, School of Ocean and Earth Science and Technology, University of Hawai'i at Mānoa, Honolulu, HI*
[12]*Research and Exploratory Development Department, Johns Hopkins University Applied Physics Laboratory, Laurel, MD*

Abstract

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

their benefit to the monitoring and assessment community.

CITATION

Stein, E.D., C.L. Jerde, E. Andruszkiewicz Allan, A.J. Sepulveda, C.L. Abbott, M.R. Baerwald, J. Darling, K.D. Goodwin, R.S. Meyer, M.A. Timmers, P.M. Thielen. 2024. Critical considerations for communicating environmental DNA science. *Environmental DNA* DOI:10.1002/edn3.472.

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

Toward a national eDNA strategy for the United States

Ryan P. Kelly[1], David M. Lodge[2], Kai N. Lee[3], Susanna Theroux[4], Adam J. Sepulveda[5], Christopher A. Scholin[6], Joseph M. Craine[7], Elizabeth Andruszkiewicz Allan[1], Krista M. Nichols[8], Kim M. Parsons[8], Kelly D. Goodwin[9], Zachary Gold[10], Francisco P. Chavez[6], Rachel T. Noble[11], Cathryn L. Abbott[12], Melinda R. Baerwald[13], Amanda M. Naaum[14], Peter M. Thielen[15], Ariel Levi Simons[16], Christopher L. Jerde[17], Jeffrey J. Duda[18], Margaret E. Hunter[19], John A. Hagan[20], Rachel Sarah Meyer[16], Joshua A. Steele[4], Mark Y. Stoeckle[21], Holly M. Bik[22], Christopher P. Meyer[23], Eric Stein[4], Karen E. James[24], Austen C. Thomas[25], Elif Demir-Hilton[26], Molly A. Timmers[27], John F. Griffith[4], Michael J. Weise[28], Stephen B. Weisberg[4]

[1]University of Washington, School of Marine and Environmental Affairs, Seattle, WA, USA
[2]Cornell Atkinson Center for Sustainability, Cornell University, Ithaca, NY, USA
[3]Owl of Minerva LLC, Indianapolis, IN, USA
[4]Southern California Coastal Water Research Project Authority, Costa Mesa, CA, USA
[5]U.S. Geological Survey Northern Rocky Mountain Science Center, Bozeman, MT, USA
[6]Monterey Bay Aquarium Research Institute, Moss Landing, CA, USA
[7]Jonah Ventures, Boulder, CO, USA
[8]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[9]Atlantic Oceanographic & Meterological Laboratory (stationed at Southwest Fisheries Science Center), National Oceanic and Atmospheric Administration, La Jolla, CA, USA
[10]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA
[11]Department of Earth, Marine, and Environmental Sciences, Institute of Marine Sciences, UNC Chapel Hill, Morehead, NC, USA
[12]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, British Columbia, Canada
[13]Division of Integrated Science and Engineering, California Department of Water Resources, Sacramento, CA, USA
[14]NatureMetrics North America Ltd, Guelph, Ontario, Canada
[15]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA
[16]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA, USA
[17]University of California, Santa Barbara, CA, USA
[18]U.S. Geological Survey, Western Fisheries Research Center, Seattle, WA, USA
[19]U.S. Geological Survey, Wetland and Aquatic Research Center, Gainesville, FL, USA
[20]Northwest Indian Fisheries Commission, Olympia, WA, USA
[21]Program for the Human Environment, The Rockefeller University, New York, NY, USA
[22]Department of Marine Sciences and Institute of Bioinformatics, University of Georgia, Athens, GA, USA
[23]National Museum of Natural History, Smithsonian Institution, Washington, DC, USA
[24]Maine Center for Genetics in the Environment, University of Maine, Orono, ME, USA
[25]Molecular Division, Smith-Root, Inc, Vancouver, WA, USA
[26]Oceankind, Palo Alto, CA, USA
[27]National Geographic Society, Washington, DC, USA
[28]Office of Naval Research, Marine Mammals & Biology Program, Arlington, VA, USA

ABSTRACT

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

CITATION

Kelly, R.P., D.M. Lodge, K.N. Lee, S. Theroux, A.J. Sepulveda, C.A. Scholin, J.M. Craine, E.A. Allan, K.M. Nichols, K.M. Parsons, K.D. Goodwin, Z. Gold, F.P. Chavez, R.T. Noble, C.L. Abbott, M.R. Baerwald, A.M. Naaum, P.M. Thielen, A.L. Simons, C.L. Jerde, J.J. Duda, M.E. Hunter, J.A. Hagan, R.S. Meyer, J.A. Steele, M.Y. Stoeckle, H.M. Bik, C.P. Meyer, E.D. Stein, K.E. James, A.C. Thomas, E. Demir-Hilton, M.A. Timmers, J.F. Griffith, M.J. Weise, S.B. Weisberg. 2024. Toward a national eDNA strategy for the United States. *Environmental DNA* DOI:10.1002/edn3.432.

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

Reach-scale models show heterogeneity of stream benthic invertebrate responses to eutrophication stress

David Gillett[1], Raphael D. Mazor[1,2], Martha Sutula[1], and Anne Holt[1]

[1]Southern California Coastal Water Research Project, Costa Mesa, CA
[2]California Department of Fish and Wildlife, Rancho Cordova, CA

ABSTRACT

Statistical stressor-response models are a common approach to derive biologically relevant water quality criteria for the management of waterbody health. These types of models are typically derived at state-wide or ecoregional scales and consequently incorporate a large amount of natural and disturbance-related variability that may obscure the relationship that one is interested in quantifying. We demonstrate an alternative approach termed "reach-specific modeling" to identify potential biological response thresholds to eutrophication in the Santa Margarita River watershed (California, U.S.A.). Individual models of benthic invertebrate response to eutrophication stress were created for both bioassessment sampling sites and NHD + stream-segments in the watershed (46 sites, 832 segments). Each model was built using only data from environmentally similar sites from a state-wide dataset to minimize variation from natural environmental gradients, while allowing eutrophication stress to vary. Thresholds of potential biological impact were extracted from each stressor-response model. Across the whole watershed thresholds varied from location-to-location: total nitrogen (1.14–1.26 mg L^{-1} TN), total phosphorus (0.12–0.15 mg L^{-1} TP), benthic algal biomass (29–39 mg m^{-2} benthic chl-a), and benthic ash-free dry mass (2.5–3.0 mg cm^{-2} AFDM). Notably, nearly all of the thresholds derived from these reach-specific models were ~10–90% higher than those from a similar state-wide model. Furthermore, there were a number of spatial groupings of thresholds for each eutrophication indicator across the watershed, suggesting reach-scale natural gradients in hydrogeomorphology and natural land cover type may mediate the stressor-biology interaction. Reach-scale models tended to have better fits than their state-wide counterparts, but had equivalent or slightly worse accuracy. The reach-specific approach to threshold development illustrates that the biological response to stress is likely not uniform within a single system, much less between systems. As a consequence, this approach can allow managers to identify systems that are more sensitive or resistant to a given stressor across diverse landscapes and make better informed decisions on their management accordingly.

CITATION

Gillett, D.J., R.D. Mazor, M. Sutula, A. Holt. 2024. Reach-scale models show heterogeneity of stream benthic invertebrate responses to eutrophication stress. *Ecological Indicators* 160:111791.

SCCWRP Journal Article #1366
Full text available online: www.sccwrp.org/publications

Streamflow Duration Assessment Methods for the Arid West and Western Mountains of the United States of America

Raphael Mazor[1], Amy James[2], Ken M. Fritz[5], Brian Topping[3], Tracie-Lynn Nadeau[4], Rachel Fertik Edgerton[3], and Kristina Nicholas[6]

[1]Southern California Coastal Water Research Project, Costa Mesa, CA
[2]Ecosystem Planning and Restoration, Raleigh, NC
[3]U.S. Environmental Protection Agency – Office of Wetlands, Oceans, and Watersheds, Washington, D.C.
[4]U.S. Environmental Protection Agency – Region 10, Portland, OR
[5]U.S. Environmental Protection Agency – Office of Research and Development, Cincinnati, OH
[6]Oak Ridge Institute of Science and Education (ORISE) Fellow at U.S. Environmental Protection Agency – Office of Wetlands, Oceans, and Watersheds, Washington, D.C.

CITATION

Mazor, R.D., A. James, K.M. Fritz, T. Nadeau, R.F. Edgerton, K. Nicholas. 2024. Streamflow Duration Assessment Methods for the Arid West and Western Mountains of the United States of America. Technical Report 1407. U.S. Environmental Protection Agency. Washington, D.C.

SCCWRP Technical Report #1407
Full text available online: www.sccwrp.org/publications

Streamflow Duration Assessment Methods for the Great Plains of the United States

Amy James[1], Ken M. Fritz[2], Brian Topping[3], Tracie-Lynn Nadeau[4], Rachel Fertik Edgerton[3], Kristina Nicholas[5], and Raphael Mazor[6]

[1]Ecosystem Planning and Restoration, Raleigh, NC
[2]U.S. Environmental Protection Agency – Office of Research and Development, Cincinnati, OH
[3]U.S. Environmental Protection Agency – Office of Wetlands, Oceans, and Watersheds, Washington, D.C.
[4]U.S. Environmental Protection Agency – Region 10, Portland, OR
[5]Oak Ridge Institute of Science and Education (ORISE) Fellow at U.S. Environmental Protection Agency – Office of Wetlands, Oceans, and Watersheds, Washington, D.C.
[6]Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

James, A., K.M. Fritz, B. Topping, T. Nadeau, R.F. Edgerton, K. Nicholas, R.D. Mazor. 2024. Streamflow Duration Assessment Method for the Great Plains of the United States. Technical Report 1408. U.S. Environmental Protection Agency. Washington, D.C.

SCCWRP Technical Report #1408
Full text available online: www.sccwrp.org/publications

Candidate metrics for an index to assess the ecological condition of intermittent and ephemeral streams in Southern California when they are dry

Raphael D. Mazor[1], Rachel Darling[1], Jeff Brown[1], Chad Loflen[2], John Olson[3], Garrett Michael Keating[1,5], and Matthew Robinson[3,4]

[1]Southern California Coastal Water Research Project, Costa Mesa, CA
[2]Water Quality Control Board—San Diego Region, San Diego, CA
[3]California State University at Monterey Bay, Monterey, CA
[4]Arizona Department of Environmental Quality, Phoenix, AZ
[5]University of California at Irvine, Irvine, CA

CITATION

Mazor, R.D., R. Darling, J.S. Brown, C. Loflen, J. Olson, G.M. Keating, M. Robinson. 2024. Candidate metrics for an index to assess the ecological condition of intermittent and ephemeral streams in Southern California when they are dry. Technical Report 1398. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1398
Full text available online: www.sccwrp.org/publications

Tools released to help determine whether streams subject to Clean Water Act

The U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers have released final versions of regional flow classification tools intended to help watershed managers determine which streams the federal government has jurisdiction to regulate under the Clean Water Act – the culmination of a sweeping, five-year national research initiative co-led by SCCWRP.

The Streamflow Duration Assessment Methods (SDAMs), released in final form in 2024, are designed to help managers across the U.S., including in Southern California, rapidly distinguish among intermittent, ephemeral and perennial streams using easily observable indicators, such as wetland vegetation and aquatic invertebrates.

Watershed managers need to be able to distinguish among different types of stream flows because, in certain cases, they are subject to different regulatory requirements.

In 2023, the Supreme Court ruled that the Clean Water Act oversight applies only to "relatively permanent bodies of waters."

In California, about two-thirds of streams are classified as ephemeral or intermittent, according to the California Surface Water Ambient Water Monitor Program's Perennial Streams Assessment.

Staff from the U.S. Environmental Protection Agency and U.S. Army Corps of Engineers participate in a SCCWRP-led field training in Oakland for newly developed stream flow classification tools. The tools are designed to help watershed managers rapidly distinguish among intermittent, ephemeral and perennial streams.

Study sheds initial insights into how water temperature affects stream health

SCCWRP and its partners have completed an initial set of analyses for an ongoing study working to improve managers' understanding of how water temperature affects the health of sensitive aquatic life in Southern California streams where treated wastewater effluent is being discharged.

The initial temperature analyses, completed in 2024, focus on the Upper Santa Clara River watershed, and complement a similar ongoing study in the San Gabriel watershed. Treated wastewater effluent is discharged into Southern California streams at temperatures that are different than the stream's own.

Unlike much of the San Gabriel River watershed, the Santa Clara River naturally receives inputs from groundwater. Groundwater is thought to have a cooling effect on river temperature, meaning the groundwater in the Santa Clara River has the potential to help offset increased temperatures from the treated wastewater discharges.

The investigations are motivated by a new generation of treated wastewater discharge permits that have lowered the maximum temperature at which receiving water is required to be maintained.

Researchers are working to understand how water temperature affects the health of sensitive aquatic life in the Santa Clara River watershed, above, where treated wastewater effluent is being discharged.

Flows framework applied to groundwater management

The California Department of Water Resources (DWR) has begun using a statewide scientific framework that was originally developed to help managers determine the environmental flow needs of California streams to also help shape more sustainable groundwater management practices statewide.

The California Environmental Flows Framework (CEFF), which was co-developed by SCCWRP, is in the process of being incorporated into ongoing efforts by DWR to determine when groundwater pumping may adversely affect the environmental flows that sustain aquatic ecosystems, as well as DWR efforts to set sustainability criteria for groundwater management that help protect beneficial uses provided by flowing surface waters.

SCCWRP trained DWR staff in 2024 on how to use CEFF. CEFF was developed to help managers make informed decisions about how to allocate limited surface flows that balance both human and ecosystem needs for flowing water.

Channel restoration in urbanized systems: Guiding design using ecological flow targets and future management scenarios

Anneliese Sytsma[1], Daniel Philippus[1], Jordyn M. Wolfand[2], Katie Irving[3], Kristine T. Taniguchi-Quan[3], Eric D. Stein[3], Terri S. Hogue[1]

[1]*Department of Civil and Environmental Engineering, Colorado School of Mines, Golden, CO*
[2]*Shiley School of Engineering, University of Portland, Portland, OR*
[3]*Southern California Coastal Water Research Project, Costa Mesa, CA*

Abstract

Restoration of urban rivers must simultaneously design for ecological habitat while accounting for altered flow regimes associated with urban runoff, flood protection, and industrial/wastewater discharge. The goal of this study was to use ecological flow targets to guide channel restoration of the Los Angeles (LA) River across potential future flow regimes. Using a one-dimensional hydraulic model, we simulated a range of channel cross section configurations subject to different flow management decisions (wastewater reuse, low-flow [LF] treatment, and baseflow augmentation). Hydraulic results were assessed relative to ecohydraulic targets for desirable aquatic species in the LA River (willow, steelhead trout, and Santa Ana sucker). Results suggest that, along the mainstem of the LA River, restoration designs that include narrow LF channels may support Santa Ana sucker habitat and steelhead migration if management decisions decrease instream flows (e.g., by reusing treated wastewater). However, the same channel design and management decisions may not provide conditions needed to propagate floodplain vegetation such as willows. In tributary reaches, flows are too low to support habitat conditions for Santa Ana sucker or steelhead but may be able to support riparian habitat if a soft-bottom LF channel and active floodplain are present. In general, results illustrate the trade-offs between water management goals and habitat requirements for target species.

Citation

Sytsma, A., D. Philippus, J.M. Wolfand, K. Irving, K.T. Taniguchi-Quan, E.D. Stein, T.S. Hogue. 2024. Channel restoration in urbanized systems: Guiding design using ecological flow targets and future management scenarios. Journal of the American *Water Resources Association* DOI:10.1111/1752-1688.13232.

SCCWRP Journal Article #1397
Full text available by request: pubrequest@sccwrp.org

Macroinvertebrate, algal and diatom assemblages respond differently to both drying and wetting transitions in non-perennial streams

Michelle H. Busch[1,2], Kate S. Boersma[3], Stephen C. Cook[1], C. Nathan Jones[4], Chad Loflen[5], Raphael D. Mazor[6], Rosalina Stancheva[7,8], Adam N. Price[9], Rachel Stubbington[10], Margaret A. Zimmer[11], Daniel C. Allen[12]

[1]*Biology Department, University of Oklahoma, Norman, OK*
[2]*Environmental Studies Department, University of Kansas, Lawrence, KS*
[3]*Department of Biology, University of San Diego, San Diego, CA*
[4]*Department of Biological Sciences, University of Alabama, Tuscaloosa, AL*
[5]*State of California Water Quality Control Board San Diego Region, San Diego, CA*
[6]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[7]*Department of Biological Sciences, California State University San Marcos, San Marcos, CA*
[8]*Department of Environmental Science and Policy, George Mason University, Fairfax, VA*
[9]*USDA Forest Service, Pacific Northwest Research Station, La Grande, OR*
[10]*School of Science and Technology, Nottingham Trent University, Nottingham, UK*
[11]*Department of Earth and Planetary Sciences, University of California, Santa Cruz, CA*
[12]*Department of Ecosystem Science and Management, Pennsylvania State University, University Park, PA*

Abstract

1. Biological assemblages in streams are influenced by hydrological dynamics, particularly in non-perennial systems. Although there has been increasing attention on how drying impacts stream organisms, few studies have investigated how specific characteristics of drying and subsequent wetting transitions influence biotic responses via resistance and resilience traits.

2. Here, we characterized how hydrologic metrics, including those quantifying drying and wetting transitions as well as dry and wet phases, alter diversity and composition of three aquatic assemblages in non-perennial streams in southern California: benthic macroinvertebrates, soft-bodied algae and diatoms.

3. We found that flow duration prior to sampling was correlated with variation in macroinvertebrate and soft-bodied algal assemblage composition. The composition and richness of diatom assemblages, however, were predominantly influenced by the drying start date prior to sampling. Contrary to other studies, the duration of the dry phase prior to sampling did not influence the composition or richness of any assemblage. Although our study was conducted within a region in which each assemblage experienced comparable environmental conditions, we found no single hydrologic metric that influenced all assemblages in the same way.

4. The hot-summer Mediterranean climate of southern California likely acts as a strong environmental filter, with taxa in this region relying on resistance and resilience adaptations to survive and recolonize non-perennial streams following wetting. The different responses of algal and diatom assemblages to hydrologic metrics suggest greater resilience to drying and wetting events, particularly for primary producers.

5. As drying and wetting patterns continue to change, understanding biodiversity responses to hydrologic metrics

could inform management actions that enhance the ecological resilience of communities in non-perennial streams. In particular, the creation and enhancement of flow regimes in which natural timing and duration of dry and wet phases sustain refuges that support community persistence in a changing environment.

CITATION

Busch, M.H., K.S. Boersma, S.C. Cook, C.N. Jones, C. Loflen, R.D. Mazor, R. Stancheva, A.N. Price, R. Stubbington, M.A. Zimmer, D.C. Allen. 2024. Macroinvertebrate, algal and diatom assemblages respond differently to both drying and wetting transitions in non-perennial streams. *Freshwater Biology* 69:1568-1582.

SCCWRP Journal Article #1400
Full text available by request: pubrequest@sccwrp.org

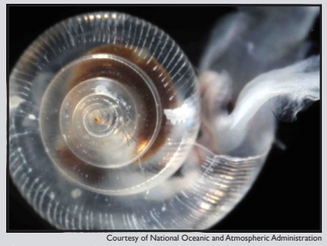
Expert panel completes review of coastal OAH modeling tools

An international panel of scientific experts has completed an independent review of a set of computer modeling tools designed to assess how land-based coastal discharges are influencing ocean water quality, including the trajectory of ocean acidification and hypoxia (OAH) in California coastal waters.

The independent review panel, which released its findings in 2024, found that the tools are built on fundamentally sound science and recommended specific actions to increase community confidence and acceptance of the tools' predictive capabilities, including making the modeling outputs and other work more accessible to a broad community of end users.

The coastal ocean water-quality model that was reviewed by the expert panel is made up of two component models – collectively known as ROMS-BEC (Regional Ocean Modeling System-Biogeochemical Elemental Cycling) – that work in tandem to predict the relative influence of natural oceanic sources of nutrients vs. local nutrient discharges on seawater chemistry and low trophic ecosystems.

To ensure a fair, transparent expert review, stakeholders established a steering committee made up of water-quality regulatory agencies, regulated agencies, and environmental advocacy groups to vet and select panelists. The six selected panelists spanned the disciplines of physical and biogeochemical oceanography, ocean numerical modeling, the biological effects of low oxygen and pH levels, and the application of models to support management decisions.



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 panel of scientific experts has completed a review of a set of computer modeling tools designed to assess how land-based coastal discharges are influencing the trajectory of ocean acidification and hypoxia (OAH) in coastal waters.

Best practices developed to advance use of satellite imagery for inland HABs monitoring

SCCWRP and its partners have developed 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 2024 by a SCCWRP-facilitated technical advisory committee, offers quality-assurance safeguards to help improve management confidence in satellite imaging data as a decision-making tool. 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.

Already, SCCWRP and its partners have successfully used satellite imaging data to build a comprehensive picture of when and where HABs have been occurring in California's large lakes and reservoirs over a five-year period.

The HABs guidance document is expected to be published in 2025.

National science strategy outlines next decade of HABs research priorities

A national group of scientific experts on harmful algal blooms (HABs) that includes SCCWRP has developed a 10-year strategy outlining how the U.S. should coordinate and prioritize the next decade of investments in HABs research.

The Harmful Algal Research and Response: A National Environmental Science Strategy (HARRNESS) – released in 2024 by the U.S. National Office for Harmful Algal Blooms – is closely aligned with the strategies that California has already developed for studying and managing HABs in both freshwater and marine environments.

Moreover, the national strategy points to multiple key California HAB investments – including the California Cyanobacteria and HAB Network (CCHABs) – as national models for how to coordinate HABs research and monitoring among state agencies, researchers and stakeholders.

SCCWRP's Dr. Jayme Smith served on the 26-member Scientific Steering Committee that oversaw the strategy's development. The newly released strategy is an update to the group's original HARRNESS strategy, which covered the period 2005-2015.

Clear Lake, the largest freshwater lake in California, is home to elevated levels of toxins produced by cyanobacteria blooms. A national group of scientific experts on harmful algal blooms that includes SCCWRP has developed a strategy outlining how the U.S. should coordinate and prioritize the next decade of investment in HABs research.

Cross-shore transport and eddies promote large scale response to urban eutrophication

Faycal Kessouri[1,2], Martha A. Sutula[1], Daniele Bianchi[2], Minna Ho[1,2], Pierre Damien[2], James C. McWilliams[2], Christina A. Frieder[1], Lionel Renault[3], Hartmut Frenzel[4,6], Karen McLaughlin[1], and Curtis Deutsch[5]

[1]*Department of Biogeochemistry, Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA*
[3]*Laboratoire d'Études en Géophysique et Océanographie Spatiale, IRD, CNRS, CNES, UPS, Toulouse, France*
[4]*School of Oceanography, University of Washington, Seattle, WA*
[5]*Department of Geosciences, High Meadows Environmental Institute, Princeton University, Princeton, NJ*
[6]*CICOES, University of Washington and NOAA PMEL, Seattle, WA*

Abstract

A key control on the magnitude of coastal eutrophication is the degree to which currents quickly transport nitrogen derived from human sources away from the coast to the open ocean before eutrophication develops. In the Southern California Bight (SCB), an upwelling-dominated eastern boundary current ecosystem, anthropogenic nitrogen inputs increase algal productivity and cause subsurface acidification and oxygen (O_2) loss along the coast. However, the extent of anthropogenic influence on eutrophication beyond the coastal band, and the physical transport mechanisms and biogeochemical processes responsible for these effects are still poorly understood. Here, we use a submesoscale-resolving numerical model to document the detailed biogeochemical mass balance of nitrogen, carbon and oxygen, their physical transport, and effects on offshore habitats. Despite management of terrestrial nutrients that has occurred in the region over the last 20 years, coastal eutrophication continues to persist. The input of anthropogenic nutrients promote an increase in productivity, remineralization and respiration offshore, with recurrent O_2 loss and pH decline in a region located 30–90 km from the mainland. During 2013 to 2017, the spatially averaged 5-year loss rate across the Bight was 1.3 mmol m^{-3} O_2 , with some locations losing on average up to 14.2 mmol m^{-3} O_2 . The magnitude of loss is greater than model uncertainty assessed from data-model comparisons and from quantification of intrinsic variability. This phenomenon persists for 4 to 6 months of the year over an area of 278,40 km^2 (~30% of SCB area). These recurrent features of acidification and oxygen loss are associated with cross-shore transport of nutrients by eddies and plankton biomass and their accumulation and retention within persistent eddies offshore within the SCB.

Citation

Kessouri, F., M. Sutula, D. Bianchi, M. Ho, P. Damien, J.C. McWilliams, C.A. Frieder, L. Renault, H. Frenzel, K. McLaughlin, C. Deutsch. 2024. Cross-shore transport and eddies promote large scale response to urban eutrophication. *Scientific Reports* 14:7240.

SCCWRP Journal Article #1368
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Circulation and dispersal in California's borderland basins

James C. McWilliams[1], Pierre Damien[1], and Faycal Kessouri[1,2]

[1]*Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA*
[2]*Biogeochemistry Department, Southern California Coastal Water Research Project, Costa Mesa, CA*

Abstract

The Borderland Basins off Southern California are semi-isolated sea-floor depressions with connections to each other and to the open Pacific Ocean over narrow sills. A high-resolution, multi-year simulation is analyzed for its currents, stratification, and dissolved oxygen, with a focus on the mean conditions, intrinsic variability, and exchange rates with surrounding waters. The three shallowest, closest basins are given the most attention: Santa Barbara, Santa Monica, and San Pedro. Below the basin sill depths, the water masses in the basins are distinct from surrounding waters at the same density indicating a degree of dynamical isolation. The mean circulations are anti-clockwise around the topographic edges of the basins, consistent with eddy-driven flows (i.e., topostrophy). The mesoscale eddy variability is stronger than the mean flow, and at least partially it is comprised of topographic Rossby waves circuiting the edge slopes. Its magnitude is similar to the high-frequency currents (mostly tidal). There are recurrent cross-sill flows driven by an unbalanced pressure-gradient force, and these intermittently cause water mass flushing of the basins. The oxygen levels in the basins are occasionally anoxic, and they are maintained by a balance of downward physical transport from above, local respiration, and flux into the sediments. From a combination of multiple means of estimation, the deep basin water mass renewal times are on the order of a year or more, and this time is somewhat shorter in the Santa Barbara Basin than the others. The renewal processes are by intermittent sill overflows and by vertical exchanges through eddies and tides.

Citation

McWilliams, J.C., P. Damien, F. Kessouri. 2024. Circulation and dispersal in California's Borderland Basins. *Progress in Oceanography* 229:103349.

SCCWRP Journal Article #1396
Full text available by request: pubrequest@sccwrp.org

The shelf-to-basin transport of iron from the northern U.S. West Coast to the Pacific Ocean

Anh Le-Duy Pham[1], Pierre Damien[1], Daniel McCoy[1], Matthew Mar[1], Faycal Kessouri[2], James C. McWilliams[1], James Moffett[3], and Daniele Bianchi[1]

[1]*Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA*
[2]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[3]*Department of Biological Sciences, University of Southern California, Los Angeles, CA*

Abstract

Release of iron (Fe) from continental shelves is a major source of this limiting nutrient for phytoplankton in the open ocean, including productive Eastern Boundary Upwelling Systems. The mechanisms governing the transport and fate of Fe along continental margins remain poorly understood, reflecting interaction of physical and biogeochemical processes that are crudely represented by global ocean biogeochemical models. Here, we use a submesoscale-permitting physical-biogeochemical model to investigate processes governing the delivery of shelf-derived Fe to the open ocean along the northern U.S. West Coast. We find that a significant fraction (~20%) of the Fe released by sediments on the shelf is transported offshore, fertilizing the broader Northeast Pacific Ocean. This transport is governed by two main pathways that reflect interaction between the wind-driven ocean circulation and Fe release by low-oxygen sediments: the first in the surface boundary layer during upwelling events; the second in the bottom boundary layer, associated with pervasive interactions of the poleward California Undercurrent with bottom topography. In the water column interior, transient and standing eddies strengthen offshore transport, counteracting the onshore pull of the mean upwelling circulation. Several hot-spots of intense Fe delivery to the open ocean are maintained by standing meanders in the mean current and enhanced by transient eddies and seasonal oxygen depletion. Our results highlight the importance of fine-scale dynamics for the transport of Fe and shelf-derived elements from continental margins to the open ocean, and the need to improve representation of these processes in biogeochemical models used for climate studies.

Citation

Le-Duy Pham, A., P. Damien, D. McCoy, M. Mar, F. Kessouri, J.C. McWilliams, J. Moffett, D. Bianchi. 2024. The Shelf-To-Basin Transport of Iron From the Northern U.S. West Coast to the Pacific Ocean. *Global Biogeochemical Cycles* DOI:10.1029/2023GB008029.

SCCWRP Journal Article #1376
Full text available by request: pubrequest@sccwrp.org

Extremes and short-term fluctuations in coastal ocean acidification and hypoxia

Pierre Damien[1], Daniele Bianchi[1], Faycal Kessouri[1,2], and James C. McWilliams[1]

[1]*Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA*
[2]*Southern California Coastal Water Research Project, Costa Mesa, CA*

Abstract

In Eastern boundary upwelling systems, such as the California Current System (CCS), seasonal upwelling brings low oxygen and low pH waters to the continental shelf, causing ocean acidification and hypoxia (OAH). The location, frequency, and intensity of OAH events is influenced by a combination of largescale climatic trends, seasonal changes, small-scale circulation, and local human activities. Here, we use results from two 20-year long submesoscale-resolving simulations of the Northern and Southern U.S. West Coast (USWC) for the 1997–2017 period, to describe the characteristics and drivers of OAH events. These simulations reveal the emergence of hotspots in which seasonal declines in oxygen and pH are accompanied by localized short-term extremes in OAH. While OAH hotspots show substantial seasonal variability, significant intraseasonal fluctuations occur, reflecting the interaction between low- and high-frequency forcings that shape OAH events. The mechanisms behind the seasonal decreases in pH and oxygen vary along the USWC. While remineralization remains the dominant force causing these declines throughout the coast, physical transport partially offsets these effects in Southern and Central California, but contributes to seasonal oxygen loss and acidification on the Northern Coast. Critically, the seasonal decline is not sufficient to predict the occurrence and duration of OAH extremes. Locally enhanced biogeochemical rates, including shallow benthic remineralization and rapid wind-driven transport, shape the spatial and temporal patterns of coastal OAH.

Citation

Damien, P., D. Bianchi, F. Kessouri, J.C. McWilliams. 2024. Extremes and Short-Term Fluctuations in Coastal Ocean Acidification and Hypoxia. *Journal of Geophysical Research: Oceans* DOI:10.1029/2024JC021197.

SCCWRP Journal Article #1406
Full text available online: www.sccwrp.org/publications

Panel evaluates nature-based solutions for managing stream temperature

A panel of scientific experts convened by SCCWRP has identified options for how to optimally incorporate natural features and processes into stream management to help offset increased temperatures from wastewater discharges in the upper Santa Clara River.

The expert panel, which developed its recommendations in 2024, explored how different combinations of nature-based solutions, such as diverting wastewater effluent into groundwater to naturally cool it, could be deployed to optimally mitigate increased water temperatures at Southern California streams where treated wastewater effluent is being discharged. NBS are designed to improve or protect ecological health by closely mimicking natural processes.

New wastewater discharge permits have lowered the maximum temperature at which receiving water is required to be maintained from 86 to 80 degrees Fahrenheit, which is more difficult to reach because wastewater effluent is typically discharged above the stream's ambient temperature.

The panel's work is part of an ongoing investigation probing how water temperature affects the health of sensitive aquatic life in Southern California streams receiving wastewater discharges.

While the panel's charge was to offer recommendations for managing effluent discharges, the project represents an early foray by Southern California into developing best practices for managing stream temperatures – a challenge that is expected to become pervasive as water temperatures rise in response to climate change.

Nature-based solutions are viewed as an important alternative to traditional engineered solutions, as they have less harmful environmental effects while providing co-benefits like increasing green space for both humans and wildlife.

Courtesy of U.S. Fish and Wildlife Service

The unarmored three spine stickleback is an endangered fish found in the upper Santa Clara River, a shallow stream that is vulnerable to warming temperatures. An expert panel recently explored how nature-based solutions could be used to offset rising water temperatures.

Workshop helps clarify path for evaluating mCDR environmental effects in California

A workshop co-hosted by SCCWRP that explored the implications of piloting marine carbon dioxide removal (mCDR) technologies in California coastal waters has helped bring clarity to the technical and regulatory challenges that remain for these prototype approaches to be evaluated at larger scales.

The two-day workshop, held in 2024, brought together multiple State agencies, scientific experts, industry and environmental advocacy organizations to discuss the potential environmental consequences of mCDR and how these effects might be evaluated.

mCDR technologies involve either modifying the ocean's chemistry to increase seawater's ability to take up carbon dioxide from the atmosphere (such as by altering ocean alkalinity), or increasing the photosynthetic power of the upper ocean to move and/or sequester carbon dioxide in deeper waters (a research area that includes kelp farming). Researchers hypothesize that if mCDR could be scaled in coastal marine environments, these technologies have the potential to help draw down carbon dioxide from the atmosphere that is driving global climate change.

Courtesy of Captura Corporation

Electrodialysis technology, pictured above on a pier in Newport Beach, is one example of a type of marine carbon dioxide removal (mCDR) technology that may be able to draw down carbon dioxide levels in coastal waters. A two-day workshop explored the implications of piloting mCDR projects in California's coastal ocean.

Climate drivers and human impacts shape 35-year trends of coastal wetland health and composition in an urban region

Cheryl L. Doughty[1], Hanfeng Gu[1], Richard F. Ambrose[2], Eric D. Stein[3], Evyan Borgnis Sloane[4], Meghan Martinez[4], and Kyle C. Cavanaugh[1]

[1]*Department of Geography, University of California, Los Angeles, Los Angeles, CA*
[2]*Department of Environmental Health Sciences, University of California, Los Angeles, CA*
[3]*Biology Department, Southern California Coastal Water Research Project, Costa Mesa, CA*
[4]*South Coast Program, California State Coastal Conservancy, Oakland, CA*

Abstract

The future of coastal wetlands will depend on the combined effects of climate change and human impacts from urbanization and coastal management. Disentangling the effects of these factors is difficult, but satellite imagery archives provide a way to track biological and physical changes in wetlands over recent decades to reveal how coastal wetlands have been changing in response to climate and human drivers. In this study, we used Landsat to monitor the conditions of 32 coastal wetlands in southern California from 1984 to 2019 and identify environmental and human drivers of these trends. Wetland conditions were characterized by vegetation greenness, using the normalized difference vegetation index (NDVI), and by habitat composition, derived from areal estimates of wetland and subtidal habitats. Overall, wetlands displayed three types of long-term response: greening and gaining wetland (10), greening and losing wetland (16), and browning and losing wetland (6). Regional environmental drivers with overall positive effects on wetland NDVI were sea level, wave height, and precipitation, whereas stream discharge, vapor pressure deficit, and air temperature had negative or nonlinear effects. Wetland area change was primarily correlated with sea level, but response was highly contextual among sites. Negative trends in wetland NDVI and area were more common in larger sites with low elevations and in sites with open inlets. Restoration had mixed effects, with only half of the restored sites showing positive changes in NDVI and wetland area post-restoration. The important work of managing and restoring urban coastal wetlands is complicated by variability and context and requires us to account for the influence of humans and climate as we build a regional understanding of historic, present, and future wetland health.

Citation

Doughty, C.L., H. Gu, R.F. Ambrose, E.D. Stein, E. Borgnis Sloane, M. Martinez, K.C. Cavanaugh. 2024. Climate drivers and human impacts shape 35-year trends of coastal wetland health and composition in an urban region. *Ecosphere* DOI:10.1002/ecs2.4832.

SCCWRP Journal Article #1370
Full text available online: www.sccwrp.org/publications

Nutrient replenishment by turbulent mixing in suspended macroalgal farms

Tong Bo[1], James C. McWilliams[1], Christina A. Frieder[2], Kristen A. Davis[3,4], and Marcelo Chamecki[1]

[1]*Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA*
[2]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[3]*Department of Civil and Environmental Engineering, University of California, Irvine, Irvine, CA*
[4]*Department of Earth System Science, University of California, Irvine, Irvine, CA*

Abstract

This study uses large eddy simulations to investigate nutrient transport and uptake in suspended macroalgal farms. Various farm configurations and oceanic forcing conditions are examined, with the farm base located near the nutricline depth. We introduce the Damkohler number *Da* to quantify the balance between nutrient consumption by macroalgae uptake and supply by farm-enhanced nutrient transport. Most cases exhibit low *Da*, indicating that farm-generated turbulence drives sufficient upward nutrient fluxes, supporting macroalgae growth. High *Da* and starvation may occur in fully grown farm blocks, a configuration that generates the weakest turbulence, particularly when combined with densely planted macroalgae or weak flow conditions. Flow stagnation within the farm due to macroalgae drag may constrain the uptake efficiency and further increase the starvation risk. Mitigation strategies involve timely harvesting, avoiding dense macroalgae canopies, and selecting farm locations with robust ocean currents and waves. This study provides insights for sustainable macroalgal farm planning.

Citation

Bo, T., J.C. McWilliams, C.A. Frieder, K.A. Davis, M. Chamecki. 2024. Nutrient Replenishment by Turbulent Mixing in Suspended Macroalgal Farms. *Geophysical Research Letters* DOI:10.1029/2024GL109128.

SCCWRP Journal Article #1382
Full text available online: www.sccwrp.org/publications

Understanding the risks of co-exposures in a changing world: A case study of dual monitoring of the biotoxin domoic acid and *Vibrio* spp. in Pacific oyster

Alle A. Y. Lie[1], Amity G. Zimmer-Faust[1,2], Rachel E. Diner[3,4], Emily Kunselman[3], Zachary Daniel[3], Kathryn Van Artsdalen[3], Mariana C. Salas Garcia[3,5], Jack A. Gilbert[3,5], Dana Shultz[1], Jeff Chokry[1], Kylie Langlois[1], and Jayme Smith[1]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*The Nature Conservancy, Arlington, VA*
[3]*Scripps Institute of Oceanography, University of California, San Diego, La Jolla, CA*
[4]*University of Memphis, Memphis, TN*
[5]*Department of Pediatrics, University of California, San Diego, La Jolla, CA*

Abstract

Assessing the co-occurrence of multiple health risk factors in coastal ecosystems is challenging due to the complexity of multi-factor interactions and limited availability of

simultaneously collected data. Understanding co-occurrence is particularly important for risk factors that may be associated with, or occur in similar environmental conditions. In marine ecosystems, the co-occurrence of harmful algal bloom toxins and bacterial pathogens within the genus *Vibrio* may impact both ecosystem and human health. This study examined the co-occurrence of *Vibrio* spp. and domoic acid (DA) produced by the harmful algae *Pseudo-nitzschia* by (1) analyzing existing California Department of Public Health monitoring data for *V. parahaemolyticus* and DA in oysters; and (2) conducting a 1-year seasonal monitoring of these risk factors across two Southern California embayments. Existing public health monitoring efforts in the state were robust for individual risk factors; however, it was difficult to evaluate the cooccurrence of these risk factors in oysters due to low number of co-monitoring instances between 2015 and 2020. Seasonal co-monitoring of DA and *Vibrio* spp. (*V. vulnificus* or *V. parahaemolyticus*) at two embayments revealed the co-occurrence of these health risk factors in 35% of sampled oysters in most seasons. Interestingly, both the overall detection frequency and co-occurrence of these risk factors were considerably less frequent in water samples. These findings may in part suggest the slow depuration of *Vibrio* spp. and DA in oysters as residual levels may be retained. This study expanded our understanding of the simultaneous presence of DA and *Vibrio* spp. in bivalves and demonstrates the feasibility of co-monitoring different risk factors from the same sample. Individual programs monitoring for different risk factors from the same sample matrix may consider combining efforts to reduce cost, streamline the process, and better understand the prevalence of co-occurring health risk factors.

Citation

Lie, A., A.G. Zimmer-Faust, R.E. Diner, E. Kunselman, Z. Daniel, K. Van Artsdalen, M.C. Salas Garcia, J.A. Gilbert, D. Shultz, J. Chokry, K. Langlois, J. Smith. 2024. Understanding the risks of co-exposures in a changing world: a case study of dual monitoring of the biotoxin domoic acid and Vibrio spp. in Pacific oyster. *Environmental Monitoring and Assessment* 196:447.

SCCWRP Journal Article #1369
Full text available by request: pubrequest@sccwrp.org

Effects of urban eutrophication on pelagic habitat capacity in the Southern California Bight

Christina A. Frieder[1], Faycal Kessouri[1,2], Minna Ho[1,2], Martha Sutula[1], Daniele Bianchi[2], James C. McWilliams[2], Curtis Deutsch[3,4], and Evan Howard[5]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA*
[3]*Department of Geosciences, Princeton University, Princeton, NJ*
[4]*High Meadows Environmental Institute, Princeton University, Princeton, NJ*
[5]*Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA*

Abstract

Land-based nutrient inputs to the ocean have been linked to increased coastal productivity, subsurface acidification and O_2 loss, even in upwelling systems like the Southern California Bight. However, whether eutrophication alters the [environment's] capacity to support key taxa has yet to be evaluated for this region. Here, we assess the impact of land-based nutrient inputs on the availability of aerobic and calcifying habitat for key pelagic taxa using ocean model simulations. We find that acute, lethal conditions are not commonly induced in epipelagic surface waters, but that sublethal, ecologically relevant changes are pervasive. Land-based nutrient inputs reduce the potential aerobic and calcifier habitat during late summer, when viable habitat is at its seasonal minimum. A region of annually recurring habitat compression is predicted 30 – 90 km from themainland, southeast of Santa Catalina Island. Here, both aerobic and calcifier habitat is vertically compressed by, on average, 25%, but can be as much as 60%. This effect can be traced to enhanced remineralization of organic matter that originates from the coast. These findings suggest that effects of land-based nutrients are not restricted to chemistry but extend to habitat capacity formultiple taxa of ecological and economic importance. Considerable uncertainty exists, however, in how this habitat compression translates to population-level effects.

Citation

Frieder, C.A., F. Kessouri, M. Ho, M. Sutula, D. Bianchi, J.C. McWilliams, C. Deutsch, E. Howard. 2024. Effects of urban eutrophication on pelagic habitat capacity in the Southern California Bight. *Frontiers in Marine Science* 11:1392671.

SCCWRP Journal Article #1402
Full text available online: www.sccwrp.org/publications

Effects of burrowing crabs on coastal sediments and their functions: A systematic meta-analysis

Shelby A. Rinehart[1,2], Jacob M. Dybiec[2], Janet B. Walker[3], Lance Simpson[4], and Julia A. Cherry[2,5]

[1]*Department of Biodiversity, Earth and Environmental Science, Drexel University, Philadelphia, PA*
[2]*Department of Biological Sciences, University of Alabama, Tuscaloosa, AL*
[3]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[4]*University Libraries, University of Alabama, Tuscaloosa, AL*
[5]*New College, University of Alabama, Tuscaloosa, AL*

Abstract

Burrowing ecosystem engineers, such as termites, crabs, marmots, and foxes, can profoundly affect the biological structure and ecosystem functions of their environments. However, the relative importance of the effects of burrowing engineers on sediments are challenging to predict and are expected to be influenced by engineer density, engineer functional traits (e.g., burrow morphology), and environmental conditions (e.g., geomorphology, vegetation presence). To develop robust hypotheses predicting the impacts of burrowing ecosystem engineers, we conducted a systematic meta-analysis evaluating the effects of burrowing crabs on sediment properties, nutrient stocks, and ecosystem functions in soft-sediment coastal habitats (e.g., salt marshes, mangrove forests, tidal flats). Additionally, we tested the impacts of crab burrow density, burrowing crab superfamily (a proxy for crab burrow morphology and diet), and biotic conditions (i.e., vegetation) on the effects of burrowing crab engineers on coastal sediments. Burrowing crabs rework and oxygenate sediments and accelerate rates of nutrient cycling (i.e., nitrification and CO_2 flux). However, the magnitude and direction of burrowing crab effects depend on burrowing crab superfamily, the presence of vegetation, and their interaction. Crab burrow density did not consistently predict burrowing engineer effects on sediments. Future efforts need to focus on implementing rigorous manipulative experiments to assess crab ecosystem engineering effects, since methodological variation has hindered efforts to generalize their effects. Our findings suggest that crab engineering effects are predictable across environmental contexts, and understanding the context dependency of crab engineering effects may promote the management and restoration of the critical ecosystem services that are mediated by crab engineers.

Citation

Rinehart, S.A., J.M. Dybiec, J.B. Walker, L. Simpson, J.A. Cherry. 2024. Effects of burrowing crabs on coastal sediments and their functions: A systematic meta-analysis. *Ecosphere* 15:e4927.

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Researcher effects on the biological structure and edaphic conditions of field sites and implications for management

Shelby A. Rinehart[1,2], Jacob M. Dybiec[2], Parker Richardson[3,4], Janet B. Walker[3,4,5], James D. Peabody[6], and Julia A. Cherry[2,7]

[1]*Department of Biodiversity, Earth and Environmental Science, Drexel University, Philadelphia, PA*
[2]*Department of Biological Sciences, University of Alabama, Tuscaloosa, AL*
[3]*Department of Biology, San Diego State University, San Diego, CA*
[4]*Coastal and Marine Institute, San Diego State University, San Diego, CA*
[5]*Biology Department, Southern California Coastal Water Research Project, Costa Mesa, CA*
[6]*Department of Psychological Sciences, Texas Tech University, Lubbock, TX*
[7]*New College, University of Alabama, Tuscaloosa, AL*

Abstract

Field studies are necessary for understanding natural processes in spite of the human-induced disturbances they cause. While researchers acknowledge these effects, no studies have empirically tested the direct (e.g., harvesting plants) and indirect (i.e., trampling) effects of researcher activities on biological structure and edaphic conditions. We leveraged field studies in Alabama and California to monitor the recovery of tidal marshes following research activities. Researcher effects on animals, plants, and sediment conditions remained prevalent almost one year after the disturbance ended. For instance, trampled plots had 14%–97% lower plant cover than undisturbed plots after >10 months of recovery. Researcher effects also impacted plant composition, leading to increased subordinate species abundance. We encourage field researchers to adopt strategies that reduce their scientific footprints, including reducing field visits, limiting field team size, and considering ways to limit potential environmental impacts during study design.

Citation

Rinehart, S.A., J.M. Dybiec, P. Richardson, J.B. Walker, J.D. Peabody, J.A. Cherry. 2024. Researcher effects on the biological structure and edaphic conditions of field sites and implications for management. *Ecosphere* DOI:10.1002/ecs2.4750.

SCCWRP Journal Article #1360
Full text available online: www.sccwrp.org/publications

Assessing wetland recovery: Building capacity to understand and support regional wetland health and resilience – Development of a coastal wetland sentinel site network

Southern California Wetlands Recovery Project

Southern California Wetlands Recovery Project, Oakland, CA

Citation

Southern California Wetlands Recovery Project. 2024. Assessing Wetland Recovery: Building Capacity to Understand and Support Regional Wetland Health and Resilience – Development of a Coastal Wetland Sentinel Site Network. Technical Report 1393.A. Southern California Coastal Water Research Project. Costa Mesa, CA.

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

Microplastics sampling methods standardized for sediment and shellfish

SCCWRP and its partners have developed standardized methods for collecting and measuring microplastic particles in sediment and aquatic life – the latest step in California's ongoing effort to build a scientifically robust microplastics monitoring toolbox.

The set of standardized methods, completed in 2024, ensures researchers can generate high-quality, directly comparable data on microplastics pollution in water bodies statewide. Traditionally, researchers have not used a consistent set of collection methods when sampling ambient water, stormwater, sediment and aquatic life.

The Southern California Bight 2023 Regional Monitoring Program and the California Estuarine Marine Protected Area (EMPA) Monitoring Program already have leveraged the new sampling methods to collect sediment and shellfish samples.

Researchers are also working on standardizing sampling methods for ambient water and stormwater. In 2024, SCCWRP and its partners completed a series of flume experiments that will help standardize methods for collecting stormwater samples in preparation for measuring their microplastics content.

A crew places sediment collected from the seafloor into jars during field sampling for the Sediment Quality element of the Southern California Bight 2023 Regional Monitoring Program. SCCWRP and its partners have develop standardized methods for collecting and measuring microplastic particles in sediment and shellfish.

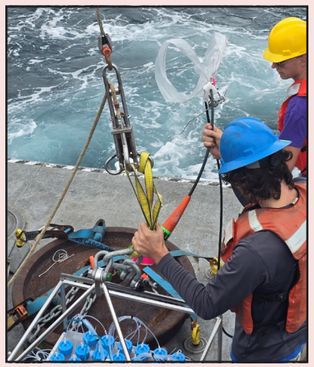
Assessment of sediment contamination at Palos Verdes Superfund site completed

The U.S. Environmental Protection Agency, Region 9 has finalized an assessment of the state of sediment contamination along the Palos Verdes shelf – an effort that included participation by SCCWRP, which measured contaminant levels to support the study.

The study, summarized in an EPA technical report published in 2024, found that levels of the pesticide DDT and an industrial class of chemicals known as PCBs have been slowly decreasing in seafloor sediment, overlying water column, and fish tissue, but still exceed the target levels for cleanup.

SCCWRP was not a co-author on the study, but contributed to the study by using passive samplers to measure the levels of DDT and PCBs that are leaching out of surface layers of sediment into the water column above.

The EPA will use the study's findings and updated human health and ecological risk assessments to develop recommendations for cleanup remedies. The study's findings may also inform ongoing efforts to evaluate additional instances of offshore DDT contamination.



A field crew deploys passive samplers into the coastal ocean to evaluate the effects of legacy contamination in seafloor sediment. SCCWRP used the technology as part of an assessment of the Palos Verdes Superfund site.

Lab accreditation assessors trained on PFAS measurement methods

Assessors who audit environmental laboratories in California received training on how to measure per- and polyfluoroalkyl substances (PFAS) in drinking water and environmental matrices during a three-day workshop co-presented by SCCWRP in 2024.

About 12 accreditors from California's Environmental Laboratory Accreditation Program (ELAP), along with third-party assessors and State Water Board staff, attended the workshop. ELAP accredits all public and private laboratories that produce environmental data that get used in State decision-making processes.

The workshop marked the first training opportunity for ELAP assessors following the EPA's 2024 decision requiring drinking water agencies to limit levels of certain types of PFAS in drinking water.

The workshop was the second in an ongoing series of statewide trainings designed to enhance assessors' proficiency and expertise.

Development of an accreditation process for analytical methods to measure microplastics in drinking water for regulatory monitoring

Charles S. Wong and Stephen B. Weisberg

Southern California Coastal Water Research Project, Costa Mesa, CA

Abstract

Development of a laboratory accreditation program to ensure competency of laboratories performing analytical measurements is a key step in adopting new analytical measurement methods for regulatory decision-making. Here, we describe California's three-part accreditation process for spectroscopically measuring microplastics in drinking water, and show how data from a multi-laboratory method comparison study informed development of accreditation programs for the resulting methods, which can inform analogous future work for other analytes. The first part is periodic performance evaluation (PE) samples, in which laboratories are provided blind samples of known composition to quantify within acceptable performance limits. The second is inspection, or audit, assessing whether the laboratory has the proper equipment to conduct the work and whether it is correctly employing proper procedures. The third is implementation of a quality management system providing documentation that protocols demonstrated during inspection are continuously maintained. These fell into three broad categories: instrument maintenance; laboratory cleanliness, especially important for microplastics and one that must be accompanied by a blanks measurement and correction process; and training so samples are being processed by qualified analysts. An intercomparison exercise among 22 laboratories was necessary to determine what parameter permutations were important for PE samples, and expected accuracy from competent laboratories. The recommended PE sample composition was two size categories (20-50 µm and 500 µm-1mm), two polymer types, and two morphologies (fibers and non-fibers). Discussions among intercomparison exercise participants were key in determining the factors that most contributed to laboratory variability, and the focus for both on-site inspections and quality management systems.

Citation

Wong, C.S., S.B. Weisberg. 2024. Development of an accreditation process for analytical methods to measure microplastics in drinking water for regulatory monitoring. *Chemosphere* 353:141568.

SCCWRP Journal Article #1365
Full text available by request: pubrequest@sccwrp.org

The potential for toxicity to fishes from micro- and nanoplastics, and their additives

Susanne M. Brander[1], Azora König[2], Bethanie Carney Almroth[2], and Leah Thornton Hampton[3]

[1]*Oregon State University, Corvallis, OR*
[2]*University of Gothenburg, Gothenburg, Sweden*
[3]*Southern California Coastal Water Research Project, Costa Mesa, CA*

Abstract

Over the past several decades, the intense production and use of plastics have led to the contamination of all types of ecosystems with microplastics. Microplastics, plastic particles less than 5 mm in size, and nanoplastics which are less than 1 µm, are a diverse contaminant suite comprised of different sizes, shapes, polymer properties, additives and sorbed pollutants, and biofilms. Micro and nanoplastics (MNPs) may pose a potential danger for organisms who are exposed to the particles and the chemicals associated with the plastics. As many marine and freshwater systems are highly contaminated with MNPs, fish are continuously exposed to them, which may lead to a variety of adverse effects.

This chapter describes current knowledge on the relationship between nano- and microplastic occurrence in freshwater and marine ecosystems and the potential toxicological effects in fish. First, the MNP properties, associated additives, pollutants, and biofilms are described. Following, it is illustrated how fish can be exposed to MNPs and which adverse effects exposure can have on the different levels of biological organization of fish. These effects range from altered gene expression, oxidative stress, and immune responses to changes in behavior and impaired reproduction. Finally, new multivariate approaches to address microplastic toxicity and recommended future research directions are summarized.

Citation

Brander, S.M., A. Konig, B.C. Almroth, L.M. Thornton Hampton. 2024. The Potential for Toxicity to Fishes from Micro- and Nanoplastics, and Their Additives. in: K.L. Willett, N. Aluru (eds.), *Toxicology of Fishes (2nd ed.)* pp. 362-391. CRC Press. Boca Raton, FL.

SCCWRP Book Chapter #1374
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Development and validation of an acid/alkaline digestion method for efficient microplastic extraction from wastewater treatment plant effluents: Sulfuric acid concentration and contact time do matter

Wenjian Lao, Sydney Dial, Marina Salmon, and Charles S. Wong

Southern California Coastal Water Research Project, Costa Mesa, CA

Abstract

Accurate analysis of microplastic particles (MPs) in environmental samples requires removal of interferences during sample preparation. Wastewater samples are interference-rich and thus particularly challenging, with concentrated sulfuric acid currently deemed impractical as a reagent. Therefore, this study aimed to establish a straightforward, effective, and safe method employing concentrated sulfuric acid and potassium hydroxide to eliminate interferents from effluent samples obtained from wastewater treatment plants (WWTPs). We found that 80% sulfuric acid at room temperature with a brief contact time of 5 min was viable through a qualitative spot test involving 37 plastics categorized into three types (I, II, and III) based on their polymer structure's oxygen position. A quantitative assessment revealed that treatments involving H_2SO_4 and KOH (20%, 24 h, 48 °C), either separately or in combination, had no discernible physical impact on the overall plastics, except for a subtle one for Type III plastics (e.g., nylon and PMMA) known to be labile under harsh pH conditions. This acid/alkaline digestion (AAD) method, incorporating such conditions for H_2SO_4 and KOH treatments, yielded a high mass removal efficacy (97.8 ± 2.4%, n = 13) for eliminating natural particle interferents for primary, secondary, and tertiary effluent samples. Furthermore, the AAD method allowed for the determination of MPs in effluents with high surrogate particle recoveries (e.g., 95.1% for larger than 500 µm size fraction). This method is readily adaptable to create appropriate protocols for different types of environmental matrices.

Citation

Lao, W., S. Dial, M. Salmon, C.S. Wong. 2024. Development and validation of an acid/alkaline digestion method for efficient microplastic extraction from wastewater treatment plant effluents: Sulfuric acid concentration and contact time do matter. *Science of the Total Environment* 917: 170528.

SCCWRP Journal Article #1361
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One4All: An open source portal to validate and share microplastics data and beyond

Hannah Sherrod[1], Nicholas Leong[1], Hannah Hapich[2], Fabian Gomez[1], Shelly Moore[1], Ben Maurer[3], Scott Coffin[4], Leah Thornton Hampton[5], Tony Hale[6], Richard Nelson[7], Clare Murphy-Hagan[2], Oluniyi O. Fadare[2], Anna Kukkola[8], Hsuan-Cheng Lu[9], Laura Markley[10], and Win Cowger[1,2]

[1]*Moore Institute for Plastic Pollution Research, Long Beach, CA*
[2]*University of California, Riverside, Department of Environmental Sciences, Riverside, CA*
[3]*National Renewable Energy Laboratory, Golden, CO*
[4]*Office of Environmental Health Hazard Assessment, Sacramento, CA*
[5]*Southern California Coastal Water Research Project Authority, Costa Mesa, CA*
[6]*San Francisco Estuary Institute, Richmond, CA*
[7]*California State Water Resources Control Board, Sacramento, CA*
[8]*University of Birmingham, Life and Environmental Sciences, Birmingham, United Kingdom*
[9]*Australian Rivers Institute, School of Environment and Science, Griffith University, Nathan, Queensland, Australia*
[10]*Syracuse University, Syracuse, NY*

Abstract

Microplastics are a diverse suite of contaminants (Rochman et al., 2019) requiring a variety of data types to capture particle characteristics and study methodologies (Division of Drinking Water, State Water Resources Control Board, State of California, 2022; Jenkins et al., 2022). Data sharing is critical to advance science and policy (Coffin, 2023). The One4All portal was created to harmonize and share structured and unstructured microplastic data (and beyond) through validation. Validated data can be automatically uploaded to the following cloud services: Amazon S3, CKAN, and/or MongoDB. One4All is both a graphical user interface (GUI) and an R package. The tools are general-purpose and can be used for applications outside of microplastics. This manuscript provides information about the usage, workflow, and configuration of One4All, emphasizing its adaptability for diverse purposes.

Citation

Sherrod, H., N. Leong, H. Hapich, F. Gomez, S. Moore, B. Maurer, S. Coffin, L.M. Thornton Hampton, T. Hale, R. Nelson, C. Murphy-Hagan, O.O. Fadare, A. Kukkola, H.C. Lu, L. Markley, W. Cowger. 2024. One4All: An Open Source Portal to Validate and Share Microplastics Data and Beyond. *The Journal of Open Source Software* 9:6715.

SCCWRP Journal Article #1386
Full text available online: www.sccwrp.org/publications

Where the rubber meets the road: Emerging environmental impacts of tire wear particles and their chemical cocktails

Paul M. Mayer[1], Kelly D. Moran[2], Ezra L. Miller[2], Susanne M. Brander[3], Stacey Harper[4], Manuel Garcia-Jaramillo[5], Victor Carrasco-Navarro[6], Kay T. Ho[7], Robert M. Burgess[7], Leah M. Thornton Hampton[8], Elise F. Granek[9], Margaret McCauley[10], Jenifer K. McIntyre[11], Edward P. Kolodziej[12], Ximin Hu[13], Antony J. Williams[14], Barbara A. Beckingham[15], Miranda E. Jackson[5], Rhea D. Sanders-Smith[16], Chloe L. Fender[5], George A. King[17], Michael Bollman[1], Sujay S. Kaushal[18], Brittany E. Cunningham[19], Sara J. Hutton[22], Jackelyn Lang[20], Heather V. Goss[21], Samreen Siddiqui[3], Rebecca Sutton[2], Diana Lin[2], Miguel Mendez[2]

[1]*US Environmental Protection Agency, Office of Research and Development, Center for Public Health and Environmental Assessment, Pacific Ecological Systems Division, Corvallis, OR*
[2]*San Francisco Estuary Institute, Richmond, CA*
[3]*Department of Fisheries, Wildlife, and Conservation Sciences, Coastal Oregon Marine Experiment Station, Oregon State University, Corvallis, OR*
[4]*Department of Environmental and Molecular Toxicology, School of Chemical, Biological and Environmental Engineering, Oregon State University, Corvallis, OR*
[5]*Department of Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR*
[6]*Department of Environmental and Biological Sciences, University of Eastern Finland, Kuopio Campus, Kuopio, Finland*
[7]*US Environmental Protection Agency, ORD/CEMM Atlantic Coastal Environmental Sciences Division, Narragansett, RI*
[8]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[9]*Environmental Science & Management, Portland State University, Portland, OR*
[10]*US Environmental Protection Agency, Region 10, Seattle, WA*
[11]*School of the Environment, Washington State University, Puyallup Research & Extension Center, Washington Stormwater Center, Puyallup, WA*
[12]*Interdisciplinary Arts and Sciences (UW Tacoma), Civil and Environmental Engineering (UW Seattle), Center for Urban Waters, University of Washington, Tacoma, WA*
[13]*Civil and Environmental Engineering (UW Seattle), University of Washington, Seattle, WA*
[14]*US Environmental Protection Agency, Center for Computational Toxicology and Exposure, Chemical Characterization and Exposure Division, Computational Chemistry & Cheminformatics Branch, Research Triangle Park, NC*
[15]*Department of Geology & Environmental Geosciences, College of Charleston, Charleston, SC*
[16]*Washington State Department of Ecology, Lacey, WA*
[17]*CSS, Inc., Corvallis, OR*
[18]*Department of Geology and Earth System Science Interdisciplinary Center, University of Maryland, College Park, MD*
[19]*Department of Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR*
[20]*Department of Anatomy, Physiology, and Cell Biology, Department of Medicine and Epidemiology and the Karen C. Drayer Wildlife Health Center, University of California, Davis School of Veterinary Medicine, Davis, CA*
[21]*US Environmental Protection Agency, Office of Water, Office of Wastewater Management, Washington, DC*
[22]*GSI Environmental, Inc., Olympia, WA*

Abstract

About 3 billion new tires are produced each year and about 800 million tires become waste annually. Global dependence upon tires produced from natural rubber and petroleum-based compounds represents a persistent and complex environmental problem with only partial and often-times, ineffective solutions. Tire emissions may be in the form of whole tires, tire particles, and chemical compounds, each of which is transported through various atmospheric, terrestrial, and aquatic routes in the natural and built environments. Production and use of tires generates multiple heavy metals, plastics, PAHs, and other compounds that can be toxic alone or as chemical cocktails. Used tires require storage space, are energy intensive to recycle, and generally have few post-wear uses that are not also potential sources of pollutants (e.g., crumb rubber, pavements, burning). Tire particles emitted during use are a major component of microplastics in urban runoff and a source of unique and highly potent toxic substances. Thus, tires represent a ubiquitous and complex pollutant that requires a comprehensive examination to develop effective management and remediation. We approach the issue of tire pollution holistically by examining the life cycle of tires across production, emissions, recycling, and disposal. In this paper, we synthesize recent research and data about the environmental and human health risks associated with the production, use, and disposal of tires and discuss gaps in our knowledge about fate and transport, as well as the toxicology of tire particles and chemical leachates. We examine potential management and remediation approaches for addressing exposure risks across the life cycle of tires. We consider tires as pollutants across three levels: tires in their whole state, as particulates, and as a mixture of chemical cocktails. Finally, we discuss information gaps in our understanding of tires as a pollutant and outline key questions to improve our knowledge and ability to manage and remediate tire pollution.

Citation

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SCCWRP Journal Article #1373
Full text available online: www.sccwrp.org/publications

Informing methods for detecting and quantifying microplastics through the lens of a global intercalibration exercise: An editorial overview of the special issue and beyond

Charles W. Wong[1], Scott Coffin[2], Chelsea M. Rochman[3], and Stephen B. Weisberg[1]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*Office of Environmental Health and Hazard Assessment, Sacramento, CA*
[3]*University of Toronto, Department of Ecology and Evolutionary Biology, Toronto, ON, Canada*

Abstract

This Special Issue highlights the results of an international multi-laboratory microplastics measurement intercomparison study that evaluated multiple processing and quantification methods for environmental microplastics analysis. Its purpose was to determine strengths and limitations of different techniques for measuring microplastics in drinking water, surface water, sediment, and fish tissue. These studies were geared towards both technical performance (e.g., accuracy, precision), as well as feasibility for routine environmental

monitoring (e.g., costs, processing time, etc.). While the study was designed specifically for the needs of the State of California, it is also applicable to other jurisdictions.

The impetus for this study lies with legislative mandates, passed in 2018, by the State of California-the first jurisdiction worldwide to require monitoring for microplastics. Senate Bill 1422 requires adoption of standardized methods for measuring microplastics in drinking water, along with four years of monitoring. Senate Bill 1263 requires the development of a management strategy for microplastics contamination in the state's coastal waters.

Citation

Wong, C.S., S. Coffin, C.M. Rochman, S.B. Weisberg. 2024. Informing methods for detecting and quantifying microplastics through the lens of a global intercalibration exercise: An editorial overview of the special issue and beyond. *Chemosphere* 356:141662.

SCCWRP Journal Article #1371
Full text available by request: pubrequest@sccwrp.org

High-throughput transcriptomics of water extracts detects reductions in biological activity with water treatment processes

Jesse D. Rogers[1,2], Frederic D.L. Leusch[3], Bryant Chambers[1], Kevin D. Daniels[4], Logan J. Everett[1], Richard Judson[1], Keith Maruya[5], Alvine C. Mehinto[5], Peta A. Neale[3], Katie Paul-Friedman[1], Russell Thomas[1], Shane A. Snyder[6], and Joshua Harrill[1]

[1]*Center for Computational Toxicology and Exposure, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC*
[2]*Oak Ridge Institute for Science and Education, Oak Ridge, TN*
[3]*Australian Rivers Institute, School of Environment and Science, Griffith University, Southport, Queensland, Australia*
[4]*Stantec Inc., Chandler, AZ*
[5]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[6]*Nanyang Environment & Water Research Institute (NEWRI), Nanyang Technological University, Singapore*

Abstract

The presence of numerous chemical contaminants from industrial, agricultural, and pharmaceutical sources in water supplies poses a potential risk to human and ecological health. Current chemical analyses suffer from limitations, including chemical coverage and high cost, and broad-coverage *in vitro* assays such as transcriptomics may further improve water quality monitoring by assessing a large range of possible effects. Here, we used high-throughput transcriptomics to assess the activity induced by field-derived water extracts in MCF7 breast carcinoma cells. Wastewater and surface water extracts induced the largest changes in expression among cell proliferation-related genes and neurological, estrogenic, and antibiotic pathways, whereas drinking and reclaimed water extracts that underwent advanced treatment showed substantially reduced bioactivity on both gene and pathway levels. Importantly, reclaimed water extracts induced fewer changes in gene expression than laboratory blanks, which reinforces previous conclusions based on targeted assays and improves confidence in bioassay-based monitoring of water quality.

Citation

Rogers, J.D., F.D.L. Leusch, B. Chambers, K.D. Daniels, L.J. Everett, R. Judson, K. Maruya, A.C. Mehinto, P.A. Neale, K. Paul-Friedman, R. Thomas, S.A. Snyder, J. Harrill. 2024. High-Throughput Transcriptomics of Water Extracts Detects Reductions in Biological Activity with Water Treatment Processes. *Environmental Science & Technology* 58:2027-2037.

SCCWRP Journal Article #1362
Full text available by request: pubrequest@sccwrp.org

Adverse outcome pathways and their relevance

Alvine C. Mehinto[1], Susanne M. Brander[2], and Samreen Siddiqui[2]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*Oregon State University, Corvallis, OR*

Abstract

There are millions of chemicals registered for use worldwide, but only a fraction of them have been studied to prevent environmental health effects especially in aquatic environments (van Dijk et al. 2021). While hazard assessment is a key component for ensuring chemical safety, documentation on the hazards associated with chemi¬cal exposure is often incomplete for nontarget ecologically relevant aquatic species due to lack of ecotoxicological data. Some of the main impediments to generating such data include limited understanding of sensitive life stages, most vulnerable species, and underlying toxicity mechanisms which are critical to identify relevant toxicity endpoints (Breitholtz et al. 2006). As a result, to date, many currently used chemicals do not have sufficient information to determine environmental hazard and risk to aquatic environments. In parallel, public awareness of the potential risks of chemical exposure in the environment is increasing, and environmental managers are now actively considering the use of precautionary approaches to prevent eco¬logical health impacts. This is a significant shift in the current paradigm which typi¬cally relies on evidence of impacts before actions are taken.

Citation

Mehinto, A.C., S.M. Brander, S. Siddiqui. 2024. Adverse Outcome Pathways and Their Relevance. in: S. Siddiqui, S.M. Brander (eds.), *Aquatic Ecotoxicology: Understanding Pollutants, Aquatic Organisms, and their Environments* pp. 139-145. Springer Cham. New York, NY.

SCCWRP Book Chapter #1375
Full text available by request: pubrequest@sccwrp.org

The persistent DDT footprint of ocean disposal, and ecological controls on bioaccumulation in fishes

Lillian McGill[1], Toni Sleugh[2], Colleen Petrik[2], Kenneth Schiff[3], Karen McLaughlin[3], Lihini Aluwihare[4], and Brice Semmens[1]

[1]*Marine Biology Research Division, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA*
[2]*Integrative Oceanography Division, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA*
[3]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[4]*Geosciences Research Division, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA*

Abstract

Globally, ocean dumping of chemical waste is a common method of disposal and relies on the assumption that dilution, diffusion, and dispersion at ocean scales will mitigate human exposure and ecosystem impacts. In southern California, extensive dumping ofagrochemical waste, particularly chlorinated hydrocarbon contaminants such as DDT, via sewage outfalls and permitted offshore barging occurred for most of the last century. This study compiled a database of existing sediment and fish DDT measurements to examine how this unique legacy of regional ocean disposal translates into the contemporary contamination of the coastal ocean. We used spatiotemporal modeling to derive continuous estimates of sediment DDT contamination and show that the spatial signature of disposal (i.e., high loadings near historic dumping sites) is highly conserved in sediments. Moreover, we demonstrate that the proximity of fish to areas of high sediment loadings explained over half of the variation in fish DDT concentrations. The relationship between sediment and fish contamination was mediated by ecological predictors (e.g., species, trophic ecology, habitat use), and the relative influence of each predictor was context-dependent, with habitat exhibiting greater importance in heavily contaminated areas. Thus, despite more than half a century since the cessation of industrial dumping in the region, local ecosystem contamination continues to mirror the spatial legacy of dumping, suggesting that sediment can serve as a robust predictor of fish contamination, and general ecological characteristics offer a predictive framework for unmeasured species or locations.

Citation

McGill, L., T. Sleugh, C. Petrik, K.C. Schiff, K. McLaughlin, L. Aluwihare, B. Semmens. 2024. The persistent DDT footprint of ocean disposal, and ecological controls on bioaccumulation in fishes. Proceedings of the National Academy of Sciences 121:e2401500121.

SCCWRP Journal Article #1404
Full text available online: www.sccwrp.org/publications

Principles of passive sampling for ex situ measurement of hydrophobic organic compounds in sediment: Key considerations on dilution, depletion, and equilibrium

Wenjian Lao[1] and Gi Beum Kim[1,2]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*Department of Marine Environment Engineering, Gyeongsang National University, Tongyeong, Republic of Korea*

Abstract

Passive sampling techniques have undoubtedly proven effective for determining freely dissolved concentrations (*Cfree*) in sediment. However, the absence of a rationale-based, hands-on protocol for guiding practitioners in conducting ex situ exposure of passive samplers in sediment underscores the need for research and development in this area. The goal of this study was to address three critical issues for passive sampling in sediment ex situ: sediment dilution, depletion, and nonequilibrium. Polyethylene (PE) and polymethyl methacrylate (PMMA) film samplers were utilized in experiments involving hydrophobic organic compounds (HOCs, including PAHs, PCBs, PBDEs, and pesticides) spiked sediments. The results indicated that the influence of sediment dilution could be safely disregarded for HOCs with a larger *K*d value (i.e., > 140) when moisture content of 80% was selected for the exposure. Given some data deviations stemming from sample analysis, the depletion extent could significantly vary within a wide range (up to 36.4%) rather than being fixed at a specific level (e.g., 5%). Most HOCs reached equilibrium in a 10-d exposure for the PE sampler, and compounds with a log *K*ow value <7.12 did not need correction for nonequilibrium. An equation for estimating the nonequilibrium correction factor and an approach for correcting nonequilibrium exposure were introduced. The passive sampling method with PE was applied to a set of field-contaminated sediments under the depletion extents ranged from 7.1% to 77%. Based on the relatively comprehensive understanding of the passive sampling in sediment ex situ, a practical and standardized protocol was provided for *Cfree* measurement of HOCs.

Citation

Lao, W., G.B. Kim. 2024. Principles of passive sampling for ex situ measurement of hydrophobic organic compounds in sediment: Key considerations on dilution, depletion, and equilibrium. *Science of the Total Environment* 954:176277.

SCCWRP Journal Article #1395
Full text available online: www.sccwrp.org/publications

AQUA-GAPS/MONET-derived concentrations and trends of PAHs and polycyclic musks across global waters

Rainer Lohmann[1], Branislav Vrana[2], Derek Muir[3], Foppe Smedes[2], Jaromir Sobotka[2], Eddy Y. Zeng[4], Lian-Jun Bao[4], Ian J. Allan[5], Peleg Astrahan[6], Terry Bidleman[7], Denis Crowley[8], Evgen Dykyi[9], Nicolas Estoppey[10,11], Gilberto Fillmann[12], Liisa Jantunen[13], Sarit Kaserzon[14], Keith A. Maruya[15], Brendan McHugh[8], Brent Newman[16,17], Raimon M. Prats[18], Manolis Tsapakis[19], Mats Tysklind[7], Barend L. van Drooge[18], and Charles S. Wong[15]

[1]*Graduate School of Oceanography, University of Rhode Island, Narragansett, RI*
[2]*RECETOX, Faculty of Science, Masaryk University, Brno, Czech Republic*
[3]*Environment and Climate Change Canada, Aquatic Contaminants Research Division, Ontario, Canada*
[4]*Guangdong Key Laboratory of Environmental Pollution and Health, Jinan University, Guangzhou, China*
[5]*Norwegian Institute for Water Research (NIVA), Oslo, Norway*
[6]*Kinneret Limnological Laboratory, Israel Oceanographic and Limnological Research, Israel*
[7]*Department of Chemistry, Umeå University, Umeå, Sweden*
[8]*Marine Institute, Rinville, Ireland*
[9]*National Antarctic Scientific Center, Kyiv, Ukraine*
[10]*School of Criminal Justice, University of Lausanne, Batochime Building, Lausanne, Switzerland*
[11]*Norwegian Geotechnical Institute (NGI), Oslo, Norway*
[12]*Instituto de Oceanografia, Universidade Federal do Rio Grande (IO-FURG), Av. Itália s/n Campus Carreiros, Rio Grande, Brazil*
[13]*Air Quality Processes Research Section, Environment and Climate Change Canada, Ontario, Canada*
[14]*Queensland Alliance for Environmental Health Sciences, (QAEHS), The University of Queensland, Woolloongabba, Queensland, Australia*
[15]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[16]*Coastal Systems Research Group, CSIR, Durban, South Africa*
[17]*Nelson Mandela University, Port Elizabeth, South Africa*
[18]*Institute of Environmental Assessment and Water Research (IDAEA-CSIC), Barcelona, Spain*
[19]*Institute of Oceanography, Hellenic Centre for Marine Research, Crete, Greece*

Abstract

Polycyclic aromatic hydrocarbons (PAHs), released from petrogenic, pyrogenic or diagenetic sources (degradation of wood materials), are of global concern due to their adverse effects, and potential for long-range transport. While dissolved PAHs have been frequently reported in the literature, there has been no consistent approach of sampling across water bodies. Passive samplers from the AQUA/GAPS-MONET initiative were deployed at 46 sites (28 marine and 18 freshwater), and analyzed for 28 PAHs and six polycyclic musks (PCMs) centrally. Freely dissolved PAH concentrations were dominated by phenanthrene (mean concentration 1500 pg L^{-1}; median 530 pg L^{-1}) and other low molecular weight compounds. Greatest concentrations of phenanthrene, fluoranthene, and pyrene were typically from the same sites, mostly in Europe and North America. Of the PCMs, only galaxolide (72% of samples) and tonalide (61%) were regularly detected, and were significantly cross-correlated. Benchmarking of PAHs relative to penta- and hexachlorobenzene confirmed that the most remote sites (Arctic, Antarctic, and mountain lakes) displayed below average PAH concentrations. Concentrations of 11 of 28 PAHs, galaxolide and tonalide were positively correlated ($P < 0.05$) with population density within a radius of 5 km of the sampling site. Characteristic PAH ratios gave conflicting results, likely reflecting multiple PAH sources and postemission changes.

Citation

Lohmann, R., B. Vrana, D. Muir, F. Smedes, J. Sobotka, E.Y. Zeng, L.J. Bao, I.J. Allan, P. Astrahan, T. Bidleman, D. Crowley, E. Dykyi, N. Estoppey, G. Fillmann, L. Jantunen, S. Kaserzon, K.A. Maruya, B. McHugh, B. Newman, R.M. Prats, M. Tsapakis, M. Tysklind, B.L. van Drooge, C.S. Wong. 2024. AQUA-GAPS/MONET-Derived Concentrations and Trends of PAHs and Polycyclic Musks across Global Waters. *Environmental Science & Technology* 58:13456-13466.

SCCWRP Journal Article #1390
Full text available by request: pubrequest@sccwrp.org

Utility of a modified o-DGT passive sampler for measurement of bisphenol analogues in freshwater and coastal waters

Po Wang[1], Jie Li[1], Meng Yi Xie[2], Chen Chou Wu[1,2], Charles S. Wong[3], and Eddy Y. Zeng[2]

[1]*Guangdong Key Laboratory of Environmental Pollution and Health, Jinan University, Guangzhou, China*
[2]*Key Laboratory of Pollution Control and Ecosystem Restoration in Industry Clusters (Ministry of Education), School of Environment and Energy, South China University of Technology, Guangzhou, China*
[3]*Southern California Coastal Water Research Project, Costa Mesa, CA*

Abstract

Bisphenol analogues (BPs) are commonly found in riverine and coastal waters. However, the lack of a reliable and robust passive sampling method has hindered our ability to monitor these compounds in aquatic systems. The study developed a novel organic-diffusive gradients in thin film (o-DGT) sampler based on stainless steel mesh membrane, polyacrylamide diffusive gel, and hydrophilic-lipophilic balance (HLB) binding gel. This innovative design tackled issues of filter membrane sorption in traditional o-DGT devices and potential gel damage in membrane-less o-DGT devices, showing promising application prospects. The mass accumulation of 15 target BPs was linear over 10 days in both freshwater ($r^2 \geq 0.92$) and seawater ($r^2 \geq 0.94$), with no saturation observed. The diffusion coefficients (D) through polyacrylamide diffusive gels ranged from 4.04×10^{-6} to 5.77×10^{-6} cm^2 s^{-1} in freshwater and from 1.74×10^{-6} to 4.69×10^{-6} cm^2 s^{-1} in seawater for the target BPs (except for bisphenol PH) at 22 °C. The D values of the target BPs in seawater were lower than those in freshwater due to the high salinity in seawater (35‰). The o-DGT samplers demonstrated good integrity in field applications. The total concentrations of the eight detected BPs ranged from 9.2 to 323 ng L^{-1}, which was consistent with the measurements obtained by grab sampling. Among all BPs, bisphenol S, bisphenol F, and bisphenol A were consistently detected at all sites using both sampling methods. The concentrations of some novel BPs in coastal water measured by grab sampling were comparable to those measured in rivers, suggesting the need to strengthen pollution control of BPs in coastal areas. These results indicate that the o-DGT passive sampling method developed in the present study can be effectively used for monitoring BPs in freshwater and coastal environments.

Citation

Wang, P., J. Li, M.Y. Xie, C.C. Wu, C.S. Wong, E.Y. Zeng. 2024. Utility of a modified o-DGT passive sampler for measurement of bisphenol analogues in freshwater and coastal waters. *Science of the Total Environment* 931:172978.

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Distribution and composition of redox-active species and dissolved organic carbon in Arctic lacustrine porewaters

Danhui Xin[1,2], Jeffrey M. Hudson[3], Anthony Sigman-Lowery[1], and Yu-Ping Chin[1]

[1]*Department of Civil and Environmental Engineering, University of Delaware, Newark, DE*
[2]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[3]*OHSU/PSU School of Public Health, Oregon Health & Science University, Portland, OR*

Abstract

The interaction between redox-active species and dissolved organic carbon (DOC) is crucial in driving lacustrine benthic microbial processes. In lacustrine porewaters, many redox-active species exist in their reduced form, while DOC acts as a substrate and an electron acceptor. Understanding the types and abundance of redox-active species in porewaters along with their complementary DOC substrate is pivotal for gaining insights into benthic processes, particularly in regions susceptible to climate change. We report the *in-situ* measurement of redox-active species in sediment porewaters, alongside the ex-situ measurement of DOC extracted from cores collected from two Arctic lakes (Toolik and Fog 1). Fe^{2+} was abundantly detected below 4 cm of the sediment-water interface in all cores and was inversely related to dissolved O2. Additionally, two distinct Fe(III)- complexes were identified. DOC ranged in the order of 10s of mg/L and either remained stable or increased with depth. A comparison between Toolik and Fog 1 lakes revealed a higher accumulation of Fe^{2+} and DOC in the latter. This study marks the first of its kind to assess spatial distributions of redox-active species and DOC as a function of depth from multiple sites in Arctic lacustrine porewaters.

Citation

Xin, D., J.M. Hudson, A. Sigman-Lowery, Y. Chin. 2024. Distribution and composition of redox-active species and dissolved organic carbon in Arctic lacustrine porewaters. *Arctic, Antarctic, and Alpine Research* 56:2371534.

SCCWRP Journal Article #1383
Full text available online: www.sccwrp.org/publications

Characterizing the removal of microplastics by California wastewater treatment plants: Implications for management strategies

Charles S. Wong[1], Wenjian Lao[1], Sydney Dial[1], Duy Nguyen[1], Robert Butler[1], Diana Lin[2]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*San Francisco Estuary Institute, Oakland, CA*

Citation

Wong, C.S., W. Lao, S. Dial, D. Nguyen, R. Butler, D. Lin. 2024. Characterizing the Removal of Microplastics by California Wastewater Treatment Plants: Implications for Management Strategies. Technical Report 1378. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1378
Full text available online: www.sccwrp.org/publications

Multimedia investigations of microplastic concentrations in the Los Angeles and San Gabriel Rivers

Charles S. Wong, Wenjian Lao, Sydney Dial, Duy Nguyen, and Leah M. Thornton Hampton

Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Wong, C.S., W. Lao, S. Dial, D. Nguyen, L.M. Thornton Hampton. 2024. Multimedia investigations of microplastic concentrations in the Los Angeles and San Gabriel Rivers. Technical Report 1389. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1389
Full text available online: www.sccwrp.org/publications

Screening for emerging contaminants in the Santa Ana Region

Alvina Mehinto, Emily Darin, Darrin Greenstein, and Kameron Wong

Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Mehinto, A.C., E. Darin, D.J. Greenstein, K. Wong. 2024. Screening for Emerging Contaminants in the Santa Ana Region. Technical Report 1358. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1358
Full text available online: www.sccwrp.org/publications

Development and standardization of bioanalytical screening tools Part I – Final report

Alvine C. Mehinto[1], Victoria McGruer[1,2], Emily Darin[1], Kameron Wong[1], Daniel Schlenk[2]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*University of California, Riverside, Riverside, CA*

CITATION

Mehinto, A.C., V. McGruer, E. Darin, K. Wong, D. Schlenk. 2024. Development and Standardization of Bioanalytical Screening Tools Part I – Final Report. Technical Report 1381.A. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1381.A
Full text available online: www.sccwrp.org/publications

Development and standardization of bioanalytical screening tools Part II – Protocols for laboratory and data analysis

Alvine C. Mehinto[1], Victoria McGruer[1,2], Daniel Schlenk[2]

[1]Southern California Coastal Water Research Project, Costa Mesa, CA
[2]University of California, Riverside, Riverside, CA

CITATION

Mehinto, A.C., V. McGruer, D. Schlenk. 2024. Development and Standardization of Bioanalytical Screening Tools Part II – Protocols for Laboratory and Data Analysis. Technical Report 1381.B. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1381.B
Full text available online: www.sccwrp.org/publications

Stormwater Monitoring Coalition laboratory guidance document (Fourth edition)

Charles S. Wong, Sydney Dial, and Wenjian Lao

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Wong, C.S., S. Dial, W. Lao. 2024. Stormwater Monitoring Coalition Laboratory Guidance Document (Fourth Edition). Technical Report 1379. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1379
Full text available online: www.sccwrp.org/publications

Study quantifies human fecal pollution in urban stormwater

SCCWRP and its partners have completed a five-year effort to quantify the relative contributions of six major sources of human fecal contamination to the San Diego River watershed during wet weather – an investigation that has helped managers gain insights into the origins of elevated levels of this wet-weather contamination.

The multicomponent study, completed in 2024, found that public sewer overflows, exfiltration from public sewers, and onsite wastewater treatment systems are the three largest contributors to human fecal contamination measured at the end of the highly urbanized San Diego River watershed.

People experiencing homelessness contribute the smallest fraction of human fecal contamination, followed by private sewer overflows and exfiltration from private laterals.

The study marked the first time that researchers have attempted to systematically tease apart the relative contributions of each of six major hypothesized sources of human inputs.

While the study produced insights for one Southern California watershed, it remains unclear how broadly applicable the study's findings are to other watersheds; the relative contributions of each of the six major fecal sources could be different in different watersheds.

With the study's completion, San Diego River watershed managers are now poised to explore how best to mitigate each of the six identified sources of human fecal contamination.

A field crew recovers water from a sewer manhole in San Diego County as part of an effort to measure potential leaks in underground sewer pipes. Researchers have completed a five-year investigation quantifying the relative contributions of six major sources of fecal contamination – including exfiltration from sewer pipes – to the San Diego River watershed during wet weather.

Second phase completed for study revisiting shellfish water-quality standard

SCCWRP and its partners have completed the second and final phase of a study examining whether an existing water-quality standard designed to protect the health of people who consume shellfish from Newport Bay is built on solid scientific footing.

The study's second phase, completed in 2024, probed whether California's existing standard for permissible bacterial levels correlates to potentially unsafe levels of pathogens in bivalve shellfish that are harvested from Newport Bay during wet weather.

During the study's first phase, researchers examined this same relationship during dry weather, and found no correlation.

The study's outcomes are expected to have implications for water bodies like Newport Bay that are failing to meet this water-quality standard year-round.

SMC completes study probing relationship between HF183 and illness risk

The Southern California Stormwater Monitoring Coalition (SMC) has completed a three-year study probing the relationship between levels of the fecal contamination marker HF183 in wet-weather runoff and the risk that humans exposed to this contamination will become sick.

The SCCWRP-led study, completed in 2024 and expected to be published in 2025, is designed to increase the management utility of HF183 by shedding light on how much HF183 is too much HF183 – that is, defining for managers at what level HF183 in wet-weather runoff corresponds to a public health risk for people swimming at beaches and other contaminated receiving waters.

Managers are required under existing regulations to eliminate fecal contamination from aquatic environments. However, when HF183 is detected in a water body, managers lack a way to interpret how much of a public health risk that exposure to this water represents for swimmers and other beachgoers, as no health risk thresholds for HF183 have historically been available.

Surfers paddle away from shore at San Diego's Ocean Beach shortly after a storm. Researchers have completed a study probing the relationship between levels of the fecal contamination marker HF183 in Southern California wet-weather runoff and the risk that humans exposed to this contamination will become sick.

Assessing the defecation practices of unsheltered individuals and their contributions to microbial water quality in an arid, urban watershed

J.B. Hinds[1], Teevrat Garg[3], Sarah Hutmacher[2], Andrew Nguyen[1], Zhongqi Zheng[1], John Griffith[4], Joshua Steele[4], Adriana González Fernández[4], Kenneth Schiff[4]

[1]*Department of Urban Studies and Planning, University of California, San Diego, La Jolla, CA*
[2]*San Diego River Park Foundation, San Diego, CA*
[3]*School of Global Policy and Strategy, University of California, San Diego, La Jolla, CA*
[4]*Southern California Coastal Water Research Project, Costa Mesa, CA*

Abstract

Outdoor defecation by people experiencing homelessness is frequently perceived as a potentially large source of human fecal pollution and a significant source of health risk in urban waterbodies with recreational contact. The goal of this study was to count the number of people experiencing homelessness and quantifies their sanitation habits in an urban river corridor setting, then use this information for estimating human fecal pollutant loading on a watershed scale. Two types of census counts were conducted including periodic point-in-time counts over six years and weekly counts of encampments. While the population census varied from count-to-count, the range of population estimates in the river corridor varied from 109 to 349 individuals during the six-year span, which mirrored the weekly counts of encampments. A face-to-face survey of people experiencing homelessness assessed the sanitation habits of the unsheltered population (N = 63), including outdoor defecation frequency and containment practices. Overall, 95% of survey respondents reported defecating outdoors; 36% practiced outdoor defecation between 4 and 7 days/week and 27% practiced outdoor defecation <1 day/week. Of those that did practice outdoor defecation, 75% contained their feces in a bucket or bag, thereby limiting fecal material contributions to the river; 6.7% reported defecating on low ground near the river that could wash off when flood waters rise during a storm event. Only a single survey respondent reported defecating directly into the river.

Citation

Hinds, J.B., T. Garg, S. Hutmacher, A. Nguyen, Z. Zheng, J.F. Griffith, J.A. Steele, A. Gonzalez Fernandez, K.C. Schiff. 2024. Assessing the defecation practices of unsheltered individuals and their contributions to microbial water quality in an arid, urban watershed. *Science of the Total Environment* 920:170708.

SCCWRP Journal Article #1364
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Using HF183 to estimate watershed-wide annual loadings of human fecal pollution from onsite wastewater treatment systems

Kenneth Schiff[1], Amity Zimmer-Faust[1,2], Duy Nguyen[1], John Griffith[1], Joshua Steele[1], Darcy Ebentier McCargar[3,4], and Sierra Wallace[3,4]

[1]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[2]*The Nature Conservancy, Seattle, WA*
[3]*WSP, San Diego, CA*
[4]*Rick Engineering, San Diego, CA*

Abstract

Onsite wastewater treatment systems (OWTSs or septic systems), when properly sited, designed, operated, and maintained, treat domestic wastewater to reduce impacts on and maintain sustainability of aquatic resources. However, when OWTSs are not performing as expected, they can be a potential source of human fecal pollution to recreational waters, resulting in an increased risk of illness to swimmers. Quantifying the contribution of poor-performing OWTSs relative to other sources of fecal pollution is particularly challenging in wet weather when various sources commingle as they flow downstream. This study aimed to estimate the total load of human fecal pollution from OWTSs in an arid watershed with municipal separate storm sewer systems (MS4). The novel study design sampled HF183, a DNA-based human marker, from six small catchments containing only OWTSs and no other known human fecal sources, such as sanitary sewer collection systems or people experiencing homelessness. Then, the human fecal loading from the representative catchments was extrapolated to the portions of the watershed that were not sampled but contained OWTSs. Flow-weighted mean HF183 concentrations ranged from 10^4 to 10^7 gene copies/100 mL across 29 site-events. HF183 mass loading estimates were normalized to the number of parcels per catchment and inches of rainfall per storm event. Assuming the normalized loading estimate was representative, extrapolation to all of the OWTS parcels in the watershed and average annual rainfall quantity illustrated that HF183 loading from OWTSs was a small but measurable fraction of the total HF183 mass loading emanating at the bottom of the watershed. Clearly, other human fecal sources contributed HF183 during storm events in this watershed. The loading estimate approach used in this study could be applied to other watersheds facing similar challenges in prioritizing resources for monitoring and mitigation among co-located human fecal sources.

Citation

Schiff, K.C., A. Zimmer-Faust, D. Nguyen, J.F. Griffith, J.A. Steele, D.E. McCargar, S. Wallace. 2024. Using HF183 to Estimate Watershed-Wide Annual Loadings of Human Fecal Pollution from Onsite Wastewater Treatment Systems. *Sustainability* 16:9503.

SCCWRP Journal Article #1403
Full text available online: www.sccwrp.org/publications

The influence of urbanization and water reclamation plants on fecal indicator bacteria and antibiotic resistance in the Los Angeles River watershed: A case study with complementary monitoring methods

Ileana A. Callejas[1,2], Yuwei Kong[1], Katie Osborn[1], Wei-Cheng Hung[3], Marisol Cira[1], Taylor Cason[1], Ashlyn Sloane[1], Alexis Shenkiryk[1], Aaron Masikip[1], Akshyae Singh[1], Adriane Jones[4], Joshua A. Steele[5], Jennifer A. Jay[1]

[1]*Department of Civil and Environmental Engineering, University of California, Los Angeles, Los Angeles, CA*
[2]*Department of Biological Sciences, Biola University, La Mirada, CA*
[3]*Department of Chemistry, Southern Oregon University, Ashland, OR*
[4]*Department of Biological Sciences, Mount Saint Mary's University, Los Angeles, CA*
[5]*Department of Microbiology, Southern California Coastal Water Research Project, Costa Mesa, CA*

Abstract

Urban land use and water reclamation plants (WRPs) can impact fecal indicator bacteria (FIB) and antimicrobial resistance (AMR) in coastal watersheds. However, there is a lack of studies exploring these effects on the US West Coast. Additionally, there is limited research using a complementary approach across culture-, qPCR-, and metagenomics-based techniques for characterizing environmental AMR. In this study, sixteen locations were sampled in the Los Angeles River, encompassing both upstream and downstream of three WRPs discharging into the river. Culture-dependent methods quantified *Enterococcus*, total coliforms, *E. coli*, and extended spectrum beta-lactamase-producing *E. coli* as a low-cost screening tool for AMR, while qPCR measured selected antibiotic resistance genes (ARGs): sul1, ermF, tetW, blaSHV, along with intI1 and 16S rRNA genes. Bacteroides HF183 and crAssphage markers were quantified via ddPCR. All samples underwent shotgun sequencing to investigate gene abundance and mobility and an overall risk score for AMR. Results reveal downstream sites contain ARGs at least two orders of magnitude greater than upstream locations. Developed areas had the highest ARG sequence abundances and the most ARG classes as indicated by metagenomic analysis. WRP effluent exhibited elevated ARGs and co-location of ARGs, mobile genetic elements, and pathogens. A culture-based assessment of AR in *E. coli* and *Pseudomonas aeruginosa* revealed increased resistance ratios for most antibiotics from upstream to downstream a WRP discharge point. This study highlights the impacts of land use and WRPs on ARGs and FIB, offering a multi-pronged analysis of AMR.

Citation

Callejas, I.A., Y. Kong, K. Osborn, W. Hung, M. Cira, T. Cason, A. Sloane, A. Shenkiryk, A. Masikip, A. Singh, A. Jones, J.A. Steele, J.A. Jay. 2024. The influence of urbanization and water reclamation plants on fecal indicator bacteria and antibiotic resistance in the Los Angeles River watershed: A case study with complementary monitoring methods. *Science of The Total Environment* 957:177577.

SCCWRP Journal Article #1409
Full text available online: www.sccwrp.org/publications

Longitudinal sequencing and variant detection of SARS-CoV-2 across Southern California wastewater

Jason A. Rothman[1], Andrew Saghir[1], Amity G. Zimmer-Faust[2], Kylie Langlois[2], Kayla Raygoza[1,2], Joshua A. Steele[2], John F. Griffith[2], and Katrine L. Whiteson[1]

[1]*Department of Molecular Biology and Biochemistry, University of California, Irvine, CA*
[2]*Southern California Coastal Water Research Project, Costa Mesa, CA*

Abstract

Wastewater-based epidemiology (WBE) is useful for detecting pathogen prevalence and may serve to effectively monitor diseases across broad scales. WBE has been used throughout the COVID-19 pandemic to track disease burden through quantifying SARS-CoV-2 RNA present in wastewater. Aside from case load estimation, WBE is being used to assay viral genomic diversity and emerging potential SARS-CoV-2 variants. Here, we present a study in which we sequenced RNA extracted from sewage influent obtained from eight wastewater treatment plants representing 16 million people in Southern California from April 2020 to August 2021. We sequenced SARS-CoV-2 with two methods: Illumina Respiratory Virus-Enriched metatranscriptomic sequencing (N = 269), and QIAseq SARS-CoV-2-tiled amplicon sequencing (N = 95). We classified SARS-CoV-2 reads into lineages and sublineages that approximated named variants and identified single nucleotide variants (SNVs), of which many are putatively novel SNVs and SNVs of unknown potential function and prevalence. Through our retrospective study, we also show that several SARS-CoV-2 sublineages were detected in wastewater before clinical detection, which may assist in the prediction of future variants of concern. Lastly, we show that sublineage diversity was similar across Southern California and that diversity changed over time, indicating that WBE is effective across megaregions. As the COVID-19 pandemic moves to new phases, and SARS-CoV-2 variants emerge, monitoring wastewater is important to understand local- and population-level dynamics of the virus. These results will aid in our ability to monitor the evolutionary potential of SARS-CoV-2 and help understand circulating SNVs to further combat COVID-19.

Citation

Rothman, J.A., A. Saghir, A.G. Zimmer-Faust, K. Langlois, K. Raygoza, J.A. Steele, J.F. Griffith, K.L. Whiteson. 2024. Longitudinal Sequencing and Variant Detection of SARS-CoV-2 across Southern California Wastewater. *Applied Microbiology* 4:635-649.

SCCWRP Journal Article #1372
Full text available online: www.sccwrp.org/publications

Optimizing wastewater surveillance: The necessity of standardized reporting and proficiency for public health

Ishi Keenum[1], Nancy J. Lin[2], Alshae' Logan-Jackson[2], Adam J. Gushgari[3], Nishita D'Souza[4], Joshua A. Steele[5], Devrim Kaya[6], and Lydia R. Gushgari[7]

[1]*Civil, Environmental, and Geospatial Department, Michigan Technological University, Houghton, MI*
[2]*Biosystems and Biomaterials Division, National Institute of Standards and Technology, Gaithersburg, MD*
[3]*Eurofins Pandemic Prevention Services, Sacramento, CA*
[4]*Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI*
[5]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[6]*School of Public Health, San Diego State University, San Diego, CA*
[7]*SPOC Proteomics, Inc., Scottsdale, AZ*

Abstract

Wastewater-based surveillance (WBS) has emerged as a valuable tool for public health, allowing a greater understanding of disease prevalence in communities. With historical significance in monitoring polio transmission, WBS gained further prominence in 2020 by enhancing the population-level monitoring of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) trends. Since then, WBS has been used to track diseases such as influenza, respiratory syncytial virus, norovirus, and mpox. The global implementation of WBS signifies its movement from a research initiative to a staple public health tool, which is especially critical for virus monitoring. However, the diverse methodologies adopted for WBS present challenges. Although each method may address specific stakeholder needs, the lack of standardized reporting guidelines and external validation limits the scope and utility of the data.

A key advantage of WBS is that it enables public health authorities at the state and federal levels to determine where to allocate resources, ideally before a wider spread outbreak. Data aggregation is possible only when metrics such as target concentration and recovery are reported in the same concentrations and with similar driving calculations. This concern is amplified when data from a variety of methods are aggregated at a state, national, or global scale. Therefore, our objective is to promote standardized reporting guidelines in WBS as a critical part of a public health framework.

Citation

Keenum, I., N.J. Lin, A. Logan-Jackson, A.J. Gushgari, N. D'Souza, J.A. Steele, D. Kaya, L.R. Gushgari. 2024. Optimizing Wastewater Surveillance: The Necessity of Standardized Reporting and Proficiency for Public Health. *American Journal of Public Health* 114:859-863.

SCCWRP Journal Article #1394
Full text available online: www.sccwrp.org/publications

Universal microbial indicators provide surveillance of sewage contamination in harbours worldwide

Sandra L. McLellan[1] , Anthony Chariton[2], Annachiara Codello[2], Jill S. McClary-Gutierrez[1], Melissa K. Schussman[1], Ezequiel M. Marzinelli[3], Judith M. O'Neil[4], Eric J. Schott[5], Jennifer L. Bowen[6], Joe H. Vineis[6], Lois Maignien[7], Clarisse Lemonnier[7], Morgan Perennou[7], Karen S. Gibb[8], Guang-Jie Zhou[9], Kenneth M. Y. Leung[9], Marek Kirs[10], John F. Griffith[11], Joshua A. Steele[11], Stephen E. Swearer[12,27], Allyson L. O'Brien[12], Dehai Song[13], Shengkang Liang[14], Junfeng Li[15], Laura Airoldi[16,17], Francesco P. Mancuso[17,18], Paulo S. Salomon[19], Arthur W. Silva-Lima[19], Renato C. Pereira[20], Alexandria B. Boehm[21], Elton W. X. Lim[22], Stefan Wuertz[22], Emilio Fernández[23], Eva Teira[23], Ming-Ling Liao[24], Yun-Wei Dong[24] & Peter D. Steinberg[25,26]

[1]*School of Freshwater Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI*
[2]*School of Natural Sciences, Macquarie University, Sydney, New South Wales, Australia*
[3]*School of Life and Environmental Sciences, University of Sydney, Sydney, New South Wales, Australia*
[4]*University of Maryland Center for Environmental Science, Horn Point Laboratory, Cambridge, MD*
[5]*University of Maryland Center for Environmental Science, Institute of Marine and Environmental Technology, Baltimore, MD*
[6]*Northeastern University Marine Science Center, Nahant, MA*
[7]*Univ Brest (UBO), CNRS, IFREMER, Laboratoire de Microbiologie des Environnements Extrêmes, Plouzané, France.*
[8]*Research Institute for the Environment and Livelihoods, Charles Darwin University, Darwin, Northern Territory, Australia*
[9]*State Key Laboratory of Marine Pollution and Department of Chemistry and School of Energy and Environment, City University of Hong Kong, City University of Hong Kong, Hong Kong, China*
[10]*Water Resources Research Center, University of Hawaii at Manoa, Honolulu, HI*
[11]*Microbiology Department, Southern California Coastal Water Research Project, Costa Mesa, CA*
[12]*School of BioSciences, University of Melbourne, Melbourne, Victoria, Australia*
[13]*Frontier Science Center for Deep Ocean Multispheres and Earth System, and Key Laboratory of Physical Oceanography, Ministry of Education, Ocean University of China, Qingdao, China*
[14]*Frontier Science Center for Deep Ocean Multispheres and Earth System, and State Key Laboratory of Marine Pollution and Department of Chemistry, Ministry of Education, Ocean University of China, Qingdao, China*
[15]*Shandong Provincial Key Laboratory of Biochemical Engineering, College of Biological Engineering, Qingdao University of Science and Technology, Qingdao, China*
[16]*Hydrobiological Station 'Umberto D'Ancona', Department of Biology, University of Padova, Uo CoNISMa, Chioggia, Italy*
[17]*National Biodiversity Future Center, Palermo, Italy*
[18]*Department of Earth and Marine Sciences, University of Palermo, Palermo, Italy*
[19]*Departamento de Biologia Marinha, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil*
[20]*Departamento de Biologia Marinha, Universidade Federal Fluminense, São Domingos, Brazil*
[21]*Civil and Environmental Engineering, Stanford Doerr School of Sustainability and School of Engineering, Stanford University, Stanford, CA*
[22]*Singapore Centre for Environmental Life Sciences Engineering, Nanyang Technological University, Singapore, Singapore*
[23]*Centro de Investigación Marina, Departamento de Ecología e Biología Animal, Universidad de Vigo, Vigo, Spain*
[24]*Key Laboratory of Mariculture, Ministry of Education, Fisheries College, Ocean University of China, Qingdao, China*
[25]*Centre for Marine Science and Innovation, School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, New South Wales, Australia*
[26]*Sydney Institute of Marine Science, Mosman, New South Wales, Australia.*
[27]*Present address: Oceans Institute, University of Western Australia, Perth, Western Australia, Australia*

Abstract

Human population pressures and activities pose unprecedented challenges to water resources in urban environments. However, standard methods of assessing microbial water quality have relied on the same cultured organisms for decades. We show that there is a conserved microbial assemblage in untreated sewage that can be exploited to improve global sewage surveillance. Among harbour and coastal water samples from 18 cities across 5 continents (n = 442), nearly half had evidence of sewage contamination using two human faecal bacteria as molecular indicators. In contrast, conventional measures using cultured *Escherichia coli* or enterococci only exceeded water quality limits in ~18% of samples, with less than half of these demonstrating sewage indicators. Contaminated locations also displayed a signature characteristic of microorganisms mainly derived from sewer infrastructure. Given the human health risk, loss of ecosystem services and economic costs associated with contaminated coastal waters, molecular approaches could provide more reliable information on sewage contamination of urban waterways.

Citation

McLellan, S.L., A. Chariton, A. Codello, J.S. McClary-Gutierrez, M.K. Schussman, E.M. Marzinelli, J.M. O'Neil, E.J. Schott, J.L. Bowen, J.H. Vineis, L. Maignien, C. Lemonnier, M. Perennou, K.S. Gibbs, G.J. Zhou, K.M.Y. Leung, M. Kirs, J.F. Griffith, J.A. Steele, S.E. Wearer, A.L. O'Brien, D. Song, S. Liang, J. Li, L. Airoldi, F.P. Mancuso, P.S. Salomon, A.W. Silva-Lima RC Pereira, A.B. Boehm, E.W.X. Lim, S. Wuertz, E. Fernandez, E. Teira, M.L. Liao, Y.W. Dong, P.D. Steinberg. 2024. Universal microbial indicators provide surveillance of sewage contamination in harbours worldwide. *Nature Water* DOI:10.1038/s44221-024-00315-5.

SCCWRP Journal Article #1401
Full text available online: www.sccwrp.org/publications

Summary of technical research: Quantifying sources of human fecal pollution in the lower San Diego River watershed

Kenneth Schiff, John Griffith, Joshua Steele, Adriana Gonzalez-Fernandez

Southern California Coastal Water Research Project, Costa Mesa, CA

Citation

Schiff, K.C., J.F. Griffith, J.A. Steele, A. Gonzalez-Fernandez. 2024. Summary of Technical Research: Quantifying Sources of Human Fecal Pollution in the Lower San Diego River Watershed. Technical Report 1380. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1380
Full text available online: www.sccwrp.org/publications

Study finds replacing spray irrigation with drip irrigation can eliminate runoff

SCCWRP and the County of San Diego have completed a three-year study that found that replacing spray-irrigated turf with drip irrigation and drought-tolerant landscaping can reduce or eliminate the volumes of irrigation and rain water running off these surfaces.

The study, completed in 2024, found that turf replacements – a type of non-structural stormwater BMP (best management practice) – can fully eliminate irrigation-derived runoff, plus eliminate wet-weather runoff during an estimated 85% of all storms.

Already, the findings have helped convince the County to expand its turf-replacement program to encompass 13 residential and commercial properties as of the end of 2024. Five additional turf-replacement applications were pending.

Wet- and dry-weather runoff from residential grass areas can become a significant source of pollution in storm drain systems; discharge permits in the County of San Diego require stormwater managers to eliminate dry-weather runoff from these areas.

Other Southern California municipalities are considering replicating San Diego County's turf-replacement program.

SCCWRP's Adriana Le Compte-Santiago, left, and Jerod Gray install a trench drain and above-ground sensors in a residential community where the County of San Diego replaced turf with drought-tolerant landscaping. Researchers found that replacing spray irrigation with drip irrigation and drought-tolerant landscaping at this site can reduce or eliminate the volumes of irrigation and rain water running off these surfaces.

Tool developed for rating BMP performance

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

The BMP performance index tool, which was unveiled in 2024, is intended to bring consistency and standardization to how stormwater managers determine whether a BMP is helping to achieve downstream water-quality objectives, and whether the BMP is capturing runoff volumes consistent with its design specifications.

Managers historically have not had access to a standardized tool for systematically integrating and comparing BMP performance data.

Researchers plan to adapt the tool for use across Southern California, including being able to evaluate BMP performance data collected from across the region.

Method developed to measure street sweeping's effectiveness

SCCWRP and its partners have developed a novel method for quantifying the effectiveness of routine street sweeping in removing contaminants that would otherwise enter storm drains and contribute to runoff pollution – a study that moves managers one step closer to being able to understand street sweeping's capacity to help protect runoff water quality.

The method, which was developed in 2023 and approved in 2024 for implementation, provides a feasible path forward for pursuing follow-up investigations that will shed light on what role street sweeping plays in reducing runoff pollution – and how managers might be able to optimize their street sweeping regimes.

Municipalities commonly rely on street sweeping to remove debris that is unsightly and can clog storm drain systems, but what has historically been unclear is what portion of stormwater pollutants – sediment, nutrients, trace heavy metals, microplastics and bacteria – remain on roadways after street sweeping.

Street sweeping is considered a type of non-structural BMP (best management practice).

A SCCWRP field crew tests a custom-built rainfall generator, above, that was used to develop a method for quantifying the effectiveness of routine street sweeping in removing contaminants that would otherwise enter storm drains and contribute to runoff pollution.

Effects of postprocessing decisions on flow-weighted event mean concentrations

Edward Tiernan, Elizabeth Fassman-Beck, and Nicholas Lombardo

Southern California Coastal Water Research Project, Costa Mesa, CA

Abstract

The sensitivity of an industry-defining stormwater quality metric, the flow-weighted event mean concentration (EMC), to non-standardized calculation protocols was evaluated. Our objective was to explicate quantitative methods and practical aspects of obtaining EMCs and provide recommendations for minimizing bias where validation is not possible. EMCs may be generated by post-storm compositing of discrete (also known as grab) samples or by collecting flow-weighted composite samples using automated equipment. Three methodological crossroads (flow attribution, volume integration, and flow-sample resolution) were assessed for their relative impact on the flow-weighted EMC. Field monitoring campaigns produced 38 total suspended solids (TSS) pollutographs and hydrographs characterizing untreated and treated runoff that were used to generate EMCs using each available calculation scheme. Untreated runoff was collected from a parking lot and an asphalt street. Treated runoff was collected from a grassed swale system, a proprietary treatment system in series with a constructed wetland, and a permeable pavement. A combinatorial averaging method was utilized to quantify each scheme's effect; the resultant EMC was compared against an adopted benchmark EMC. EMC outcomes from methodologies that use prior flow attribution underestimate the presumed highest accuracy benchmark EMC by 12.9% on average, regardless of the volume integration method or flow-sample resolution used. No other decision variables demonstrated a meaningful effect size. Composite sampling with autosamplers fits a prior flow-sample attribution scheme, but advanced program options can ameliorate the significant bias associated with prior flow attribution. Outcomes are meaningful for stormwater managers to reduce potential uncertainty when characterizing stormwater control measure (SCM) and collating SCM monitoring data across studies with differing sample collection methods. An open-source web application is offered for any user to conduct flow-weighted EMC calculations using the benchmark method.

Citation

Tiernan, E., E. Fassman-Beck, N. Lombardo. 2024. Effects of Postprocessing Decisions on Flow-Weighted Event Mean Concentrations. *Journal of Sustainable Water in the Built Environment* 10:04024005.

SCCWRP Journal Article #1385
Full text available by request: pubrequest@sccwrp.org

Introducing SWMM5+

Ben R. Hodges[1], Sazzad Sharior[1], Edward D. Tiernan[2], Eric Jenkins[1], Gerardo Riaño-Briceño[1], Cesar Davila-Hernandez[1], Ehsan Madadi-Kandjani[3], Cheng-Wei Yu[4]

[1]*Maneesh Department of Civil, Architectural, and Environmental Engineering, University of Texas at Austin, Austin, TX*
[2]*Southern California Coastal Water Research Project, Costa Mesa, CA*
[3]*Department of Mechanical and Aerospace Engineering, California State University, Long Beach, Long Beach, CA*
[4]*Department of Bioenvironmental Systems Engineering, National Taiwan University, Taipei, Taiwan*

Abstract

The US Environmental Protection Agency Storm Water Management Model (EPA SWMM) has been the preeminent stormwater model for more than 50 years (CDM Smith 2023; Dickinson 2015; Huber et al. 2010; Rossman et al. 2004). However, the EPA SWMM hydraulic solver sometimes has poor mass conservation and requires a modeler's art to find a fix Furthermore, future faster computers will require efficient parallel computing (Flamm 2017), and the best parallel speed-up for EPA SWMM is about 10× (Burger et al. 2014). Finally, the EPA SWMM water quality module uses an approximate solution to a first-order kinetics transport equation rather than simulation of general advection-diffusion-reaction (ADR) transport (Medina et al. 1981; Rossman and Huber 2016), which limits the model's use for water chemistry with more complex source/sink processes.

The SWMM5+ project began with the observation that the EPA SWMM hydraulic solver (1) is the primary consumer of computational time, (2) is the source of model instability/mass non-conservation, (3) limits parallelization, and (4) cannot support mass-conservative ADR transport modeling. The new SWMM5+ solver provides the foundations for addressing these issues with a mass-conservative hydraulic model that is coded for parallel efficiency. The SWMM5+ code acts as the top-level controlling program with the EPA SWMM code providing a library of functions for hydrology and input data parsing.

Citation

Hodges, B.R., S. Sharior, E. Tiernan, E. Jenkins, G. Riano-Briceno, C. Davila-Hernandez, E. Madadi-Kandjani, C.W. Yu. 2024. Introducing SWMM5+. *Journal of Environmental Engineering* 150:02524003.

SCCWRP Journal Article #1387
Full text available online: www.sccwrp.org/publications

Characterization of nitrogen discharge from extensive sedum green roofs with multiple amending designs and materials

Yang Cheng[1], Birgitte G. Johannessen[2], David A. Vaccari[1], and Elizabeth Fassman-Beck[3]

[1]*Department of Civil, Environmental, and Ocean Engineering, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ*
[2]*Department of Municipal Engineering, Trondheim Municipality, Trondheim, Norway*
[3]*Southern California Coastal Water Research Project, Costa Mesa, CA*

ABSTRACT

Green roofs are effective stormwater control measures for mitigating urban hydrology; however, their potential to manage nutrient discharges has not been consistently documented. Thirty-two pilot scale newly constructed experimental extensive green roof trays were established to evaluate the effect of substrate composition on total nitrogen (TN) discharge. Two lightweight-based green roof substrates are compared in combination with zeolite as either a mixed-in component in the substrate or a downstream permeable reactive barrier (PRB), or both. Wood and oat-hull-derived biochar are also tested as PRB materials. Precipitation, runoff volumes, and event mean concentrations (EMCs) of TN in runoff discharged from green and reference roofs were measured for 25 storm events during three growing seasons. TN discharge from newly established extensive green roofs demonstrates a strong temporal effect. The high substrate nitrogen (N) concentration at installation (~2.98–3.91 mg/L) generated elevated TN EMCs in storm event discharge (median 3.34 mg/L). The effect rapidly decreased within one growing season, such that green roof TN EMCs were comparable with the reference roof EMCs (median 1.32 mg/L), and substrate nitrogen was measured at ~1–1.98 mg/L after two years. Zeolite, mixed in at 10% v/v, has no influence on reducing TN EMCs; however, at 20% v/v (combination of mixed-in and PRB), zeolite significantly reduced TN EMCs in the first growing season. Neither wood biochar nor oat hull biochar was effective in TN mitigation. Mass load analysis estimated from measured storms that extensive green roofs discharge 33%–45% less N mass than did the reference roof due to significant runoff retention. The evidence that reflects the lack of a statistical difference between extensive green and reference roofs' TN EMCs and less nitrogen mass discharged from extensive green roofs in the latter two monitoring seasons suggests that atmospheric deposition is a likely source of TN in roof discharge over the long term.

CITATION

Cheng, Y., B.G. Johannessen, D.A. Vaccari, E. Fassman-Beck. 2025. Characterization of Nitrogen Discharge from Extensive Sedum Green Roofs with Multiple Amending Designs and Materials. *Journal of Sustainable Water in the Built Environment* 11:04024009.

SCCWRP Journal Article #1415
Full text available by request: pubrequest@sccwrp.org

Turf replacement BMPs to reduce dry and wet weather runoff

Elizabeth Fassman-Beck, Edward Tiernan, Duy Nguyen, and Robert Butler

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Fassman-Beck, E., E. Tiernan, D. Nguyen, R. Butler. 2024. Turf Replacement BMPs to Reduce Dry and Wet Weather Runoff. Technical Report 1391. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1391
Full text available online: www.sccwrp.org/publications

SMC non-structural BMP workshop report

Elizabeth Fassman-Beck and Ken Schiff

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Fassman-Beck, E., K.C. Schiff. 2024. SMC Non-Structural BMP Workshop Report - March 1, 2022. Technical Report 1405. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP Technical Report #1405
Full text available online: www.sccwrp.org/publications

Sentinel network completed to support planned wetlands monitoring program

SCCWRP and its partners have completed the first major component of a planned coastal wetland monitoring program for Southern California – a milestone that brings coastal managers one step closer to ongoing, coordinated regional monitoring of Southern California's approximately 100 coastal wetlands.

Researchers in 2024 unveiled the monitoring program's sentinel site network, a 37-site network that will provide a baseline for comparison to other sites.

Once fully built, the Southern California wetland monitoring program will enable researchers to use standardized, rigorously vetted methods for comprehensively assessing the regional health of wetlands, including determining the relative success of different restoration projects across Southern California.

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 assessment tools and a unified monitoring program through which to assess the effectiveness of management interventions.

Researchers are expected to complete planning for Southern California's wetlands monitoring program by the end of 2025.

Batiquitos Lagoon in Carlsbad is one of 37 coastal wetlands that will serve as sentinel sites for a planned Southern California coastal wetland monitoring program. The sentinel site network, built in 2024, will provide a baseline for comparison to other sites.

Year 2 sampling completed for BMP regional monitoring program

The Southern California Stormwater Monitoring Coalition (SMC) has completed the second year of sampling for its new Regional BMP Monitoring Network, a collaborative monitoring program that uses standardized methods to collect data on BMP performance effectiveness.

The SCCWRP-facilitated monitoring program collected data from six stormwater BMPs across Southern California during the 2023-2024 wet-weather season.

Collecting monitoring data from BMPs requires extensive planning and training. Because some BMPs were damaged during the season's larger-than-average storm events, researchers also verified the viability of the data collected from those sites.

The insights generated from this new regional monitoring program have the potential to address significant, persistent knowledge gaps in managers' understanding of how to optimize the performance, operation and maintenance of structural stormwater BMPs.

Bight '23 shellfish study benefits 4 study elements

The 2023 cycle of the Southern California Bight Regional Monitoring Program has completed field sampling for a new, cross-disciplinary effort to track the accumulation of multiple different types of contaminants in shellfish – a highly leveraged investigation that will generate insights benefitting four Bight '23 study elements.

The Bight '23 shellfish assessment, which wrapped up field sampling in 2024, is investigating the degree to which legacy contaminants, PFAS (per- and polyfluoroalkyl substances), toxins produced by harmful algal blooms (HABs), microplastics, and pathogens are accumulating in the tissues of oysters and mussels.

Via this study, four separate Bight '23 study elements that have traditionally operated mostly in silos – Sediment Quality, HABs, Trash and Microbiology – are working collaboratively to oversee and manage the shellfish assessment.

Shellfish, which are filter feeders that can inadvertently take up and concentrate contaminants from surrounding water, are a cornerstone of marine food webs. Humans also consume locally harvested shellfish and use shellfish as fishing bait, underscoring the importance of assessing what levels and types of contaminants are accumulating in their tissues.

SCCWRP's Thomas Shields collects mussels from a pier at Cabrillo Beach as part of field sampling for the Southern California Bight 2023 Regional Monitoring Program's shellfish assessment. Field sampling was completed in 2024.

Bioassessment survey of the Stormwater Monitoring Coalition: Workplan for years 2021 through 2025 Version 4.0

Raphael D. Mazor

Southern California Coastal Water Research Project, Costa Mesa, CA

CITATION

Mazor, R.D. 2024. Bioassessment Survey of the Stormwater Monitoring Coalition: Workplan for Years 2021 through 2025 Version 4.0. 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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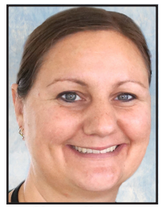

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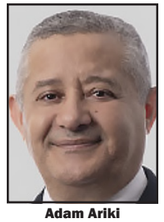
Los Angeles County Flood Control District



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Laboratory Assistant

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Programmer

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