

# SCCWRP Director's Report



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SUMMER 2021 ISSUE

## Bight partnerships to expand understanding of acidification

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

The paired chemistry and biology data sets – which will eventually span eight sampling quarters – will offer unprecedented insights into the pace at which OA conditions are changing in the Southern California Bight, as well as enable researchers to directly compare Bight OA changes to West Coast-wide trends.

The coordinated sampling effort, which kicked off in July, is the product of a joint partnership between the SCCWRP-facilitated Bight program and the National Oceanic and Atmospheric Administration (NOAA), California Cooperative Fisheries Investigations (CalCOFI) and Applied California Current Ecosystem Studies

(ACCESS) Program. Before the partnership, the programs sampled OA chemistry data only at various specific locations along the West Coast, and had never coordinated to produce both comparable OA chemistry and biology data.

OA researchers and managers have long cited improved coordination among West Coast OA monitoring programs as a key goal to work toward. In 2016, the [West Coast Ocean Acidification and Hypoxia Science Panel](#) – which included two SCCWRP scientists – recommended, among other things, that West Coast monitoring programs work together to generate more spatially and temporally rich data sets on OA's West Coast trajectory.

Robust OA data sets are foundational to improving understanding of which marine habitats will be disproportionately affected by OA and which actions managers should take to mitigate and offset OA's intensifying effects.

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**Cover photo:** A field crew aboard a NOAA research vessel deploys a plankton net to capture pteropods and other small plankton during a 2021 West Coast ocean acidification monitoring survey. The Southern California Bight Regional Monitoring Program has partnered with NOAA and two other marine monitoring groups to produce comparable data sets.

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### Calendar

- Thursday, August 5**  
CTAG quarterly meeting  
(Remote participation only)
- Friday, September 3**  
Commission meeting  
(Remote participation only)

The four-way partnership, which was forged over the past year, was largely a fortuitous consequence of delays caused by the COVID-19 pandemic. Originally, the OA element of Bight '18 had planned to coordinate with NOAA's West Coast Ocean Acidification Survey only. But as a result of a year-long interruption in the planned sampling effort, SCCWRP and the Bight program had additional time to coordinate and plan with CalCOFI and ACCESS.

The end result is that all four groups are coordinating their OA chemistry sampling efforts, and all four groups are adding OA biology sampling to their programs. Additionally, the Bight program and CalCOFI are leveraging their OA biology sampling effort to also explore how to use the DNA that organisms have shed into their environment – known as environmental DNA, or eDNA – as a potential alternative for monitoring vulnerable marine communities.

Traditional OA biology sampling involves collecting certain sentinel organisms – including tiny sea snails known as pteropods – that are sensitive to changing seawater chemistry, then analyzing them under a microscope for signs of impairment to growth and development. Bight '18 test-drove and validated pteropod collection and analysis methods during an initial 2019-2020 sampling event, just prior to the start of the pandemic.

This biological monitoring will be coupled with OA chemistry sampling, which



**SCCWRP's Kelcey Chung, traveling aboard a NOAA research vessel during a summer 2021 West Coast ocean acidification monitoring survey, removes pteropods from the cod end of plankton nets to assess shell condition. The Southern California Bight Regional Monitoring Program is partnering with NOAA and two other West Coast marine monitoring groups to produce the most comprehensive picture to date of how vulnerable marine organisms, including pteropods, are being affected by ocean acidification.**

involves taking measurements of multiple chemical properties of seawater at various depths, including pH, carbonate saturation and conductivity.

When researchers couple OA chemistry and biology data that have been collected in tandem, they're able to improve understanding of how changing seawater

chemistry conditions manifest as adverse biological effects in vulnerable marine organisms. These insights are particularly important as researchers work to model and predict how West Coast OA conditions will change over time.

For more information, contact Dr. [Karen McLaughlin](#).

## Scientific foundation established to question California shellfish water-quality objective

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

During the two-year study, which was completed in the spring, researchers found

that bacterial and pathogen levels in Newport Bay do not correlate with potentially unsafe levels of viral pathogens found in bivalve shellfish harvested from the bay. The existing water-quality objective for recreational shellfish – abbreviated SHEL – is intended to protect recreational shellfish harvesters by limiting

bacterial levels in coastal waters where shellfish can grow.

Based on the findings of the study – which was conducted during the dry summer months – researchers have begun planning for a second phase, which involves largely repeating the study during wet weather. Newport Bay bacterial levels tend to be





A SCCWRP field crew deploys oysters in cages in specific locations across Newport Bay in Orange County for a study examining whether the bacterial water-quality numeric objective designed to protect the health of people who consume shellfish from the bay has been appropriately set. Findings from the first phase of the study have established a scientific foundation for questioning the appropriateness of the objective.

higher during wet weather as stormwater runoff flows through the bay to the coastal ocean.

The outcomes of the back-to-back studies are expected to help inform decision-making about a looming regulatory compliance deadline regarding Newport Bay's SHEL objective. Under Newport Bay's fecal coliform TMDL (total maximum daily load), the watershed's stormwater discharge permittees face a December 2022 deadline to meet the SHEL objective. Newport Bay, which will be the first water body in California to reach an enforceable compliance deadline for SHEL, fails to

meet the objective year-round at certain locations in the Bay.

The Santa Ana Regional Water Quality Control Board is among the regulatory agencies that have questioned whether the commercial shellfish sanitary standard – set nearly a century ago and not validated using local shellfish data – is supported by a sufficient technical foundation. The State Water Resources Control Board, meanwhile, has identified the SHEL standard as a strategic priority to address.

To protect consumers of recreationally harvested shellfish in Newport Bay and

elsewhere, California presently uses the numeric food safety standard as the ambient water quality objective.

The SHEL water quality objective is significantly more difficult to achieve than California's bacterial water-quality objective designed to protect the health of beachgoers, known as the REC-1 objective. The REC-1 objective caps monthly median fecal coliform counts in the water column – a proxy for potential pathogenic contamination – at 200 MPN/CFU per 100 mL, among other measures.

By contrast, the SHEL objective caps monthly median fecal coliform counts at 14 MPN per 100 mL.

Newport Bay recreational beaches are largely in compliance with REC-1 water-quality objectives during the popular summer beachgoing months, although they often exceed REC-1 objectives during wet weather.

During the Newport Bay study's first phase, oysters were placed in cages in Newport Bay, then harvested at different time points over a six-week period. Researchers measured viral pathogens and fecal bacterial indicators in the oysters' tissue, as well as simultaneously collected water samples to quantify contaminants that the filter feeders would have been exposed to.

The findings of the dry-weather study will be published in a forthcoming technical report and journal manuscript. The wet-weather work is expected to be launched in winter 2022-2023.

For more information, contact Dr. [Amy Zimmer-Faust](#).

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

A group of international experts on aquatic microplastics pollution has reached consensus on a recommended framework that California could use to implement health-based thresholds that explain when microplastics contamination at different

levels can be expected to trigger adverse biological effects in aquatic life.

The proposed management framework, which will be formally unveiled during a public webinar meeting on September 8,

2021, features four numeric thresholds for microplastics that, when exceeded, would trigger specific follow-up management actions, such as targeted microplastics monitoring, initiation of mitigation

strategies, or posting of fish consumption advisories.

The framework, along with the initial proposed thresholds that are aligned to it, could help inform the ongoing development of a comprehensive California management strategy for mitigating the ecological risks of microplastics pollution in coastal marine ecosystems. The California Ocean Protection Council is required under Senate Bill 1263 to develop this microplastics ocean management strategy by the end of 2021.

The framework and thresholds are the product of nine months of deliberations by microplastics researchers from around the world; the participants convened virtually through the [Microplastics Health Effects Workshop](#), a multi-component event co-hosted and facilitated by SCCWRP that began last fall.

While the microplastics experts who participated in the workshop were able to reach consensus on recommendations for how to set health-based thresholds for aquatic life, they were not able to develop

similar recommendations for setting thresholds for humans who consume drinking water.

The experts concluded that existing human health data are still too limited to be able to propose numeric microplastics thresholds for drinking water. Instead, the experts developed a conceptual framework into which human health-related microplastics thresholds could be subsequently developed, and provided recommendations on how to design studies capable of generating the data necessary to develop these thresholds in the future.

The health effects of microplastics exposure is not the only area that researchers have been studying. In parallel with the Microplastics Health Effects Workshop, an international group of microplastics experts also has been working to ensure researchers and managers worldwide are using robust, standardized methods to measure microplastics.

In June, a group of 40 laboratories in six countries completed [a SCCWRP-facilitated](#)

[intercalibration study](#) that compared five different measurement methods. The findings of the intercalibration study are expected to inform the development of a draft policy that will require microplastics to be monitored in drinking water; the draft policy is expected to be released by the end of 2021.

In developing proposed microplastics health-based thresholds for aquatic life, the scientific experts decided to focus on two relevant pathways by which aquatic organisms can be adversely impacted due to microplastics exposure:

- » **Food dilution:** When fish and other aquatic organisms ingest microplastics, the particles can cause false satiation and reduced nutrient absorption.
- » **Tissue translocation:** When tiny microplastics particles less than 100 micrometers migrate from the gut into other tissues, the particles can trigger oxidative stress and tissue damage.

For both of these pathways, researchers derived health-based thresholds using a method known as Species Sensitivity Distribution, which is commonly used in risk assessment to determine pollutant levels that will protect 90-95% of exposed species from adverse biological effects.

The microplastics experts also estimated the levels of uncertainty associated with the microplastics thresholds they proposed, concluding that uncertainty levels were moderate and that more data are needed to improve confidence.

The threshold-setting approach and initial set of numeric thresholds will be described in a forthcoming journal publication, as well as during a public webinar meeting scheduled for September 8, 2021. To register for the webinar, go to the [Microplastics Health Effects Workshop page](#).

For more information, contact Dr. [Alvina Mehinto](#) or Dr. [Leah Thornton Hampton](#).



Image courtesy of Kennedy Buccl, University of Toronto

Fish larvae that have been exposed to increasing concentrations of microplastics in a University of Toronto laboratory accumulate the particles in their digestive tract; the particles appear as black flecks visible through the larvae's largely transparent bodies. SCCWRP helped facilitate an international effort to build scientific consensus on the thresholds at which aquatic organisms experience adverse health effects from microplastics exposure.



# DNA-based community fingerprinting used to link Mexican sewage to U.S. beach pollution

SCCWRP and its partners have tracked sewage from a wastewater treatment plant in Mexico to south San Diego County beach water – a proof-of-concept study that illustrates the power of using a next-generation, DNA-based technology known as community fingerprinting for linking fecal contamination to specific sources.

During the cross-border study, which was [published online](#) in provisional form by the journal *Frontiers in Microbiology* in July, researchers found that the genetic microbial community signature of a Tijuana treatment plant is also present along a 12-mile stretch of coastline spanning the U.S.-Mexico border.

The fecal contamination follows a predictable dilution gradient that is consistent with south swell ocean currents. The San Antonio de Los Buenos treatment plant discharges partial primary-treated effluent through a Tijuana outfall to the coastal ocean.

The study's main conclusions are consistent with the findings of a research team at the Scripps Institution of Oceanography that [used an ocean currents model](#) to show that the Tijuana wastewater plume could be reaching San Diego beaches during south swell events.

The three-year study marks one of the first efforts in Southern California to use DNA-based community fingerprinting technology to differentiate among specific infrastructure sources where human fecal contamination could be originating.

Community fingerprinting involves looking for unique overall genetic patterns in the microbial community associated with specific sources or types of infrastructure, such as treatment plants, sewer pipes and storm drain pipes. When these genetic signatures are detected downstream, researchers can use the signal to link fecal contamination to a specific source.

SCCWRP and its partners are applying the same community fingerprinting approach to help investigate whether the human



SCCWRP's Dr. Amy Zimmer-Faust collects a water sample at the site where Mexico's San Antonio de los Buenos treatment plant discharges partial primary-treated effluent into the coastal ocean. Researchers used DNA-based community fingerprinting technology to help link this sewage to fecal contamination in San Diego County during south swell events.

fecal contamination found in San Diego-area waterways [can be linked to sanitary sewer pipes](#); this study is ongoing.

The cross-border study was motivated by reports from beachgoers and lifeguards at Imperial Beach – just north of the border – about persistent sewage odors during south swell events.

During the study – completed in partnership with the U.S. Environmental Protection Agency and the County of San Diego, among others – beach water samples were collected along a 12-mile stretch of coastline on summer days when coastal swells travel south to north. Researchers analyzed the samples to look for the genetic signature found at the Tijuana treatment plant; they also used the HF183 genetic marker to confirm that the fecal contamination was from a human source.

Researchers were able to detect similar trends using both the community fingerprinting and HF183 analyses, measuring the contamination gradient as far north as Silver Strand State Beach, which is north of Imperial Beach and about 15 miles north from the Tijuana treatment plant outfall.

The cross-border study has served to help validate decisions by public health officials in Imperial Beach to routinely post beach advisories during south swell events. The study's findings also have helped inform more focused conversations in Mexico about how to reduce fecal pollution loading from the Tijuana treatment plant.

For more information, contact Dr. [Amy Zimmer-Faust](#).

# Updates by Thematic Area

SCCWRP Research Themes **BIOASSESSMENT** • **ECOHYDROLOGY** • **EUTROPHICATION** • **CLIMATE CHANGE** • **SEDIMENT QUALITY** • **CONTAMINANTS OF EMERGING CONCERN** • **MICROBIAL WATER QUALITY** • **STORMWATER BMPs** • **REGIONAL MONITORING**

## BIOASSESSMENT

### SCCWRP asked to host national workshop on transitioning eDNA to management applications

SCCWRP has been asked to host a national scientific workshop next year focused on helping water-quality managers make use of the DNA that aquatic organisms shed into their environment – known as environmental DNA, or eDNA – to better understand marine biodiversity.

The [2nd National Workshop on Marine eDNA](#), scheduled for February 1-4, 2022, will work to identify research gaps necessary to incorporate eDNA technology into environmental management, as well as strengthen partnerships among researchers and managers.

eDNA-based monitoring has the potential to serve as a cost-effective complement and/or alternative to traditional morphology-based monitoring, which revolves around sampling specific types of aquatic organisms. eDNA has the potential to offer insights about a broader range of organisms, and with greater speed and accuracy than traditional approaches.

The workshop is scheduled to be an in-person meeting at SCCWRP, with select portions available for remote participation. Registration is [now open](#) for the workshop.

and count harmful algal bloom (HAB) species in marine waters, part of an [ongoing pilot study](#) to develop a statewide early-warning system for coastal HABs.

Work on the software, which began this spring, will support development of a pilot network for HABs monitoring that will use special underwater microscopes to provide a continual stream of information on the types and abundance of HAB species.

Already, two Imaging FlowCytobot (IFCB) units have been successfully deployed – at Del Mar mooring in San Diego and Newport Beach Pier in Orange County – to begin capturing hourly images of phytoplankton a few meters beneath the water's surface. A third unit is monitoring offshore waters, and five more units will be deployed during the pilot project.

The real-time stream of HABs data generated through this network has the potential to dramatically improve water-quality managers' ability to predict when a bloom event is imminent.

### National HABs symposium co-convened by SCCWRP attracts more than 300 participants

A special national scientific meeting on harmful algal blooms (HABs) that was co-convened and co-facilitated by SCCWRP attracted more than 300 researchers, students and managers over a three-day period in May.

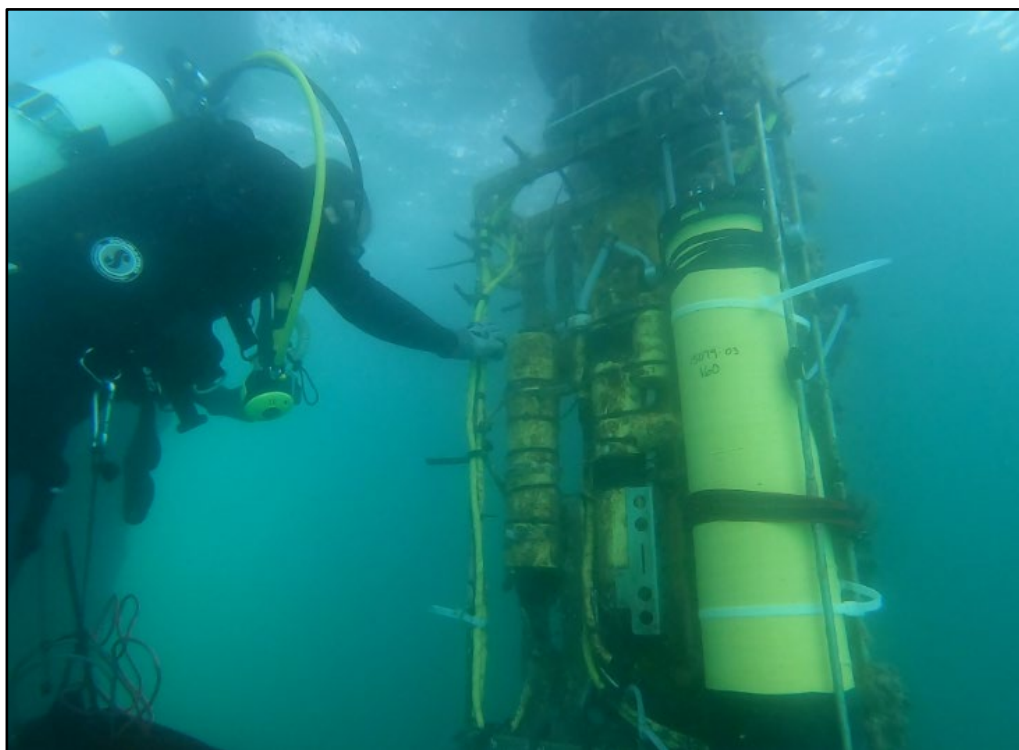


Photo courtesy of Melissa Carter, Scripps Institution of Oceanography

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

## EUTROPHICATION

### HABs image recognition software under development to support monitoring network

SCCWRP and its partners have begun working to develop image recognition software that can autonomously identify



The virtual meeting, titled the [10.5 U.S. Symposium on Harmful Algae](#) because it was held between the National HAB Committee's 10th and 11th biennial symposia, covered numerous managerially relevant HAB topics, including approaches to monitor, manage and mitigate HABs, HAB ecophysiology, and diversity and the impacts of HABs on human and wildlife health.

More than 20% of registrants were from state management agencies, and 45 U.S. states and 10 countries were represented among attendees.

Multiple SCCWRP staff and SCCWRP member agencies presented on ongoing projects, including the HABs element of Bight '18, cyanotoxin surveys in Los Angeles-area recreational lakes, cyanobacterial diversity in Clear Lake in Northern California and predictive domoic acid modeling.

## Three L.A.-area lakes the focus of intensive sampling to better understand bloom events

SCCWRP has selected three Los Angeles-area lakes that will be the focus of intensive sampling this summer to better understand the underlying factors that promote ecologically disruptive cyanobacterial bloom events and how these events unfold.

The three lakes – Machado Lake, Lake Piru and Legg Lake – were selected from among 17 recreational lakes where HAB (harmful algal bloom) sampling activities were conducted in the days surrounding the popular Labor Day holiday weekend last year.

During the sampling, which will be conducted every other week from June to September, researchers will document which specific cyanobacteria and cyanotoxins are being produced during bloom events, as well as track temporal progression of the blooms.

The sampling activities represent an early opportunity to test-drive elements of a proposed statewide strategy for monitoring harmful algal blooms (HABs) in freshwater environments. The strategy, which calls for significantly boosting



Runoff from a parking lot drains to a bioretention system containing special engineered soil media designed to remove contaminants. A SCCWRP-hosted international conference scheduled for January 2022 will provide a forum for advancing modeling of urban stormwater drainage systems.

capacity to track freshwater HABs in California, was [published this spring](#).

## Second sampling phase launched to study cyanotoxin-producing blooms in Northern California lake

SCCWRP and its partners have launched the second sampling phase of a two-year study investigating the environmental and genetic factors that are driving the proliferation of ecologically disruptive, toxin-producing cyanobacterial blooms in Northern California's Clear Lake.

The study, which kicked off in fall 2019, will use state-of-the-art remote sensing and molecular methods to gain insights into when, where and why the blooms are occurring, as well as the genetic potential of cyanobacterial species to produce different types of cyanotoxins. Clear Lake is California's largest freshwater lake; concentrations of the microcystin toxin have been above the state's trigger levels for recreational uses in five out of the past six years.

The methods and technologies being tested in Clear Lake will help inform similar efforts statewide to better understand how managers can mitigate and prevent cyanobacterial blooms.

### STORMWATER BMPs

## SCCWRP-hosted stormwater drainage conference soliciting abstracts

A SCCWRP-hosted international conference next year that will focus on improving modeling of urban stormwater drainage systems has begun soliciting abstracts for presentations, workshops and special sessions.

The triennial [Urban Drainage Modeling Conference](#), scheduled to take place January 10-12, 2022 at SCCWRP, will provide a forum for engineers, scientists, and others to advance the modeling work that underlies many routine stormwater planning and permitting activities.

Topics relevant to Southern California will include changing assumptions about historical models due to climate change and fires, as well as Reasonable Assurance Analysis, a type of modeling used to demonstrate whether planned stormwater

BMPs (best management practices) will achieve their intended water-quality improvement targets in the future.

SCCWRP is working closely with the Joint Committee on Urban Drainage to put together the conference, which will allow

attendees to attend in person or via the web. Abstracts are due August 6, 2021. For more information, contact [udm2022@scswrp.org](mailto:udm2022@scswrp.org).

## New SCCWRP Publications

### Journal Articles

[Bednarsek](#), N., P. Calosi, R.A. Feely, R.F. Ambrose, M. Byrne, K.Y. Chan, S. Dupont, J.L. Padilla-Gamino, J.I. Spicer, F. [Kessouri](#), M. Roethler, [M. Sutula](#), [S.B. Weisberg](#). 2021. [Synthesis of thresholds of ocean acidification impacts on echinoderms](#). *Frontiers in Marine Science* DOI:10.3389/fmars.2021.602601.

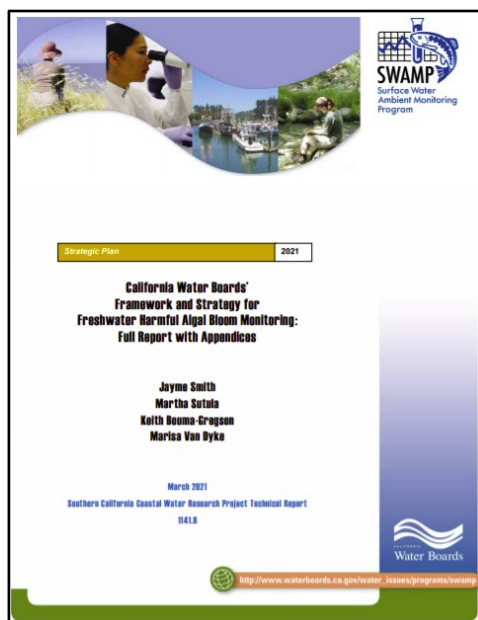
Chaves-Barquero, L.G., B.W. Humeniuk, K.H. Luong, N. Cicek, C.S. [Wong](#), M.L. Hanson. 2021. [Crushed recycled glass as a substrate for constructed wetland wastewater treatment: a case study of its potential to facilitate pharmaceutical removal](#). *Environmental Science and Pollution Research* DOI:10.1007/s11356-021-14483-4.

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

Diner, R.E., D. Kaul, A. Rabines, H. Zheng, J.A. [Steele](#), J.F. [Griffith](#), A.E. Allen. 2021. [Pathogenic Vibrio species are associated with distinct environmental niches and planktonic taxa in Southern California \(USA\) aquatic microbiomes](#). *mSystems* 6:e00571-21.

[Ho](#), M., J.M. Molemaker, F. [Kessouri](#), J.C. McWilliams, T.W. Gallien. 2021. [High-resolution nonhydrostatic outfall plume modeling: Cross-flow validation](#). *Journal of Hydraulic Engineering* DOI:10.1061/(ASCE)HY.1943-7900.0001896.

[Kessouri](#), F., J.C. McWilliams, D. Bianchi, M. [Sutula](#), L. Renault, C. Deutsch, R.A.



The State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP) and SCCWRP have co-authored a new report that outlines a statewide strategy for boosting California's capacity to monitor the growing threat posed by harmful algal blooms (HABs) in California freshwater environments. The report includes both a full-length version and an executive synthesis.

Feely, K. [McLaughlin](#), M. [Ho](#), E. Howard, N. [Bednaršek](#), P. Damien, J. Molemaker, and S.B. [Weisberg](#). 2021. [Coastal eutrophication drives acidification, oxygen loss and ecosystem change in a major oceanic upwelling system](#). *Proceedings of the National Academy of Sciences* DOI:10.1073/pnas.

McClary-Gutierrez, J., Z. Aanderud, M. Al-faliti, C. Duvall, R. Gonzalez, J. Guzman, R. Holm, M. Jahne, R. Kantor, P. Katsivelis, K. Gaardbo Kuhn, L. Langan, C. Mansfeldt, S. McLellan, L. Mendoza Grijalva, K. Murnane, C. Naughton, A. Packman, S.

Paraskevopoulos, T. Radniecki, F. Roman, A. Shrestha, L. Stadler, J.A. [Steele](#), B. Swalla, P. Vikesland, B. Wartell, C. Wilusz, J. Chui Ching Wong, A. Boehm, H. Rolf, K. Bibby, J. Delgado Vela. 2021. [Standardizing data reporting in the research community to enhance the utility of open data for SARS-CoV-2 wastewater surveillance](#). *Environmental Science: Water Research & Technology* d1ew00235j.

[Mehinto](#), A.C., J. [Smith](#), E. Wenger, B. Stanton, R. Linville, B.W. Brooks, M.A. [Sutula](#), M.D.A. Howard. 2021. [Synthesis of ecotoxicological studies on cyanotoxins in freshwater habitats – Evaluating the basis for developing thresholds protective of aquatic life in the United States](#). *Science of The Total Environment* 148864.

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

Niemi, A., N. [Bednarsek](#), C. Michel, R.A. Feely, W. Williams, K. Azetsu-Scott, W. Walkusz, J.D. Reist. 2021. [Biological impact of ocean acidification in the Canadian Arctic: Widespread severe pteropod shell dissolution in Amundsen Gulf](#). *Frontiers in Marine Science* DOI:10.3389/fmars.2021.600184.

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

Rogers, J.B., E.D. [Stein](#), M.W. Beck, K. Flint, A. Kinoshita, R.F. Ambrose.



2021. [Modelling future changes to the hydrological and thermal regime of unaltered streams using projected changes in climate to support planning for sensitive species management](#). *Ecohydrology* DOI:10.1002/eco.2299.

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

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

## Journal Articles (Accepted)

[Walker](#), J.B., E.D. Grosholz, and J.D. Long. In press. Predicting burrowing crab impacts on salt marsh plants. *Ecosphere*.

[Zimmer-Faust](#), A.G., J.A. [Steele](#), X. Xiong, C. Staley, M. [Griffith](#), M.J. Sadowsky, M. Diaz, and J.F. [Griffith](#). In press. A combined digital PCR and next generation DNA-sequencing based approach for tracking nearshore pollutant dynamics along the southwest US/Mexico border. *Frontiers in Microbiology*.

## Technical Reports

[Smith](#), J., M. [Sutula](#), K. Bouma-Gregson, M. Van Dyke. 2021. [California Water Boards' framework and strategy for freshwater harmful algal bloom monitoring: Executive synthesis](#). Technical Report 1141.A. Southern California Coastal Water Research Project. Costa Mesa, CA.

[Smith](#), J., M. [Sutula](#), K. Bouma-Gregson, M. Van Dyke. 2021. [California Water Boards' framework and strategy for freshwater harmful algal bloom monitoring: Full report with appendices](#). Technical Report 1141.B. Southern California Coastal Water Research Project. Costa Mesa, CA.

[Stein](#), E.D., K.T. [Taniguchi-Quan](#), J. Wolfand, E. Gallo, K. [Irving](#), D. Philippus, R. Abdi, V. Hennon, A. Tinoco, P. Mohammadi, A. Rust, T.S. Hogue. 2021. [Process and decision support tools for evaluating flow management targets to support aquatic life and recreational beneficial uses of the Los Angeles River: Los Angeles River environmental flows project](#). Technical Report 1196. Southern California Coastal Water Research Project. Costa Mesa, CA.

# Quarter in Review

## Conference Presentations

Coffin, S., L.M. Thornton Hampton, B. Koelmans, M. Kooi, W. Cowger. Leveraging big data to predict microplastics toxicity for aquatic organisms. 6<sup>th</sup> Annual Water Data Science Symposium. June 28-30, 2021. Via webinar.

Coffin, S., L.M. Thornton Hampton. Untangling the multi-variable microplastics toxicity issue with an interactive data exploration application. 6<sup>th</sup> Annual Water Data Science Symposium. June 28-30, 2021. Via webinar.

Fassman-Beck, E. Modeling Stormwater infrastructure (session moderator). Environmental & Water Resources Institute Water Resources and Environmental Congress. June 7-11, 2021. Via webinar.

Irving, K. Establishing flow targets for management: decision process sensitivity, a challenge for implementation. Society of Freshwater Science Annual Meeting. May 25, 2021. Via webinar.

Irving, K. and K. Taniguchi-Quan. Scaling the effects of flow regimes over space, time, and biology (panel discussion). Society of Freshwater Science Annual Meeting. May 25, 2021. Via webinar.

Mazor, R. A multi-method biomonitoring program for California's variable non-perennial streams. Nottingham-Trent University Temporary Rivers and Streams Meeting. June 22, 2021. Via webinar.

Mazor, R. Development of a three-tiered assessment framework for ephemeral and intermittent streams in the Southwestern US. Society of Freshwater Science Annual Meeting. May 27, 2021. Via webinar.

Mazor, R. Development of a beta streamflow duration assessment method (SDAM) for the Arid West USA. Society of Freshwater Science Annual Meeting. May 27, 2021. Via webinar.

Mazor, R. Ecological assessments of dry-phase temporary rivers (discussion moderator). Nottingham-Trent University Temporary Rivers and Streams meeting. June 22, 2021. Via webinar.

Mazor, R. Freshwater ecosystems in states of transformation: Inclusive approaches to advance temporary river science (session moderator). Society of Freshwater Science Annual Meeting. May 25-27, 2021. Via webinar.

Mazor, R. High-frequency temperature and conductivity loggers as a method to classify perennial, intermittent, and ephemeral flow classes in the Great Plains. Society of Freshwater Science Annual Meeting. May 27, 2021. Via webinar.

Mehinto, A. Bioanalytical Tools for Water Quality Monitoring: Assessing the occurrence and potential toxicity of endocrine disrupting chemicals in California waters. 6<sup>th</sup> Biennial North American Society for Comparative Endocrinology. May 25-27, 2021. Via webinar.

Smith, J., D. Shultz, M.D.A. Howard, B. Du, S. Theroux, D. Caron. Diversity of cyanobacteria and cyanotoxins in Southern California recreational waterbodies. World Microbe Forum. June 20-24, 2021. Via webinar.

Stein, E. Regional and local work on climate change effects on coastal wetlands. Inaugural International Workshop on Intermittent Estuaries in a Changing Climate. June 15-18, 2021. Via webinar.

Taniguchi-Quan, K. A functional flows decision support approach for watershed prioritization and flow management. Society of Freshwater Science Annual Meeting. May 25, 2021. Via webinar.

Theroux, S. DNA methods and standardization (panel participant). International Workshop on Environmental Genomics. June 18, 2021. Via webinar.

Thornton Hampton, L.M., A. Mehinto, C. Wong, S. Weisberg. Microplastics in the environment: Challenges and opportunities (panelist). Optical Society (OSA) Imaging and Applied Optics Congress. July 21, 2021. Via webinar.

## Conference Posters

Castorena, R., D. Shultz, V. Phonsiri, V. Renick, J. Smith. Methods Towards Measuring the impacts and cycling of domoic acid in benthic environments. 10.5 U.S. Symposium on Harmful Algae. May 25-27, 2021. Via webinar.

Moreno, A.R., C. Anderson, R.M.K. Kudela, F. Kessouri, M. Sutula, J. Smith, D. Daniele Bianchi. Estimating Pseudo-nitzschia domoic acid production in a changing world. 10.5 U.S. Symposium on Harmful Algae. May 25-27, 2021. Via webinar.

Shultz, D., S. Theroux, B. Du, W. Lao, E. Duncan, J. Smith. Cyanobacterial blooms

and eutrophication in recreational lakes near Los Angeles, CA. 10.5 US Symposium on Harmful Algae. May 25-27, 2021. Via webinar.

## Other Presentations

Fassman-Beck, E. Translating green infrastructure research to practice. American Society of Civil Engineers Capital Branch (Oregon) Seminar Series. May 20, 2021. Via webinar.

Schiff, K. San Diego River investigative order and exfiltration from sanitary sewers. California Association of Sanitation Agencies. May 19, 2021. Via webinar.

Schiff, K. Southern California monitoring of trash and debris. Los Angeles County Department of Public Works. July 13, 2021. Via webinar.

Schiff, K. San Diego River investigative order and exfiltration from sanitary sewers. San Diego Metro Technical Advisory Committee. July 21, 2021. Via webinar.

Schiff, K. Stormwater runoff effects on Santa Monica Bay. Department of Toxic Substances Control Public Workshop on Motor Vehicle Tires Containing Zinc Priority Product Proposal. July 28, 2021.

Stein, E. Decision support tools developed to support decisions on the Wastewater Change Petition process for the Los Angeles River Environmental Flows project. State Water Resources Control Board. May 18, 2021. Via webinar.

Stein, E. Los Angeles River environmental flows project. Los Angeles County Department of Public Works. June 16, 2021. Via webinar.

Stein, E. Southern California Water Coalition (SCWC) Stormwater Task Force on Los Angeles River environmental flows project. June 24, 2021. Via webinar.

Taniguchi-Quan, K. New study to evaluate vulnerability of streams to hydrologic alteration across San Diego Region. San Diego Monitoring & Management Coordination Meeting. June 23, 2021. Via webinar.

Taniguchi-Quan, K. Los Angeles River flows project: Decision support tools for flows in the Los Angeles River. Re-inventing the Nation's Urban Water Infrastructure (ReNUWIt) Spring Meeting. May 27, 2021. Via webinar.

Theroux, S. Molecular methods standardization for biomonitoring and bioassessment. California Environmental Laboratory Accreditation Program (ELAP) Conference. June 2, 2021. Via webinar.

Wong, C.S. Intercalibration study to support microplastics monitoring and methods accreditation in drinking water. California Environmental Laboratory Accreditation Program (ELAP) Conference, June 2, 2021. Via webinar.

Wong, C.S. Microplastics measurement intercalibration study for drinking water. ThermoFisher Global Microplastic Symposium. April 15, 2021. Via webinar.



# SCCWRP Personnel Notes

## New Faces



**Dan Ortiz**, who recently graduated from California State University, Fullerton with a B.S. in computer science, started in May as a Research Technician

supporting SCCWRP's IT infrastructure. His responsibilities encompass both network and programming work.

## Promotions



**Robert Butler**, who has been working as a Research Technician on SCCWRP's IT team for the past two years and started as a part-time Laboratory

Assistant in 2018, was promoted in July to Senior Research Technician.



**Dr. Karen McLaughlin**, who has been working as a Senior Scientist in the Biogeochemistry Department and began her SCCWRP career in

2007, was promoted in July to Principal Scientist.



**Dr. Jayme Smith**, who has been working as a Scientist in the Biogeochemistry Department since 2018, was promoted in July to Senior Scientist.



**Dr. Joshua Steele**, who has been working as a Scientist in the Microbiology Department since 2014, was promoted in July to Senior Scientist.



**Dr. Amy Zimmer-Faust** who has been working as a Scientist in the Microbiology Department since 2018, was promoted in July to Senior Scientist.

## Scientific Leadership

**Dr. Elizabeth Fassman-Beck** has been appointed to the Technical Advisory Committee for the San Francisco Estuary Institute's Next Generation Urban Greening project.

**Dr. Elizabeth Fassman-Beck** has been appointed to the Advisory Group for Accelerate Resilience LA's Building Consensus Around Balanced Watershed Projects.

**Dr. Elizabeth Fassman-Beck** was appointed the external examiner for the Ph.D. dissertation defense of Zhangjie Peng at the University of Sheffield, held in June 2021.

**Dr. Jayme Smith** has been elected a voting member of the National Harmful Algal Blooms Committee.

**Dr. Eric Stein** was appointed co-organizer of the Inaugural International Workshop on Intermittent Estuaries in a Changing Climate, held June 15-18, 2021 via webinar.

**Dr. Eric Stein** has been appointed editor for a special issue of the journal *Water* titled "New Perspectives and Directions in Wetland Bioassessment and Monitoring."

**Dr. Martha Sutula** has been appointed co-chair of the Coastal and Estuarine Research Federation 2023 Conference, to be held in Portland, Oregon.

**Dr. Martha Sutula** has been re-appointed to the National Academy of Sciences Committee on Independent Scientific Review of Everglades Restoration Progress.

**Dr. Stephen Weisberg** has been appointed to the Science Advisory Board of the National Oceanic and Atmospheric Administration.

**Dr. Charles Wong** has been appointed Managing Guest Editor for a virtual special issue of the journal *Chemosphere* titled "Informing methods for detecting and quantification of microplastics through the lens of a global intercalibration exercise."

## Departures

**Valerie Raco-Rands**, who has worked as a SCCWRP Research Technician since 1979, retired in July. She is SCCWRP's longest-serving staff member, completing 42 years of service at SCCWRP.

**Ellie Wenger**, who has been working as a Research Technician in the Chemistry Department since 2018, left SCCWRP in May to take a research position with Cedars-Sinai.

CTAG SPOTLIGHT

# Scientist enjoys service on technical committees

At the Santa Ana Regional Water Quality Control Board, Dr. Jason Freshwater is constantly interfacing with external agencies through membership on their technical committees and workgroups.



**Dr. Jason Freshwater**

He's part of committees ranging from the Southern California Dredge Material Management Team, to the National Oceanic and Atmospheric Administration's Offshore Aquaculture Interagency Workgroup, to the Southern California Bight Regional Monitoring Program's Technical Advisory Committees.

Across all these groups, Freshwater enjoys looking for opportunities to collaborate on issues of mutual interest – as well as simply broadening his own horizons.

"We all share a lot of similar problems – sediment toxicity, bacteria, monitoring, impaired water body listing – so it's important for us to be talking to each other," said Freshwater, who works in the Regional Board's Coastal Planning Section. "Serving on these committees is intellectually novel for me – I get to learn about so many things that I wouldn't have known about otherwise."

Freshwater started in April as a CTAG Representative, replacing Jason Bill, who left the Santa Ana Regional Board to take a position with another agency.

Freshwater's primary job is working on planning issues related to a bacterial TMDL (total maximum daily load) for Newport Bay, as well as a TMDL for legacy pesticides in San Diego Creek and Newport Bay. He looks forward to serving on CTAG because of the opportunities to find synergies with the other committees and workgroups on which he already serves.

"CTAG is really an extension of what I've already been doing," he



**Dr. Jason Freshwater hikes along the San Gorgonio Mountain Trail during a 2018 backpacking trip in the San Bernardino National Forest.**

## Jason Freshwater, Ph.D.

**Job:** Environmental Scientist, Santa Ana Regional Water Quality Control Board (since 2016)

**SCCWRP role:** CTAG Representative (started April 2021)

**Prior jobs:** Environmental Specialist, Arizona Department of Environmental Quality (2015-2016); Scientific Assistant, U.S. Fish and Wildlife Service (2013); IT/network technician (2011-2013); Senior Clinical Research Associate, Pharmanet (2004-2007); Graduate Researcher, UC San Diego (1998-2004); Clinical Research Associate, Quintiles Pacific (1996-1998)

**Education:** Ph.D. Molecular Pathology, University of California, San Diego (2004); B.A. Chemistry/Biochemistry, UC San Diego (1993)

**Residence:** Corona

**Hometown:** San Diego

**Hobbies:** Reading classics and graphic novels; hiking; playing video games

said. "A lot of agencies I collaborate with are also associated with SCCWRP – and SCCWRP is a hub of collaboration."

Freshwater's path to a career in the environmental sciences was a circuitous one. After graduating with a degree in Chemistry from UC San Diego, he attended three years of medical school at Boston University before transferring to a doctoral program in Pathology at UCSD.

After working for six years in animal model pre-clinical evaluation of investigational drugs, Freshwater went on to spend five years as a drug development consultant and due-diligence auditor in clinical drug trials. He enjoyed working with professional staff from medical centers and drug companies across the country, but decided he could not maintain a life of constant travel. He also became frustrated with decisions in large pharmaceutical companies that he said can favor interest in profits rather than improvements in patient care.

After reevaluating his personal ethics, he decided to parlay his extensive experience working within regulatory frameworks into a public-service career in environmental protection, initially for the Arizona Department of Environmental Quality for a year, and now for the Santa Ana Regional Board for the past 5-1/2 years.

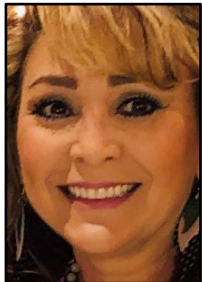
In his spare time, Freshwater is an avid reader of the classics, with Hugo and Dostoevsky among his favorite authors. He also enjoys playing video games – a break from the stress of work.



SCCWRP PARTNER SPOTLIGHT

# Hotel manager hosts SCCWRP's overnight guests

For the past 14 years, Annette Anderson has been working behind the scenes to make sure all of SCCWRP's out-of-town guests in need of hotel accommodations have a stress-free, pleasant stay.



Annette Anderson

As Director of Sales for the Holiday Inn Orange County Airport in Santa Ana, Anderson is SCCWRP's main point of contact at the hotel that SCCWRP recommends to all of its visitors. From negotiating special nightly rates and perks for SCCWRP visitors, to offering complimentary, on-demand hotel transportation to SCCWRP, Anderson is the planning wizard behind it all.

"I love working with SCCWRP – there aren't a lot of clients that make me feel like I'm part of their family," Anderson said. "It makes me feel special when I'm able to engage with a client like this."

Anderson has been SCCWRP's hospitality liaison since the agency moved its headquarters from Westminster to Costa Mesa in 2007. Initially, SCCWRP began working with Anderson when she was at the Holiday Inn Costa Mesa – now a Crown Plaza – but when Anderson switched jobs to work at the nearby Holiday Inn Orange County Airport a few months later, she invited SCCWRP to make the switch with her.

Anderson has been working in management for mid-sized hotels in the central Orange County area for more than 35 years. Her hospitality career began in the mid-1980s, when she took a part-time job as a PBX phone operator at an Anaheim Travelodge near Disneyland. Anderson rose quickly through the Travelodge's ranks to become the Sales Administrator and Catering Manager. Then, she was tapped to be the sales and catering manager for a nearby Ramada, where she worked for seven years. In 1999, Anderson began working for the Holiday Inn Costa Mesa, where she first connected with SCCWRP.



Annette Anderson, crouching near the center of the photo, celebrates the holidays during a 2018 Christmas party at the Santa Ana Elks Lodge, where she is a member.

## Annette Anderson

**Job:** Director of Sales, Holiday Inn Orange County Airport (since 2013)

**SCCWRP role:** Main point of contact for the hotel SCCWRP recommends to all out-of-town visitors

**Prior jobs:** Sales and Catering/Sales Manager, Holiday Inn Anaheim Resort (2012-2013); Sales Manager, Holiday Inn Orange County Airport (2007-2012); Regional Sales Manager and Sales and Catering Manager, Holiday Inn Costa Mesa (1999-2007); Sales and Catering Manager, Carousel Inn and Anabella Hotel Anaheim (1997-1999); Sales and Catering Manager, Conestoga Hotel (1995-1997); Sales and Catering Manager/Tour and Travel Sales Manager, Ramada Maingate Anaheim (1987-1995); Sales Administrator and Catering Manager, Travelodge at the Park Anaheim (1985-1987)

**Residence:** Tustin

**Family:** Son Austin, a recent marketing graduate of Humboldt State University

**Hometown:** Anaheim

**Hobbies:** Membership in Santa Ana Elks Lodge and Anaheim Moose Lodge; attending music concerts, especially '80s rock and roll, and comedy shows; crocheting; watching professional football games

"I love making my clients happy, and I love seeing all the planning that I do with them come full circle," Anderson said.

The COVID-19 pandemic presented Anderson with the biggest challenge of her career. At one point, more than 90% of her hotel's staff was laid off, including Anderson's entire sales team, and Anderson was reassigned to help out in other areas of the hotel, including the front desk, housekeeping, laundry and trash cleanup.

"The pandemic ended up being such a blessing," Anderson said. "It made me more well-rounded, and it gave me new appreciation for the hard work that all of my colleagues do that makes my own job easier."

In her spare time, Anderson is an active member of the Santa Ana Elks Lodge and the Anaheim Moose Lodge – two philanthropic community organizations that keep Anderson busy with a variety of volunteer and social activities. She joined the groups about seven years ago, when her son went off to college and she became an empty nester.

"They're my home away from home – they keep me sane," she said.

## SCCWRP STAFF SPOTLIGHT

# Undergrad researcher sets goal to publish paper

Two years ago, Emily Darin set a personal goal to get a scientific paper published as an undergraduate – and never wavered, even after she ran into roadblocks.



**Emily Darin**

First, every lab she wanted to join when she transferred to Cal State Long Beach in 2019 was full.

Then, even after she came up with an idea for a toxicology study that had the potential to result in a manuscript, she couldn't find lab space on campus to actually run her experiments.

Meanwhile, a faculty mentor suggested to her that a more modest goal might be to present a poster at a scientific conference by the time she graduated.

But Darin remained determined to get a peer-reviewed journal article published, even if she had to go it alone.

"I'm a self-starter, and I like doing things that are a little bit out of the norm," said Darin, whose project chronicled the biological impacts to sand dollar larvae from exposure to an industrial chemical known as BPA (bisphenol A) used in plastics production.

In 2019, Darin applied for and received funding and lab space at San Pedro's Cabrillo Marine Aquarium to do her year-long project independently. Then, she spent another year learning how to write a scientific paper – all on her own time.

Along the way, faculty mentors provided informal guidance and input, as did SCCWRP's Darrin Greenstein, who reviewed her manuscript just before she submitted it.



**Emily Darin explores the underwater reefs of O'ahu's Hanauma Bay during a January 2020 vacation in Hawaii.**

## Emily Darin

**Job:** Research Technician, SCCWRP Toxicology Department (started May 2021)

**Prior jobs:** SCCWRP Laboratory Assistant (2020-2021); Research Assistant, Cal State Long Beach (2020-2021); pool lifeguard, City of Los Angeles (2017-2019); biology tutor, Cuesta College in San Luis Obispo (2017-2018)

**Education:** B.S. marine biology (expected December 2021), California State University, Long Beach; A.S. biology and A.A. liberal studies, Cuesta College (2019)

**Residence and hometown:** San Pedro

**Family:** Boyfriend Jacob, a beach lifeguard; two cats, Felix and Franklin

**Hobbies:** Container gardening at home; surfing

Darin's paper was accepted in April 2021 by the journal *Invertebrate Reproduction and Development*. She is the sole author.

"I get a lot of, 'Are you sure you published a paper by yourself?'" said Darin, who graduates this December with her bachelor's in marine science. "Getting through peer review was the hardest thing I've ever done in my entire life, but I'm so glad I stepped out of my comfort zone."

Darin, who has worked as a Laboratory Assistant in SCCWRP's Toxicology Department for the past 14 months, was promoted in May to a full-time Research Technician. She will support multiple SCCWRP laboratory and data analysis projects, including an ongoing effort to document the health effects in fish exposed to glucocorticoid-mimicking chemical contaminants.

"The decision to work at SCCWRP was so easy – we're doing research to make a change," Darin said.

Darin intends to apply to grad school – likely to study environmental toxicology – as soon as she graduates, and will stay at SCCWRP for about a year. Darin has just one undergraduate class left to take this fall, and none this summer.

Darin's interest in environmental science was formed when she had an opportunity to enroll in a marine biology magnet program in high school. She loved the experience, which enabled her to volunteer and do research at the Cabrillo Marine Aquarium.

In her spare time, Darin is an avid surfer. Her favorite surfing spot is RAT (Right After Torrance) Beach just south of Torrance Beach.

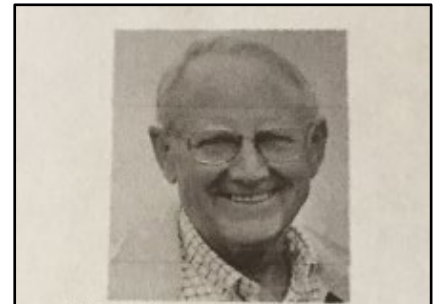


SCCWRP SCENES

# Remembering a brilliant legal mind

B. Richard "Dick" Marsh, who was involved in the creation of SCCWRP and served as SCCWRP's legal counsel for nearly four decades, passed away July 2, 2021 at age 93. Marsh was at the beginning of his legal career when he became SCCWRP's legal counsel in 1969. He'd been working for one year prior as General Counsel for the Sanitation Districts of Los Angeles County – the agency that led efforts to conceptualize and plan for SCCWRP's establishment. Marsh provided invaluable legal perspective during SCCWRP's first four decades, presiding over transformational events such as extending SCCWRP's existence from a three-year research project to a more permanent research agency in the early 1970s, and remaking the composition of the SCCWRP Commission in 1990 to encompass regulatory agencies as well as the wastewater management agencies that founded the organization. Marsh retired from his law firm in 2008; his successor at SCCWRP is Wesley Beverlin.

Clockwise from right: Dick Marsh served as SCCWRP's legal counsel for four decades; Marsh's newspaper obituary chronicling his personal and professional life; and Marsh at a 2008 SCCWRP Commission meeting, seated alongside SCCWRP Executive Director Stephen Weisberg and SCCWRP Administrative Officer Bryan Nece.



**MARSH, Byron Richard "Dick"**

November 10, 1927 - July 3, 2021

Beloved father and grandfather, Dick, passed away from natural causes on July 3rd at age 93. Dick was born in Los Angeles to Wes and Betty Marsh. He grew up in San Marino where he attended South Pasadena/San Marino High School. After high school he graduated from UCLA and then went on to earn a Juris Doctorate at USC Law School. Upon graduation he served in the United States Air Force as a Judge Advocate Officer. He then returned to Los Angeles, where he began a long legal career from which he retired in 2008. He spent the majority of his career as a partner in the law firm of Knapp, Marsh, Jones, and Doran. He was General Counsel for the Los Angeles County Sanitation District from 1968 to 2008.

He was a lifelong member of the Jonathan Club, where he regularly attended Toastmasters, Breakfast Club and club events. He thoroughly enjoyed Sunday brunch with his family. Dick was an avid traveler, opera enthusiast, reader, UCLA football fan and dog lover. In fact, he never met a dog that he did not like. Dick was predeceased by his sister Bettina and is survived by his son David, daughter Diane (George), granddaughters Katherine and Megan, and his former spouse Carolyn. Family remembrance to be held in the future.

