

Ecological Dissertations in the Aquatic Sciences: An Effective Networking and Professional Development Opportunity for Early Career Aquatic Scientists

Patrick T. Kelly, Tom Bell, Alexander J. Reisinger, Trisha L. Spanbauer, Lauren E. Bortolotti, Jennifer A. Brentrup, Christian Briseño-Avena, Xiaoli Dong, Alison M. Flanagan, Elizabeth M. Follett, Julia Grosse, Tamar Guy-Haim, Meredith A. Holgerson, Rachel A. Hovel, Jessica Y. Luo, Nicole C. Millette, Aric Mine, Mario E. Muscarella, Samantha K. Oliver, and Heidi J. Smith

What is ecological dissertations in the aquatic sciences?

Historically, the Association for the Sciences of Limnology and Oceanography (ASLO) has facilitated the exchange of ideas among scientists of different disciplines in the aquatic sciences in order to address contemporary pressing issues and to advance cutting-edge ideas. Ecological Dissertations in the Aquatic Sciences (Eco-DAS; pronounced “eco-days”), is one example of

a symposium providing an opportunity to bring together researchers who are within 1 yr of (before or after) receiving their Ph.D. in the field of aquatic sciences. The weeklong symposium gathers ~ 35 participants and up to five mentors every other year to focus on building cross-disciplinary interactions. In addition to the focus on self-organized collaboration, the symposium offers direct training in team leadership, career panels, discussion of funding opportunities or

funding strategies, practical experience with collaboration, and a variety of mentorship opportunities.

The National Science Foundation (NSF) and other funding sources of Eco-DAS are committed to supporting early career scientists. NSF Biological Oceanography program manager Dr. Dave Garrison feels that programs like Eco-DAS will give scientists a “leg-up” in the development of their scientific careers. Specifically, he states “A lot

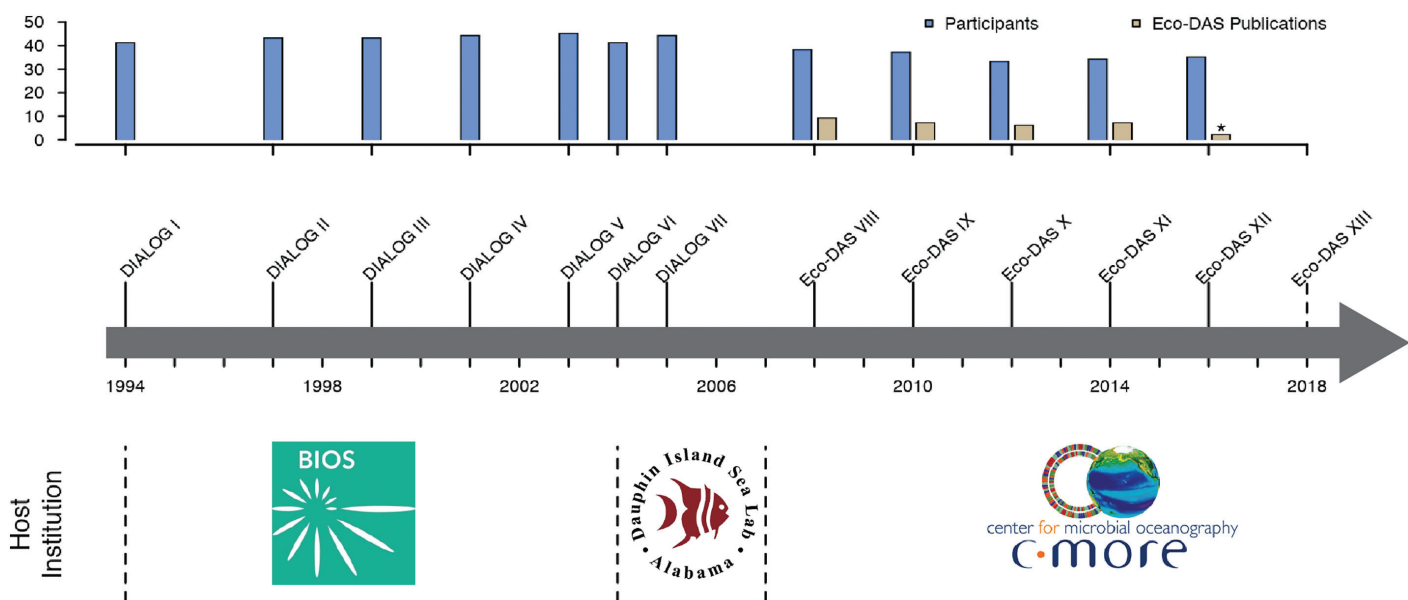


FIG. 1. Timeline showing when various DIALOG and Eco-DAS symposia convened, the host institutions, and demographic data relating to each symposium. Host institutions include the Bermuda Biological Station (BIOS), the Dauphin Island Sea Lab, and the Center for Microbial Oceanography (C-MORE). Publications are listed only for Eco-DAS symposia. The asterisk for 2016 indicates that publications are still in preparation and have not been submitted.

of public money has been invested by the time someone gets an advanced degree, and a bit more spent on things like Eco-DAS are good insurance that the country will get a return on the investments". Eco-DAS supports career development by creating collaborative environments allowing for a range of cutting-edge ideas, and also by providing early career scientists with tools to excel in research, collaboration, and mentoring. Eco-DAS offers a unique career development experience, as group heterogeneity and a diversity of backgrounds and ideas have been demonstrated to be key in creating high-performing collaborative teams (Cheruvilil et al. 2014). To this end, the facilitation of early career oceanographers and limnologists to openly collaborate on ideas they deem of most importance to the aquatic science community is a net benefit, not only to the participants of the program, but to the scientific community at large.

Here, a group of participants from the most recent Eco-DAS symposium (October 2016) take this opportunity to highlight the unique aspects of this program. We provide some historical context in both funding and collaborative potential since its early beginnings in 1993, as well as a short narrative on our experiences at the 2016 Eco-DAS symposium. We hope that this article will underscore the importance

of this collaborative opportunity for early career scientists in the aquatic sciences, as well as motivate current graduate students to start thinking about participating in future iterations.

Historical context

The concept for a program dedicated to graduate student and early career networking in the aquatic sciences originated in 1993 and has since benefited hundreds of early-career scholars. The first grant was awarded to Dr. C. Susan Weiler in 1993 by NSF. Since then, the program has been renewed continuously five times (by Dr. C. Susan Weiler for three renewal grants, and by Dr. Paul Kemp for the recent two renewal grants), summing to a total of approximately \$1.67 million. The primary funding source of Eco-DAS has been and continues to be NSF (Division of Ocean Science for recent grants and Division of Environmental Biology for DIALOG programs; see below), with supplementary funds from ASLO and other funding sources, including NASA, NOAA, ONR, and the European Commission.

Eco-DAS has experienced changes in many aspects in the past two decades. The program was originally named the Dissertations Initiative for the Advancement of Limnology and Oceanography (DIALOG). The name was changed to Eco-DAS during

a change in program leadership starting in 2008 (Eco-DAS VIII). Eco-DAS continues the series of symposia established through the DIALOG program, but moved the program in a new direction by including collaborative writing pieces by the symposium participants (such as this one). The first collaborative chapters were published in ASLO open-access, web-based books. In more recent symposia, Eco-DAS participants have published articles in both peer-reviewed and non peer-reviewed journals, such as *Limnology and Oceanography Bulletin*, *Limnology and Oceanography: Fluids and Environments*, *Limnology and Oceanography Letters*, *Limnology and Oceanography*, and *Oecologia*.

In total, there have been seven DIALOG and five Eco-DAS symposia thus far (Fig. 1). The first five DIALOG symposia were held at the Bermuda Biological Station for Research (BBSR, today BIOS) and DIALOG VI and VII were held at Dauphin Island Sea Lab, Alabama. All Eco-DAS symposia (VIII–XII) have been hosted by the Center for Microbial Oceanography: Research and Education (C-MORE) at the University of Hawaii at Mānoa, Honolulu, Hawai'i. The number of symposium participants varied between 35 and 44, summing to a total of 478 DIALOG and Eco-DAS participants throughout the past two decades. In order to also facilitate international collaborations,

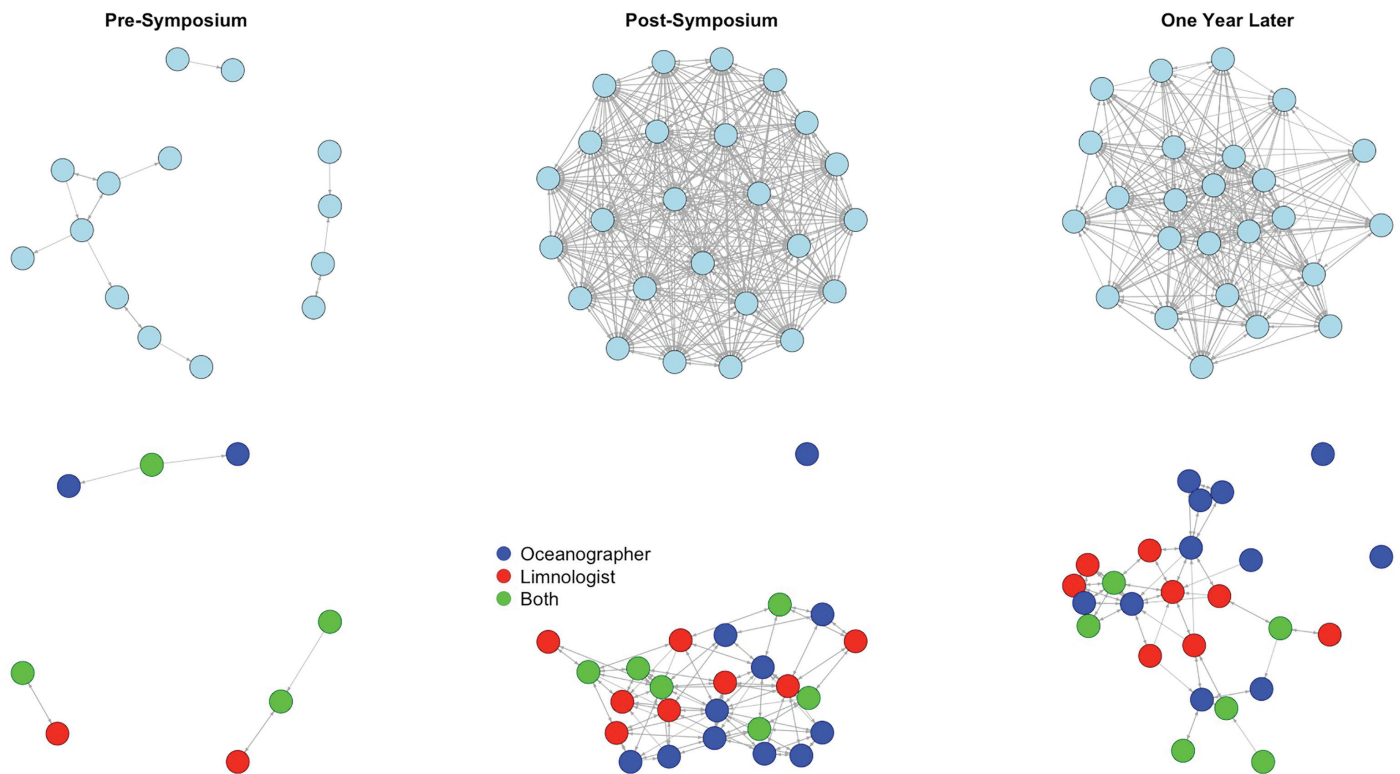


FIG. 2. Network diagrams generated from the 2010 Eco-DAS survey. Top: Responses for “I trust this person’s scientific expertise” only show the connections among participants, but does not show participants with zero connections. Bottom: Responses for “I have collaborated with this person,” indicating primary research field: red, limnologist; blue, oceanographer; green, both. Note: Single unconnected participant post-symposium not able to actively participate due to illness.

the programs have included both US and non-US citizens and participants affiliated with both US and non-US institutions. Most support for Eco-DAS participants from outside the USA is provided by ASLO.

A history of collaboration and networking experiences

One of the primary goals of Eco-DAS is to foster collaboration and promote networking between early career limnologists and oceanographers. The symposium achieves this goal by facilitating interdisciplinary, collaborative manuscripts between the participants. By the end of the weeklong symposium, each participant joins one or more working groups, where they can provide their unique skills and knowledge. The size of each working group varies. Most groups have four to eight members, but some groups involve most of the attendees. As attendees often become involved with more than one group, this creates an interconnectedness among attendees that strengthens the network of scientists. Generally,

developing solid networks leads to broader knowledge, an increased capacity for innovation, more professional opportunities, and greater overall satisfaction with one’s work (Casciaro et al. 2016). The networks formed at Eco-DAS last well beyond the weeklong symposia, and even beyond the working groups. Previous Eco-DAS networks have led to successful grant proposals, eased the uncertainty associated with starting a job at a new institution, and diversified mentorship opportunities for students.

While many of the successful collaborations originating at Eco-DAS fall along traditional discipline lines (e.g., freshwater or marine), the symposium presents a unique opportunity for scientists to address large-scale questions across systems. A past Eco-DAS paper has discussed the challenges and benefits of working across the freshwater-marine divide (Kavanaugh et al. 2013). During the most recent Eco-DAS symposium, multiple large collaborations have emerged to develop meta-analyses or review papers addressing multiple systems. One meta-analysis addresses the power and limitation of

mesocosms in climate change research, and this large effort, including over 16 authors from varied backgrounds, synthesizes literature from freshwater and marine examples (Guy-Haim et al. 2017). A second working group composed of both marine and freshwater scientists is working on a manuscript about how sensor technology is developed and implemented, highlighting technology development and transfer from marine to freshwater systems and vice versa through a review of current optical and molecular sensors, interviews with the inventors of sensor technology, and a case study on how some marine sensors could be used in freshwater systems. A smaller group is synthesizing current knowledge of how changes in nutrient budgets associated with climate change play out along a continuum of freshwater and marine systems; this project also unites researchers working across physical and biological realms. By encouraging collaboration across disciplines, Eco-DAS provides an opportunity for early career scientists to learn about important current work in other fields, cross-pollinate research ideas and

techniques, and advance research on global change in marine and freshwater systems.

Symposium organizers have tracked the development and success of networks and working groups developed during Eco-DAS. Prior to and after each symposium, participants fill out surveys with a variety of questions regarding whether participants are familiar with one another (i.e., previous collaborations; networking at conferences, symposia, or workshops; through published literature). This allows the coordinators of the Eco-DAS program to assess the success of fostering networking and collaboration initiatives. The results of the survey from the 2010 Eco-DAS symposium show how collaboration and trust evolved from pre-symposium to a year later (Fig. 2). Each individual participant expanded their network through attending the 2010 Eco-DAS symposium, and this is true for the more recent symposia as well. Products of these professional networks generally manifest as manuscripts, but some networks have even produced sustained research collaborations and long-term professional connections.

Past participants of Eco-DAS noted the networks they established at the symposium lasted beyond their initial collaborative work and led to diverse professional opportunities. The persistence of these networks can be simple, such as conversations at academic meetings or by seeing a familiar face at a new institution. Upon starting a new postdoctoral position, one past attendee noted that a fellow group member welcomed him to the institution and helped integrate him into social circles. The trials of relocating for relatively short-term positions is common for early career scientists and knowing someone at the new institution can have a positive impact on quality of life and productivity. The networks can also evolve into more tangible professional returns. Another former attendee wrote their first successful NSF award with a fellow Eco-DAS group member. This collaboration continued to flourish with the former attendee sending a graduate student to intern in the other's lab for the summer. Connections like these largely develop only when there are shared interests, trust between members, and unique skills offered by all parties involved. Eco-DAS brings early career aquatic scientists from diverse backgrounds together for a fast-paced week to interact, form collaborative working groups, and rely

on each other to complete novel projects. The symposium format, combined with a remote and memorable meeting location, creates a shared experience for attendees and perhaps facilitates a hot spot and hot moment of creative, collaborative science (Parker and Hackett 2012) that builds long-lasting and fruitful relationships.

The Eco-DAS XII experience

The authors of this article were all participants from the most recent Eco-DAS XII group (October 2016). Overall, the group had various expectations for the goals and the focus of the symposium. Given the long-standing legacy of the Eco-DAS symposium, a majority of participants had someone in their network that had attended a previous symposium, and therefore had some prior expectations for how the week would work. These expectations included an opportunity to meet new people and further develop a professional network, the potential to learn about funding opportunities, manuscript construction with the potential for publication, and a boost to the *curriculum vitae* (we are early career scientists after all). Our high expectations were, for the most part, met in spades. As a result of our attendance, we can look forward not only to a strong network of early career scientists with which to socialize at the next ASLO meeting, but the potential for professional connections that may continue as our research careers mature.

One of the particularly noteworthy moments of the symposium was a discussion of how many of the participants were currently involved in projects with multiple collaborators. A significant number of us indicated that we had already experienced a highly collaborative experience as early career scientists. This likely reflects the increasingly collaborative nature of the field, even amongst graduate students. Despite that experience, many of us were surprised to discover how much easier collaboration and networking was during the symposium, as well as how easily ideas flowed among all participants despite the "salty divide." Particularly striking was the ease of discussion among researchers in sub-disciplines that may be seen as diametrically opposed. For example, one discussion included someone interested in an investigation of the interactions among water flow, particles, and submerged plant distribu-

tions and another studying resource use in marine organisms, which may rely on passive particle transport for nutrient acquisition and dispersal. Another included interactions among researchers studying mixotrophy and auxotrophy in aquatic ecosystems, leading to a fruitful discussion of the role of cryptic processes across the aquatic continuum. These surprising cross-disciplinary interactions led to a diverse range of interesting ideas discussed throughout the week and have the potential to lead to high-impact and thought-provoking manuscripts in the future.

The format of the symposium was designed to maximize the collaborative potential of all 38 participants. Each participant developed a short proposal idea for a manuscript before arriving, or an idea for a collaborative project that could utilize the diverse skillset of those in attendance. In general, these were based on each participant's dissertation work and, as a result, were often specific to a system or theoretical construct. At the symposium, manuscript ideas were presented in groups of three, followed by 15 minutes of discussion with the larger group. This exercise was specifically designed to encourage us to think creatively to make connections among the three proposals, with seemingly little in common, and ultimately to discuss how a collaborative manuscript might materialize. Given the breadth and diversity of research represented in the group (from carbon cycling in small ponds to urban stream contaminants to imaging and sensors in the open ocean), the connections were not always obvious. However, these unconventional pairings often sparked interesting conversation and served as a springboard for future discussions. Through these dialogues, some key ideas emerged that had broad interest within the group and would go on to be developed into more complete ideas for a potential manuscript.

One of the unique benefits of the symposium design and format is that Eco-DAS is comprised entirely of scientists at the same career stage. As peers, participants are immersed in a non-hierarchical atmosphere without the normal pressure for clear and well thought-out ideas that may often accompany PI-led collaborations or a more formal scientific conference. This prompted us to be more open to sharing ideas without the fear of judgment of more senior scientists. The more free-form and discussion-based brainstorming was integral in condensing ideas and the ultimate

design of our working groups, and led to a set of interesting, thoughtful, and sometimes controversial ideas.

The diversity of topics that were ultimately of interest to the most recent Eco-DAS group matched the diversity of participants. Some of the main ideas included big data in aquatic sciences, improved sharing of data collection techniques between limnologists and oceanographers, and the impact of climate change on aquatic ecosystem processes and function. Research questions spanned the aquatic continuum, from small ponds to the large lake ecosystems to coastal wetlands and ultimately the open ocean. These research questions and ideas from the symposium represent topics that early career scientists see as either areas of interest to develop future research, or current gaps in our understanding of theory that can be filled with new statistical or technological techniques. Generally, these research ideas represent where we think the field is heading, and based on the experience that the participants had during their just completed or nearly completed graduate work.

The latter half of the symposium was focused on the development of ideas into potential manuscripts, with the aim of publication in a peer-reviewed journal. This was an opportunity for participants to form groups based on shared interests, further develop an idea into testable hypotheses or a theoretical framework, and chart a path forward as a group. Many of us had extensive collaboration experience as graduate students; however, very few had previous experience in actively leading a research project among peers. While experience in networking and collaboration and the overall tangible outcomes of this symposium will obviously be beneficial for our professional development, it will also benefit the scientific community and society.

In addition to forming collaborative groups and working on proposed manuscripts, the Eco-DAS symposium leverages past participants of the program as well as representatives from NSF and the local research community to form expert panels on a variety of different topics throughout the week. These topics held broad interest among the group, and aimed to provide exposure to the diversity of funding opportunities in aquatic science, various career trajectories (academic, industry, government, and outreach), team-based and open-data science, and the transition from postdoc to

faculty member. There were also opportunities to develop our scientific communication skills, with expert advice from Elisha Wood-Charlson from C-MORE and Ethan Allen, the host of the local science television program “Likeable Science.” These speakers helped us describe our research for the general public, distilling our dissertations into short and relatable “sound bites.” The format of the symposium was such that these panel discussions and the availability of experts transitioned seamlessly into more informal, personalized conversations, covering science communication, funding, collaboration, and general career advice.

Overall, Eco-DAS XII participants would agree that the experience was once-in-a-lifetime, both in terms of the network we built while attending, as well as the skills gained during the symposium. We all had an excellent opportunity to meet scientists from a variety of different backgrounds, discover new areas of research, learn about where the field of aquatic ecology is going, and stimulate discussion and foster ideas about topics in aquatic science. In the tradition of past Eco-DAS, we look forward to keeping this network going. Additionally, as other past participants have done, we are excited to recommend the symposium to any graduate students or postdocs that we may mentor in the future, and to promote this amazing experience to a broader audience through the publication of this article. We believe we left Hawaii as better scientists, and look forward to future generations having the opportunity to participate in a similar experience.

The true test of the efficacy of any collaborative experience is the continued motivation for the project when everyone returns to their home institutions. As early career scientists, the bulk of us are preparing to defend our dissertations, applying for permanent positions, or even starting our own labs or assistant professor positions. Despite this pressure, the excitement for collaborations formed during Eco-DAS has not abated, as this *Bulletin* article can attest. While we do not yet know what the symposium products will be, the majority of participants are involved in two to three projects that are in progress toward becoming fruitful manuscripts. We look forward to sharing these ideas and the outcome of this hard work with the members of ASLO, so stay tuned.

Acknowledgments

We thank the countless organizers for their work in continuing the Eco-DAS program. Specifically, we would thank Paul Kemp, Lydia Baker, Jennifer Kondo, Lori Serikawa, Dave Garrison, Chris Filstrup, Pat Soranno, Elisha Wood-Charlson, Craig Nelson, Rosie Alegado, and Sasha Tozzi for their work on Eco-DAS XII. We also thank the other Eco-DAS participants not included as co-authors in this article for sharing this experience.

Author contributions

All authors contributed to the conception of the work as an outcome of the Ecological Dissertations in the Aquatic Sciences (Eco-DAS XII) symposium held at the University of Hawaii at Mānoa from 23–29 October 2016. After the lead author, authors are listed in three tiers according to contribution. PTK lead the writing of the article. TB, AR, and TS led individual working groups dedicated to specific sections of the article. All other authors are listed alphabetically, and contributed to conceptual framing of the article, data collection, and critically revised the article for publication.

References

- Cheruvilil, K. S., P. A. Soranno, K. C. Weathers, P. C. Hanson, S. J. Goring, C. T. Filstrup, and E. K. Read. 2014. Creating and maintaining high-performing collaborative research teams: The importance of diversity and interpersonal skills. *Front. Ecol. Environ.* **12**: 31–38. doi:10.1890/130001
- Casciaro, T., F. Gino, and M. Kouchaki. 2016. Learn to love networking. *Harvard Business Review*.
- Guy-Haim, T. and others. 2017. What are the type, direction, and strength of species, community, and ecosystem responses to warming in aquatic mesocosm studies and their dependency on experimental characteristics? A systematic review protocol. *Env. Evid.* **6**: 1–6. doi:10.1186/s13750-017-0084-0
- Kavanaugh, M. T., G. W. Holtgrieve, H. Baulch, J. R. Brum, M. L. Cuvelier, C. T. Filstrup, K. J. Nickols, and G. E. Small. 2013. A salty divide within ASLO. *Limnol. Oceanogr. Bull.* **22**: 34–37.
- Parker, J. N., and E. J. Hackett. 2012. Hot spots and hot moments in scientific collaborations and social movements. *Am. Sociol. Rev.* **77**: 21–44. doi: 10.1177/0003122411433763

Patrick T. Kelly, Department of Biology, Miami University, Oxford, Ohio, kellypt2@miamioh.edu

Tom Bell, Earth Research Institute, University of California Santa Barbara, Santa Barbara, California

Alexander J. Reisinger, Cary Institute of Ecosystem Studies, Millbrook, New York

Trisha L. Spanbauer, Department of Integrative Biology, University of Texas at Austin, Austin, Texas

Lauren E. Bortolotti, Institute for Wetland and Waterfowl Research, Ducks Unlimited Canada, Stonewall, Manitoba, Canada

Jennifer A. Brentrup, Department of Biology, Miami University, Oxford, Ohio

Christian Briseño-Avena, Hatfield Marine Science Center, Plankton Ecology Lab, Oregon State University, Newport, Oregon

Xiaoli Dong, Nicholas School of the Environment, Duke University, Durham, North Carolina

Alison M. Flanagan, U.S. Geological Survey, Western Ecological Research Center, San Francisco Bay Estuary Field Station, Vallejo, California

Elizabeth M. Follett, Department of Earth and Environmental Science, Boston College, Chestnut Hill, Massachusetts

Julia Grosse, GEOMAR, Helmholtz Centre for Ocean Research Kiel, Biological Oceanography, Kiel, Germany

Tamar Guy-Haim, GEOMAR, Helmholtz Centre for Ocean Research Kiel, Benthosökologie, Kiel, Germany

Meredith A. Holgerson, Department of Environmental Science and Management, Portland State University, Portland, Oregon

Rachel A. Hovel, School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington

Jessica Y. Luo, National Center for Atmospheric Research, Climate and Global Dynamics Laboratory, Boulder, Colorado

Nicole C. Millette, Northern Gulf Institute, Mississippi State University, Starkville, Mississippi; NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, Florida

Aric Mine, Earth and Environmental Science Department, California State University, Fresno, Fresno, California

Mario E. Muscarella, Department of Plant Biology, University of Illinois at Urbana-Champaign, Urbana, Illinois

Samantha K. Oliver, Center for Limnology, University of Wisconsin-Madison, Madison, Wisconsin

Heidi J. Smith, Center for Biofilm Engineering, Montana State University, Bozeman, Montana