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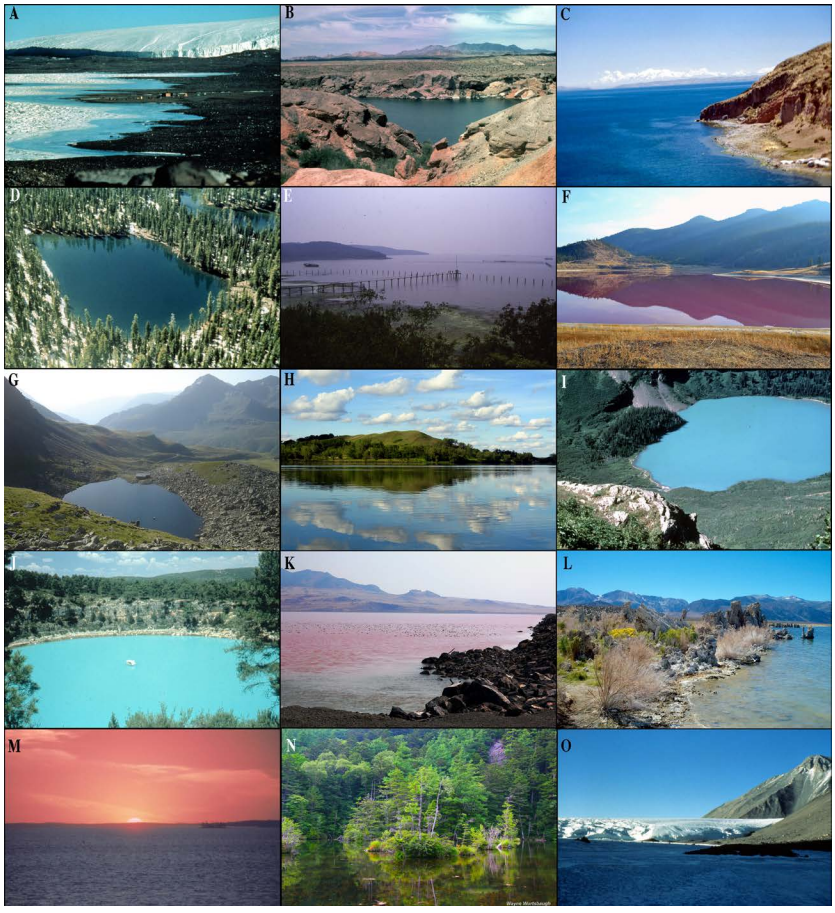
LIMNOLOGY AND OCEANOGRAPHY

# BULLETIN

ASLO

Association for the Sciences of Limnology and Oceanography

## LIMNOLOGY IN THE 21ST CENTURY




Images of lakes from the ASLO Image Library. A. Lake Fryxwell, Antarctica, by D. McKnight, B. Lake Mojave, NV, by D.F Brakke, C. Lake Titicaca, Peru, by W. Wurtsbaugh, D. Lake Notasha, OR, by D.F. Brakke, E. Taihu Lake, China, by W. Wurtsbaugh, F. Bute Lake Kamloops, Canada, by John, G. Gossenköllesee, Austria, by R. Sommaruga, H. Lake Christina, MN, by M.L. Konsti, I. Grinnel Lake, MN, by D.F. Brakke, J. Laguna de La Cruz, Spain, by A. Camacho, K. Great Salt Lake, UT, by W. Wurtsbaugh, L. Mono Lake, CA, by G. Kroh, M. Mille Lacs Lake MN, by D.F. Brakke, N. Myojin-ike Pond, Japan, by W. Wurtsbaugh., O. Lake Hoare, Antarctica, by D. McKnight.

# LIMNOLOGY AND THE PERFECT STORM

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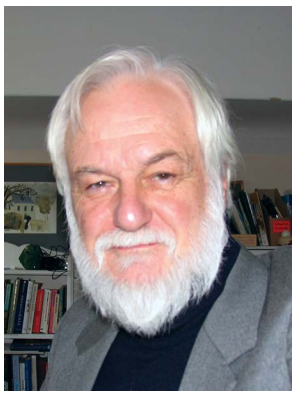

Limnology is a demanding environmental science. To understand lakes and rivers, limnologists have to know things from geology to food growing and land management, with a lot of biology, physics and chemistry on the way. The detail can be daunting; the archive now runs to millions of publications. A distinguished freshwater ecologist once told me that when he went into a bookshop, he became quickly depressed by the welter of new information, and came out without buying anything. I had felt the same way, and was heartened for, nonetheless, he was productive and influential because he saw that there were fewer, larger themes, and that, so long as he dealt with these, most details could be left in the books. One of our problems may be that we are becoming buried in the details of our own particular interests. In the business of making a career, finding funds, surviving in science, worrying about our individual futures (all of them real worries and not to be trivialized), we may sometimes lose the bigger plot that otherwise gives meaning and pleasure. The three articles in this edition of the *L&O Bulletin* are about the bigger plot.

The recently retired chief scientist to the UK government, a population ecologist, John Beddington, has described the world as heading for a 'perfect storm' of climatic, population, food, and water problems. If I take analogy from the book from which the phrase is borrowed, the storm could be devastating. As scientists, a group generally much better trusted by the public than, for example, journalists, businesspeople, and politicians, we have had some influence (much of the sane part of the population, at least, accepts that climate is changing, that rivers and lakes have been much abused and that the ocean is overfished), but not nearly enough to change the way that society is managed so that the storm may be avoided or at least weathered. One reason for this might be in our increasingly isolated approach, our intense digging for more and more arcane details (with the detriment on arcane, not detail) and also the ways in which we organize our own societies.

In the past, scientific societies have been politically influential. The British Association for the Advancement of Science, in the nineteenth and early twentieth centuries, was a force with which to be reckoned, as measured by its role in the acceptance of Darwin's ideas on the one hand, and the creation of a major freshwater laboratory on Windermere on the other; the meetings of the American Association for the Advancement of Science still raise some dust, at least for a day or two, in the world's quality newspapers. But in every capital city, lobby groups much more effectively whisper in the ears of government, covertly feeding their views and using their money to plot the courses that lead us into the heart of the perfect storm. Meanwhile science has split into thousands of small societies, each now to some extent struggling for its own survival and thus deflected from the bigger issues.

Many, perhaps most, scientific societies have declining memberships. Some of the reasons for which they were set up (cheap access to a printed journal; convenient meetings in the subject area) have been usurped: the first by electronic publication and bundling of journals to libraries, which now gives access to almost anything; the second by e mail and SKYPE and a proliferation of small workshops and meetings by many different groups. There remains some sense of collegiality in belonging to a society of like-minded people, but even that is threatened as young people consider the many demands on their cash and the older of us join the cycles of biogeochemistry. You can associate with like-minded people without paying a subscription to do so.

There is also a new trend – of open access publication. Those of us associated with the libraries of large universities or research institutions can find most of what we need without even thinking of the cost. Other people, whose taxes pay for much of the research, and those in less well-endowed countries, can not, and the large profits of commercial journals, subsidized by a largely voluntary system of refereeing and editing, are increasingly seen as unacceptable. At least in the UK, all publications that can be submitted for future assessments of the quality of universities will have to be open access, and the European Commission has indicated its intention to follow. The United States has been more cautious, but the trend will snowball. Unfortunately scientific societies, presently ploughing back into science the surpluses they make from well-established journals, could suffer. Many library subscriptions will disappear, but society-based journals can use their intellectual prestige and favorable pricing structures for their members to compete very effectively for the best papers. We could gain more than we suffer.

But if we are to be faced by a publishing revolution that will certainly change how we operate, perhaps then this is the time also to look outwards at how we are organized. Can we do more to avert 'the perfect storm' as a flotilla of randomly- moving small boats, borne down upon by the battleships of the rich and powerful consumptive industries, or as fewer but bigger ships, or at least by a well-coordinated fleet? Will we be more effective pottering in the safe backwaters of esoteric curiosity or by circling the storm on the open sea?

We have a lot to offer in the aquatic sciences. Our subject demands a long and broad view, and global problems are nothing if not wide-ranging and set in a long history. We know much about the really important issues of the future; our metier is very much a planet that runs on a water-based biological system; we know that economics is ultimately the servant of biogeochemistry. We are not infallible; we have our human subjectivities, but I believe that we are honest people, and despite the cynics among historians, the truth eventually emerges. Yet we allow ourselves to be overridden by the narrow, the selfish and the downright dishonest. The three articles in this issue emphasize the importance of long and broad views, and the urgency of strong and courageous advocacy. Perhaps we should take some cues from them; perhaps we should examine more deeply the ways in which we organize ourselves.

# THE GLOBAL LAKE ECOLOGICAL OBSERVATORY NETWORK (GLEON): THE EVOLUTION OF GRASSROOTS NETWORK SCIENCE

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A grassroots, global network to examine lake function using sensor data? Why not? That was the perspective of Drs. Tim Kratz (limnologist), David Hamilton (limnologist), Peter Arzberger (mathematician), and Fang-Pang Lin (computer scientist) in 2004 when they hatched the idea of the Global Lake Ecological Observatory Network (Fig. 1). Nine years later, with over 380 members from 40 countries, and 50 publications to its credit, GLEON is growing at a rapid pace and pushing the boundaries of the practice of network science. GLEON is really three networks: a network of lakes, data, and people (Fig. 1). While the first two underpin the scientific products and analyses that GLEON members produce (Fig. 2), explicit attention to the people network has served both GLEON science and its members exceedingly well.

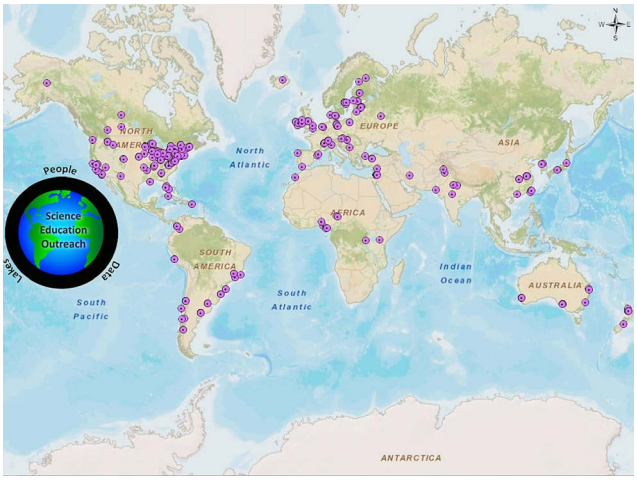


**Fig 1**. GLEON (www.gleon.org) conducts innovative science by sharing and interpreting high-resolution sensor data to understand, predict, and communicate the role and response of lakes in a changing global environment. More than 380 members from 40 countries form networks of people, lakes, and data. GLEON encourages participation across multiple disciplines of environmental science and information technology, by openly and informally sharing ideas, expertise, and data, and by moving ideas to products via working groups. Education, especially the training of early career scientists, and outreach are central to GLEON's activities.

*Lake and Data Network* - Over the past few years, GLEON research has focused on analytical tools for the use of high frequency sensor data in understanding lake function. Analyses of data from a broad spectrum of lakes across the globe have been used to address metabolism and carbon cycling in lakes (Hanson et al., 2011; Solomon et al., 2013), the role of wind and advection in lake physics (Read et al., 2012), the development of models (Staehr et al., 2010; Read et al., 2011; Kara et al., 2012) and response and recovery of lakes to extreme events (e.g., Jennings et al., 2012; Klug et al., 2012; Fig. 2). The diversity of science derives, in part, from the large gradients inherent in the world's lake ecosystems. The power of comparative research is well illustrated by these studies where the importance of lake context—for example, its watershed (Klug et al., 2012), its bathymetry (Read et al., 2012), and its meteorology is revealed. Recently, groups of GLEON members have initiated several large-scale projects and cross-site experiments. One exciting example is the Spring Blitz, a coordinated survey of biology, chemistry, and physics in GLEON lakes around the world during the onset of spring thermal stratification. The GLEON network of sensors in lakes differing in stratification regime is central to the project's design. The overarching goal of the experiment is to test whether lakes with strong stratification in spring develop higher plankton diversity.

*People Network* - How do we accomplish our work? GLEON advances science both synchronously – at annual meetings, and asynchronously – using a variety of cyber-enabled technologies and working group formats (Fig. 3). Face-to-face meetings hosted around the world where attendees roll up their sleeves, gather into working groups, and brainstorm are the primary mechanism by which scientific products are catalyzed and new collaborations are formed. These meetings have been supported, in part, by an NSF Research Coordination Network grant, funds from the Gordon and Betty Moore Foundation, and local meeting hosts. Research costs are born by the members, and in some cases, the organizational infrastructure and collective resources have underpinned research funding initiatives,

both in the US and abroad. Work is sustained through smaller face-to-face meetings complemented by virtual communication. Frequently, graduate students or early career stage scientists take the lead on projects and papers, with later career stage scientists providing guidance and leadership from within.

Attention to organizational structure and operations has enabled GLEON to learn and adapt to the network's needs. Governance and overall leadership are provided by a GLEON-elected, 14-member Steering Committee (SC) with 3-year renewable terms. One seat is reserved for the chair of the GLEON Graduate Student Association (GSA) and another for chair of the GLEON Collaborative Climate Committee (CCC). Both of these committees are central to the vibrancy and operation of GLEON; both also grew organically from members and in response to perceived opportunities or challenges. Over 30% of GLEON members are students, many of whom have led or participated in the analysis and writing for GLEON manuscripts. The GSA organizes some GLEON all-hands' meeting sessions, holds a graduate student workshop to train leadership skills and complex data analysis tools, has facilitated site exchange visits for students to broaden skill sets, and runs the Network Partners Program, which matches mentors (those familiar with GLEON meetings) and mentees (those new to GLEON meetings) for all-hands' meetings. The CCC evolved to guide the activities and advise governance of GLEON, promote diversity of engagement and inclusivity, and explore the best practices of the science of team science. The CCC has been instrumental in such activities as training Working Group facilitators and creating processes that encourage maximum participation and open dialogue by members (e.g., world café –style discussions).

Diverse and distributed leadership for a suite of activities is encouraged throughout GLEON, and we are developing tools and programs to assess the value of network science to early-career, as well as all-career stage scientists. These latter activities are supported both by the RCN and Moore Foundation awards, and through a recent NSF Macrosystems Biology Graduate Student Training award.

The importance of network science: Does network science lead to innovative research? While traditional field-based science remains a hallmark of limnology, there is broad recognition of the need for interdisciplinary science and more extensive collaboration that crosses institutional and even political boundaries. Whether the promises of network science are realized will depend on how well we are able to confront issues of global importance – rapid degradation of water quality, profound changes in biodiversity and invasion by exotic species, and availability of water to support a growing world population. Confronting these issues requires skills in data integration, modeling, and a suite of social skills necessary to harness the communities' resources (Porter et al., 2011). These skills, as well as the training necessary to develop them, are difficult to find at any one institution but are a key attribute of the cumulative expertise and knowledge of GLEON members. Perhaps the best of GLEON's science is just now emerging and is exemplified by a combination of the physical sciences (Read et al., 2012), the ecological sciences (Klug et al., 2012; Solomon et al., 2013),

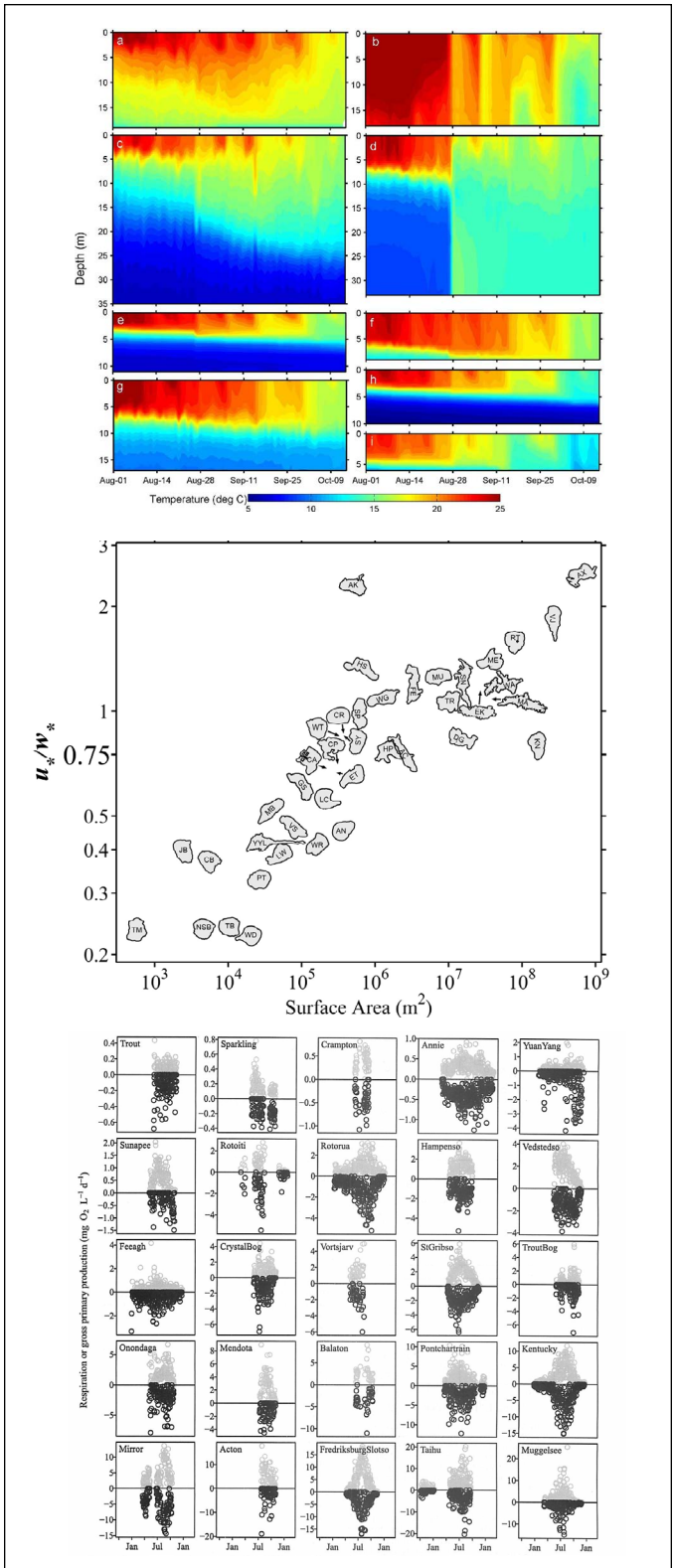


**Fig 2.** Examples of GLEON network science, including (a) the impacts of tropical storm Irene on thermal stratification in 9 lakes in northeastern North America (Klug et al., 2012, reprinted courtesy of ACS); (b) ratio between the temporally-averaged velocity scales for wind shear (u*) and convection (w*) for 40 GLEON lakes (Read et al. 2012, reprinted courtesy of AGU); and (c) rates of gross primary production (GPP; gray points) and respiration (black points, plotted on negative scale to facilitate viewing) estimated at a daily scale in 25 lakes (Solomon et al., 2013, reprinted courtesy of ASLO).

as well as the perspectives of members on issues of future water quality (Brookes and Carey, 2011; http://newswatch.nationalgeographic.com/2013/03/07/warming-lakes-climate-change-threatens-the-ecological-stability-of-lake-tanganyika/). While the future cannot be predicted, often organizational structures dictate the nature and methods of how science is accomplished (Uriarte et al., 2007). As GLEON pays careful attention to the process of team science (e.g., http://sites.nationalacademies.org/DBASSE/BBCSS/CurrentProjects/DBASSE_080231#.UbtTyPkce8A), it is facilitating an organizational structure

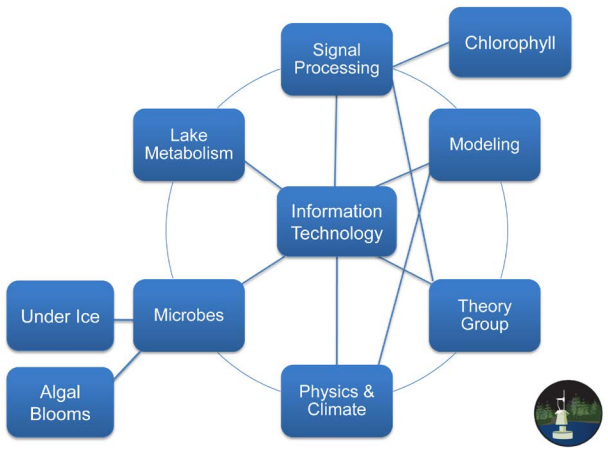


**Fig 3.** Current structure of GLEON working groups (WG). The groups are open to participation and have evolved, in grass-roots fashion, from GLEON meetings and workshops. The core groups are depicted in the circle (Signal Processing, Modeling, Theory, Physics and Climate, Microbes, and Lake Metabolism). Subgroups and projects have evolved from the WGs (e.g., with more specific foci on Chlorophyll, Under Ice dynamics, and Algae Blooms). Group activities and products are supported and enhanced by Information Technology (IT) (e.g., in support of virtual communication, sharing models, and data sharing).

adapted to training and producing talented network scientists and innovative scientific products.

Organizations, technologies, and the scientific enterprise change rapidly. GLEON is a powerful example of both a learning organization, as it seeks to continually reevaluate both its weaknesses and strengths and adjust accordingly, and a working example of the emerging field of the science of team science. In short, GLEON is an ever-evolving organization whose successes are attributable to the network of members. Our strengths and opportunities, as well as some of our challenges, are intimately tied to the facts that: no one person's career and identity is wholly interwoven with GLEON (unlike, say, an investigator-initiated research program), we are bound by a common mission (Fig. 1) and are committed to sharing data and ideas openly, we encourage broad leadership, and we are learning by doing network science. The rapid growth in membership, scientific productivity, and reputation of GLEON is a testament to its current timeliness. Its subsequent longevity will depend on its ability to continue to learn, innovate, and be inclusive of new ideas and new people.

## ACKNOWLEDGMENTS

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## WEB SITES

http://newswatch.nationalgeographic.com/2013/03/07/warming-lakes-climate-change-threatens-the-ecological-stability-of-lake-tanganyika/

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# LONG-TERM PERSPECTIVES ON LAKE SCIENCE AND MANAGEMENT

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Long-term limnological data sets are increasingly valued for the unique perspective they provide on the complex dynamics of organisms and ecosystems, particularly as lakes respond to both anthropogenic perturbations and longer-term environmental phenomena. Even a quick perusal of Limnology and Oceanography's publication history demonstrates the increasing contributions of long-term data to scientific productivity (Figure 1), and several large collaborative projects focused on integrating long-term data sets over the past decade (e.g., Jeppesen et al 2005, Lenters et al 2012) have drawn attention to a multitude of ongoing long-term limnological programs that generate rich data sets.

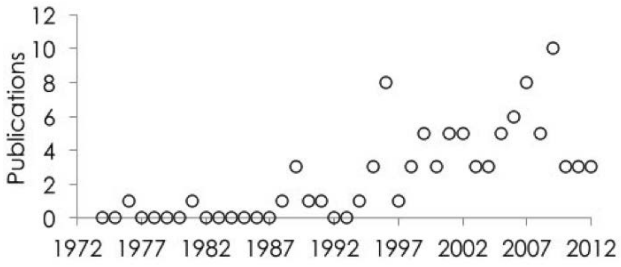


**Fig 1.** The number of Limnology and Oceanography publications referring to long-term field data in their abstracts has increased over time. To generate an index of the use of long-term data in limnological publications, we did a targeted Web of Science search ( ["long-term" or "monitor*" or "time series"] and "lake*") in L&O, resulting in 214 records; a quick perusal of the abstracts reduced this number to a total of 90 publications that used long-term limnological data.

Recent studies provide powerful examples of the role of multi-decadal data sets in elucidating major ecological processes in lakes, from documenting surprising patterns of ecosystem response to shifting climate to unraveling complex underlying mechanisms. Typically, these high-value long-term studies are based on lakes that have long histories of limnological research. However, long-term limnological data collection is far more extensive than is suggested by either the current state of the literature or the current availability of long-term limnological data in public repositories. Many government and citizen-based programs have produced a wealth of lake data that have received limited attention in both research and management arenas.

At the 2013 meeting of the Association for the Sciences of Limnology and Oceanography in New Orleans, a special session convened researchers who discussed the challenges, creative opportunities, and value to society and science that are presented by long-term data collection in lakes. A diversity of perspectives was captured - from those who work with high-resolution data collected by professional scientists, to those who use citizen science and local knowledge to gain long-term perspective in their research and lake management strategies.

The recent (and ongoing) tumultuous events experienced by Canada's Experimental Lakes Area (ELA), where scientists have provided multiple exemplars of the value of long-term research, provide a timely moment to enrich the discussion and to learn what might be lost when long-term data collection ceases. The Canadian federal government's decision to stop supporting the ELA in 2012 led to a large outcry from the scientific community that underscored the value of this unique resource and the opportunity it provided for both limnological experiments and observing long-term trends in water quality - a value recognized by Provincial governments and the International Institute for Sustainable Development, who will now provide support for ELA.

Here we reflect on topics highlighted in the recent ASLO session in order to focus discussion on key roles that long-term data sets have played in limnology and the management of lakes. The value of long-term environmental data collection for fueling major scientific advances as well as sound lake stewardship by managers was clearly demonstrated in the session. While the positive attitude toward this topic is perhaps not surprising given that all the session presenters are engaged in long-term lake research at some level, the points they made were robust, providing a diverse body of evidence to support the importance of ongoing investments in long-term limnological research (e.g., Dodds et al. 2012). Scandinavian and European researchers have been particularly successful in fostering both the proliferation and the synthesis of long-term lake data sets (e.g., Jeppesen et al. 2003, 2005). These highly collaborative analyses have coalesced large groups of geographically distributed colleagues to move limnology forward in fundamental ways while providing robust evidence-based guidance for lake managers. For example, attempts to reverse anthropogenic eutrophication have been monitored in a large number of long-term limnological programs; the synthesis of results provides guidance to lake managers and other decision-makers about the conditions under which re-oligotrophication is most likely to be successful (Jeppesen et al 2003).

Inspired by a diversity of successes in synthesizing distributed lake data sets to uncover large-scale patterns (e.g., Magnuson et al. 2000, Bastviken et al. 2011), several ASLO presenters updated the group on new efforts to create collaborative data sets in search of new discovery, most of them based in the United States where such syntheses have been comparatively rare. The Global Lake Temperature Collaboration is a rapidly growing group of over 75 researchers who are collating long-term summer water temperature data, estimated from both satellite and in situ measurements, to better understand world-wide rates and patterns of inland water warming as climate continues to change. Another new distributed collaboration in the upper Midwestern and Northeastern U.S. – CSI: Limnology - is gathering an estimated 18,000 lake data sets from a 17-state region

that includes >1,400 records with 20+ years of data collected by academic scientists and lake managers. This data set will be used to examine lake responses to drivers across multiple scales from climate to local human activities. While this project is still in early stages where data collation and integration are dominant activities, they received inspiration from a presenter who discussed some of the first major successes of the Global Lake Ecological Observatory (GLEON) project. The GLEON network confederates data from globally distributed lake buoys that have sensors measuring temperature and other parameters on fine temporal resolution. Using GLEON data, Solomon et al. (2013) recently demonstrated the power of synthesizing these fine-scale temporal measurements across a large number of lakes, discovering for the first time the fine-scale changes in microbial respiration historically thought to be simply measurement error.

A number of presenters recognized the urgent need for and the widespread lack of long-term data that would inform management and policy actions to relieve problems in water quality and availability worldwide, and they showcased creative solutions to filling gaps and extending time series. Where long-term lake data are available for certain parameters, but others that are of interest to lake managers and scientists are missing, modeling can provide estimations of some ecosystem properties over the long term, such as describing likely effects of anthropogenic ecosystem change on fish growth and habitat. And where data gaps exist or time series are shorter than desired, sediment cores from lakes may provide long-term perspective on baseline conditions, yielding information on primary producers and nutrient status, frequently on an annual timescale and over hundreds or thousands of years. Similarly, a greater breadth of temporal and spatial coverage can be provided through employing public participation in scientific research (PPSR). One presenter described a Bayesian statistical model that helps researchers to dovetail PPSR data and local social-science survey data with professionally collected in situ and remote sensing data; in this case, every scrap of data helps to piece together the trends of water quality and availability in a developing country ravaged by war, where long-term limnological data are simply not available.

Overall, the presentations highlighted a need for both more sophisticated statistical techniques than normally used by limnologists to analyze these diverse long-term time series, and a need for more widespread training in data-intensive, quantitative science. Such training would include not only the appropriate analytical approaches but also generalizable informatics skills that aid collaborative use of long-term data. A recent publication (Hernandez et al. 2012) highlighted the urgent need for training that would allow environmental scientists to take advantage of new technologies and quantitative approaches. This survey of 434 graduate students calls out a large number of deficiencies in preparing students for modern scientific opportunities, and just to mention a few: 74% had never had any coursework in managing or analyzing complex data, 80% had no coursework in information science or data management, and 88% had never had training in time series analysis.

All of the researchers with whom we interacted in the ASLO session professed a painful awareness of the massive informatics and sociocultural challenges that must be overcome in order to collate and synthesize heterogeneous data contributed by a multiple individuals. Thus, probably more than many scientific audiences, this session's participants were both humbled and enthused by exemplars of environmental data management presented by an established data repository for aquatic data sharing (bco-dmo.org). This collaboration demonstrated the uses of not just sound archive of data but value added by interface tools such as mapping and customized retrievals that encourage researchers to upload and re-use a wealth of existing long-term data. As the National Science Foundation and other internationally distributed funding organizations move toward more rigorous data management and sharing requirements, the session presenters shared enthusiasm for the scientific and management value that will be gained from the use and re-use of long-term limnological data, and optimism for a future in which training in these activities will become more commonplace.

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# SCIENTISTS, ON SAVING SCIENCE

## LESSONS FROM THE CAMPAIGN TO SAVE THE EXPERIMENTAL LAKES AREA

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At the end of March 2013, federal funding for Canada's Experimental Lakes Area (ELA) officially came to an end. For over four decades, 58 lakes in northwestern Ontario served as the platform for a world-class public science program. The program's mandate was to understand, and learn how to mitigate, the impacts of human activities on freshwater ecosystems and their fish populations. The ELA brought Canada to the forefront of aquatic sciences through its unique, whole-ecosystem experiments and comprehensive, long-term ecological monitoring programs. Moreover, the ELA provided rigorous scientific evidence to governments and industries for developing sound environmental policies and effective management strategies.

The imprudent decision by the Government of Canada to shutter the ELA was not only an international disgrace, but a potential threat to the future health of the world's freshwater. Realizing the enormity of what was at stake, a year-long concerted effort to oppose the ELA's closure began. Thanks to the tremendous support of thousands of people, it now appears that this vital research center may still have a future. Here, we share the story of the fight for the ELA, so that the lessons learned are helpful for 'saving science' in future campaigns.

## NEWS OF ELA'S CLOSURE

We learned of the government's decision to close the ELA on May 17, 2012. The ELA research team – a group of public servants employed at Fisheries and Oceans Canada (DFO) – was informed by their regional science director that the ELA would be shut down at the end of the fiscal year. ELA staff were given workforce adjustment letters and warned not to speak to the media. The rationale provided was that the ELA was no longer aligned with DFO's "core mandate" and was couched by the government as a "responsible management" decision.

Within hours, concerned scientists alerted colleagues, journalists, and federal opposition critics. The forthcoming closure of the ELA made national news that evening, and was raised in the House of Commons of Canada the following morning. Over the next few days, scientists launched the 'Coalition to Save ELA' to coordinate a campaign to advocate for the ELA.

For a 'Save ELA' movement to gain traction, outcry needed to come not only from the scientific community, but also from the public. The ELA had unequivocally achieved worldwide recognition for its scientific excellence – as exemplified by its pivotal contributions towards policies on eutrophication and acid rain, numerous prestigious national and international awards, and more than 1000 peer-reviewed publications. Despite these successes, the public relations arm of the DFO seemed rather intent on keeping the ELA out of the news, presumably to shield the department from potential criticism, and had done little over the years to actively promote the ELA to Canadians. Public outreach by the DFO was narrowly focused on the two towns adjacent to the research area, and the official ELA website was outdated and tired looking. Thus, many people in Canada outside the aquatic science community had no clue about this internationally-acclaimed scientific gem hidden away in northwestern Ontario.

A public awareness campaign was started to inform people about the importance of the ELA to the health of Canada's lakes and fish. An attractive website was created as a resource of information, including plain-language fact sheets, descriptions of research projects, a list of scientific publications, photos and videos, and daily news updates. This website was complimented by a Facebook page and Twitter account. A handful of people spearheaded these initiatives, and were soon bolstered by other scientists, concerned citizens, and organizations from around the world.

Before the House of Commons went on summer recess, scientists and their supporters scrambled to grab the attention of the country and parliamentarians with four major strategies.

First, a public petition was drafted to call upon the government to "recognize the importance of the ELA to [its] mandate to study, preserve and protect aquatic ecosystems," and "reverse the decision to close the ELA research station." Many volunteers generously donated their time taking this petition door-to-door and to major events in their communities. Thousands of signatures were collected in a few weeks.

Second, an open letter condemning the cancellation of the ELA was sent to Canada's Prime Minister, Fisheries and Oceans Minister, and Environment Minister, and published in a major national newspaper. This letter, signed by the world's top aquatic scientists, explained that the value of the ELA "lies in the irreplaceable capacity for Canadian scientists and their partners to conduct experiments on entire lake ecosystems" which "provide key information, unattainable elsewhere, for objective, evidence-based decision-making."

Third, large ads were run in newspapers across the country with the headline "ELA is closing just when the planet needs it most." The ad included an endorsement of the ELA by high-profile individuals, such as former prime ministers, deans of academic institutions, heads of scientific organizations, chiefs of First Nations, and directors of environmental organizations, among others.

Fourth, a series of press conferences was organized at the National Press Gallery in Ottawa featuring esteemed aquatic scientists, federal politicians, and well-known water advocates. These press conferences provided journalists with new information and a diversity of voices, triggering a near daily flow of news stories on the ELA by dozens of media outlets.

## PUBLIC CAMPAIGN TO SAVE ELA

Unfortunately, the government showed no sign of relenting to this initial pressure by the time the House of Commons rose last summer. Therefore, a sustained campaign was necessary to keep the ELA in the public eye and in the government's ear. ELA supporters worked hard to spur on hundreds of articles. Many hours were spent brainstorming ideas, drafting press releases, giving media interviews, writing feature stories, and submitting letters to the editor. The ELA issue was followed by major newspapers, radio shows, television programs, and popular magazines. More than 500 articles mentioned the ELA in less than a year. News of the impending shutdown of the ELA also appeared in prestigious international scientific journals, such as Nature and Science.

Public events promoting the ELA were organized across the country. Scientists, politicians, activists, and concerned citizens spoke about the ELA at town halls, forums, and other public meetings. ELA presentations and special sessions were also arranged at scientific conferences. Protests opposing the closure of the ELA took place in several cities. These events fostered public discourse on the ELA's future, and encouraged people to advocate for this crucial science facility.

The fight for the ELA soon took on a life of its own. Initially, it was the freshwater science community in Canada that was swift to denounce the defunding of the ELA. Soon, support also came from the United States, United Kingdom, Australia, Israel, Japan, China, and Korea. All the major national and international aquatic science associations sent letters to Canadian Ministers stating their concern over the loss of the ELA and calling upon the government to rescind its decision. As the public became better informed on the important work of the ELA, concerned citizens from across the country flooded the offices of Members of Parliament with phone calls and emails outraged over the termination of the ELA. Letters urging the government to continue funding the ELA were sent by cottage owner associations, lake stewardship groups, hunting and fishing federations, First Nations, environmental organizations, and many others.

Public figures began to take notice and speak out about the government's plans to shutter the ELA. A popular comedian performed a satirical rant about the ELA on a national TV show to an audience of over 1 million viewers, the video of which was viewed nearly 90,000 times on YouTube. Science personalities also wrote several articles and blogs, and a prominent filmmaker produced a short video to encourage people to take action. Political pundits and activists repeatedly pointed to the defunding of the ELA as a prime example of the Canadian government's 'war on science' and 'muzzling of scientists.'

When Members of Parliament returned to Ottawa last fall, the ELA was so highly publicized that it became a hot topic of discussion in the House of Commons. The ELA has been was mentioned more than 300 times in Canada's 41st Parliament. Members of opposition parties regularly asked the government about the ELA in Question Period, and placed several questions concerning the ELA on the Order Paper. 'Save ELA' petitions were tabled in the House of Commons over 140 times – totalling over 30,000 signatures by Canadians. Parliamentarians also attended press conferences, breakfast meetings, and rallies in support of the ELA, and debated its closure on political news programs.

Despite worldwide support for the ELA, the Government of Canada refused to reinstate funding for the ELA. Canada officially gave notice of its withdrawal from the long-standing agreement with Ontario to operate the ELA on provincial lands. The Fisheries Minister made it clear that the government "made the decision that the experimental lakes will be ending as a federal facility," and planned to mothball or decommission the ELA. In an eleventh hour appeal at the end of March, the Official Opposition introduced a motion to extend funding for the ELA until a new operator was found. But, to the disappointment of many people, the governing party voted against this motion, thereby defeating it.

This disappointing outcome for the ELA was not in keeping with the wishes of the majority of Canadians, not even the government's own supporters. According to an opinion poll commissioned by the Council of Canadians, nearly three-quarters of Canadians oppose the Government's decision to cancel funding for the ELA, including 60% of Conservative voters.

## ONTARIO STEPS IN

The first positive news came on April 24, 2013, when Premier Kathleen Wynne announced the Government of Ontario is pledging funds to support the operation of the ELA. Wynne also committed to take a lead in negotiations to transfer the ELA to the International Institute for Sustainable Development (IISD) – a Manitoba-based think tank for sustainable development.

In early May, a memorandum was signed between the IISD and DFO "provid[ing] a framework" for negotiating an agreement for the IISD to be the new operator of the ELA. Importantly, this deal has permitted scientists to sample ELA lakes this field season for the long-term ecological monitoring program and on-going whole-lake experiments. However, no new experiments were allowed to proceed this year, and access to the research center was tightly controlled by the DFO.

Currently, negotiations among the federal government, provincial governments, and IISD are on-going. We learned that Ontario is prepared to provide a multi-year commitment towards the ELA of "up to" 2 million dollars per year. However, we still do not know what will happen to the ELA field station and its government scientists in September when the memorandum between Canada and Ontario will officially be terminated, and the DFO will legally cease its operation of the ELA.

It appears that the ELA may live on, not as a public science program of the Canadian government, but within an international public policy research institute. Although, at the time of this writing, no final agreement has been reached, we are optimistic this unique center for freshwater science will continue to generate high caliber science to support public policy in the future.

## LESSONS LEARNED

So, what did we, as early career scientists, learn from our experience founding the 'Save ELA' movement?

First, we came to understand that it was not only our role, but our responsibility, as scientists to advocate for science in the public domain. Scientists simply cannot afford to sit on the sidelines as governments defund and dismantle vital scientific programs, such as the ELA. In spite of this, science advocacy is not typically encouraged by universities and other research institutions. Perhaps, it is time to change the culture that disuades scientists from engaging in science advocacy.

Second, we discovered some necessary tools were missing from our toolkit. For example, we had to research the democratic options available to citizens to lobby government, as well as learn the procedures for distributing press releases and media advisories to journalists. We also needed to become proficient in using various types of social media to broadcast information. In hindsight, this capacity should have been in place for the ELA years ago in the form of an active outreach organization.

Third, we quickly appreciated that effective communication is key to getting a message to resonate with the public. This involves learning not only how to distill complex scientific concepts to their essence in an interesting manner, but also how to explain the importance of science within the context of societal values. For most scientists, speaking in sound bites is not a natural talent, but an acquired skill – and one that should be taught and practised.

Fourth, we realized that our professional connections within the scientific community were not, by themselves, adequate for this work. We needed to forge new relationships with politicians, journalists, industry leaders, unions, First Nations, environmental organizations, among others. The lesson here is for scientists to effectively interact with the public to build a broad and diverse network of supporters, as this enables allies to be efficiently mobilized when crises arise.

Finally, we learned to take ownership of past mistakes. If we had done a better job of engaging the public in our science in the first place, perhaps it may have prevented the government from cutting funding for the ELA. Public outreach over the last four decades should have showcased the applied and relevant research being done at the ELA on the public's behalf. If we are doing science 'in the public good,' the public has to know about it – and it is our job, as scientists, to be the voice for science.

# LINKING OPTICAL AND CHEMICAL PROPERTIES OF DISSOLVED ORGANIC MATTER IN NATURAL WATERS

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ASLO sponsored the 2013 Emerging Issues Workshop, "Linking Optical and Chemical Properties of Dissolved Organic Matter in Natural Waters," following the Aquatic Sciences Meeting in New Orleans, LA, 23-24 February 2013. A group of 31 scientists attended this workshop, ten of which were students and seven were early career (within five years of their Ph.D.). The workshop began with five plenary talks to set the stage for discussions. Following the plenaries, discussions took place focused on the major aims of the workshop. This overview reviews the motivation for the workshop, the discussions that took place, and the recommendations and agreed future research directions that arose.

## BACKGROUND FOR THE WORKSHOP

A substantial increase in the number of studies using the optical properties (absorbance and fluorescence) of dissolved organic matter (DOM) as a proxy for DOM chemical properties and biogeochemical cycling has occurred during the last decade. This is due in part to improved instrumentation and algorithms for interpreting the spectral data. Chemical characterization of DOM involves intensive laboratory work and often large sample volumes, whereas optical characterization is attractive to many scientists as it is relatively simple and inexpensive, and these techniques can also be measured in-situ and via remote sensing. Linking the optical and chemical properties of DOM is now a topic that requires consolidation and a combined effort if the aquatic science community is to continue to gain from these techniques, which are becoming routine analyses.

Despite the widespread use of DOM's optical properties, further progress is required to deliver a robust, mechanistic understanding of the chemical compounds or phenomena responsible. Ultrahigh resolution mass spectrometry has made some progress in understanding the complexity of the chemical milieu comprising DOM but few studies have made the key connections between optics and chemistry. This question is critical to answer in order to guide future biogeochemical sensors (in situ and satellite) as much as it is to examining water quality of aquatic ecosystems under changing land use and climate. Further, the topic reaches across the disciplines of limnology and oceanography.

The controversy in this topic stems from the fact that little is known about the chemical structures responsible for DOM's optical properties and, in addition, their origins in natural waters. Although there are clear correlations to terrestrial organic matter in many limnic and coastal systems, similar optical signatures are also present, albeit at lower intensities, in oceanic environments and other natural waters with little terrestrial organic matter input. Several decades of observations have revealed that optical measurements offer valuable qualitative and quantitative information on DOM across a range of temporal and spatial scales. The future use of optical measurements of DOM potentially hinges on the community improving the current understanding of the linkages between optics and chemistry of DOM.

This ASLO Emerging Issues Workshop provided an opportunity to discuss the current state of knowledge and develop areas for future research foci. The goals of

the workshop were to explore: the links between organic compounds (e.g. lignin), classes of compounds (e.g. humic substances), and electronic phenomena (e.g. charge transfer) and the optical properties of DOM in natural waters; and how DOM's optical properties vary with DOM sources, sinks and the wider biogeochemical properties of aquatic systems (i.e. the role that DOM has in aquatic ecosystems).

## WORKSHOP ACTIVITIES

Day 1 began with opening remarks to review the two aims of the workshop. It was apparent that more and more studies are combine optics and chemistry, largely using optics as proxy for chemistry. Next, a series of plenary talks was given to frame the discussion.

George Aiken initiated the plenary talks by reviewing the optics and chemistry of XAD hydrophobic isolates (humic substances). He focused on using a key set of tools to examine DOM: dissolved organic carbon (DOC) concentration, CDOM absorbance and CDOM fluorescence. For the latter, it is helpful to use FDOM in order to distinguish the chromophores (the "C" in CDOM) from the fluorophores (the "F" in FDOM). Aiken reminded us that our analytical window is such that optical measurements only represent the properties of a fraction of the DOM pool. A fraction of DOM absorbs light and can be termed "CDOM", and a small fraction of CDOM actually emits light as fluorescence: DOM > CDOM >> FDOM. Similarly a variable fraction of DOM, CDOM and FDOM can be isolated from natural waters and characterized by the range of different extraction techniques.

Aiken also showed the importance of humic substances isolation on understanding the relationship between the optics and the chemistry, at least from the perspective that the operationally defined hydrophobic acid fraction (HPOA) exerts a large control on the overall optical properties, especially in freshwaters. The specific UV absorption at 254 nm, SUVA254 (decadic light absorption coefficient per meter/DOC concentration in mg per liter; Weishaar et al. 2003) provides a good example of this, and there is a high correlation between SUVA254 and the fraction of HPOA in North American rivers (Spencer et al. 2012). A key quote from Aiken's talk was "know your system." Although strong correlations between CDOM absorption and DOC exist across a large number of river ecosystems, they are only valid for the specific systems studied. Site specific conditions do alter these relationships. One example presented was the influence of both ferric iron ($Fe^{3+}$) and nitrate on CDOM absorbance at UV wavelengths. $SUVA_{254}$ values greater than 5.5 often represent incorrect calculation (i.e. use of the Naperian as opposed to the decadic absorption coefficient) or the presence of high concentrations of iron, and iron influences should be considered for all $SUVA_{254}$ values.

The second plenary was given by Neil Blough who provided a summary of his group's research on the origins of DOM absorbance and fluorescence. CDOM absorbance at wavelengths above 300 nm typically exhibits a near-featureless exponential decay with increasing wavelength. The major absorption bands for most known aromatic organic compounds are below 400 nm. Blough and co-workers propose an electronic interaction (EI) model as an explanation for the longer wavelength absorption and fluorescence. Therefore, some of the surprisingly low energy (long wavelength) and non-descript optical properties of CDOM and FDOM can be explained by charge transfer between donor and acceptor groups. The primary absorbing species absorb light in the low

Workshop attendees. Back Row (left to right): Colin Stedmon, Ron Benner, Eero Asmala, Rob Spencer, Rudolf Jaffe, Clay Williams, Jean-Francois Lapierre, George Aiken. Middle Row: Rachel Sleighter, John Helms, Natasha McDonald, Thorsten Dittmar, Christie Wood, Paula Coble, Chris Osburn, Cedric Fichot, Anne Kellerman, Paul Mann, Aron Stubbins. Front Row: Jessica Ebert, Neil Blough, Andrea Andrew, Youhei Yamashita. Not pictured: Kaelin Cawley, Jim Cotner, Jordon Hemingway, Alia Khan, Antonio Mannino, Jutta Niggemann, Diana Oviedo-Vargas, Sarah Rosengard, Eurico D'Sa

ultraviolet (the UV-B, <320 nm) and also exhibit fluorescence excitation at these low wavelengths. Through experimentation with fluorescence quantum yields (essentially normalizing fluorescence emission to the light absorbed at the wavelength of excitation) and chemically interrupting charge transfer by reducing the acceptors (quinones), Blough and co-workers showed that a standard DOM isolate, the Suwanee River Fulvic Acid (SRFA) behaves similarly to a prepared lignin standard, and that samples from the equatorial Atlantic show similar trends (Andrew et al 2013). Blough hypothesized that the ubiquitous long wavelength absorption and fluorescence signature of DOM arises from polyphenolic structures which predominantly originate from terrestrial organic matter. Natural sources of polyphenols are rare in the oceans. Traditional study has focused upon terrestrially derived aromatics such as lignin and dissolved black carbon. Thus drainage off the land into coastal waters continues to re-supply the ocean with aromatics and, possibly, CDOM. The fact that lignin and black carbon are detectable frequently in the Ocean makes for a compelling case that polyphenolic compounds and associated donor/acceptor moieties – many of which are terrestrially-derived – contribute to oceanic CDOM. The null hypothesis that these optical properties can be produced via other biogeochemical pathways (e.g. from microbial reworking of algal DOM or remineralization of sinking particles) offers an interesting future research direction.

Next Ron Benner and Cedric Fichot reviewed the use of CDOM absorption as a proxy for lignin concentration with the goal of estimating fluxes of terrestrial DOM into the coastal ocean. This presentation began the transition of the workshop from "What is CDOM?" to "What can we gain from CDOM?" This presentation presented work from the Gulf of Mexico and Arctic Ocean. Lignin provides an unambiguous tracer for vascular plant derived organic matter, i.e. terrestrial inputs. However, measuring lignin is analytical intensive, time consuming and costly, prohibiting its use for synoptic observations. Benner and Fichot presented work showing highly significant relationships between CDOM (e.g. absorption at 355 nm) and lignin concentration. Furthermore, data was shown linking together CDOM quality as determined by the spectral slope parameter ($S_{275\text{-}295}$), to lignin as a fraction of the total DOM pool e.g. the carbon-normalized lignin concentration ($S_{275\text{-}295}$).

The result allows for using the optics to predict the chemistry of DOM in coastal waters. However, it should also be noted that the trend was developed for a large river delta front estuary (the Mississippi River and plume region). The relationship could be more complex in coastal regions having multiple riverine (or CDOM) inputs. Despite this potential complication, the applicability of the approach was demonstrated for estimating terrestrial DOM fluxes into the Arctic Ocean (Fichot et al. 2012).

This promising approach to connect optics and chemistry of DOM set the stage for a more in depth look at the second workshop aim. Paula Coble presented work on in situ observations aimed at understanding how the spectral variation in the underwater light field is controlled by CDOM. The in situ observational approach presents different analytical challenges when compared to laboratory-based measurements. Calibration and correction must be carefully conducted and in situ sensors must be corrected for interferences such as turbidity, temperature, pH, and signal degradation due to factors including saturation, quenching, self shading, and biofouling.

Coble provided an overview of potential fundamental and applied research questions that could benefit from monitoring absorbance and fluorescence in situ. She also reiterated Aiken's "know your system(s)," emphasizing that it is important to know what to expect of CDOM distributions in a particular aquatic ecosystem as much as it is important to know what CDOM distributions might tell about the biogeochemistry of a system. Coble also included a review on the development history of in situ sensors and a look forward at new sensors and instrumentation. In situ observatories are no longer only occurring in the ocean and an increasing number of coastal and freshwater observatories are incorporating a wide range of such instrumentation. Further, the installation of CDOM sensors onto gliders and towed arrays increases the spatiotemporal resolution of such measurements as a means of using them as proxies for biogeochemistry. Thus opportunities exist to examine archived data as well as to create new datasets with improved accuracy, an expanded analytical window, and a more robust means of describing such large datasets.

The discussion of our ability to have large spatiotemporal coverage from in situ observations presented by Coble was continued by the last plenary speaker, Antonio Mannino, who presented the use of satellite based remote sensing observations to quantify CDOM in the coastal ocean. Mannino's talk brought together the optical-chemical equations used by Benner and Fichot to model lignin concentrations with Coble's sense of wider geographic and temporal coverage. Remote sensing of CDOM would allow a very global picture of surface fluxes and offers potential for examining CDOM on scales relatable to climate variations.

However, Mannino presented the many challenges to such applicability. First is the nature of radiometric retrievals. Roughly 80-90% of the reflectance signal from the surface ocean is "removed" at the top of the atmosphere. Signal-to-noise ratios also can be poor. The algorithm development for retrieving CDOM from reflectance, and then DOC or lignin from CDOM work best when there is good interannual consistency, low regional variability, and strong terrestrial inputs. Second, key methods for developing algorithms to extract CDOM quantity (e.g., $a_{355}$ or $a_{412}$) and quality ($S$ values) exist, yet it is not well known how widely applicable such algorithms may be. One possibility is that a generic mathematical model could be used, but the parameterization of such a model is regionally, or perhaps locally and temporally, dependent. Third, calibration and validation must be coordinated with retrievals. Pixel size (i.e., the spatial "picture" taken by the satellite sensor) can be large. The ground-truth vessel should be measuring radiometric quantities as well as absorbance or fluorescence, and other biogeochemical parameters (e.g., DOC, lignin). These measurements should be taken within three hours (or better) of the satellite's pass over the study area. While this can

be estimated, local weather and sea conditions can complicate matching the ground-truth measurements with the satellite's overpass. Despite these challenges, clear opportunities exist for the greater observational window afforded by satellite-based observations.

Mannino concluded our plenary talks with a look forward at future satellite sensor development, emphasizing the opportunities for the next advances in utilizing CDOM to understand biogeochemistry. Reflecting on the plenary talks, it was clear that CDOM has become an important biogeochemical variable to measure in aquatic ecosystems. This is due to its key connection with organic carbon chemistry, its covariance with a multitude of known (and possibly unknown) ecosystem variables, and its influence on ocean color.

The discussion Saturday afternoon focused on the first aim: What is CDOM? We returned to the topic of CDOM's structure and much discussion centered on the use of excitation-emission matrices (EEMs) to evaluate CDOM sources in aquatic ecosystems. The issue of dissolved black carbon (DBC; soluble condensed aromatic combustion products) potentially representing part of the CDOM signal was raised and discussed as recent studies have shown a strong link between DBC, terrestrial carbon export and CDOM (Stubbins et al. 2012). DBC is present in natural waters at much greater concentrations than polycyclic aromatic hydrocarbons (PAHs) and includes oxidized substituent groups that make DBC more soluble in water than traditional PAHs and possibly also contributes to charge transfer analogous to lignin derived polyphenols.

Further discussion was on the dependence of the optical properties on the physicochemical environment in which DOM is measured. Complexation of metals by DOM can quench fluorescence and fluorescence changes systematically with pH. Similarly it was noted that most DOM isolation/separation techniques alter the natural organic matter and most likely its reactivity, which is problematic, despite the fact that for freshwaters in particular mass balance calculations show that extraction efficiencies are high for CDOM.

An important point that arose from the discussions was how little we know about the chemical characteristics of CDOM produced by phytoplankton and whether such DOM could have optical properties similar to terrestrial materials such as lignin. Numerous studies have shown increases in absorbance and fluorescence in phytoplankton culture, in phytoplankton blooms, and in eutrophic ecosystems. Presumably, DOM from phytoplankton is progressively degraded such that it exhibits optical properties similar to terrestrial DOM.

The discussion on Sunday morning focused on applications with examples and considerations of CDOM covariance with other biogeochemical properties of an ecosystem. Rob Spencer presented relationships between CDOM absorption, lignin and DBC in North American and Arctic rivers. A word of caution about using CDOM for flux calculations is that the discharge values measured for a particular river can greatly influence the yield of DOC exported from it. Aiken's point about knowing one's system also implies that local models, rather than global models, between optics and chemistry need to be developed, because of such variability.

Many of the end users who are working on using CDOM as a proxy for biogeochemistry are utilities or monitoring agencies that focus squarely on the ease with which CDOM sensors can generate measurements. Interpreting what those measurements mean and constraining their variability to create predictive models of ecosystem function is an enticing goal, but often system dependent. Likely, one size will not fit all.

The workshop concluded with a discussion of what the community needs to undertake to make progress within this field. It was clear that consistency in sampling and measurement protocols would be advantageous. Many of these are detailed in a recent book chapter by Coble and Nelson in *Practical Guidelines for the Analysis of Seawater* (Wurl 2009) and in the findings of the inter-laboratory comparison (Murphy et al. 2010). Mannino mentioned that there are also plans for a NASA initiative to inter-calibrate oceanographic CDOM absorption measurements using the Ultrapath long pathlength (2 m) spectrophotometer.

There is a clear need for more research into documenting the optical properties of model compounds expected to naturally occur in DOM. In addition to polyphenolic structures, natural occurring indoles are another likely candidate fluorophore. It also was suggested that the International Humic Substances Society (IHSS) Suwanee River Fulvic Acid (SRFA) and Pony Lake Fulvic Acid (PLFA) be used as CDOM reference material.

There is also a need for a revision of the nomenclature for labeling fluorescence peaks and signatures indentified using parallel factor analysis (PARAFAC). This would greatly facilitate comparability between studies and ultimately progress in the field. Initial steps were taken by participants at the workshop and a group is now working on a suggestion.

As is often the case with such workshops, we left with more questions than answers. But it was clear that as the community of limnologists and oceanographers who are using CDOM optics to explain biogeochemistry continues to grow it is important that we continue to remain focused on the topic of this workshop so that progress can be made towards a common framework with which to understand CDOM's dynamics. It was however clear that this will be the first of necessary series of workshops.

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# CONSORTIUM OF AQUATIC SCIENCE SOCIETIES BRIEFS POLICYMAKERS ON WATER RESOURCES

***Adrienne Sponberg,*** *ASLO Public Affairs Director, 10410 Kensington Parkway Suite 216, Kensington, MD 20895, USA, sponberg@aslo.org*

On May 9, 2013, the Consortium of Aquatic Science Societies (CASS) briefed Washington, D.C., policymakers on water resources. The briefing took place on Capitol Hill as the U.S. Senate debated the Water Resources Development Act, the legislation authorizing water resource projects in the United States. More than 30 policymakers representing members of Congress, the Army Corps of Engineers, NOAA, U.S. Fish & Wildlife Service, and nongovernmental organizations attended the event, which is the second annual briefing organized by the Consortium.

Dr. Emma Rosi-Marshall, Aquatic Ecologist at the Cary Institute of Ecosystem Studies, kicked off the event with a crash course on river ecology which emphasized the dynamic, connected nature of rivers. Drawing on examples from around the country, Rosi-Marshall highlighted the need for management strategies to balance the many societal benefits of rivers such as flood control, hydropower, waste assimilation, and recreation.

Dr. David Strayer, Senior Scientist at the Cary Institute of Ecosystem Studies, focused on the interplay between invasive species and water resource projects. Managing and combatting invasive species costs the U.S. more than $100 billion per year. Invasive species can be particularly damaging to water resource infrastructure. At the same time, water resources projects such as canals can create new pathways for invasion.

Colin Apse, Senior Freshwater Conservation Advisory for The Nature Conservancy, presented examples of infrastructure projects designed or retrofitted to meet the needs of people and the environment. In each of the case studies, a slight modification of water resource operations resulted in improved ecological function and in some cases yielded economic benefits as well.

Following the formal presentations, the speakers fielded questions from the attendees and engaged in informal dialogue.

The Consortium of Aquatic Science Societies was formed in 2010 as a means for professional scientific organizations to work together to promote international aquatic ecosystem scientific study, education, and outreach. Current members of CASS are the Association for the Sciences of Limnology and Oceanography (ASLO), the Coastal and Estuarine Research Federation (CERF), the Society for Freshwater Science (SFS), and the Society of Wetland Scientists (SWS).

CASS member society leaders were pleased with the turnout and outcome of the group's briefing. "This was an exciting event at which cooperating science societies could build important bridges to policy makers concerning the functions, values, and policies impinging on aquatic resources," said John Downing, President of the Association for the Sciences of Limnology and Oceanography (ASLO).

CASS members plan to continue working together to improve communication about aquatic sciences. "The Society for Freshwater Science (SFS) will continue to promote collective expertise via collaboration with CASS to deliver workable, sustainable solutions to regional and global water issues," said SFS President Dave Penrose. Ben LePage, past-president of the Society of Wetland Scientists, said "The mission of SWS is to promote understanding, scientifically-based management, and sustainable use of wetlands. Communicating recent advances in wetland and aquatic sciences as well as promoting the social, economic, and ecological value of wetlands to the public and our nation's lawmakers is a top priority for the SWS and our CASS partners."

# LETTERS TO THE EDITORS

## ASLO 2013 ANNUAL MEETING: STUDENTS' PERSPECTIVES

***Brie Olsen, Chris Smith, Michael Chislock, Jo-Marie Kasinak, Enrique Doster,*** *Auburn University, AL*

One of ASLO's guiding principles is to recruit and support undergraduate, graduate, and early career individuals to the aquatic sciences. Upon hearing that the Limnology class at Auburn University (Alabama) was interested in attending the 2013 meeting in New Orleans, ASLO put their principles to practice and invited five students, free of charge, to attend the meeting for one day. The students, consisting of both undergraduate and graduate, have diverse research interests including aquaculture, veterinary sciences, conservation ecology, and limnology. The five of us attended the ASLO meeting with the intent to learn about various research areas related to limnology and oceanography, to confirm our study interests, and to find our research niche. Despite our array of interests, we all left the meeting feeling we had benefited intellectually from attending.

There are some things that cannot be achieved by taking classes or running experiments. It is essential for students in science to understand the direction in which their intended fields are heading and to identify others who are conducting relevant research in order to develop effective collaborations. Scientific meetings, such as ASLO, encourage information sharing and are an excellent way for aspiring researchers to begin networking. Given the necessity of effective professional networks for success in science today, we collectively agree that the atmosphere at ASLO was conducive for our professional development and for establishing our professional networks.

The meeting's first day introduced us to the general theme of the conference. However, those of us who had never been to an academic conference, like ASLO, were initially overwhelmed. The quantity of presentations and the fast-pace at which the meetings operate is chaotic. The first day serves as an adjustment period for first-timers, but there were plenty of opportunities to speak with highly accomplished professionals or with researchers who, like ourselves, are just beginning their careers. Since the aquatic science community is relatively small, professional development and personal networking becomes essential to both undergraduate and graduate students' own intellectual growth.

The undergraduate experience is one of exploration. Before coming to the ASLO conference, some of the undergraduates had not considered research as a part of their future. Although giving presentations is common in college courses, the talks at the conference helped them understand how to present research in a realistic setting. Seeing several presentations from many backgrounds also exposed the undergraduates to different ways of visually presenting data, organizing posters, and approaching the topics in an audience-friendly manner. Along with a better understanding for presenting the posters, some of the undergraduates gained more insight into carrying out the scientific

process. After attending several talks, the undergraduates started to see patterns in the development and practices of performing experiments. With more insight into carrying out research and having experienced the enthusiasm that presenters had for their work, some of the undergraduates began to express interest in graduate school. The ASLO conference opened the door to facets of limnology and oceanography, which showed the undergraduates that many exciting opportunities exist in these fields. Although they were able to learn about the practices and potentials of aquatic sciences, they also expressed a new understanding of why this field is important.

Graduate students are always looking for resources and ideas that may improve or develop their research. Throughout the day, the graduate students not only took advantage of talks that were related to their interests, but attended a wide variety of talks on other topics. Because ASLO is centralized around aquatic sciences, it is possible that even the most far-fetched topic can apply to one's own aquatic research. Because the graduate students are well exposed to the scientific literature, they started making connections between some of the papers they had read and the presented research. The ASLO conference also offers graduate students a chance to learn about exciting new discoveries in limnology and oceanography. One thing that was particularly important to some of the graduate students was the emphasis on scientific teaching methods. It is important to do research, but it is equally important to be able to communicate the results of the research to others, especially those young enough to consider pursuing the same career path.

We all agree that being able to attend ASLO was a great experience. We look forward to attending the whole week of the conference in the future. In closing, if any of you have the opportunity to attend the ASLO meeting, do it! We would like to give a special thanks to ASLO and our advisor, Dr. Alan Wilson, for funding the trip to ASLO 2013.

## BRIDGING THE SALTY DIVIDE?

***Jon Cole**, Cary Institute of Ecosystem Studies, NY, colej@caryinstitute.org*

The essay by Kavanagh et al. in the May 2013 issue of the ASLO *Bulletin* presents some very convincing and disturbing data about ASLO. The data show that, while we like to think of ourselves as a scientific society that integrates among the sciences of limnology and oceanography, our actions tell a different story. In terms of metrics such as cross citations, we are more like two societies, one salty and one fresh, housed together but not interacting strongly.

My first impulse was to argue that this divide is an illusion created by using tangible metrics that do not reach the true, but less tangible, strong interactions among limnologists and oceanographers within ASLO. After all, there are a number of ways oceanographers and limnologists influence each other with ideas that may not show up as cross citations. Having done an oceanographic post-doc but mostly freshwater work since then, I have lots of examples of this kind of cross fertilization from my own career. Someone gives a great fresh or salty talk at an ASLO meeting that sparks interest on both sides of the salty divide.

And there is the rub: meetings. For the inspirational spark to spread, limnologists and oceanographers need to attend the same ASLO meeting. ASLO has three taxa of meetings and the most complex life cycle of meetings in the known world: The ASLO Summer Meeting, held in summers of years with an even number, which, by and large, is a freshwater affair. The ASLO-AGU-TOS Ocean Science Meeting, a largely salty affair held in winter of years with even numbers; and the Aquatic Science Meeting, the only meeting that self consciously tries to bring limnologists and oceanographers together, and this is held in the winter of years with odd numbers. While all three taxa have merit, we have created our salty divide by our well-meaning intentions to serve all ASLO members.

We could start to bridge the salty divide by repairing our own meeting schedule. There should be one kind of ASLO meeting, held at one time of the year. This meeting should have the integrative character of the Aquatic Science meeting, but not the name. Oceanographers don't like the name "Aquatic Science." The "ASLO Annual Meeting" would do just fine as a title. There ought to be one of these per year, held at roughly the same time of year. The themes could vary; the organizers could stress different research types in various environments for a given meeting. A regularized meeting schedule causes members to put the meeting on their calendars at least in a general way and plan for them. Our nutty schedule of three meetings every two years is unnecessary and causes members to choose to attend only some of our own meetings. Try explaining the ASLO meeting cycle to a colleague from outside of North America who expresses and interest in ASLO. By the time you say "…. then every other winter, the ones with even numbers…" they will be totally lost. Actually, try explaining this to another ASLO member who is not on the board, and he or she will also be totally lost.

Some years ago there was a survey that asked ASLO members to identify what they wanted for a meeting schedule. The survey revealed that each of the three kinds of meetings, and their timings (summer versus winter), had support within ASLO. Looking at these results, the board reasoned that one size does not fit all and so the complex schedule was retained. In view of the stark data on the salty divide it is time to look at this again. By trying to serve all of our members needs with three different kinds of specially tailored meetings, we have divided ourselves. It is time to try to bridge the salty divide. Maybe ASLO cannot deliver a salty and fresh water meeting, and provide meetings in both the winter and summer and stick to its goals. The mission statement reads:

"The purpose of ASLO is to foster a diverse, international scientific community that creates, integrates and communicates knowledge across the full spectrum of aquatic sciences, advances public awareness and education about aquatic resources and research, and promotes scientific stewardship of aquatic resources for the public interest. Its products and activities are directed toward these ends."

# ASLO NEWS

## MESSAGE FROM THE PRESIDENT

***John Downing**, Iowa State University, 251 Bessey Hall, Ames, IA 50011-1020, USA; downing@mail.iastate.edu*

I heard from a friend who is president of another aquatic science society that their membership has declined 15% in the past year. Several other science society presidents I know of are somewhat alarmed by annual declines in double-digit percentages. ASLO's membership remains strong, however – Our meetings are well attended, our member services are well subscribed, and our publications are of the highest quality. It is a pleasure to report continued strength in a period when the science and publication environments are changing dramatically, and economic challenges are legion. The ASLO board strives to adapt to these changes by finding new ways to keep ASLO relevant to the careers of our members – and sustainable ways to offer substantial value.

### NEW WAYS TO STAY IN TOUCH

ASLO members have some new ways to keep in touch and let the board know your needs, interests, and suggestions. One of the most exciting is our new blog called "the ASLO Forum" (http://aslo.org/forum/). This is a place where you can ask questions, give feedback, offer suggestions, participate in discussions, or simply find people who can help with scientific issues and problems. It has been live for a month or so now, and I look forward to having it populated with more discussion.

It is easy to use. When you first access it, you will need to create an account by clicking on the "create account" icon toward the top of the page. In truth, you already have an account but you need to request that your usual ASLO login gets connected to the forum. This takes a little while but is needed so we aren't heavily spammed. Once you sign in, you will be able to view and participate in threads about meetings, publications, funding opportunities, science news, chat with the president and the board, make suggestions, and exchange information with other members and forum visitors. This forum is made possible by our new enhanced bandwidth and Paul Kemp's able programming. One thing I would like Forum feedback on is your opinion on whether ASLO might launch a new, high-quality, open access journal. Please stop by the forum.

Recently I have realized that e-mail threads sometimes get so circuitous and everyone deals with so much of it, that sometimes the old fashioned telephone is the best way to get things done quickly. If you have something you would like to discuss, suggestions to make, or ways ASLO could help you, please call my new open line: 254-751-1994. I look forward to hearing from you.

**The Limnology and Oceanography**

**Bulletin**

The Association for the Sciences of Limnology and Oceanography is a membership-driven scientific society (501(c)(3)) that promotes the interests of limnology (the study of inland waters), oceanography and related aquatic science disciplines by fostering the exchange of information and furthering investigations through research and education. ASLO also strives to link knowledge in the aquatic sciences to the identification and solution of problems generated by human interactions with the environment.

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The *L&O Bulletin* publishes brief articles of broad interest to the ASLO membership, Letters to the *Bulletin* (typically responses to articles), and ASLO News on a quarterly basis. Information on the preparation and submission of articles and letters can be found on the ASLO Web site (www.aslo.org). It is recommended that you contact the editors before preparing an article or letter.

## OPEN ACCESS MANDATES AND SCIENCE SOCIETIES

I find that I am thinking about changes in the publishing environment much more than I ever thought possible (or healthy!) (see also John Dolan's interesting article in *Limnology and Oceanography Bulletin*, 22(2): 37-40). The reasons are linked to ASLO and ASLO membership. I joined ASLO because of what it did for my science and my career. I have been around long enough that, when I joined, having desktop access to a journal meant I had to own it. I joined ASLO for the journal but also for the wonderful benefits of top-notch meetings and networking opportunities. These are still good reasons to join although those of us at subscribing institutions may access journals more frequently through our libraries when we are at work than through personal subscriptions.

Now, however, there are many more reasons to be a member of a science society, especially due to the career building opportunities of early career and student programs. What most ASLO members do not realize is that the services we all receive from ASLO are subsidized 4:1 by revenues ASLO receives from library journal subscriptions. ASLO has invested heavily in providing the world with open access content, and I support this. I am a little concerned, however, that a brusque move toward mandated open access with very short embargo periods could limit the amount science societies like ASLO can invest in creating the next generation of scientists. I hope that those crafting new policies on open access science publication consider the diverse services offered by science societies and create policies that do not erode their ability to contribute to the creation, maintenance, and enhancement of the STEM workforce.

There are four facts that convey my concerns about changes in the science publishing landscape:

- Science societies have been the traditional home of objective, high-quality science publications.
- Science societies operate primarily on revenues from publishing.
- Science societies turn back all publishing revenues to provide essential services supporting the science enterprise.
- If embargo periods are mandated too short to sustain subscription revenues, science societies will no longer be able to provide those services.

There are many services provided by science societies. Among these are objective science publications; scholarly meetings; professional networking; early-career support and mentoring; professional interaction; science discourse; enhanced diversity in STEM fields; career-advancing honors and awards; outreach and public information; and independent educational resources. These are some of the reasons we are members of and work for ASLO. However open access mandates equilibrate, I hope that policy will distinguish between science societies, who are publishing to enrich the science enterprise, and for-profit publishers who use science to enrich their own enterprise.

## CHECK YOUR LIBRARY AND THEN CALL YOUR LIBRARIAN!

Although we are by no means desperate – past ASLO boards have been very proactive – and the ASLO Comprehensive Evaluation (ACE) was conceived to avoid future problems – it is remarkable to me that some of our members' libraries have let their subscriptions lapse. The business office has recently sent me a list of libraries and institutions that have failed to renew their subscriptions to Limnology and Oceanography from 2010-2012. Some of them are quite surprising and others are frankly shocking. I had considered posting them here but may put them on a "wall of shame" on the ASLO Forum. One prominent member of the ASLO board even found that their institution had let their subscription lapse. It has now been renewed! Please take a moment to check your institution's library to see if they have a current subscription and encourage them to subscribe if they have overlooked the renewal. Librarians have dwindling budgets and are faced with astronomical costs of journal bundles from the major for-profit publishers. Please take a moment to check to make sure your library subscribes to *L&O*, *L&O: Methods*, and *L&O: Fluids and Environments*. Much of the subscription cost is reinvested in the future of the aquatic sciences. Your library may need some gentle persuasion but the quality of our journals should make this an easy sell.

## LIMNOLOGY AND LIMNOLOGY'S TOP-TEN

A major strength of ASLO is our concentration on the continuity of all water on Earth. At the 2013 SIL (Societas Internationalis Limnologiae) meeting in Budapest, I will give a plenary talk on behalf of ASLO emphasizing the connections of all water and water problems on the planet as well as the connections across theories in limnology and oceanography. This continuity is increasingly clear to me from talks by oceanographers at ASLO meetings showing the large influences of marine watersheds and air-sheds on the functioning of marine systems – one of the main problems limnologists have wrestled with for a century (see also Kavanaugh et al. 2013. A salty divide within ASLO? *Limnology and Oceanography Bulletin* 22(2): 34-37). This issue of the *Bulletin* features a great deal of limnology (see articles by Moss, Weathers et al., Hampton and Stanley, and Orihel et al. in this issue). Although limnologists make up slightly less than half of ASLO members, it is my hope that the future of ASLO will hold more exchange of ideas and theories across the aquatic sciences, and a regrowth of the inland waters component of our membership. Limnology did not have a Jacques Cousteau, but the tiny fraction of the world's water studied by us (equivalent to <1 cm out of a football/soccer field length representing the world's water) is disproportionately important in fueling human civilization and the health of continental ecosystems.

In writing grants and giving news interviews on aquatic topics, I have wanted to refer to a list of limnology's top-ten scientific problems. I have searched for this list and have come up empty. A few *Bulletin* issues ago (*Limnology and Oceanography Bulletin*, 22(1): 10-12), I promised to share a list of top problems in limnology. This is because of the need for vital sciences to focus on advancing major paradigms without being too diffuse. I called for general input, but – because truth emerges more read-

ily from error than confusion – I share my top-ten list below –as well as a list of top paradigms. I have vetted my list against those of a dozen great limnologists I know. Please join my discussion on the ASLO Forum, and set me straight on those I have left out or undervalued!

## LIMNOLOGY'S TOP-TEN PROBLEMS

1. Eutrophication and related problems of nutrient limitation – including freshwater-marine transfers of pollutants
2. Global climate change – including the role of aquatic systems and effects on them
3. Harmful algae blooms – their health, economic, and ecological effects
4. Habitat destruction and biodiversity and endangerment of aquatic species
5. Pollution by anthropogenic substances (e.g., drugs, metals, organics), unknown fate and transformation
6. Landscape-waterscape exchanges and interactions
7. Invasive-exotic species
8. Hydrologic dynamics and water supply especially concerning human alteration of the hydrologic cycle
9. Alternative stable states – including anthropogenic drivers of catastrophic ecosystem change
10. Ecosystem restoration protection from degradation, including managing multiple interacting stressors and over-exploitation

## LIMNOLOGY'S TOP PARADIGMS

1. Nutrients and elemental stoichiometry as drivers of ecosystems
2. Food-web and metacommunity dynamics, their controls, and their implications
3. Aquatic biodiversity and ecosystem function
4. Alternative stables states, regime shifts, critical transitions
5. Global and regional upscaling and prediction of processes
6. Landscapes and hydrology as drivers of limnological processes
7. Heterotrophy, autotrophy, and carbon biogeochemistry
8. Microbes, parasites and diseases as ecosystem drivers
9. Genetics and evolution, including isolation, mixing, and genomics
10. Sustainable supply of aquatic ecosystem goods and services and valuation of aquatic resources

Thanks to Steve Carpenter, Jon Cole, Pat Soranno, Walter Dodds, Lars Tranvik, Mike Pace, Bea Beisner, Yves Prairie, Ville Granéli, Bill Lewis, Jack Jones, and Val Smith for engaging this discussion. Several of them suggested that a major practical problem faced by limnological scientists and others is a lack of research support that is proportional to the importance of the resource. Also, several were concerned that the problems might be exacerbated by a future lack of aquatic scientists, especially in developing nations, who are qualified to solve these problems and advance these paradigms.

## CONGRATULATIONS TO OUR NEW BOARD MEMBERS-AT-LARGE

Congratulations to our newest board members, Susanne Menden-Deuer (University of Rhode Island) and Gillian Stewart (Queens College). I appreciate their dedication for volunteering to help guide ASLO over the next years. I want to extend my thanks to Roxane Maranger and Uta Passow who are rotating off the board after several years of outstanding service. You will both be greatly missed, although we will contrive to find many ways of keeping you both very involved. I would like to extend my special thanks to Sudeep Chandra and Phillip Taylor who also had the dedication to run for Member-at-Large. We are looking forward to keeping you both involved and busy with ASLO activities. Thank you to all for volunteering to help keep this great society working!

I am writing this at one of my favorite research sites in the North Temperate Zone. I hope that your research seasons are going as pleasantly as mine and I look forward to seeing you again either at our February meeting in Honolulu or our May meeting (with several CASS partners) in Portland!

Sincerely,
John

# MESSAGE FROM THE BUSINESS OFFICE

***Helen Schneider Lemay**, ASLO Business Office, 5400 Bosque Blvd., Suite 680, Waco, TX 76710-4446; Tel.: 254-399-9635 or 800-929-2756, Fax: 254-776-3767; business@aslo.org*

Dear ASLO Members:

Over Spring Break, my family and I visited the Mystic Aquarium and exhibit of Bob Ballard's Nautilus explorations. It was fun and informational, and my grandkids loved it. The presentation shows included "live" feeds that were from last summer's explorations and involved interaction by the scientists and other crew members. At the end, we were given materials to "go in and follow" the explorations again this summer through http://nautiluslive.org/keepexploring.

Sounds good, right? However, here's where we sometimes break down and don't meet the public's (in this case, my grandkids') expectations. When you go to the site, there is nothing new. The "live" feeds are still from August 2012 and are old news. This is disappointing and destroys the excitement and the show's credibility. They have moved on to more stimulating things. Not good for our science. I know this isn't an ASLO Web site, but may be something that addresses our communication efforts with the public. Looking through the eyes of children is always interesting and beneficial if we can capture their hearts and minds.

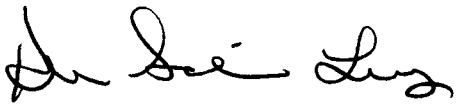
A good Web site I would recommend is "Cradle to Cradle-Remaking the Way We Make Things." This site uses nature and her wonderful inventiveness as a way to find environmental solutions to manufacturing things. Just type in "Cradle to Cradle" to preview.

Renewals for 2014 memberships are just around the corner along with library subscriptions. Please think about becoming a life member or sustaining member of ASLO as well as making a donation. Donations support student travel to meetings, student and early career professional activities, and education projects. Please, encourage your library to subscribe. This is a very important way to support our published journals, limnology and oceanography, and our society. We have an amazing offering of journals!

Watch for a new link on your renewal form. ASLO is working hard to be inclusive and find ways to make sure that our membership offers diversity. A new drop-down questionnaire for U.S. members only will be part of your membership renewal form. Please complete to allow us to review our current membership and to continue to grow.

As for ASLO meetings, 2014 will be a year of joint meetings and collaborations with other societies. This is a continuation of our strategic plan. During 2014, you can meet with other scientists from AGU, TOS, PSA, SFS and SWS. (Watch for more information in the upcoming months.) Session submission is open for the Joint Aquatic Sciences Meeting that will take place in May in Portland, Oregon. Abstract submission opens mid-August for the Ocean Sciences Meeting in Honolulu, Hawaii, in February 2014.

Please contact us at the ASLO business office (business@aslo.org), and we hope to see you in person at one or both of the meetings in 2014.



Helen Schneider Lemay
ASLO Business Manager

# MESSAGE FROM THE PUBLIC AFFAIRS DIRECTOR: WHERE PUBLIC OUTREACH AND POLICY COLLIDE

***Adrienne Sponberg**, ASLO Public Affairs Director, 10410 Kensington Parkway Suite 216, Kensington, MD 20895, USA, sponberg@aslo.org Twitter: @aquaticscinews*

This June I attended AGU's Science Policy Conference in Washington, D.C. The opening plenary, "Preparing for Our Future: The Value of Science" featured acting Director of the National Science Foundation, Cora Marrett, and former chair of the House Committee on Science and Technology, Bart Gordon. The entire 90-minute session can be viewed online (http://spc.agu.org/2013/), but the major take-home of the plenary was that *the scientific community must do a better job at outreach if science is to continue to prosper.*

After working for more than a decade at the science policy interface, this is not news to me. However, I still get questions from ASLO members about why ASLO puts effort and resources into outreach events such as the USA Science and Engineering Festival, which is geared towards children, or why we have "so many" workshops on communicating to the public when scientists should be focused on science. So I want to use this column to relay the message from the policymakers themselves. And to repeat my standard disclaimer: while the text below refers to the U.S. federal government, the principles discussed should apply to just about any form of democratic government. In fact, you'll see that much of what is said below repeats the "lessons learned" by our Canadian colleagues during their campaign to save the Experimental Lakes Area (ELA; see Orihel et al. page 76).

So how is it that a plenary led by two policymakers charged with discussing the future of federal investment in science resulted in so much conversation about public outreach? An

obvious answer is that the money for the NSF and other federal grant programs comes directly out of the pockets of taxpayers; approximately 1% of the U.S. taxpayers tax bill goes to science and technology programs. As budgets shrink, pressure on policymakers to scale back spending increase. In his concluding remarks, Gordon charged scientists to "put a face on science" for the public by telling them what you're investigating and what the benefits of your work are. Gordon said this was necessary because politicians "have to have that type of ammunition if we're going to go and fight the battles for funding that's necessary in these very difficult times." Marrett also appealed to scientists to be more active in public outreach stating that the government cannot be solely responsible for promoting science to the public: "it's all of you." She noted that many citizens are intrigued by the excitement of new discoveries but being able to "translate" science and talk to the public "becomes extremely important for making the case for basic research."

Each of us has a role to play in promoting science to the public, but how do scientists obtain the skills necessary to do so? Gordon told the audience that in 2007, Rep. Doris Matsui (D-CA) introduced an amendment to the NSF Reauthorization Act that he said would require scientists to "take a course in English – not the spoken English but being able to communicate what you're doing to the public." More specifically, the amendment provided supplemental funding to institutions receiving Integrative Graduate Education and Research Traineeship (IGERT) programs to train graduate students in communicating their research to "non-scientist audiences." Matsui said the program was necessary "because if scientists can't tell the rest of us what they have discovered, we are not fully recognizing the benefits of our investment in scientific research." Interestingly, former Rep. Vernon Ehlers, a staunch advocate for NSF and Ph.D. physicist, voted against the amendment. While he supported the goal of the program, he said he felt "this is the responsibility of the colleges and universities to do, and they shouldn't need an NSF grant to do this."

While the amendment ultimately passed, the bill died in the Senate so it was never implemented. However, six years later policymakers are continuing to beat the drum that scientists need to do more to engage the public and build support. This may seem like a daunting task, but thanks to the multiplier effect, if researchers or even lab groups added one outreach project per year, it would go a long way to narrowing the chasm between scientists and the public. And as Orihel et al noted above (see lessons #1 and #5, pages 77-78), having those pre-existing ties with the local citizenry can make a world of difference in keeping research programs alive.

# ASLO AWARD AND BOARD NOMINATIONS DUE OCTOBER 15

### BOARD NOMINATIONS

This fall the Nominations Committee will be selecting candidates for ASLO President, Treasurer, two Members-at-Large, and one Student Member to the board. The candidates you ultimately vote for come from member-generated suggestions from which this committee selects potential candidates and asks them to stand for election. If you do not suggest them, the committee does not know that you wanted them. To contact the Nominations Committee you can email nominationscom@aslo.org. The current nominations committee includes Debbie Bronk, Chair (to 12/14, ex-officio), Joel Hoffman (to 12/13), Jens Nejstgaard (to 12/13), and Carolyn Oldham (to 12/13).

Nominations may be submitted online at http://aslo.org/cgi-bin/nominations/index.cgi (login required). The deadline for nominations is October 15, 2013. In suggesting people, think about the composition of the board in terms of diversity of field, geography, gender, ethnicity, etc. Ultimately, ASLO should have a board that reflects, more or less, the membership. The composition of the present board and their terms of office can be viewed at http://www.aslo.org/information/board.html. The members leaving the board are the ones whose terms expire in 2014. You can find out about the current Board members by looking up their profiles in the member address section of the website.

### AWARD NOMINATIONS.

It's time again for the annual ASLO awards nominations! As always, ASLO awards provide a great opportunity to recognize outstanding individual performance and to highlight accomplishments of the aquatic science research community. The deadline for nominations is Tuesday, 15 October 2013.

Please take the time to nominate your colleagues for these awards. Nominations are short, simple to make, and can be submitted electronically via our dedicated online nomination form at www.aslo.org/forms/awards.html.

Our awards cover all career stages and activities, and are described briefly below. Detailed information on each award and its nomination process can be found at http://www.aslo.org/information/awards.html.

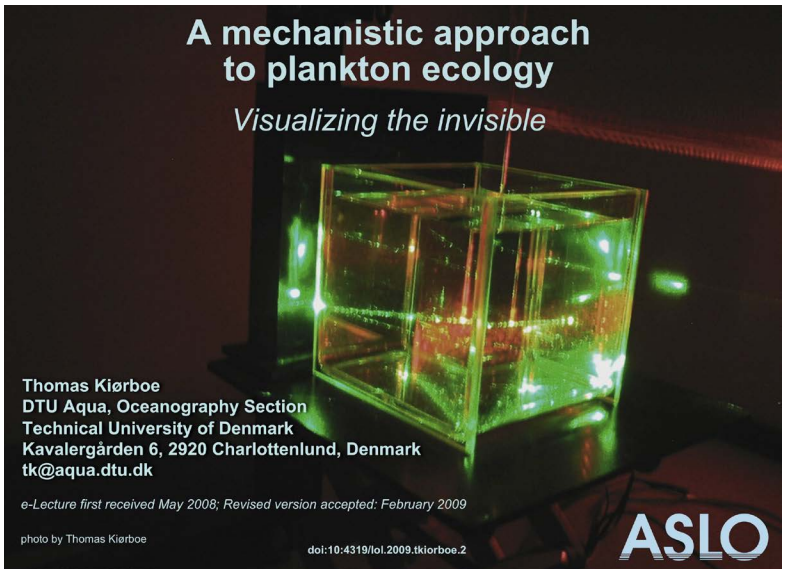
- Raymond L. Lindeman Award recognizes an outstanding paper written in the past two years by a young aquatic scientist.
- Yentsch-Schindler Early Career Award for scientists less than 12 years beyond their PhD and who have demonstrated outstanding and balanced contributions to research, training, and broader societal issues.
- G. Evelyn Hutchinson Award recognizes scientists within 25 years of their terminal degree who have made considerable contributions to knowledge of limnology or oceanography, and whose future work promised a continuing legacy of scientific excellence.
- A.C. Redfield Lifetime Award honors senior scientists who have made major, long-term achievements in any fields of limnology and oceanography, including research, education and service to the community and society.
- John Martin Award recognizes a paper in aquatic sciences, ten or more years old, that is judged to have had a high impact on subsequent research in the field.
- Ruth Patrick Award honors outstanding research by a scientist in the application of basic aquatic science principles

to the identification, analysis and/or solution of important environmental problems.

- Ramón Margalef Award for Excellence in Education recognizes excellence in teaching and mentoring in the field of limnology and oceanography.
- Citation For Scientific Excellence recognizes ASLO members who could not fulfill their career potential because of early death or disability.
- Tommy and Yvette Edmondson Distinguished Service Award recognizes members who have displayed exceptional efforts that support the professional goals and enhance the stature of ASLO.

Please note that some award criteria and nomination eligibility have changed since 2012.

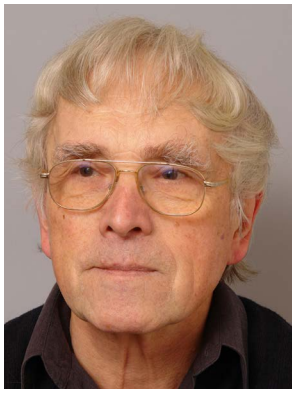
For further information, please have a look at the awards pages on the ASLO website, or contact ASLO Awards Committee Chair, Peter Leavitt, via email Peter.Leavitt@uregina.ca.




## OUTSTANDING L&O REVIEWER

***Everett Fee**, Limnology & Oceanography Editorial Office, 343 Lady MacDonald Crescent, Canmore, AB T1W 1H5, Canada; lo-editor@aslo.org*

Peer review is a crucial component of modern science. The fact that L&O is able to utilize the services of the best scientists as reviewers allows it to be a leading journal in the aquatic sciences. However, these individuals seldom get the recognition they deserve for this selfless work. Therefore, the Bulletin cites outstanding reviewers that Everett Fee, L&O Editor, feels deserve special recognition for their overall reviewing efforts. The ASLO membership extends its sincerest appreciation and thanks these outstanding scientists.



**WINFRIED LAMPERT**

Winfried Lampert is an emeritus professor at the Max Planck Institute for Evolutionary Biology (former MPI for Limnology) at Ploen, Germany. He has been interested in the role of adaptive evolution in the functioning of plankton communities and zooplankton-phytoplankton interactions for 40 years. One of his main goals was the establishment of Daphnia as a model organism in evolutionary and environmental ecology, integrating physiological, ecological, and population genetic approaches. He developed rigorous large-scale laboratory experiments to test hypotheses derived from field studies. In July 2012, he received the Alfred C. Redfield Lifetime Achievement Award of ASLO.

## FEATURED E-LECTURE: A MECHANISTIC APPROACH TO PLANKTON ECOLOGY BY T. KIØRBOE

Limnol. Oceanogr. e-Lectures, doi:10:4319/lol.2009.tkiorboe.2

Our limited intuition of the small-scale world of the plankton has biased the way we describe and understand ocean ecology. Classical approaches consider fluxes of energy and matter between species and populations to describe marine ecosystems, but biological interactions occur between individuals rather than between the abstract entities of 'populations' or 'trophic levels.' A complementary approach is to derive system properties from mechanistic insights in individual functioning and interactions. Through numerous examples, video clips, animations, and simple models, this lecture attempts to visualize the invisible world of the plankton, and to develop a mechanistic understanding of individual interactions and from here to deduce properties of populations and ecosystems.

L&O's e-lecture series is a welcome source of information for teachers and students alike. They offer the opportunity of fresh syntheses of hot topics in aquatic science that are spiced by the personal experience and insights of the lecture authors. They are thus an important complement to traditional general textbooks and specialized original papers, and they are served in a more appetizing form than typical review papers.

About the Author: Thomas Kiørboe is a professor of Ocean Ecology and the Director of Centre for Ocean Life at the

Technical University of Denmark. His main interest is in understanding the quantitative natural history as well as the small-scale organism-fluid interactions of marine pelagic organisms, from microbes to fish.

# MEETING HIGHLIGHTS

## 2014 OCEAN SCIENCES MEETING

The planning for the 2014 Ocean Sciences Meeting promises an interesting and exciting February gathering in Honolulu. The call to members for sessions garnered a record number of submissions and the full committee has refined the list prior to the call for abstracts (August 15). The meeting will contain the well-liked usual features (such as interesting plenary sessions and exclusive poster sessions) plus some additional new ones. One of the new ideas is to not have the occasional tutorial talks within specific sessions, but instead to have a limited number of tutorial only sessions. With the call for abstracts, we will ask members to submit tutorial proposals and if selected, it will be possible for an individual to present a tutorial as well as another oral or poster presentation. The meeting will open on Sunday evening, February 23rd, with a welcome and a keynote address by Elizabeth Kapu'uwailani Lindsey, native Hawaiian and the first Polynesian explorer and female Fellow in the history of the National Geographic Society. ASLO is the lead for this, the 17th biennial Ocean Sciences Meeting. The meeting co-chairs are Jon Sharp (University of Delaware) representing ASLO, Mel Briscoe representing TOS, and Eric Itsweire (NSF) representing AGU.

## ASLO MEETING IN GRANADA, SPAIN FEBRUARY 22-27, 2015

***Isabel Reche**, Departamento de Ecologia, Universidad de Granada, 18071 Granada, Spain, ireche@ugr.es; **Michael L. Pace**, Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia 22904-4123, mlp5fy@virginia.edu*

Dear Friends and Colleagues,

We invite you to dream for a moment about the next international ASLO meeting in Granada. The meeting theme will be "Aquatic Sciences: Global and Regional Perspectives – North Meets South." We hope to promote plenary talks and special sessions on global and regional patterns of aquatic systems in diverse northern and southern inland water biomes and oceanographic provinces emphasizing both similarities and differences. We see this theme as a critical scientific challenge as our discipline moves to understand and confront human accelerated environmental change. Along with ASLO members from North America and Europe, we anticipate Granada will be attractive to Latin American, African and Middle Eastern aquatic scientists. We hope to attract all in a dialogue about patterns of environmental change in aquatic systems at global and regional scales. This meeting in Granada will contribute to the ongoing international development of ASLO by bringing together a diverse group of participants at a site where many cultures have engaged through the centuries.

Granada is a multicultural, southern and old town. Its skin still conserves many footprints of the Moorish, Jewish and Catholic pasts. From its rich history, the city displays a unique architecture and an enduring quality of openness and tolerance. The University of Granada was founded in 1531 by the King Carlos I of Spain and V of Germany continuing a long teaching tradition, the roots of which can be traced back to the last

View of the Alhambra, the palace and fortress constructed by Yusuf I, Sultan of Granada during the Moorish dominion in Spain, and the Palace of Charles V, inserted within the Nasrid fortifications after the Catholic Reconquista. Behind these emblematic monuments are the Sierra Nevada mountains. Photo Credit: Provincial Tourism Board of Granada

Nasrid Kingdom. This University currently is the heart and head of the town, with more than sixty thousand students that contribute to the many cultural activities, bars, cafes, terraces, and energy of the city. You can feel this energy in Granada's streets. We hope this reverie is not just a nice dream but evolves to your attending the meeting in the winter of 2015. We welcome your thoughts on this forthcoming international gathering of ASLO and look forward to welcoming you to Granada.

Isabel Reche and Mike Pace
Co-chairs Granada 2015

# OBITUARIES

## JOHN J. GOERING, 1934 – 2013

*Contributed by **David Nelson**, Institut Universitaire Européen de la Mer, 29280, Plouzané, France; davidnelson77@excite.com; **Dennis Hansell**, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL 33149, USA; dhansell@rsmas.miami.edu.*

The field of ocean biogeochemistry lost one of its true pioneers on May 4th of this year, when John J. Goering died from complications of Inclusion Body Myositis. John was 78. Born in Clifton, Kansas, John graduated from Bethel College in 1956 and received his Ph.D. in aquatic sciences from the University of Wisconsin in Madison in 1962. After spending one year at the Bermuda Biological Station (now the Bermuda Institute of Ocean Sciences) he took a faculty position at the newly formed Institute of Marine Science at the University of Alaska in Fairbanks. He soon fell in love with Alaska, helping build the institute throughout his career and remaining in Fairbanks for the rest of his life.

During the early 1960s John and others at the University of Wisconsin, working under the direction of John Neese, broke new ground in using stable-isotope tracers to measure rates of biological processes in natural waters. Beginning with 15N tracer studies of nitrogen fixation in lakes and ocean surface waters and denitrification in the oxygen-minimum layer of the eastern tropical Pacific, he went on to study the uptake of nitrogenous nutrients, primarily nitrate and ammonium, by marine phytoplankton. The most acclaimed result is no doubt the paper by Dugdale and Goering (1967) published in *Limnology and Oceanography.* The paper was a major landmark in the understanding of nitrogen cycling in the ocean and has garnered over >2100 citations. The study led to our understanding that the production of organic matter by phytoplankton can be separated into its 'new' (i.e. supported by nutrients supplied to surface waters from elsewhere, typically upwelling and mixing from below) and 'regenerated' (supported by internal recycling of nutrients within the surface layer) components. The resulting realization that only the 'new' component is capable of supporting the net growth of plankton biomass in surface waters, net export of organic matter to depth or delivery of food to upper trophic levels has become a central paradigm in ocean biogeochemistry. Much of the field today has as its basis that fundamental understanding of the biogeochemical system; current ideas regarding the microbial loop, export production, carbon sequestration, etc. originate there.

John also conducted the pioneering studies of nitrogen cycling within the subsurface chlorophyll maximum, a pervasive feature in the tropical and subtropical oceans that contributes significantly to primary productivity in those systems (Goering et al. 1970). More broadly, the early 15N studies that John and his colleagues conducted (e.g. Dugdale and Goering 1967, Goering et al. 1970) showed that, by working within the cycle of a limiting nutrient such as nitrogen, tracers could reveal processes and relationships that are of fundamental ecological and biogeochemical importance.

John went on to apply the stable-isotope tracer approach to silicon cycling in the oceans, using 29Si and 30Si tracer experiments to study the uptake of silicic acid by marine phytoplankton and its regeneration in marine surface waters (Goering et al. 1973). Those studies showed that silicon is also recycled within the surface layer, although less rapidly than nitrogen, and that silicon can at times act as a limiting nutrient for diatoms. His breakthrough in developing isotopic tracers for Si has led to a tremendous increase in the understanding of Si cycling in the ocean and its role in regulating biogeochemical fluxes in both open-ocean and coastal waters.

In later years, John initiated landmark studies using natural 15N/14N and 13C/12C ratios to evaluate the flux of marine-derived nitrogen into freshwater systems by salmon runs, with several years devoted to studying the runs into Sashin Creek, Lake Iliamna and Karluk Lake, Alaska with his friends Pat Parker and Ole Mathisen. Those studies showed that salmon runs are a quantitatively important source of 'new' nitrogen to Alaskan

John J. Goering. Photo by Celeste Goering.

lakes and streams (Kline et al. 1993). This line of investigation also permitted him to combine three of his lifelong passions – research, fishing and Alaska – as it was essential for him and his colleagues to obtain samples from many of the major Alaskan salmon runs.

John had a rare combination of scientific and interpersonal skills that nurtured a series of graduate students who shared his passion for field oceanography and helped him to develop and carry out groundbreaking, interdisciplinary field programs in the Bering Sea (PROBES, Processes and Resources of the Bering Sea Ecosystem, and ISHTAR, Inner-Shelf Transfer and Recycling) and other marine systems. John was a particular inspiration at sea. Even when experiments were conducted in rough seas, he would give students an encouraging word or have a happy comment to make them feel better. His kindness and light-hearted spirit were famous among all who had the pleasure of working with him, and he consistently infused those around him with the idea that the whole enterprise of ecological and biogeochemical research at sea is both important and great fun.

John married his high-school sweetheart, Jackie, in 1956 and they remained a loving couple until her death in 2012. Their many friends, including John's students, knew their home as a place of warmth and welcome. As one of those students has put it, Jackie "…was a model for the care and feeding of grad students," and many became John and Jackie's lifelong friends. John's love for Alaska and its way of life was manifest. He particularly enjoyed hunting and fishing, and provided much of his family's sustenance via his annual moose hunting trips throughout the 1960s and 1970s. He also enjoyed duck hunting and fly-fishing for grayling, and his yearly halibut fishing trips were much anticipated by his sons and friends in his later years. John is survived by his sons Doug, Greg and Brent, by his grandchildren Annie and Spencer, and by countless former students and other colleagues whose understanding of the oceans and – just as importantly – of the delight to be found in discovering new things about them, is richer because it was our good fortune to know him.

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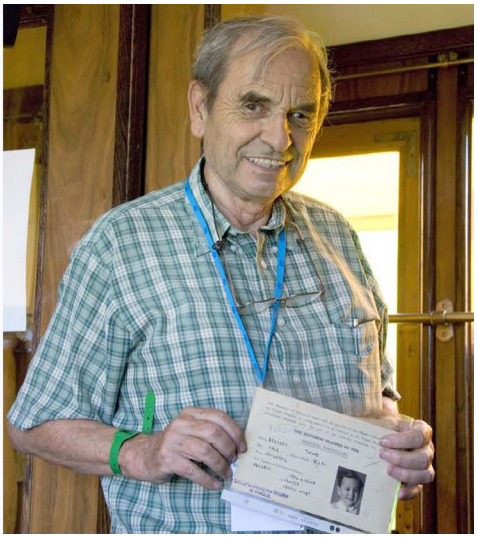
## TOM BERMAN, 1934-2013

*Contributed by* ***Tamar Zohary,*** *Kinneret Limnological Laboratory, Israel Oceanographic & Limnological Research*

It is with great sorrow that we announce the death of Prof. Tom Berman. He died on 13 April 2013, at the age of 79, while hiking alone in the Galapagos Islands, a place he always wanted to see. Apparently he fell on his forehead while hiking, hit a rock, and probably died on the spot. Only a week previously Tom had participated in a working session at the Kinneret Limnological lab, and everything seemed as usual with no hint of black clouds on the horizon. In fact, the only special item was Tom's enthusiastic announcement



Tom Berman. Left photo. Tom and his beloved dog Fuzzy (~1998) presenting Lake Kinneret (Israel) and the Kinneret Limnological Lab to one of the many visitors to the lab. Photographer – unknown. Right. Prague 2009. Commemorating the "kindertransport" trains and Sir Nicholas Winton who saved Tom's life from the Nazis by bringing him, at the age of 5, out of the Czech Republic to Scotland in 1939. Photographer. Shaquéde Frank

of his forthcoming trip to Galapagos. He had been healthy, professionally active, and extremely productive till his very last day.

Tom Berman was an active and prolific microbial ecologist, with a feel for where the scientific wind is blowing and making sure he is always at the frontier. He made major contributions in a diversity of fields, including algal nutrient uptake and excretion, the microbial loop, organic N as a source of N for algae, and recently transparent exo-polymers (TEP) and their role in desalination technology. We have lost a great scientist, an enthusiastic colleague, and a dear friend.

Tom was born in 1934 to a Jewish family in the Czech republic. Just before the onset of World War II, in 1939, his parents had the incredible foresight and courage to send Tom, their 5-year old son, alone, on the "Kindertransport" train with several hundred other refugee kids, from Prague to Holland, then by ferry to London, to foster families in Britain. This saved his life, while his parents and nearly all other family members perished in the Nazi concentration camps. Tom was lucky to have a new home and was raised by loving foster parents in Scotland.

As a teenager Tom joined a youth movement, immigrated to Israel in 1952, and settled in Kibbutz Amiad in northern Israel. He then travelled to the USA to study Agriculture for his BSc at Rutgers University (1956-1960), and continued with PhD studies in Microbiology at MIT (1960-1964). During his stay in the USA he also married Debby, whom he met earlier in Israel and had two daughters. The young family returned to Israel and Kibbutz Amiad in 1964 where daughter number three was born.

Tom was one of the founders of the Kinneret Limnological Laboratory - the Lake Kinneret (Sea of Galilee) Branch of the then new Israel Institute for Oceanographic & Limnological Research. He was the first Director of the laboratory, serving from 1967 to 1971, and again from 1986 until his retirement in 1998. Retirement didn't stop him at all, he continued to be an active and productive scientist to his very last day. He was also the longest-serving colleague at the Kinneret Limnological Lab, the only one remaining from the first day the lab was established.

As head of the lab, he set up scientific infrastructure, was responsible for recruiting excellent professionals, and led the limnological research of the Kinneret to impressive international heights. He maintained research ties with scientists and research organizations all over the world. In parallel, he kept close ties with the Israel Water Authority who financed the long-term monitoring program on Lake Kinneret, a central activity of the Kinneret Limnological Laboratory. He foresaw the crucial role of long-term records for understanding the functioning of ecosystems, and fostered the close ties between monitoring and research, understanding that this combination forms both the basis for future research and the basis for recommendations regarding the management of the lake as a main source of drinking water for the State of Israel.

Tom made a major contribution to research of Lake Kinneret, as well as to science in general, in many varied topics usually associated with aquatic microorganisms. Tom was a gifted writer, and wrote not only science but also English poetry of which he published two volumes ("Shards", and "Rambles"). His excellent work combined with his friendly personality and his willingness to share his knowledge gave him international recognition. He was blessed with vitality, scientific curiosity and a sense of humor that never changed or aged. He was recently awarded the Lifetime Achievement Award of the Israel Association for Aquatic Sciences. He was a role model, showing the younger scientists how to retire from full-time/professional work and enjoy a creative, enriching time with friends and family.

Tom's absence has left a great void in the life of the Kinneret Limnological laboratory, the environment that filled such a large part of his adult life for so many years. A special session to commemorate Tom Berman is being organized at the upcoming SIL congress, Budapest, in August 2013. Tom Berman was survived by his wife Debby and three daughters, Ilana, Rina and Ora.

***Between Breaths***

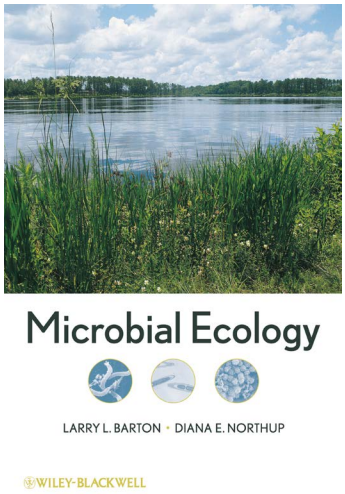
Descending
Into blue waters
Swirl of white light
Foam of bubbles
Down, down
Into an azure chasm
To a silent Cathedral
Where prayers are diluted
With salt water
Pressure reverberating
In the hollow of the skull
Ascending
Rising again
Farewell, receding Eden
Glimpsed between
The heartbeats
Of two breaths

The poem 'Between Breaths' from Tom Berman's poetry book Shards.

# BOOK REVIEW

**BARTON L. L. and NORTHUP D. E.** 2011**. Microbial Ecology** Wiley-Blackwell, ISBN 978-0-470-04817-7. 407 pp $104.95

*Reviewed by* ***Télesphore Sime-Ngando****, LMGE, Laboratoire Microorganismes : Génome et Environnement, UMR CNRS 6023, Clermont Université Blaise Pascal, BP 80026, 63171 Aubière Cedex, France; telesphore.sime-ngando@univ-bpclermont.fr*




"Microbial Ecology" is a new reference text authored by Barton L.L. and Northup D.E. as an outgrowth of their extensive experience in teaching courses in microbiology. The book covers both traditional and cutting-edge issues in the ecology of microbes in the biosphere, with an emphasis on microbial activities and interactions within their environment and communities. The organization of the book is highly pedagogic, reflecting the main objective of the authors which was to provide a concise and comprehensive text, primarily for upper-level undergraduate and first-year graduate students in biology, microbiology, ecology or environmental sciences. The overview of the topic is broad while providing numerous special features to assist both students and instructors: (i) basic principles in ecology and microbial ecology, (ii) information boxes in each chapter to highlight specific microbial ecology issues of particular interest, (iii) a glossary and key words, (iv) a selected reading list for each chapter, (v) mini case exercises to promote critical thinking in relation with the activities of microorganisms in specific environments, (vi) a special section in each chapter on "microbial spotlights" that focus on the latest works and findings of selected scientists from around the world, and (vii) chapter summaries and review questions for class discussion. The book also provides insights into relevant methodologies for characterizing environmental microorganisms. Because of theses characteristics, and the integrative approach used, this new book is valuable addition to the growing field of microbial ecology. In addition to serving as textbook for students, can also serve as a highly useful reference for scientists, teachers, molecular biologists, environmental professionals, and engineers.

The two authors produced a text of 13 chapters with a homogeneous style, with few overlaps. Each chapter has an expressive title and address a specific subject, establishing the book as a general guide for the topics. The first chapter – Microbial ecology: beginning and the road forward – serves as introduction to the book, with a description of the roots of microbial ecology from the pre-cellular world to the early and contemporeanous microbial life characteristics (cell shape, taxonomy, metabolisms, growth, adaptation and the changing face of microbial ecology with applications of 'omic' technologies). This is a concise but represents an up-to-date state of the art of microbial ecology, including recent concepts (e.g. ecotypes) and bibliographical materials, most of which were published during the past decade. A powerful educational tool used in the book is in the form of information boxes. In the first chaper the box is on the exponential growth of procaryotes and the significance of controlling factors. Assuming 2.5 x $10^{-13}$ g weight per cell, fast growing procaryotes like E. coli divide every 20 min and would produce a mass of about 2.2 x $10^{24}$ kg in 48 h, which is inappropriate because the mass of Earth is 5.97 x $10^{24}$ kg!

Chapter two (Diversity of microorganisms) and three (Complexity and simplicity of cell systems) provide keys for the understanding of microbial processes in specific environments, focusing on structural (i.e. diversity and cell architecture and morphologies) and functional (physiology, metabolisms) characteristics of microbes considered in a large sense, including bacteria, archaea, algae, protozoa, fungi and viruses. The differences between Archaea and Bacteria are well covered on the light of recent research, and it is a pleasure to welcome the inclusion of viruses. The continuously growing knowledge acquisition on the diversity of microorganisms with the increasing sophistication of molecular and both genomic and postgenomic techniques are underlined. I read with special interest the chapter three which elegantly relates cell morphologies, metrics and systems to microbial niche-specific specializations for particular environments through differential motility, chemotaxis, cell attachment, persistence strategies, specific cellular and metabolic processes, bioenergetics, etc.. While r and K strategies and the corresponding environments along the r-K continuum are not included, the ecological significance of cell size and the differences between large vs small cells or between procaryotes and eucaryotes is deeply informative.

The two following chapters correspond to a sort of "materials and methods" of the book, titled "The microbial habitat: an ecological perspective" (chapter four) and "The how of microbial ecology studies" (chapter five). The range of habitats covered in chapter four is quite large but not exhaustive (absence of microbiome), comprising diverse aqueous, soil, rock, and atmospheric habitats, some of which are extreme in terms of pH, temperature, ultraviolet radiation, etc.. The relatively recent idea that microorganisms are omnipresent in almost all habitats on Earth where their composition at a particular moment is controlled by a given set of chemical, physical and biological conditions, is clearly given to the readers. The classical aquatic and soil food webs are well contrasted with the new view of the importance of microorganisms and microbial food webs in the environmental trophic networks. The role of atmospheric habitat in the long distance transport of microorganisms offers the link with the ecological debate on the microbial population exchanges across habitats and the related biogeography, in relation to the so-called Baas Becking statement 'everything is everywhere, but the environment selects', also known as the EiE hypothesis. Chapter five describes and conceptualizes the different methodological steps and approaches to study microor-

ganisms, from sampling and storage to microscopic observations, cultivation, molecular phylogenetics, community figerprinting, metagenomics, environmental proteomics, and stable-isotope methods. The challenge of linking molecular studies to cultivation and microscopic studies and their complementarity in understanding the whole organism and its physiology and functions in natural community is particularly highlighted.

Chapters six, seven and eight are devoted to microbial interactions: "Microbe-microbe interactions", "Interactions between microorganisms and plants", and "Interactions between microorganisms and animals", respectively. Cell-cell associations are well described following a yin-yang approach, interconnecting the positive (e.g., commensalism, synthrophy, mutualism…) and negative (competition, parasitisism, predation…) driving forces and mechanisms, including the mediated-effects of inhibitory substances (e.g. bacteriocins, antibiotics). This is given to the readers on the basis of cell-cell classification of interactions, and classical case-study interactions as well, with targeted examples summarized in tables. This also includes viral-cell interactions, restricted however as the most widespread example of obligate parasitism. The emergence of sexuality through same species cell-cell interactions is described. The biogeochemical cycling in microbe-plant interactions forms the bulk of chapter seven, with the well known model systems of rhizosphere or mycorrhiza associations, where bacteria and fungi can act as beneficial partners to plant metabolisms or as plant pathogens. The beneficial effects of the fixation of atmospheric molecular nitrogen by cyanobacteria and other free living prokaryotes are well illustrated with three major types of symbioses: rhizobia with leguminous, Frankia with specific woody plants, and cyanobacteria with lower plants. The chapter on microbe-animal interactions are centered on the endosymbiotic theory where symbioses between animals and microorganisms has led to new metabolic capabilities through evolutionary processes, and are considered the origin of mitochondria and chloroplasts. Few examples of symbioses are described, e.g. between fungi and beetles, bacteria and insects, bacteria and birds, bacteria and ruminants, and squid and fish. Overall, the complexity of evolutionary and ecological interactions where microbes are involved as partners or pathogens, and their dependence on specific organisms are well highlighted, and presented as mainly the fruit of selection by specific environments.

Chapters nine and ten are titled "Living together: microbial communities" and "Microbial processes contributing to biogeochemical cycles," respectively. Based on dominant issues and questions in microbial community ecology, the authors first stress the great window opened by new molecular tools, primarily by metagenomics, on the nature of the members of microbial community and the functions they perform in the environment. This has greatly expanded our knowledge of habitats in which microbes thrive, including for example newborn gut, human mouth, terrestrial and deep-sea hot springs, and even wine and cheese! The extensive novel lineages from underexplored habitats are increasingly adding to the tree of life, providing also cues

for microbial biogeography in support of the idea that everything is everywhere but the environment selects. Microbiologists have also moved from studying free-living, planktonic microorganisms to the study of biomats and biofilms, perhaps the predominant microbial phenotype in natural and pathogenic systems. I found very informative the points on quorum sensing as a possible starting point of multicellularity, on colonization/recolonization, and on microbial successions. Same for microaganisms as engineers of elemental cycling, primarily of carbon, nitrogen, phosphorus, sulfur, manganese, selenium, mercury, iron, as well as of oxygen and hydrogen in the biosphere.

The three last chapters of the book are less fundamental, dealing with the role of microbes in geomicrobiological interactions and ecological engineering, primarily in biomineralization, microbial weathering, decomposition of natural compounds, and bioremediation, and some of their impacts on socio-economical activities. The capability of microbes to form mineral phases, precipitate or dissolve some minerals, or to bind mineral such as iron through extracellular polymeric substance production is well documented. The connection with the formation and recovery of economical products of interest such as ore and biomining, petroleum, oil and gas deposits is well given to the readers, as well as the disastrous effects such as corrosion of metallic surfaces (water pipes, chip hulls) or stone monuments. Regarding the decomposition of natural organic compounds, the description of microbial specific enzymes able to initiate the decomposition of recalcitrant plant materials such as cellulose, pectin and lignin, or of animal materials such as chitin, collagen, keratine or silk, is sound. The Chapter on natural compound decomposition also stress the anaerobic microbial digestion (fermentation) and the related production of organic acid terminates, hydrogen, methane, ethanol, biofuels, etc.. Microbial metabolisms also have a negative impact on human by contributing to the 'sick building' syndrome and defacing of historic art objects. The last Chapter of the book highlights the beneficial use of microbes for bioremediation of pollutants such as petroleum products, toxic metals, and anthropogenic chemicals such as xenobiotics. The scientific frame of bioremediation as a technology is underlined and the related designs and implementations described for biofarming, permeable reactive barriers or the use of nutrients or of aeration as tools for optimizing bioremediation. This last Chapter of the book really provides a nice overview of the interactions between microbes and chemicals, and their exploitation as a tool for bioremediation.

Overall, I found that most of the chapters are well written, academic, informative reading. Many of the texts, information boxes, mini case exercises, and "microbial spotlights" focusing on selected scientists are interesting and at times fascinating, although some current developments such as those regarding the 'phycosphere' and the 'good viruses' (Roossinck 2011) in microbe-microbe interactions, or those regarding the 'rare biosphere' (Hugoni et al. 2013 and references therein) or the roles of eukaryotic microparasites in microbial food web dynamics (Sime-Ngando 2012, Dunne et al. 2013), are lacking. It is also a pity that the need for general theories and ecological concepts in microbial ecology, compared to those well-known in macroecology, is not stressed. This is a compelling challenge facing contemporary ecology (Prosser et al. 2007). Overall, I can recommend this book as a reference teaching text and as an outstanding reference book on general microbial ecology.

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## E Komo Mai – Welcome!

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