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STEPS TO INCREASING MINORITY PARTICIPATION IN THE AQUATIC SCIENCES: CATCHING UP WITH SHIFTING DEMOGRAPHICS

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African Americans, Hispanics, Native Americans and Pacific Islanders are entering the ranks of aquatic scientists, but remain under-represented in comparison to their share of the U.S.A. population. This paper explores this issue in the context of dynamic demographics and reviews some programmatic solutions.

The U.S.A. population is undergoing a rapid shift in demography (U.S. Census Bureau, 2001). While people of primarily European ancestry still dominate the population and workforce, their overall percentage of the population continues to shrink as several minority groups show disproportionately large growth. High minority population growth traces to both higher rates of reproduction and immigration (Lollock 2001). If current trends continue, some time near the mid-21st century minority groups as a whole will constitute the new majority in the U.S.A. (Day, 1996; Table 1). This rapid expansion in the overall minority population is not uniform among all people of color. Hispanic Americans are displacing African Americans as the largest minority group, and numbers of Asians will double in the next 50 years (Table 1).

To fully serve the nation's population, our social institutions must respond to these demographic shifts. Additionally, institutional vibrancy depends upon the influx of talented individuals, including those from minority groups. What does this mean for the aquatic sciences? First, the watersheds and coastal areas adjacent to aquatic systems in the U.S.A. are increasingly populated by members of minority groups. Effective management of these systems requires links to the resident population, and this could be facilitated by scientists and managers who look like the population they serve. Getting the attention of political leaders is often easier if the call to action comes from their constituent base. If, for example, a city council was considering a development project that would have an impact on a neighborhood stream, the advocates for preserving the waterway will get further if they appear to be part of the community.

Second, expanding the ethnic diversity of aquatic scientists affords more opportunities for intellectual advancement of the discipline. People of varied experiences bring new perspectives to the science. Different cultural systems also engender different styles of thinking. Ethnic diversity can promote diverse approaches to our science.

THE PROBLEM

What are the impediments to increasing the diversity of aquatic scientists? Foremost is the legacy of oppression born by many members of minority groups. Just a few generations ago, the ancestors of many of today's minority students emerged as survivors from slavery or genocide. For many, this was followed by decades of segregation, discrimination, and a second-class citizenship that continues today. Recent immigrants must also be considered. These new Americans fled political or economic oppression at

Table 1. Attributes of the U.S.A. population along ethnic lines. Population demographics are based upon the 2000 census (U.S. Census Bureau, 2001), but projections and 2000 median age are based upon the 1990 census (Day, 1996). The projection data combines Pacific Islanders and Asians. White = non-Hispanic whites, A.A. = African American, Hisp. = Hispanic, Native = Native American, P.I. = Pacific Islander. Total U.S.A. population reported in 2000 was 281,421,906.

	White	A.A.	Hisp.	Native	Asian	P.I.
% of total US pop. in 2000	75.1	12.3	12.9	0.9	3.6	0.1
% of total US pop. in 1990	80.3	12.1	0.9	0.8	2.8	0.1
Median age (years) of 2000 pop.	36.9	29.2	27.0	27.6	31.4	
Projected % of pop. in 2050	47.8	15.8	25.7	1.0	9.7	

The ASLO Bulletin

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home, but in the U.S.A. they face barriers of language and culture, and are 1.5 times more likely to live in poverty than native born citizens (Lollock, 2001). While the effects of such legacies of oppression at home or abroad are certainly varied and complex, a common theme is the resulting lack of full educational opportunities and career choices. Although many people of color have ascended to the middle class and beyond, such economic and educational achievements have not completely freed them from their history. The world around them responds first to their color, for it is more obvious than the size of their bank account or the length of their resume. Thus, to be a person of color in the U.S.A. today means to have to bear two burdens. One is the legacy of oppression and the other is the set of assumptions laid upon them by the greater society.

What factors lead a student, minority or majority, to a career in the aquatic sciences? The student must enjoy the study of science in general and have his or her abilities affirmed by a measure of academic success. The student also should be exposed to the actual environments that aquatic scientists study, and to what these studies entail. Finally, the student must not only become exited about the possibility of the career, but also must perceive it as an obtainable goal. I will examine each of these issues as they relate to the special experiences of minority students.

Since the aquatic sciences are interdisciplinary by nature, practitioners must be proficient in all of the basic scientific disciplines, including mathematics. But are minority students as likely as whites to enter college, let alone have the skills to succeed in a science curriculum? Due to lower median ages of their populations (Table 1), minority students are actually over represented in primary and secondary (K-12) schools, yet they have a lower rate of direct transition to college than their white counterparts (Table 2). Despite this, many minority students eventually enroll in college, with college demographics being nearly identical to those in the general population (Tables 1 and 3). However, for African Americans, men enroll and graduate from college at ca. half the rate of women (NSF, 1999). In comparison to white students, a higher percentage of minority students do not seem well prepared to undertake a science curriculum in college. In particular, greater than half of African American, Hispanic and Native American 12th graders score below the basic math proficiency level prescribed by the U.S. Department of Education (2000; Table 2). While math proficiency is not the sole predictor of success in the sciences, it does give some indication of general weakness in quantitative preparation. Perhaps as a result, minorities account for a third fewer BS/BA degrees in science and engineering than predicted by their enrollment in college (Olson, 1999; Table 3).

Are minority students generally aware of the aquatic sciences as a profession? Most aquatic scientists probably develop an affinity for water long before their academic interests mature. Exposure to lakes, creeks, or the oceans in childhood helps ignite initial interest. These sorts of opportunities are often not as available to minority youth, especially those growing up in inner cities. This is ironic for African Americans, since they have a rich maritime heritage. During the Great Age of Sail, black men were actually over-represented in the crews of many American sailing ships (Bolster, 1997). Going to sea was one of the few career paths readily open to black men during the early days of our republic. Steam propulsion and the rise of Jim Crow racism in the late 1800's drove most African-Americans ashore, thus breaking their communities' historic link to the sea. Additionally, the legacy of segregated facilities means that parents and grandparents who were kept away from swimming pools, beaches, and state parks, are less inclined to introduce their own children to water-related activities. While minority youth are probably aware of various aquatic systems from the media, this does not replace direct experiences with these systems. Without "getting their feet wet," it is probably difficult for these students to think of aquatic systems as being part of their personal world.

There are some minority youth that do have exposures to aquatic systems and who consequently begin to think about careers in the field. However, minority students that show academic promise in the sciences generally are steered toward careers in medicine. People know about physicians, and see the wealth and status associated with the profession. There are also growing numbers of minority healthcare professionals who serve as role models (American Medical Association, 2000). The present dearth of minority aquatic scientists means there are few to serve as role models for young students of color, making it difficult for students and their parents to see a career in the profession as feasible.

PROGRAMMATIC SOLUTIONS TO THE PROBLEM

One part of the solution to increasing diversity in the aquatic sciences lies simply in increasing the number of minority students earning BS degrees in science. Any general efforts to improve science and math education in K-12 for minority students will help in this effort. Beyond the ability to succeed, the students must also have the interest and desire for the field. In the world of K-12 education, this means developing programs that provide exposures to the aquatic sciences. These can range from single exposure field trips, to Internet based explorations, to summer or after-school programs. Minority-focused programs at venues of informal education, such as aquaria and museums, can also provide hands-on exposures.

At the college level there are two basic approaches for funneling minority students towards aquatic science careers. The most direct is to have aquatic specialty programs at institutions with substantial minority enrollments. On-campus, degree-granting tracks are in place at several minority-serving institutions. Marine science programs flourish at both Hampton University and Savannah State University (Gilligan, 1996). Both schools began their programs circa 1980, have waterfront campuses with dedicated facilities, and between them have graduated nearly 200 minority students. Other minority-serving institutions with specialized aquatics programs include: University of Puerto Rico, Mayaguez; Jackson State University (Marine Biology); University of Maryland, Eastern Shore (Fisheries/Marine Science); Fort Valley State University (Georgia; Fisheries/Limnology); and the University of District of Columbia (Marine Biology). Oregon State University is a majority campus, but runs the Native Americans in Marine Science Program (NAMS), and has graduated 97 students with degrees that include aquatic science training.

The other approach to getting minority science majors interested in limnology or oceanography is to run enrichment programs. This generally entails a semester or summer off-campus experience in aquatic studies. Many marine and freshwater institutions have established summer programs of course work and research for undergraduates, some of which are tailored for minority students (Table 4). Shannon Point Marine Center, Western Washington University, hosts a program for visiting minority students (MIMSUP) that is unique in that it runs during the academic year. Hampton University recently began the interdisciplinary Minorities At Sea Together (MAST) program that combines a scientific cruise with explorations of marine policy, marine science, African American heritage of the Chesapeake Bay, and sailing.

Certain features are common to all of the successful minority-targeted

Table 2. Distribution and performance of students in public schools in 1998 (except as noted). Data are from the U.S. Department of Education (2000) and NSF (1999). White = non-Hispanic whites, A.A. = African American, Hisp. = Hispanic, Native = Native American, P.I. = Pacific Islander. NA indicates data not available.

	White	A.A.	Hisp.	Native	Asian/PI.
% of total K-12 school population	62.7	17.1	15.1	NA	NA
% of group going directly to college	68.5	61.9	47.4	NA	NA
% of 12th graders scoring below basic proficiency in math (1996 data)	21.0	62.0	50.0	66.0	19.0

Table 3. Distribution of students in college and degrees awarded in 1995, except as noted (from Huang et al., 2000; NSF, 1999). White = non-Hispanic whites, A.A. = African American, Hisp. = Hispanic, Native = Native American, P.I. = Pacific Islander.

	White	A.A.	Hisp.	Native	Asian/PI.
% of total college population	73.6	11.1	8.5	1.0	5.8
% of science & engineering BS degrees	76.6	7.1	5.8	0.6	7.6
% of sci. & eng. MS degrees in 1996	82.6	5.0	4.0	0.4	9.0
% of science & engineering Ph.D.'s	73.2	2.9	3.0	0.4	19.3

Table 4. Minority Programs for Undergraduates in Aquatic Sciences. All NSF-funded except MAST, which is funded by the Pew Foundation.

Florida Institute of Technology Summer Internships Research Experiences for Undergraduates: Science in Support of Coastal Resources. Contact: irlandi@marine.fit.edu
Hampton University & ASLO, Expanding Linkages Between Under-Represented Minorities and Careers in Aquatic Sciences. http://ww2.hamptonu.edu/science/ASLO.htm
Hampton University, Minorities At Sea Together (MAST) http://ww2.hamptonu.edu/science/masthompage.htm
Old Dominion University, Minority Undergraduate Scholarship and Training (MUST) in Biogeochemistry. http://www.clt.astate.edu./asurockdoc/must.htm
Oregon State University, Native Americans in Marine and Space Sciences (NAMS). http://www.oce.orst.edu/native/
Savannah State & Harbor Branch Oceanographic Institution, A Bridge to Research in Marine Sciences. http://www.savstate.edu/scitech/MarineSci/fly2000.htm
South Carolina Department of Natural Resources, Minorities in Marine and Environmental Sciences. http://www.dnr.state.sc.us/marine/minority
Virginia Institute of Marine Science, Summer Intern Program (SIP). http://www.vims.edu/sms/intern/
Western Washington University, Minorities in Marine Science http://www.ac.wwu.edu/~mimsup/
Whitman College and ASLO, Minorities in the Aquatic Sciences: Database, student registry, and electronic resources. http://www.aslo.org/mas/

programs. A critical mass of minority students protects against cultural isolation and promotes a peer-based support system. The scientists running the programs and participating mentors need to have enough cross-cultural competency to facilitate effective interactions. Hands-on research also helps the participants feel fully vested in the science and allows them to present a poster or talk at a regional or national scientific meeting (see below). Ideally, the students should be able to interact with minority scientists who can serve as role models and help them gain confidence in their ability to enter the profession. Finally, the students should be compensated with stipends that can compete with funds they could generate by staying at home and working. These features are essentially those cited by Gilligan (1996) in his case study of the Savannah State University marine science program.

On-campus and summer programs for minority students help prepare them for careers in aquatic sciences. However, it is important for the students to go beyond these programs and build links with other individuals and institutions. The participants in these programs must understand that there are other students of color who share common interests and that there are role models who have "made it" in the profession. It is also important that these students form relationships with majority scientists and graduate institutions. Such steps will increase their chances of gaining graduate school admissions and jobs. The ASLO Minorities Program ("Expanding Links Between Under-Represented Minorities and Careers in Aquatic Sciences") was established in 1989 to facilitate such activities. The program brings about 60 minority students and a dozen mentors to annual ASLO meetings. Here the students participate in field trips, workshops addressing issues of special interest, a student symposium where they present their research, a seminar given by a noted aquatic scientist, and the regular oral and poster sessions. The students are also assigned "meeting mentors," regular ASLO members who help them navigate the meetings and introduce them to other scientists. About 20% of the participants in recent years have been graduate students, many of whom began with the program as undergraduates, but come back to serve as near-peer mentors and to continue to gain support from the activities. About 400 different students have participated since the program began, and contacts made at ASLO have led to internships and entry into graduate programs for many of these students. In addition to this program, Dr. Susan Weiler (Whitman College) was recently awarded NSF funding to develop a student registry and "virtual community" for minority students in the aquatic sciences. This program links students to each other, potential employers, graduate schools, role models, and other special opportunities (Table 4).

The various efforts mentioned above all contribute to increasing the number of minority students earning undergraduate, M.S., and even a few Ph.D. degrees in the aquatic sciences. However, the production of minority doctoral degrees in the field is still miniscule. This is not surprising in that with the exception of the University of Puerto Rico, only majority institutions offer doctoral degrees in the aquatic sciences. Minority students enrolled in these programs can't help but feel isolated. Knowing that they are likely to be about the only minority student in a department is a daunting prospect. While some minority students are graduating from majority institutions, others are probably too apprehensive to even apply to those programs. Gilligan (1996) clearly documents the essential role played by Historically Black Colleges and Universities (HBCU's) in producing undergraduate science majors. HBCU's are effective because they do the things cited above as critical features for success.

What is needed now is the development of targeted Ph.D. programs for minority students (e.g., McManus et al., 2000). Such programs should be placed at institutions committed to the concept and that have a history of success in dealing with both minority students and minority-serving institutions. The programs should create a critical mass of minority students to form a community of cooperative scholarship. Other ideals for the program should include: students interacting with visiting role models; excellent mentors; graduate students themselves serving as mentors for minority undergraduates; and full financial support. None of the several undergraduate programs at

Table 5. Results from Survey of ASLO Minorities Program participants.

XXX University, YYY University, and the University of ZZZ are developing a program designed to increase the number of minority students earning a Ph.D. in Marine Science or Oceanography. The plan is to have a critical mass of minority students (6 in the first cohort) who would share many common experiences while pursuing their doctoral degrees. This would provide a community of scholarship and mutual support. Students would take some course work in common and share in some other special activities, such as seminars from minority role models in the field, cruises where the students work together as a team, and mentoring of minority undergraduate students. Students could enter with either a BS or MS degree. All of the students will have full financial support for tuition and living expenses.
1. As a minority student, I would rather be enrolled is the above program than just the normal graduate program at YYY or ZZZ. **58% Strongly Agree 26% Agree 5% Neutral 11% Disagree 0% Strongly Disagree**
2. Knowing that I would have other minority students in a graduate program with me will increase my desire to apply to that program. **47% Strongly Agree 26% Agree 16% Neutral 11% Disagree 0%Strongly Disagree**
3. I would be more likely to apply to graduate school for a Ph.D. through this program than I would without this program. **47% Strongly Agree 32% Agree 11% Neutral 5% Disagree 5% Strongly Disagree**
4. Having such a program makes the goal of obtaining a Ph.D. seem more obtainable for me. **61% Strongly Agree 6% Agree 22% Neutral 11% Disagree 0% Strongly Disagree**
5. There is strong need for such a program. **74% Strongly Agree 26% Agree 0% Neutral 0% Disagree 0% Strongly Disagree**

minority-serving institutions (other than UPR) are at campuses developed enough to confer doctoral degrees in aquatic sciences. This means that one or more of the traditional majority institutions must offer such a program. When this happens, we may see a steady flow of minority students earning Ph.D. degrees in the aquatic sciences. These students will then serve as role models and mentors, priming the pump to get the pipeline flowing.

However, do the students themselves perceive a need for such a minority-targeted program? A survey was conducted of 50 student participants in the 2001 ASLO Minorities Program to assess student response to such a program. Half the students responded, and all gave strong support to the idea (Table 5). Recently Kellogg (2001) reported on a similar University of Maryland program to produce minority Ph.D.s in mathematics. They have graduated numerous African American Ph.D.'s in the last decade, noting that once a critical mass was reached, "The students became the draw." (Kellogg, 2001).

There is a clear need for a special focused program as proposed above, but this is not the sole avenue to success. Minority Ph.D's have and will continue to come through institutions without any special programs. Indeed, a number of the students surveyed preferred the "traditional" approach (Table 5). Professors and departments recruiting students should always cast their nets broadly and actively seek minority applicants. Simple steps include contacting the programs listed in Table 4, and interacting with students at the annual ASLO Minorities Program. Individuals inspired to greater levels of action can contact the federal agencies that fund aquatic research to take advantage of existing programs and to propose new ones. In addition to NSF, other agencies (e.g., NOAA, USEPA, and USGS) offer a variety of programs designed to promote diversity (Jearld, 1999). With some thought and effort, we can all become part of the solution.

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OXYGEN TRANSPORT ACROSS THE BENTHIC BOUNDARY LAYER: FROM A 1-D TO A 3-D VIEW

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The sediment-water interface is a fascinating environment. Bordering the dynamic processes between hydrosphere and geosphere, it is the gate-keeper for the benthic-pelagic coupling of carbon and nutrient cycles in aquatic ecosystems. In this region boundary layer hydrodynamics interact with transport processes across the interface, organic matter deposited on the sediment surface supports and focuses the biological activity to a thin veneer teeming with life, and steep chemical gradients provide diverse zones for biological and geochemical processes.

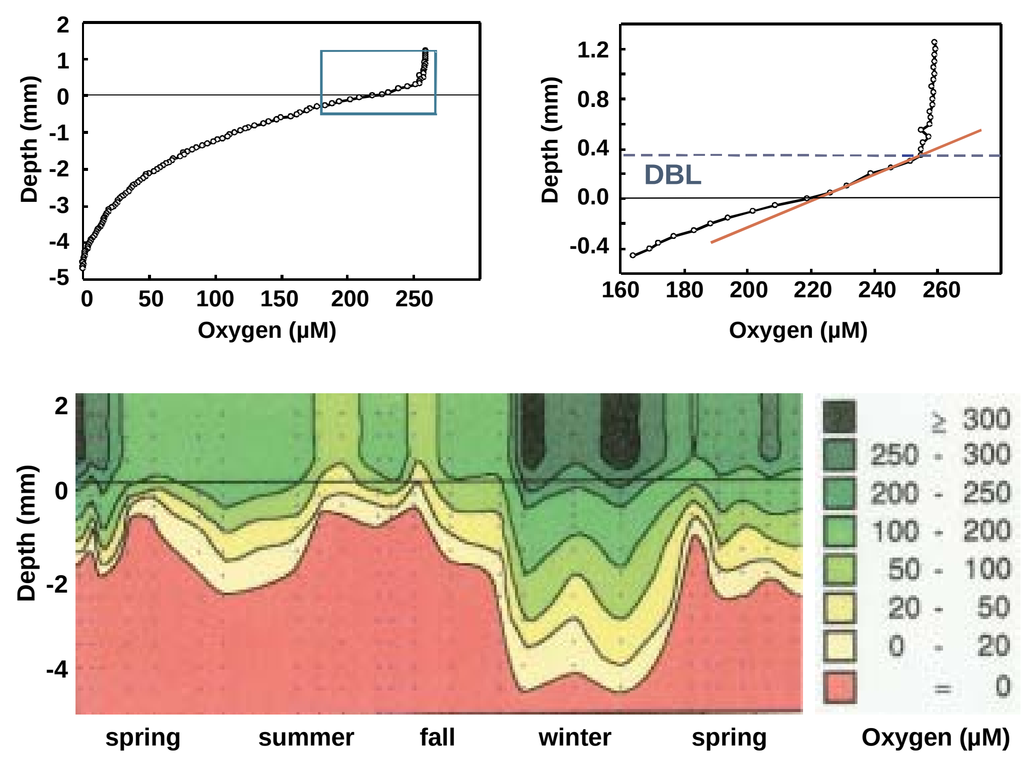
Just as the earth surface appears flat when viewed from orbit, the sediment surface appears flat when we read most biogeochemical literature which describes it with only a vertical axis. However, many aspects of sediment biology and geochemistry require a three-dimensional view to understand their essential properties. We need novel approaches with greater information capacity to study the spatial structures of biota, environments, and processes. To stimulate the development of such approaches, this short review will discuss some of the small-scale characteristics of the benthic boundary layer, and illustrates the 3-D world of the sea floor based on recent progress in analytical and experimental techniques. The few examples used are taken mostly from the work of our own group since brevity forces us to neglect the excellent work of many colleagues.

As we cross the benthic boundary layer, the hydrodynamic properties of water flow change fundamentally as the sediment surface is approached (Boudreau and Jørgensen, 2001). Descending from the free flow region to less than a meter above the sea bed, we enter the logarithmic layer affected by sediment friction and roughness. Much nearer to the sediment surface, in the centimeter thick viscous sublayer, internal friction strongly dampens turbulence and the eddy diffusivity, E, falls below the kinematic viscosity, ν, of water ($\nu \approx 10^{-2}$ cm^2 s^{-1}). The eddy diffusivity continues to decrease steeply as the sediment is further approached. At ≤1 mm from the sediment surface, it drops below the molecular diffusivity ($D \approx 10^{-5}$ cm^2 s^{-1}), and molecular diffusion becomes the faster process of vertical solute transport. This transition establishes the diffusive boundary layer (DBL) which is a well-defined water film for non-porous sediments. In sandy sediments the transition is more gradual and complex. Shear stress from the overlying water flow may penetrate a few sandgrains depth into the porous sediment and thus define the Brinkman layer. Lateral pressure gradients caused by interactions between the boundary layer current and sediment topography drive deeper advective flows through t he pore space of the permeable sediments (Hüttel et al., 1998).

Diffusive boundary layers occur everywhere at solid-water interfaces. They blanket the surface of non-permeable sediments, they envelop plants, animals, and even sinking aggregates and phytoplankton. The existence of a benthic DBL has been known for decades from hydrodynamic theory and, for example, from the growth rate of ferro-manganese nodules or from *in situ* experiments on the dissolution rate of alabaster plates positioned on the sea floor (Santschi et al., 1991). As microelectrodes were first used to measure oxygen microgradients across the sediment-water interface in the early 1980‘s, the chemical diffusive boundary layer suddenly became very visible (Jørgensen and Revsbech, 1985). The diffusive oxygen uptake of sediments could now be calculated from microsensor data, either by modeling the oxygen profile within the sediment or from the oxygen gradient in the DBL: O_2 flux = D·(dC/dz), where D is the molecular diffusion coefficient. The latter approach appears simpler, but it requires a spatial resolution of 50-100 µm in order to obtain sufficient data points in the 0.3-1.0 mm thick DBL for a linear regression (Fig. 1). Such a resolution is possible by the use of micro-sensors, and data for oxygen and a range of other gases and ions are today obtained both in laboratory experiments and directly on the sea floor using benthic *in situ* instrumentation.

Figure 1 shows, as an example, how the seasonal variation of oxygen distribution in a coastal marine sediment responds to the governing processes. After the deposition of spring and fall phytoplankton blooms, oxygen penetrated <1 mm into the sediment and the diffusive uptake rate reached 35 mmol O_2 m^{-2} d^{-1}. The theoretical maximum, which would be reached if the oxygen concentration at the sediment surface dropped to zero, is about 85 mmol O_2 m^{-2} d^{-1} and depends on the flow velocity and thickness of the DBL, the oxygen concentration in the overlying water, and the temperature (and thus the diffusion coefficient). In winter, the oxic zone was 4-5 mm thick and the uptake rate was 13 mmol O_2 m^{-2} d^{-1}. The oxygen

Figure 1. Oxygen distribution in a coastal marine sediment over the year. An oxygen profile measured during winter by a benthic lander and microelectrode profiler reveals a ca. 400 µm thick diffusive boundary layer, clearly visible when the profile at the sediment-water interface is shown with expanded scales. The linear regression of oxygen in the DBL is used to calculate the diffusive flux of oxygen to the sediment. Isopleths of oxygen show how the seasonal variations in organic sedimentation and temperature regulate the depth of oxygen penetration. Data are from Aarhus Bay, Denmark, at 16 m water depth (Gundersen et al., 1995)

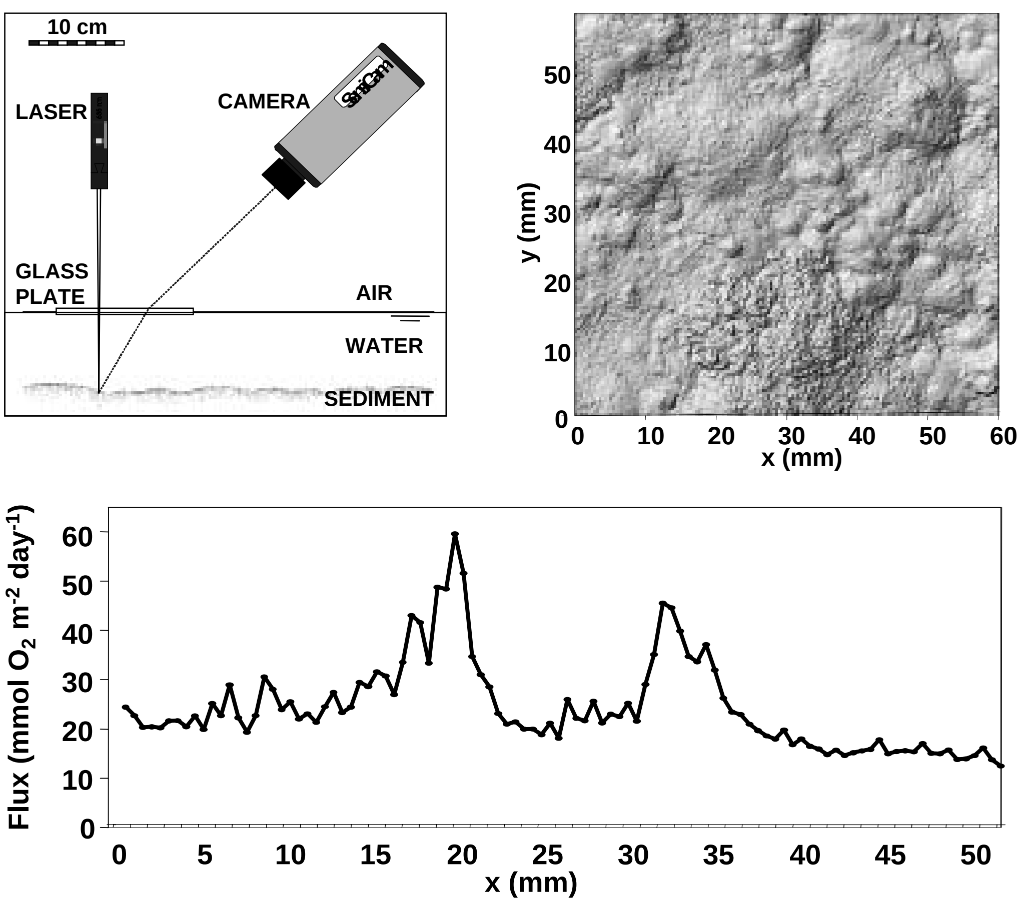


pool in the sediment is extremely dynamic, with a turnover time ranging from 40 seconds in summer to 37 minutes in winter. Although the DBL is only a fraction of a millimeter thick, it constitutes a diffusion barrier between water and sediment which may impede the oxygen uptake, particularly in summer. The diffusion time of oxygen across a 450 µm thick DBL is: $t = \pi \cdot \delta_e^2/4D = 3.14 \cdot 0.045^2/4 \cdot 1.6 \cdot 10^{-5} = 100$ seconds, where δ_e is the effective thickness of the DBL and D is the molecular diffusion coefficient of oxygen at 13°C. Thus, the DBL also causes a significant delay in the chemical exchange across the sediment-water interface.

The water flow near the sediment surface should ideally be measured at similarly high resolution as the chemical species. *In situ* measurements using an acoustic doppler anemometer currently reach a resolution of 0.5-1 cm, whereas the equivalent laser doppler technique has a 10-fold higher resolution, but is not yet developed into a practical field instrument. A flow microsensor was recently constructed which has a 20 µm wide tip and may cover ranges of flow velocities from 10 µm s^{-1} to 6 cm s^{-1} (J. K. Gundersen et al., unpublished). The first DBL results from this sensor have been obtained at a 50 µm resolution with the sensor pentrating from within the substrate and out into the flow to avoid disturbance. The results show zero flow at the solid-water interface and a linear increase of mean flow velocity with height above the interface within the DBL. Although these results are in accordance with a simple transition from inertial to viscous flow as the sediment surface is approached, the DBL is not a stable environment. Turbulence in the overflowing water induces fluctuations of the flow and the chemical gradients within the DBL, yet the net result is a diffusive transport which may be described by the mean gradients (Gundersen and Jørgensen, 1990)

In the preceding discussion, the 1-dimensional flux calculations from vertical gradients assume a perfectly flat sediment surface. However, at the sub-millimeter scale of the DBL the sediment is a spectacular landscape of mountains and valleys, and diffusion takes place across an interface of complex topography. Accordingly, the effective area available for diffusion exceeds that of a flat plane, and diffusion is not just vertical, but takes the shortest path across the sloping DBL. Topographic mapping of surfaces at sufficiently high spatial resolution is now possible with different laser techniques, both in the laboratory and in the field. A simple approach is illustrated in Fig. 2 together with a digitally generated image of a 6x6 cm sediment surface recorded at 50-100 µm resolution. The relation between the simple vertical flux, J_z, across a flat plane and the 3-D flux, J', across the topographic surface can be approximated by the simple square cosine law: $J' = J_z \cdot (1/\cos\alpha)^2$, where α is the mean slope for the entire topographic surface (Jørgensen and Des Marais, 1990). This angle, however, depends on the spatial resolution of surface topography which should first be mathematically smoothed using a smoothing kernel of similar size as the DBL thickness (H. Røy, M. Hüttel and B. B. Jørgensen, manuscript submitted).

Figure 2. Topography of a sediment surface sculptured by burrowing fauna and analyzed by laser optics. A fine line is illuminated across the sediment surface (perpendicular to the image plane) and photographed by a CCD camera. Some 600 consecutive images, each shifted to the left by 100 µm, create the basis for the shaded 3-D topographic map. From series of oxygen gradients measured in the DBL, the heterogeneous distribution of diffusive oxygen uptake can be mapped. A 50 mm long transect shows two distinct peaks of oxygen flux caused by worms which transport reduced sediment up on the sediment surface. Data from a marine coastal sediment maintained in a laboratory flume for a month (H. Røy, M. Hüttel and B. B. Jørgensen, submitted manuscript).

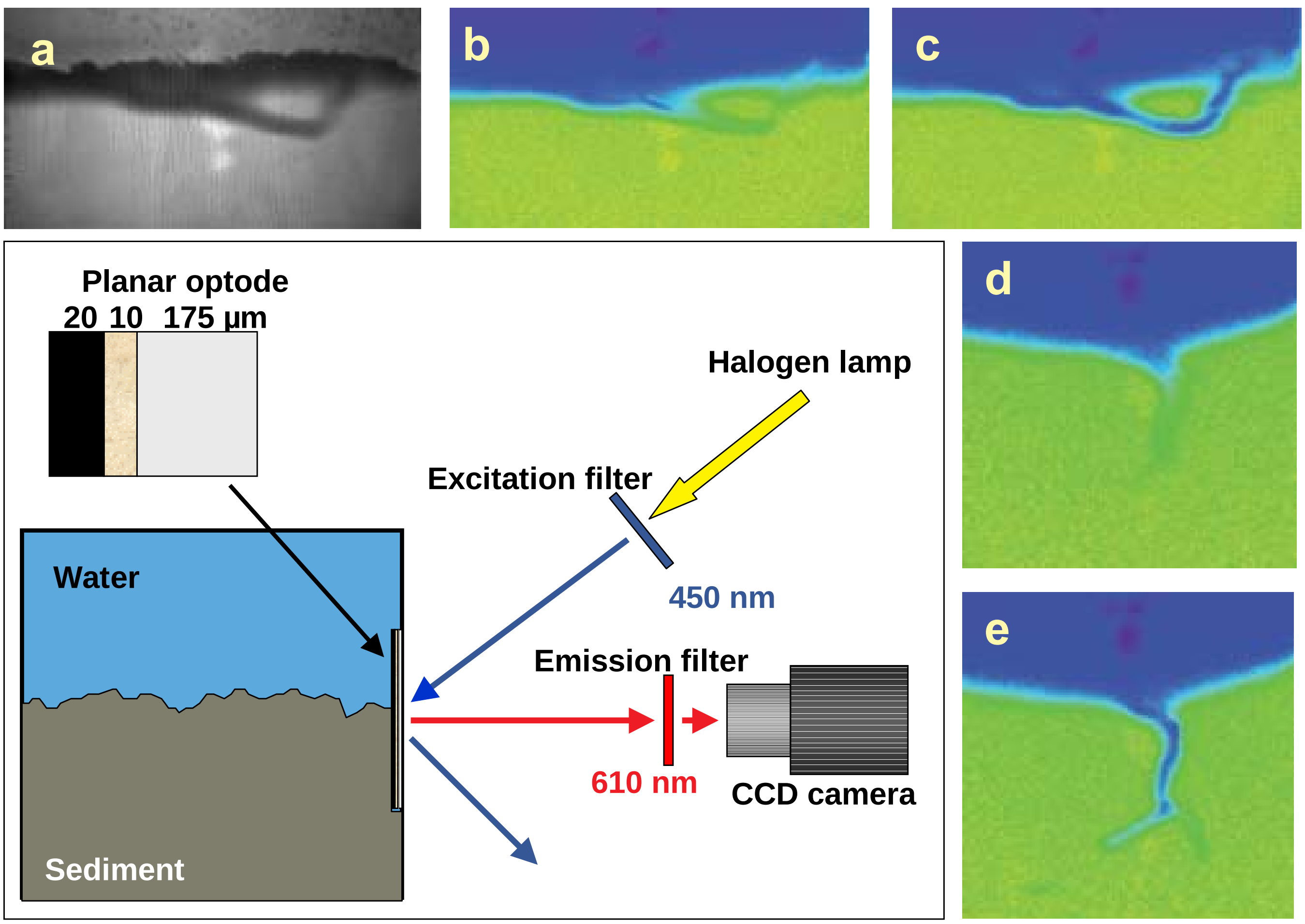


For many sediments this square cosine correction is moderate (e.g. 1.13 for α=10° and 1.7 for α=20°), whereby a mean slope of 20° is already steeper than most sediment surfaces. A field survey of surface topographies is still needed to relate the steadily growing database on chemical microprofiles to the effective 3-D diffusion field.

High-resolution mapping of oxygen microgradients across the sea floor can be done semiautomatically using computer controlled micromanipulators and online data aquisition. A linear transect was measured in the same sediment as in Fig. 1 and the results demonstrated that the oxygen flux is very heterogeneous and related to the activity of benthic invertebrates (Fig. 2). Due to the defecation by small deposit-feeding oligochaetes, hot-spots of reduced sediment were maintained on the sediment surface in the laboratory flume. Such few millimeter wide fecal spots had oxygen consumption rates up to 3-fold higher than the ambient sediment, but the oxygen flux was very dynamic and dropped within hours after the worms stopped their activity, partly due to the reoxidation of reactive iron-sulfur minerals.

Progress in the study of spatial distributions of chemical species has often come with the development of novel analytical techniques. The mapping of oxygen from individual vertical profiles tends to be a low-capacity approach, frequently interrupted by frustrations of the experimenter due to breakage of the fine electrode tip. A different sensing principle based on dynamic fluorescence quenching has in recent years opened exciting new possibilities for the analysis of oxygen in aquatic environments by optical microsensors, so called microoptodes (Klimant et al., 1995). A fluorophore such as $Ru(diph)_3$ (Ruthenium(II) tris-4-7-diphenyl-1, 10-phenanthroline perchlorate) dissolved in a liquid polymer such as polystyrene or sol-gel can be applied to the 30 µm tip of a tapered optical silica fiber by simple dip-coating and

Figure 3. Two-dimensional oxygen distribution in sediment inhabited by burrowing fauna. A planar optode was glued to the inside of a sea water aquarium half filled with marine sediment. The optode consists of a 175 µm thick supporting plastic foil, a 10 µm film with the sensing chemistry, and 20 µm black silicone (redrawn from Glud et al., 1996). The optode is excited by blue light and emits orange-red flourescence which is photographed by a CCD camera. Oxygen diffuses into the O_2-sensitive film and reversibly quenches the fluorescence, whereby the light intensity can be calibrated to oxygen concentration at the ambient temperature. By using modulated light, the planar optode can be made without the light-shielding black silicone and sediment structures may be observed through the semi-transparent film (frame a). The images show: (a-c) a shallow U-shaped burrow of the amphipod, *Corophium volutator,* and (d-e) an inverse Y-shaped burrow of the polychaete, *Nereis diversicolor.* The O_2 scale goes from air saturation (dark blue) to zero (yellow-green) and the light blue color thus delineates the extension of the DBL and oxic sediment. The sediment sections are ca. 3 cm across. (U. Franke and G. Holst, unpublished data).



drying. The fluorophore has a large Stoke shift with absorption maximum in blue light at 450 nm and emission in the red-orange at 610 nm. The blue excitation light from a light-emitting diode is guided through the fiber out to the tip and the resulting red-orange flourescence emission is guided back up through the same fiber and detected by a sensitive photomultiplier. Oxygen from the ambient water diffuses through the solidified polymer at the sensor tip and reversibly quenches the fluorescence. More oxygen causes less emission of orange light, and the sensor can thereby be calibrated against oxygen concentration at a given temperature.

When used in continuous mode, the sensor must be shielded from ambient light which would otherwise interfere with the measured flourescence. The fluorophore may, however, also be excited with modulated light whereby, for example, the exponential decay of light emission after each excitation pulse is monitored. In this mode the sensor needs no shielding from ambient light. This fluorescence life-time is also a function of oxygen quenching and can similarly be used to determine its concentration. The dynamic life-time mode of detection has the great advantage that it is independent of geometry, and the polymer-embedded fluorophore may thus be arbitrarily distributed and will still report the oxygen concentration correctly after initial calibration (Holst et al., 1998, Holst and Grunwald, 2001).

As an example, an oxygen-sensing planar optode can be constructed by coating the polymer over a plastic foil which then reports the adjacent oxygen concentration. Glud et al. (1995) first glued such a piece of foil to the inside of an aquarium and filled it half with sediment in order to measure the oxygen penetration (Fig. 3). It was later found that the natural fauna may reestablish in the mud and build burrows which are sometimes positioned directly up against the planar optode. By imaging the optode fluorescence with a CCD camera (Charge Coupled Device producing a digital video) at regular intervals, the two-dimensional oxygen distribution can thus be continuously recorded by a million pixels at a resolution ranging from 2 µm to 100 µm per pixel. Such time-lapse recordings provide a wealth of information about the oxygen transport in relation to the burrowing and ventilation activity of benthic invertebrates (Fig. 3). It is now possible to make transparent planar optodes, whereby the oxygen dynamics can be related to the observed sediment structures and animals behind the optode (Fig. 3a). An *in situ* instrument was recently developed which enables observations directly in the sea floor of the two-dimensional vertical oxygen distribution in sediments concurrent with photography of the same sediment section of ca 10x10 cm.

The analysis of the three-dimensional oxygen distributions in water is also becoming possible through the application of optical sensing techniques. A first step in this direction was made by the development of fluorescent nanoparticles which are suspended in the water and report the oxygen concentration at any point which can be reached by the excitation light and observed by a CCD camera (G. Holst, unpublished results). By illuminating the water with a thin laser curtain of blue light, the oxygen distribution is analyzed in a <1-mm thick vertical section. Consecutive sections may allow the construction of a 3-D image which, however, is a composite of non-synchronous sections and is therefore likely to require many repetitive images. As computers rapidly increase in capacity, this requirement should not limit the application of such 3-D techniques. The sensing chemistry is also well developed for pH and temperature, and further chemical species and parameters are expected to enter the program. In the future, the possibility of combining concurrent digital photographic recordings of sediment structures and organisms with optical analyses of chemistry and flow will open new dimensions, both in space and time, and in the concepts of aquatic ecology.

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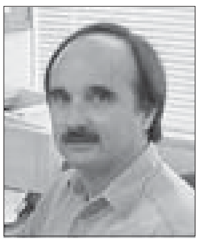
LETTERS TO *THE BULLETIN*

THE NEW *ASLO BULLETIN*

Greg Cutter, *Professor, Dept. of Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, VA 23529-0276, gcutter@odu.edu*



DEAR READERS,

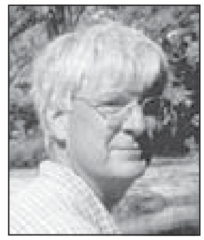
What you have in your hands (or perhaps on your computer screen) is the new version of the *Bulletin*, and I hope you like what you find in it. This new version mixes peer-reviewed, and, hopefully, thought provoking articles, with ASLO news. With respect to the latter, these will be much like the previous incarnation of the *Bulletin* and largely come from the ASLO offices (Executive Director, Business, Board) — news of a general nature like election results, reviewer citations, programs, policy trends, etc. However, these items won't be the latest information (after all, it's only a quarterly publication), and for this you should go to our companion communication device, the ASLO web site (www.aslo.org). As far as the articles and letters are concerned, these are YOURS…you need to write and submit them. We'll have up to three articles per issue and they should be of broad interest to the membership (not specific research findings that belong in *L&O* or another journal), concise (ca. 2500 words, three figures, and 10 references), and they will be peer-reviewed and hence not "gray literature." Both articles in this issue were each reviewed by two outside scientists. If you have an idea for a *Bulletin* article, you may want to run it by me, but otherwise the author instructions are on the ASLO web site under ASLO *Bulletin*. Letters will be short comments or responses to the articles, or "pleas to the community" about some scientific issue that you feel should be addressed. They won't be reviewed, although if they are about an article, the authors will be allowed to respond, and I will use editorial discretion in their acceptance and presentation. Thus, the limnology and oceanography community now has an alternative venue for communicating their ideas. So, what do you think about the new *Bulletin?* Please let me (gcutter@odu.edu), or the ASLO Board, know your opinions.

Greg Cutter, Old Dominion University

ASLO NEWS

MESSAGE FROM THE PRESIDENT

William M. Lewis, Jr., *Center for Limnology, CIRES, Campus Box 216, University of Colorado, Boulder, CO 80309-0216 (Tel: 303-492-6378; Fax: 303-492-0928), lewis@spot.colorado.edu*



POLICY: TIME TO DO SOMETHING

The ASLO membership expressed its approval of a public policy program for ASLO through a change in bylaws almost three years ago. By way of setting the stage for work in public policy, the Board voted to establish a Washington office and select an Executive Director who would be both willing and able to do policy work in Washington and elsewhere at the direction of the Board. Our Washington office is now up and running, and Jonathan Phinney is willing (even eager) to work in public policy. What confronts us now is a set of decisions about what we should do and what we should not do; also, what we can do and what we cannot do.

The content of our policy program is an issue that deserves much discussion. The ASLO Board relishes discussion, but has limited time to devote to any particular topic because there are so many topics that require Board decisions. Therefore, the Board has voted to create an ad hoc committee, which we call the Public Policy Committee, that will help guide the Board through decisions about our public policy program. You may recall that Dave Karl was chair of an earlier ad hoc committee on public policy leading up to the establishment of our Washington office. Dave has kindly agreed to continue with the new committee to provide continuity.

The Board has selected Bess Ward as chair of our new Public Policy Committee. Bess, who asserts firmly that she is not a policy wonk, was an enthusiastic choice of the Board because of her extensive experience in research and education, her knowledge of the field, and her good judgment. With the advice of Bess and various others, we have appointed the following members to the Committee: David Karl, Denise Breitberg, Samantha Joye, Hans Paerl, Tony Michaels, John Smol, Margie Mulholland, Sarah Horrigan, Jim Ammerman, Carlos Duarte, and Jonathan Phinney (ex-officio). Clearly, this qualifies as a blue ribbon committee. The Committee will begin its work with a meeting in Washington during the summer.

Public policy, as visualized collectively by the Board over the last year or so, should encompass for ASLO not only issues of law or administration that involve limnology and oceanography, but also education as it applies to non-specialists. The Board is unified in its feeling that the sciences of limnology and oceanography need to be explained not only to those who make decisions, but also to the general public in the context of numerous current environmental issues involving aquatic ecosystems. There are many ways in which we could begin to do such work, but some are probably more suitable or feasible for ASLO than others. The Public Policy Committee is charged with sorting through the possibilities and giving the Board some specific advice.

Non-profit societies such as ASLO are prohibited from attempting to influence legislation directly. I am told that this restriction can be taken with a grain of salt, as I see that is by some non-profit organizations, but perhaps we are well advised to at least consider this restriction, which appears in our Articles of Incorporation. A more likely role for ASLO, and one that should be discussed at length by the Public Policy Committee, is to provide sound information that supports good decision making at the legislative or administrative levels of government in the event that decisions might in some cases be based on information. Those who know the Washington scene point out that this is an excellent role for ASLO, but ASLO cannot expect to be effective if it cannot adapt its response schedule to the ebb and flow of demand for information in legislative and administrative circles. This raises an important question for the Committee: we rely on peer review to tell us when an opinion is defensible and when it is not; to what extent can we give information on an ad hoc basis that carries the ASLO logo?

Other strategies for providing information to be used in policy are more deliberate, although some sense of timing still is essential. For example, some professional societies have experimented with the preparation of position papers on subjects of known interest in the field of policy. The perils of such undertakings are well illustrated by a recent exchange of articles in the *Bulletin of the Ecological Society of America* (July 2000), wherein there is a heated exchange about the validity of generalizations that came out in an ESA position paper on biodiversity and ecosystem function. There is nothing inherently wrong with controversy, of course, but when we expose our controversies too blatantly to those who receive information from us, we may undermine our credibility (''when you make up your mind, I'll listen to you''). Are we interested in formulating official opinions for our society and distributing them? In what way do we assure that we have consensus on a given issue, or do we proceed even in the absence of consensus?

Broader dissemination of information, which might go under the heading of education rather than public policy, is also of interest. Here the main problem is to penetrate the thicket of information already available and make contact with consumers of information in a meaningful way. We are exploring the idea of having ASLO members who are authorities on specific subjects write overview articles as part of a United Press (UPI) science series that is organized through the Council of Scientific Society Presidents (Peter Jumars is spearheading this project). The web is an obvious tool that can be used in a similar way, but it is all too easy to give excessive attention to a website that does not get used by the target audience. The Public Policy Committee may be able to advise us on this.

We also need to think about geographic scope. Exclusive focus on Washington would probably be a mistake. Important decisions get made within the U.S. well outside Washington (at the state level, for example), and receptivity may be higher at the distributed levels of government than it is at the centralized level. In addition, we need to develop a program that fits ASLO into the international scene in an appropriate way; we have already heard from some Canadian and European members in this regard. Formal liaisons with appropriate international agencies would be one means of approaching this problem.

We have one staff position (that of the Executive Director) and one part-time helper on which to base our public policy program. Obviously, our program will be very narrow unless it includes the membership. Many members are interested in public policy, particularly if it is defined so as to take in education. We can tap this font of willing effort if we are well organized. Participation in ASLO may take on a whole new meaning if our public policy program evolves properly. Participation in ASLO in the past has meant attending meetings and, for a few individuals, serving temporarily as a Board member, officer, or committee member. Average involvement of the 3500 members of ASLO is minuscule. Many do not seek any more involvement, given that they are fully occupied already, but I know from experience that many would like to be more involved and merely need an opening; I hope that our work in public policy and education can provide such an opening.

Opinions of members can be influential in the work of committees. If you have opinions on these public policy subjects, please send them to Jonathan Phinney, who will compile them and distribute them to the Board and to the Committee. In the meantime, I look forward to bringing you more news of the Committee's work on public policy and education.

William M. Lewis, Jr., University of Colorado

2001 BOARD ELECTIONS

The ASLO Board is pleased to announce the election results for two Members-at-Large seats. Please congratulate: Morten Søndergaard, University of Copenhagen, Denmark, and Peter J. le B. Williams, University of Wales, United Kingdom.

The Board also sincerely thanks John Cullen and Heidi Nepf who rotate off the Board this year. Their insight and savvy will be sorely missed.

FROM THE BUSINESS OFFICE

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

We've had several busy months in the ASLO business office since the 2001 Aquatic Sciences Meeting convened this past February. We are working on improvements and on providing additional benefits to members via the Internet. Here are some of the newest functions that are in the works:

· Members can now use the Internet to renew their membership, join ASLO, make changes in addresses and other member information, access the *L&O,* purchase the *L&O* archive CD ROM set, plus enjoy all the other benefits and conveniences of the ASLO web site.

· One of the newest features, and one that we think will be very exciting and useful, is the "membership directory" that is now online and will allow you to search for colleagues and locate other ASLO members. This feature is in the "Members Only" area and contains CURRENT member information directly from the database. We hope you will find this a real plus for your ASLO membership.

· Beginning in 2002, libraries and other organizations will be able to add online *L&O* access as one of their subscription choices. Access only will be available at the location of the subscriber, not system-wide.

· Sales continue for the archive CD ROM set of past *L&O's*. Be sure to get your set at the introductory price of $150 for members. Contact the ASLO Business Office at business@aslo.org or go to the web for more information.

· Meetings continue to be a strong motivator for ASLO members. Abstracts are now on the ASLO web site from the 2001 meeting. The 2002 summer meeting will be held in beautiful Victoria, British Columbia, Canada, June 10-14, 2002. Following input and review of the 2001 meeting in Albuquerque, the 2003 Aquatic Sciences Meeting will be held in Salt Lake City, Utah, February 9-14, 2003 — just one year after the Winter Olympics! Watch for more information about these meetings, including convenient online housing reservations.

Be sure to contact us if you have any questions or if we can assist you in any way.

John Cullen discussing the uncertain relationship between academic and commercial interests of ocean fertilization research at the ASLO sponsored forum at the US House of Representatives

MEETING HIGHLIGHTS

WORKSHOP ON OCEAN FERTILIZATION TO TRANSFER ATMOSPHERIC CO_2 TO THE OCEANS

Jonathan T. Phinney, *1444 Eye Street, NW, #200, Washington, D.C. 20005 (Tel: 202-289-1972, Ext. 249; Fax: 202-628-1509), jphinney@aslo.org*

An ASLO-sponsored three day workshop ended April 25, 2002 in Washington, DC that assessed the scientific and legal uncertainties surrounding ocean fertilization to sequester atmospheric CO_2. Organized by Penny Chisholm, John Cullen and Jonathan Phinney, the workshop was initiated in response to growing commercial interest in stimulating phytoplankton blooms to sequester CO_2 for potential carbon credits. The workshop started with a public forum in the U.S. House of Representatives. Speakers included: Penny Chisholm, Dave Karl, Kenneth Coale, John Cole, Geoff Holland, and John Cullen. Thereafter, 32 scientists and policy experts from academia, government, and private industry met privately to develop a consensus statement and recommendations on future ocean fertilization experiments, as well as on collaborations between academic and commercial interests.

As many members remember, ASLO sponsored a scientific symposium in 1991 on iron fertilization *(Limnology and Oceanography; 36(8))*. Since then, at least three private-sector groups are now studying the feasibility of large-scale commercial operations for potential carbon credits. The idea sounds seductively simple — add iron to the ocean to spur phytoplankton growth, and as phytoplankton cells die and sink to the deep ocean, atmospheric CO_2 is removed in the form of organic carbon.

However, there are many reasons to question this proposed carbon sequestration technology. To mention a few:

· Nutrient enrichment of aquatic ecosystems causes dramatic changes in species composition at all levels of the food chain, and it is known to cause toxic algal blooms.

· Sustained fertilization would cause areas of the deep ocean to be deprived of oxygen, which could stimulate the growth of bacteria that release other gases, notably N_2O, that is 290 times more powerful than CO_2 as a greenhouse gas.

· The effects of nutrient enrichment of ecosystems are very difficult to predict and to correct if problems arise.

· Models show that sustained fertilization of certain oceans with iron could paradoxically cause others to become less productive, possibly influencing the worldwide distribution of fisheries.

· Models also show that even the most comprehensive plan of ocean fertilization could at best forestall the increase of atmospheric CO_2 by only several years.

· The High Seas - areas outside the Exclusive Economic Zones of individual countries - are a "Commons" owned by all nations. Yet, legal questions about ocean fertilization have not been addressed. Does ocean fertilization constitute "ocean dumping" prohibited by the London Convention? If the Ocean Commons were fertilized, who would provide the framework for quantifying the effects and ensuring environmental protection? Who would assume the risks?

A brief on the workshop can be found on the ASLO website (www.aslo.org/download/ocnfert.pdf), and the consensus statement and recommendations, as well as transcripts of the public forum will be available on the website later this fall. Alternatively, contact Jonathan Phinney (jphinney@aslo.org) to request copies of the consensus statement and other documents from the workshop.

OUTSTANDING *L&O* REVIEWERS

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, each issue of the *Bulletin* will cite two 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 to these two outstanding scientists.

HUGH W. DUCKLOW

Hugh Ducklow is Glucksman Professor of Marine Science at the College of William and Mary's Virginia Institute of Marine Science. Hugh's main research field is marine microbiology, and he specializes in the production and population dynamics of heterotrophic bacterioplankton. He has been active in JGOFS since 1988, and has participated in over 25 major oceanographic expeditions in all the major world oceans. He has trained 3 Ph.D. and 3 M.Sc. students and currently has students working on estuarine biogeochemistry, Antarctic bacteriology, and simulation ecological modeling.

W. GLEN HARRISON

Glen Harrison is a senior research scientist and head of the Biological Oceanography Section (Ocean Sciences Division) of the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. His research has concentrated broadly on the ocean nitrogen cycle and primary production in coastal and oceanic waters and, for the past 10 years, has been focused on the interaction of biological and physical processes in the Labrador Sea. He is also currently involved in a large-scale (NW Atlantic) ecosystem monitoring program aimed at establishing links between plankton growth cycles and fish recruitment, larval survival and stock variability.

OBITUARY

MICHAEL M. MULLIN, 1937 – 2000

Contributed by David Checkley Jr., Marine Life Research Group, Scripps Institution of Oceanography, La Jolla, CA 92093-0218

Mike Mullin died on December 19, 2000 of complications following heart bypass surgery. He was 63. Mike was a biological oceanographer interested in the ecology of zooplankton and fish. He was a Professor at the Scripps Institution of Oceanography (SIO) of the University of California, San Diego, Director of the Marine Life Research Group (MLRG) at SIO, and Editor-in-Chief of *Fisheries Oceanography*. Mike had a longstanding relationship with ASLO, having published many of his studies of plankton in *Limnology and Oceanography*.

Mike was born on November 17, 1937, in Galveston, Texas to Joseph and Alma Mullin. He attended the University of Chicago Laboratory School. As a Quiz Kid, he frequently appeared on the nationally syndicated program by that name, an early indication of his interest and aptitude in natural history. He attended the University of Chicago, Shimer College (B.A.), and Harvard University (B.A., Ph.D.). Mike's doctoral advisors were George Clarke, at Harvard, and Bob Conover, at the Woods Hole Oceanographic Institution (WHOI), where he studied copepod feeding. Makoto Omori, recently retired from the Tokyo University of Fisheries, conducted his doctoral research at WHOI simultaneously. Both Mike and Mac published their Ph.D. research in the same issue of *L&O* in 1963. Mike was a postdoctoral fellow on the International Indian Ocean Expedition and at the University of Auckland, New Zealand. He joined the Scripps Institution of Oceanography in 1964, where he was Professor and held various administrative positions, most recently as Director of MLRG. He took sabbatical as a Senior Queens Fellow at the Australian Institute of Marine Science (AIMS).

At Scripps, Mike taught graduate courses in Biological Oceanography, Pelagic Ecology, Fisheries Oceanography, and Ethics in Science. With Paul Dayton, he taught the undergraduate course, Marine Ecology. Zooplankton Ecology was taught with Karl Banse alternate summers from 1966 to 1978 at the Friday Harbor Laboratories. Mike advised or co-advised 21 Ph.D. students and mentored numerous undergraduates. Mike's students at Scripps pursued interests similar to his, including zooplankton feeding, production, trophodynamics, and pattern. Training was often by direct mentoring, including cruise participation. His advising style was largely 'hands off', fostering independence. A true scholar, Mike had a command of the literature and offered valuable advice to those he mentored. Many of his students presented parts of their dissertation at ASLO meetings and in *L&O*. His book, *Webs and Scales*, was based on his lectures at the University of Washington for the Washington Sea Grant program.

Mike's research on biological oceanography spanned the ranges from copepod feeding to food chain dynamics, from meters to 100's of kilometers. In the 1980's, he said, "I wish I were a more original thinker on large-scale oceanographic problems." He accomplished this objective in the ensuing two decades, as manifest in his publications, numbering more than 70. Mike's early work, including his Ph.D. dissertation and the *L&O* paper based on it, concerned the feeding and food of particle-grazing copepods. He explored the relation between food size and type and copepod traits. This and subsequent work exemplified his credo of combined lab and sea studies. Work on secondary production and food chain dynamics followed. Hallmarks were his large-volume and deep tank experiments in which he investigated secondary production and material transfer between trophic levels. His review of secondary production, in *Oceanography and Marine Biology Annual Review*, remains a landmark paper. While on sabbatical at AIMS, Mike studied salp feeding on phytoplankton and bacteria, diving frequently on the Great Barrier Reef. Pattern in the plankton was also a focus of Mike's research. Of note was his *L&O* paper on distributional heterogeneity of the zooplankton. Plankton sampling was, and remains, an imprecise science, and much remains unknown about the unseen interactions of grazers and their food. In this paper, Mike explored the range of possible interactions, setting the limits of what was and was not possible. Current work on the importance of thin layers of phytoplankton reflects a continued interest this topic.

Mike was a key member of the Food Chain Research Group (FCRG) at Scripps, founded and led by John Strickland. Regions studied by FCRG included the pelagic ecosystems off La Jolla, the Southern California Bight, and the Central North Pacific Gyre. Mike focused on the role of copepods in the food webs of these regions. In recent years, Mike's interests included fisheries oceanography. The zooplanktonic food of young hake was the subject of several papers, based on both sampling at sea and laboratory analysis of archived CalCOFI samples using the laboratory Optical Plankton Counter (OPC). He investigated egg production by *Calanus* and its relation to El Niño. He was also interested in time and space variation in phytoplankton size and its relation to the nitricline and zooplankton grazing. A general focus of his later works were processes affecting recruitment variation of commercially exploited fish.

Family was paramount to Mike. He devoted his time away from Scripps to his wife, Connie, and his children, Stephen, Laura, and Keith. Music was also important to Mike and his family. He directed a La Jolla renaissance group since the late 1960s. Frequently, Mike lectured at UCSD in period costume. Mike and Connie were well known for inviting students and colleagues visiting Scripps to their home for an evening.

Mike will be remembered for his fairness, intellect, and wit. He was a wonderful role model for many of us, as a family man, oceanographer, and friend. While we miss him, we are grateful for having known him.

DIALOG V IS OFFICIALLY UNDERWAY

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As you can see from the list of citations in the following article, the DIALOG Dissertation Registry is becoming larger, and more international. Fifty three percent of the 221 abstracts came from institutions located outside the United States. I know of no other compilation that provides such a rich and informative overview of emerging aquatic scientists and research from around the world. ASLO Web Editor Paul Kemp reports there were more than 60,000 visits to the registry - up more than 100% over the last year! The registry serves many needs. Students use it to see what constitutes a successful thesis project or to compare abstracts to identify a good "model". Young scientists use it to see what their peers are up to. Students and established scientists can use it to get a nice overview of science or identify specific talents. Employers use it to identify good job candidates. Paul Kemp is to be congratulated for putting everything together in such an easily searchable format. If you haven't taken a look at it, you should.

I can think of many reasons for a recent graduate to register with the DIALOG abstract compilation and no good reason not to. It's quick, it's easy, and it's of benefit to the larger community as well as to the graduate. If you are a recent graduate and don't think you need the publicity the Registry provides, think of the scientist working in isolation in some remote area of the globe who might be interested in your work. The interactive registration form is available at http://aslo.org/forms/dialogform.html. Or you can go to www.aslo.org and click on the "DIALOG" button.

A full demographic report of the 2-year DIALOG IV program cycle will appear in the next *Bulletin*. But here are a couple of statistics to whet your appetite: Overall, submissions were up by around 52% compared with DIALOG III. Of the dissertations from American citizens, only 31% were from limnologists. Forty one percent of submissions were from women, and 4.9% from underrepresented minorities. Thirty nine countries were represented.

The DIALOG V program began in January 2001 and will continue through March 31, 2003. Contingent on the availability of external funding, the DIALOG V symposium will be held in October 2003 to bring together another cohort of recent graduates interested in fostering interdisciplinary understanding and collaborations. In October 2002, the National Oceanic and Atmospheric Administration (NOAA) is funding a symposium to bring together estuarine, Great Lakes and coastal scientists interested in these systems. The symposium will be co-sponsored by the Estuarine Research Federation (ERF) and modeled after the DIALOG symposium. To apply for either symposium you will need to register your dissertation with DIALOG. Once you register, you will be placed on the DIALOG e-mail list and receive information about both symposia. The goal is to have EVERY aquatic science Ph.D. graduate included in DIALOG. To reach this goal I will need the help of professors and colleagues. **Please inform your students and recent grads of this unique opportunity.** Everyone who registers with the DIALOG V program is eligible to be included in the new **DIALOG e-mail distribution list.** This list is targeted specifically at the concerns of recent graduates. As expected, it contains a lot of job advertisements. If you want to send job advertisements or other information to recent graduates, contact aslo.dialog@whitman.edu for distribution.

Let's make DIALOG V the largest and most comprehensive program ever!

DIALOG DISSERTATION COMPILATION: CONGRATULATIONS RECENT PH.D. RECIPIENTS!

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On behalf of the DIALOG Program and ASLO membership, congratulations and best wishes to the following new Ph.D. recipients! The 120 citations below represent abstracts registered with the DIALOG Program since the last *Bulletin* deadline. This backlog was created because graduates waited until the symposium deadline to register their abstracts. To avoid this in future, we will start with degrees completed most recently and work back from there. However, space limitations for future issues of the *Bulletin* will limit the listing to up to 40 per issue. Thus, it will be in your best interest to register your dissertation with DIALOG as soon as you complete your degree. If you wish to see the most complete and up-to-date list, go to the DIALOG section of the ASLO web site and look at the "PhD Abstract Compilation." If you haven't done so already, register your dissertation at http://aslo.org/forms/dialogform.html or go to the DIALOG Program button at http://aslo.org and click on the "Abstract Submission Form."

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DIALOG

Dissertations Initiative for the Advancement of Limnology and Oceanography

Program for Recent Ph.D. Recipients in Limnology, Oceanography and Related Disciplines

BACKGROUND

The DIALOG Program was founded to enhance the exchange of information across the biologically oriented aquatic sciences. The program introduces graduates to the community, fosters interdisciplinary understanding and collaborations, and links graduates to the community-at-large.

To identify trends and assess community needs, demographic information is collected confidentially along with Ph.D. dissertation abstracts. A biennial report is published on the ASLO webpage. Once registered with the program, graduates are included on an e-mail distribution list to foster cross-institutional communication and publicize information of interest to this group. Participants also receive an abstract book and directory.

Ph.D. DISSERTATION COMPILATION

Dissertation abstracts are collected and posted on the ASLO webpage in a searchable format, providing a concise overview of the field and highlighting individual acocmplishments. Graduates completing Ph.D. requirements after January 1, 1999 and whose work in biological, chemical, geological or physical science is relevant to biologically oriented limnology or oceanography are encouraged to register. Submitted citations and abstracts are posted in a searchable format on the ASLO webpage and citations are published quarterly in the *ASLO Bulletin*.

SYMPOSIUM

Biennial symposia catalyze cross-disciplinary and international understanding and collaborations. Each participant presents a poster and a brief overview of his or her Ph.D. dissertation research. Working groups discuss emerging aquatic science research, education, and policy issues and develop recommmendations to be shared with the larger community. Funding-agency representatives describe programs and present perspectives on interdisciplinary and international aquatic science research programs.

Symposium Eligibility

Contingent on the availability of funding, a fifth symposium will be held. The DIALOG V symposium would be open to individuals completing Ph.D. requirements between **January 1, 2001 and March 31, 2003** and whose work in biological, chemical, geological, or physical science is relevant to biologically oriented limnology or oceanography. Graduates from all nations would be eligible for consideration. A committee will select participants based on the application materials submitted. Participation is limited to 40 and selection will favor grads who wish to pursue interdisciplinary aquatic science research. Funding for travel and on-site expenses is being requested from the supporting agencies.

DIALOG V SYMPOSIUM

Tentative Dates and Location

October 19 - 24, 2003

Bermuda Biological Station for Research

Application Deadline

May 1, 2003

HOW TO PARTICIPATE

Dissertation abstract-submission forms and symposium application instructions are available at

www.aslo.org/dialog.html

Submit job and other announcements to

aslo.dialog@whitman.edu

Questions

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