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THE BLANK CAN MAKE A BIG DIFFERENCE IN OCEANOGRAPHIC MEASUREMENTS

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It is hard to imagine a topic that seems more boring and trivial than the measurement of nothing. In a sense, determination of an analytical blank is exactly that — measurement of the signal associated with the absence of the property being detected. Although the magnitude and variability of an analytical blank may be very small compared to the oceanographic measurement, it must be determined as part of a calibration routine. For example, the blank for samples of particulate matter collected on filters consists of a filter that has been treated identically to field samples, except that no water with particles is drawn through it. Analysis of dissolved constituents requires measurements on samples that are analytically equivalent to field samples, but with no analyte present. It is the analyst's responsibility to determine what constitutes the appropriate blank (e.g., purified water, artificial sea water, filtered sea water treated to remove the analyte); generally, this requires a series of experiments to establish the sensitivities of the measurement system. Experience with the controversy concerning the measurement of dissolved organic carbon and nitrogen in natural waters (Benner and Strom 1993) amply demonstrates that blanks must be carefully monitored to ensure accuracy (i.e., to minimize systematic error).

For a variety of reasons, it is sometimes difficult or impossible to measure appropriate blanks concurrently with the oceanographic measurements. Deployments of *in situ* sensors can be particularly problematic. Changes in the blank due to fouling and instrument drift can confound the interpretation of long-term records from optical instruments that have internal light sources (Davis et al. 2000). Radiometric measurements of solar radiation and ocean color should be corrected for the signal generated in the absence of light: a dark correction. Generally, the signal in the dark is sensitive to temperature, so the correction from a laboratory calibration cannot be assumed to hold in the field (Cullen and Davis 2002). Uncertainty in the dark signal can strongly influence estimates of irradiance at depths corresponding to the limit of detection, leading to large errors in the estimation of attenuation coefficients (Morrow and Booth 1997). Fortunately, it is often possible to assess the uncertainty in the blank to determine if it compromises the measurement (see Laney et al. 2001 for an optical application). If the measured signal is much larger than the blank, nitpicking about blank corrections is unwarranted.

Introduced by Carl Lorenzen in 1966, *in vivo* fluorometry is used widely in limnology and oceanography to estimate phytoplankton biomass in terms of chlorophyll. Consistent with basic principles of analysis, measurements of light emitted by phytoplankton should be corrected for the signal from the same water, with phytoplankton removed by filtration (potential effects of scattering must also be assessed). Lorenzen did this and then showed through experimentation that purified water was an acceptable substitute for filtered sea water because the signals from both types of blanks were small, compared to his samples, and not sufficiently different from each other to influence his results. Our experience with standard fluorometers such as the Turner Designs series shows that the difference between filtered sea water and purified freshwater blanks is small compared to the fluorescence of phytoplankton in all but the clearest oceanic waters. However, much of the ocean has very clear water.

We discuss here the measurement of variable chlorophyll fluorescence, used as a diagnostic of nutrient limitation in phytoplankton (Kolber et al. 1988; Parkhill et al. 2001). A simulation, guided by real measurements in the Pacific Ocean, demonstrates that for measurements of variable fluorescence in ultra-oligotrophic waters, the blank can make a big difference.

VARIABLE FLUORESCENCE AS A DIAGNOSTIC OF NUTRIENT LIMITATION

The measurement and interpretation of phytoplankton fluorescence has been reviewed many times (Cullen 1982; Falkowski and Kolber 1995), and only a brief overview of variable fluorescence is presented here. Light absorbed by

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photosynthetic pigments has only three fates: photosynthesis, fluorescence, or the radiationless production of heat. The competitive relationship between photosynthesis and fluorescence is illustrated by the measurement of fluorescence during manipulation of photosynthetic reactions (i.e., modulated or active fluorescence techniques). When cells are dark-adapted so that functional reaction centers of photosystem II (PSII) are open (i.e., the likelihood for photosynthetic reactions is maximal), measured fluorescence yield is low (F_0); when the centers are closed (reduced) by saturating flashes of light, or by adding an inhibitor of noncyclic photosynthetic electron flow such as DCMU, fluorescence is maximal (F_m). Variable fluorescence, F_v (i.e., $F_m - F_0$) is thus a measure of the capacity for noncyclic photosynthetic electron flow. The ratio, F_v / F_m, can be related directly to maximum photochemical quantum efficiency.

Fluorescence parameters vary in response to environmental factors, such as light history, nutrient stress and other environmental insults. Consequently, F_v / F_m is used as a diagnostic of nutrient limitation in the ocean (e.g., Geider et al. 1993; Behrenfeld et al. 1996). For marine phytoplankton, values lower than about 0.65 are consistent with physiological stress. Variable fluorescence techniques include fluorescence +/- DCMU (e.g., references in Parkhill et al. 2001), Pulse-Amplitude-Modulated (PAM) fluorometry (Schreiber et al. 1986), Pump-and-Probe fluorometry (Kolber et al. 1988), and Fast-Repetition-Rate fluorometry (FRRF, Kolber and Falkowski 1993). Arguments about the validity and intercomparability of each method are not relevant here; we are exploring the degree to which patterns in the measurements can be associated with uncertainty in the blank.

Here we assess a potential problem in the use of an inappropriate blank (fresh water purified via deionization, dissolved organic matter adsorption, and frequently UV oxidation in Milli-Q or Nanopure water systems; hereafter referred to as "DI water") rather than filtered sea water (FSW) for shipboard measurements of variable fluorescence (e.g., Cullen and Renger 1979; Falkowski and Kolber 1995). Note that in the ratio, F_v / F_m (i.e., $(F_m - F_0) / F_m$), fluorescence from the blank affects only the denominator so that a blank with unnaturally high fluorescence leads to an underestimate of F_m, hence an overestimate of F_v / F_m. Conversely, a blank with less fluorescence than sea water with the phytoplankton removed leads to an underestimate of F_v / F_m. We show that for measurements of variable *in vivo* fluorescence in the oligotrophic open ocean, results are strongly sensitive to uncertainties in the blank, perhaps leading to erroneous conclusions about the fundamental controls of primary productivity in vast oligotrophic regions of the sea. Our message reinforces the long-standing, but sometimes weakly implemented requirement, that analysts explicitly evaluate analytical blanks when reporting oceanographic measurements. The importance of blanks has been recognized before, but we believe it bears repeating.

SPATIAL PATTERN OF VARIABLE FLUORESCENCE IN THE PACIFIC OCEAN

A transect of the Pacific Ocean along 150°W, roughly from Hawaii to Tahiti, encounters oligotrophic waters to the north and south with higher chlorophyll in the surface layer of the equatorial Pacific (Landry et al. 1997). Fluorescence at the surface, measured on discrete samples near midday and corrected for the FSW blank, is also higher in equatorial waters (Figure 1A). In oligotrophic waters at the extremes of the transect, the fluorescence signal from FSW (the appropriate blank) is nearly as high as that from whole sea water.

On one occasion, we measured the fluorescence of the ship's DI water, widely used as a blank for the measurement of fluorescence in discrete and flow-through systems. This DI had higher fluorescence than FSW (Figure 1B). The result seems surprising at first, but the system had no module for UV oxidation, and its water would have needed further treatment to serve as a good blank for dissolved organic carbon. Measurement of a DI blank was discontinued; stability of the instrument is reflected in the record of acetone blanks for the determination of extracted chlorophyll using the same fluorometer.

The effects of using different blanks are shown in Figure 1C, where F_v / F_m was calculated using either the proper FSW blank or the FSW blank increased by 50% of the observed fluorescence increment from DI water (from Figure 1B). Results are significantly different: $(F_v / F_m)_{DI}$ (using the DI blank) shows a strong pattern with latitude, suggesting high values of about 0.65 in the blue waters north and south of the iron-limited equatorial region, and $(F_v / F_m)_{FSW}$ (using the FSW blank) shows little change with latitude. We conclude that, unless proven otherwise through direct comparison with FSW blanks, DI water is an inappropriate blank for the measurement of F_v / F_m. Nonetheless, DI water from a source with UV oxidation and new cartridges is very useful for monitoring instrument response and for detecting fouling in cuvettes. We now recommend routine measurements of DI along with FSW blanks.

TEMPORAL PATTERN OF VARIABLE FLUORESCENCE

Because the magnitude of both F_0 and F_m vary through the day, generally decreasing in bright light near the surface due to non-photochemical quenching (Dandonneau and Neveux 1997), diel patterns of F_v / F_m can be subject to a bias similar to that in Figure 1C, but with respect to time, not location. Simply, F_v / F_m will be overestimated if the blank is artifactually high, and the error will increase as F_m decreases, as occurs in bright light. Our interest in the temporal effects of blanks was spurred by the results of Behrenfeld and Kolber

Figure 1. Influence of blanks on discrete determinations of F_v / F_m during cruise WEC88 along 150°W, starting at 15°N and ending at 15°S, Feb - Mar 1988 aboard the R/V Wecoma (plotted versus day of year, with days 62 - 67 on the equator). Fluorescence of dark-adapted samples was measured with a Turner Designs 10-005R fluorometer before (F_0) and after (F_m) addition of DCMU. A) Midday measurements of F_0 and F_m for the surface sample are plotted as they would be measured before subtracting the FSW blank, which is shown in black. Freshly filtered (GF/F) sea water in a scrupulously cleaned cuvette, generally from a combined sample from four depths, served as the blank for fluorescence measurements (+/- s.e.; n = 4 to 17, depending on the day). Blanks were tested +/- DCMU, which had no significant influence on the blank. B) Three blanks were run on the same fluorometer during the cruise: FSW and DI (Milli-Q) for *in vivo* fluorescence, and acetone for extracted chlorophyll using the same instrument (measurements reflect stability of the instrument). C) The fluorescence-based measure of photosynthetic efficiency, F_v / F_m (where $F_v = F_m - F_0$). Black crosses are $(F_v / F_m)_{FSW}$ calculated using FSW as the correct blank (data from 1A). A locally weighted least-squares fit (solid line) indicates the trend. Filled red circles show $(F_v / F_m)_{DI}$ that would be obtained by consistently overestimating the measured FSW blank by 0.043V, less than half the measured increment from DI water in 1B (0.087 V). Data from J.J. Cullen.

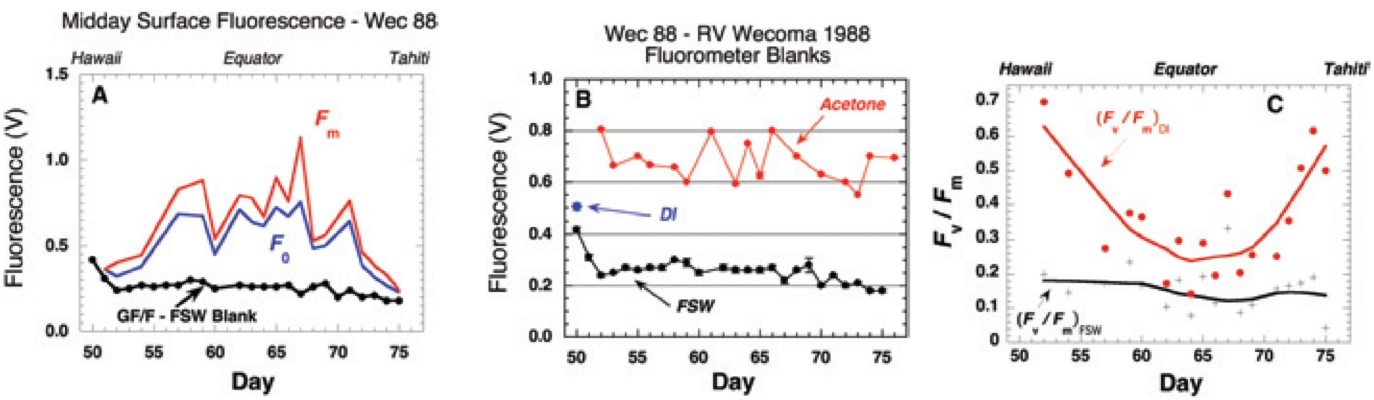
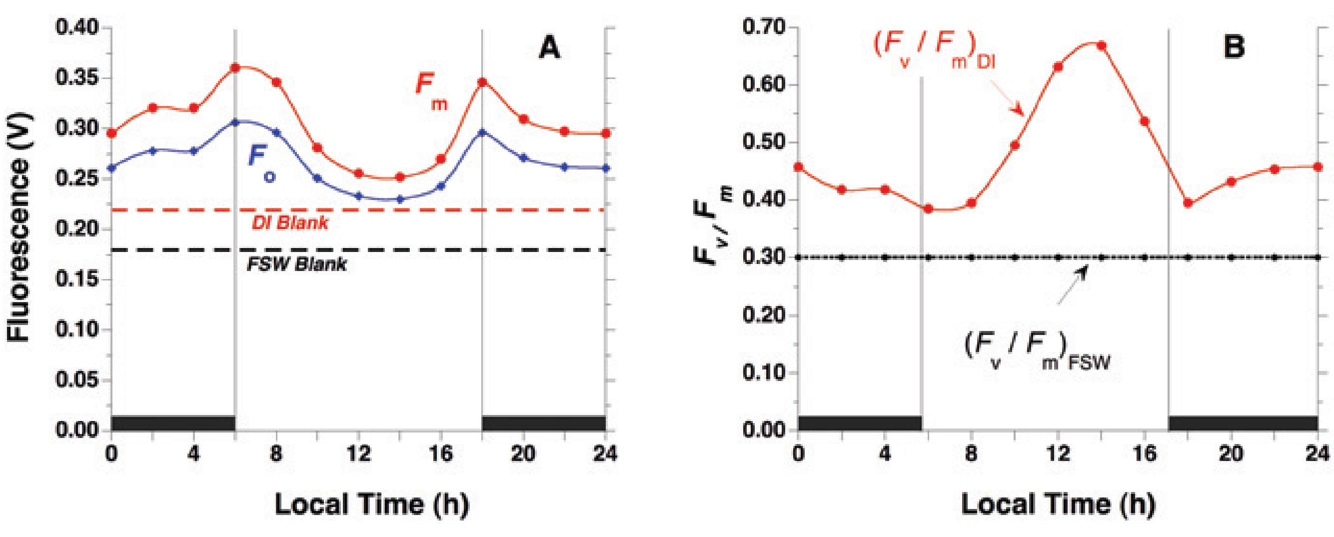


Figure 2. Hypothetical model showing a diel pattern of calculated photochemical quantum efficiency, F_v / F_m, generated using two different blanks. (A) Modeled diel pattern of F_0 and F_m scaled to be consistent with surface waters in the South Pacific. Assumptions are described in the text. The black dashed line is the FSW blank measured at midday; the dashed red line is an artifactually high blank consistent with an offset of less than 50% of the measured increment associated with using DI water, rather than FSW, at an oligotrophic station. B) The accurate diel pattern of $(F_v / F_m)_{FSW}$ is the flat line, calculated using the FSW blank; the red line, with a strong diel pattern in $(F_v / F_m)_{DI}$, was generated by using the DI blank to calculate F_v / F_m.



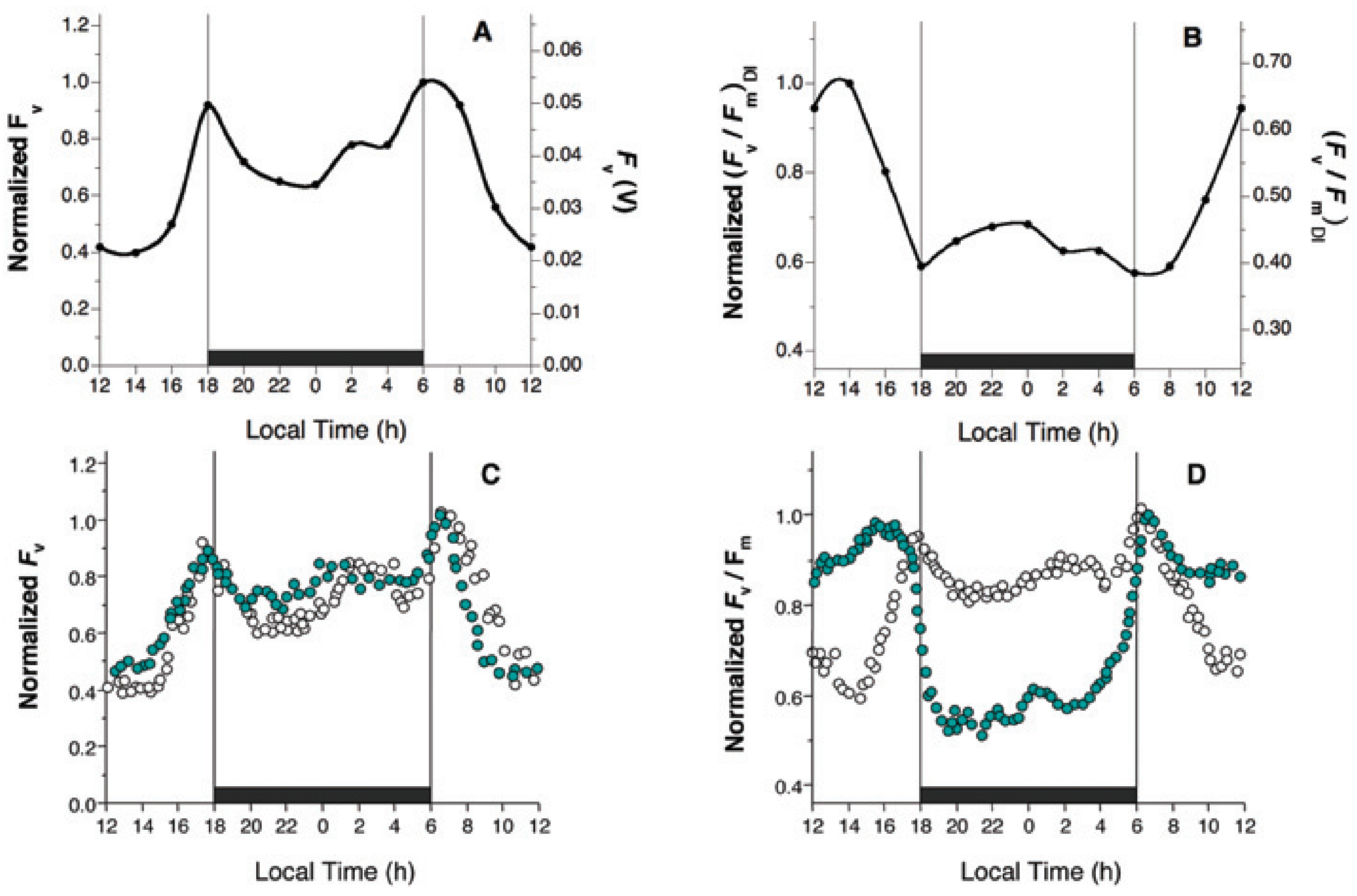
(1999). In the South Pacific, they found high values of F_v / F_m during the day, when fluorescence was low, and low values at night, when fluorescence was high. This report drew our attention because other studies (e.g., Greene et al. 1994), as well as measurements from our laboratory over more than 20 years, observe a depression of F_v / F_m at the surface during the day. Like many others, Behrenfeld and Kolber used DI water for their blank and reported no comparison with FSW. Would their reported diel pattern of F_v / F_m have been significantly different if FSW had been used for blanks, and those blanks were lower?

To examine the potential influence of blanks on the determination of F_v / F_m in the South Pacific gyre (where measurements should be most sensitive to the blank), we constructed a simple model of oligotrophic waters where both F_0 and F_m vary through the day, but F_v / F_m remains constant. The model is based on a diel record of F_v that is generally consistent with the average diel cycle reported for the South Pacific by Behrenfeld and Kolber (1999); it is constrained using our measurements of fluorescence and blanks in the Pacific Ocean. The hypothetical simulation, illustrated in Figure 2 and compared with the results of Behrenfeld and Kolber in Figure 3, follows these constraints:

- The absolute values, in volts, for F_0 (Figure 2A) are scaled to match our data for midday at 15°S, corrected for the FSW blank (from day 75 in Figure 1A).
- F_m (Figure 2A) is calculated from the blank-corrected F_0 assuming F_v / F_m is constant, night and day, at a value consistent with nutrient stress, 0.3. By definition, F_v / F_m calculated with the FSW blank, $(F_v / F_m)_{FSW}$ (Figure 2B), is equal to 0.3, the accurate result.
- $(F_v / F_m)_{DI}$ (Figure 2B) is calculated assuming the use of a blank which is 0.04 V higher than the FSW blank. This is less than 50% of the measured offset from DI water as compared to FSW in blue water of the north Pacific (from Figure 1B).

The modeling exercise clearly shows that in oligotrophic waters a strong but artificial diel pattern of F_v / F_m, high in the day and low at night, can be generated by the use of an inappropriate blank (Figure 2B, red line). As shown in Figure 3, our modeled values of F_v are similar to those of Behrenfeld and Kolber (1999). However, in our model, the accurate $(F_v / F_m)_{FSW}$ is invariant at 0.3; Behrenfeld and Kolber show a

Figure 3. Comparison of our simulation (A and B) with results published by Behrenfeld and Kolber (1999) (replotted from their Figure 2). The data from our simulation are normalized to daytime maxima and plotted with nighttime in the middle of the record for compatibility with their presentation. A.) Our simulated pattern in normalized F_v (F_m - F_0, which is insensitive to variations in the blank) is similar to their data for the South Pacific (filled symbols in C; open symbols are for central Atlantic gyres). B.) The diel pattern of $(F_v / F_m)_{DI}$, generated in our simulation by an assumed artifact, is similar in amplitude and phase, but not all details, to the pattern of F_v / F_m reported by Behrenfeld and Kolber (D), who used DI water for blanks.



pattern of normalized F_v / F_m that is similar in amplitude and phase, but not in all details, to our $(F_v / F_m)_{DI}$ which was based on an assumed artifact.

Behrenfeld and Kolber (1999) interpreted the diel pattern of F_v / F_m, particularly the decrease at night, as evidence for iron limitation of primary productivity in the oligotrophic central South Pacific, as well as in the equatorial Pacific, where, during IronExII, the diel pattern disappeared in the iron-fertilized patch while persisting in control waters outside the patch. It may be relevant that the artifactual diel pattern of F_v / F_m associated with a high blank (Figure 2) is dampened when both F_v / F_m and F_m increase, as occurs when iron limitation is relieved. We have modeled this result for a hypothetical enrichment experiment like IronExII, but the simulation involves much speculation about the value of the blank in the equatorial Pacific, reinforcing our conclusion that results cannot be interpreted with confidence if the value of the blank is not constrained. Regardless, even if the diagnostic diel variation of fluorescence was accurately recorded in the equatorial Pacific, it could not be taken as evidence that the same pattern exists somewhere else. In turn, fundamentally different diel variability reported for the Pacific vs. Atlantic Oceans (Figure 3D) might be due to physiology or, possibly, to different DI water supplies as compared to natural water. The question is difficult to resolve when measurements of FSW blanks are lacking.

We do not assert that the measurements of Behrenfeld and Kolber (1999) from the South Pacific gyre are compromised by the artifact simulated in our model. Their instrument system, and many other aspects of the measurements, were substantially different from ours, so there is no way to know if their measurements were significantly influenced by an artifactually high blank associated with DI water. That is exactly our point: if the blanks are not reported, there is no way to know.

Our simulation, based on published data from the South Pacific and direct measurements in the same region, illustrates why an appropriate blank must be measured and shown rigorously to have an insignificant influence on an analysis. Considering the importance of determining what controls primary production in the open ocean, we feel that when it comes to the measurement and interpretation of variable fluorescence, blanks do matter.

CONCLUSIONS

Researchers are measuring and interpreting F_v / F_m in many parts of the ocean, but few are reporting the measurement of appropriate blanks. Many are using a commercially available submersible instrument, and some use the readings from well below the photic zone for blanks. The appropriate blank cannot be measured directly with an unmodified instrument: it is sea water from which phytoplankton have been removed, under the same ambient irradiance as encountered through the vertical profile. The magnitude of potential errors can be assessed if the signals from deep water are compared to those from FSW (both F_0 and F_m) at the same site under a range of irradiances, with an evaluation of temperature effects and the influence of scattering. This is tractable, and we understand that some researchers have made the measurements. For flow-through and discrete-sample fluorometers, measurement of FSW blanks and comparison with DI water should be part of the calibration routine.

Problems with blanks, no matter the analyte being measured, are insignificant when the sample signal is much greater than uncertainty in the blank. Nevertheless, this should be demonstrated and reported in scientific communications or dealt with explicitly and reported when it is not true. However, inspection of the literature indicates that such measures are neither universally demanded nor routinely undertaken. Rigorous assessment of an analytical blank may not always seem worth the effort, but it is necessary, like it or not.

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BOOK REVIEWS

STERNER, ROBERT W. AND JAMES J. ELSER. 2002. **Ecological Stoichiometry: The Biology of Elements from Molecules to the Biosphere.** Princeton University Press. ISBN 0-691-07491-7 (paperback). 439 p. US $29.95

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I can still remember the intellectual epiphany that reading A.C. Redfield's 1958 paper, "The biological control of chemical factors in the environment," provided me as a post-doctoral fellow in Woods Hole, Massachusetts, where Dr. Redfield still practiced his science to a wonderfully old age. Redfield had discovered a remarkably close match between the composition of ocean plankton in terms of carbon, nitrogen, and phosphorus, and the regeneration ratios and concentrations of these same nutrients in the vastness of the deep sea. His insight suggested a primacy for biological activity in determining at least some aspects of ocean chemistry almost unimaginable at the time from first principles, but empirically convincing nonetheless. My epiphany was that the inorganic world was strongly influenced by the biological and that many small-scale biological interactions could drive global fluxes and cycles in relatively fixed proportions of the essential biological elements. A profound order emerged at a large scale from numerous, apparently chaotic, interactions at a smaller scale. Since that time, biological and chemical oceanographers have paid homage to the "Redfield Ratio" (and indirectly stoichiometry) as an organizing principle of their science. Indeed, the Redfield Ratio is scientifically well-traveled out of the ocean, and references to it are common in freshwater science and other fields such as algal ecology. However, not all global ecosystems are as well organized as the oceans, which have had enormous lengths of time for internal cycles of the elements to come to steady state, and deviations from the Redfield Ratio may be even more interesting to ecologists than the relative homogeneity of the oceans. Such deviations are addressed, both theoretically and empirically, in a new book by R.W. Sterner and J.J. Elser, who have embraced stoichiometric relationships among the earth's biota and its elemental cycles with an admirable passion and thorough scholarship.

The thesis of the book derives from the fundamentally different strategies of plants and animals in acquiring energy and essential elements. If all organisms were completely homeostatic and with a very fixed composition, there would be little for ecologists to discuss. But such is not the case. Plants are relatively passive and fixed in location within their milieu and acquire biological energy by intercepting and transforming sunlight and acquire elements as they are presented at their sites of uptake from water or soil solutions. The two processes are separable in time and space. Animals have powers of self-locomotion, or of inducing movement in their surroundings, to find packets of food that provide both elements and energy simultaneously. As a consequence, plants must have a capacity to store excess elements or energy internally, because their acquisition is variable and distinct. Plant biosynthesis can be limited by lack of energy or lack of essential elements acquired most often in inorganic form from the environment. Animals, in contrast, must actively search for their energy and elements but generally find them together, and this likely accounts for the more fixed stoichiometric composition of animals. However, for this dual reward, animals pay an energetic cost of mechanical motion.

Given this dichotomy in strategies, this Yin and Yang of the animal and plant worlds, there are two crucial stoichiometric interfaces within ecosystems. The first is the acquisition of necessary elements by plants from the abiotic environment, in which entropy must be locally overcome as disparate elements are brought together to produce highly structured cells. Plant cells may vary in composition (within stoichiometric limits) and be limited by the element available in lowest proportion relative to that needed to produce new cells or new organisms as quickly as possible under the imperatives of mortality (entropy must eventually be served) and evolutionary fitness. The other critical interface is for the grazing animals that must live and grow on the variable composition of the plants contributing to their diets. Predators have the relative luxury of diets that more or less meet their elemental needs if they can get enough of their prey. The novelty of Sterner's and Elser's book is in recognizing the importance of this second interface, because the first stoichiometric interface has long received attention of agronomists, plant ecologists, and physiologists in their search for limitations of plant growth. Animal ecologists (as opposed to animal nutritionists) have been less cognizant of the possible limitations that stoichiometric imbalances may impose on animal growth. The other strength of this book is to demonstrate that these imbalances may be more or less distorted and more or less important in different communities and ecosystems.

Sterner and Elser adopt a simple, incremental logic in the book and follow it with fidelity. They first address in Chapter One the relationship between homeostasis, a characteristic and essential attribute of life, and relatively fixed elemental stoichiometry for biological organisms. They point out that organisms are not random collections of the elements found on earth but are, in fact, a narrower subset that occur in living organisms in very different proportions than their relative abundance on earth. They argue persuasively that these elements have been selected for their chemical attributes that provide requisite functionality at the cellular level or necessary structural integrity. In Chapter 2, they survey the essential elements and identify those chemical attributes and critical functionalities of those elements. In this chapter they build cells from elements by examining the elemental composition of the major biochemical compounds and the structural and functional roles played by those biochemicals in the cell. Chapter 3 addresses the stoichiometry of plant growth with emphasis on the remarkably variable composition of plants. Chapter 4 reviews the much less elastic composition of animals; and these two chapters, contrasting plant and animal composition, material acquisition, and growth, provide the grist for the remainder of the book to mill. Chapter 5 addresses the consequences for animal growth when plant and animal compositions are not well matched, which unlike the world's oceans (Redfield's Universe), is in fact very common in terrestrial and freshwater environments. Chapter 6 reverses the perspective of Chapter 5 and looks at the consequences of unbalanced composition of plants and animals on nutrient recycling by animals. Chapter 7 begins the process of integration of small-scale interactions in time and space by examining feedbacks among organisms and the abiotic environment possible at the community level of organization. Chapter 8 suggests larger-scale consequences of stoichiometric ecological transactions, such as carbon and nutrient use efficiencies, and the tradeoffs possible by organisms in processes of elemental or energy acquisition. Chapter 9 summarizes the major points of the previous chapters in one wonderful figure and calls on the reader to join the chase to determine the limits of the predictive power inherent in a stoichiometric approach to ecological phenomena.

The book is an excellent introduction to ecological stoichiometry for graduate students; and for those already in the field, it is a thorough review of the complexities and nuances of stoichiometric ecology by two of its best practitioners. The book draws examples from both aquatic and terrestrial environments; but, not surprisingly given the ecosystem preferences of both authors, aquatic examples dominate and so aquatic ecologists will likely preferentially use the book. The book has a clear, logical structure, and it derives rigor from mathematical analyses and models that will be accessible to anyone with basic university math. The figures are clear and the text clean of typographic errors. There is an extensive glossary to help with the inescapable esoteric terminology that accumulates within new fields of endeavor. Less attractive is the authors' tendency to let their infatuation with stoichiometry lead to unnecessary and wordy excesses of enthusiasm for what a stoichiometric approach can do or promises for the field of ecology. This exuberance can come across as salesmanship rather than scholarship. It certainly adds occasional verbosity when the concepts should speak for themselves. Also, every chapter ends with a section entitled, "Catalysts for Ecological Stoichiometry," in which the authors identify unexplored or poorly known aspects of the material, as well as a "Summary and Synthesis" that addresses the factual content. Frequently the "Catalysts" and the "Summary" cover similar topics, adding unnecessary length to each chapter without increasing the information content. After eight chapters, this dual coverage amounts to overdrill if not overkill. The main courses of the intellectual meal, offered by the book, could have been presented more concisely, saving the reader from a somewhat overstuffed feeling at the end. But it does impress on the reader how dietary imbalance can require extra metabolic processing to retrieve and retain the essential elements. The intellectual nourishment the book provides is well worth the processing and the very reasonable price.

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SMOL, JOHN P. 2002. **Pollution of Lakes and Rivers: A Paleoenvironmental Perspective.** Arnold Publishers; co-published by Oxford University Press. ISBN 0-340-69167-0 (paperback). 280 p. US $29.95.

Reviewed by ***Edward Laws,*** *Department of Oceanography, University of Hawaii, Honolulu, Hawaii 96822 USA; elaws@hawaii.edu*

The impact of pollution is difficult to assess without some knowledge of average background conditions and natural variability. This fact is apparent in the current controversy over global warming. The absence in most cases of a long time series of direct observations requires that scientists resort to indirect methods to put current conditions into perspective. Thirty years ago there was much controversy and concern about the high concentrations of mercury reported in tuna and swordfish. There was speculation that the high concentrations reflected anthropogenic use of mercury and resultant pollution of the ocean. However, examination of museum specimens revealed that mercury levels in tuna and swordfish caught from 62 to 93 years earlier were in the same range as recently caught fish (Miller et al.1972). The analyses of the museum specimens lent support to the contention that the mercury levels in the tuna and swordfish were not primarily the consequence of anthropogenic pollution but in fact were of natural origin.

The use of museum specimens of tuna and swordfish to infer past environmental conditions with respect to a pollutant is but one example of the use of preserved samples to better understand the implications of current observations. In many cases the relevant samples are found frozen in ice cores, buried in fossilized deposits on land, or preserved in sediments at the bottom of aquatic systems. Smol's book focuses on the use of the sedimentary record in lakes to make inferences about both the history of pollution and the impact of pollution on modern aquatic ecosystems. The book targets upper division undergraduates and M.S. students.

The book begins with a discussion of basic concepts and techniques: collecting cores, dating, and the use of transfer functions to make inferences about past values of environmental variables. The discussion then moves on to some well-documented examples of aquatic pollution and the role the sedimentary record in lakes has played in documenting the history of the problem. The examples include acid deposition, heavy metals, persistent organic pollutants (POPs), eutrophication, and erosion. The book also includes a chapter concerned with species invasions, biomanipulations, and extirpations. While these latter subjects are not always considered to be examples of pollution, in many cases they reflect anthropogenic disturbances whose impact is documented in the sedimentary record.

The book is generally well written, and the subject has an appeal that extends beyond scientific curiosity. There are of course the practical implications of being able to say with some confidence that present conditions do not lie within the bounds of natural variability, at least over the time frame documented in the sedimentary record. There is also the intrigue associated with being able to make inferences about past environmental conditions based on snippets of information and carefully reasoned deductive logic. The appearance, for example, of the chitinized mandibles of *Chaoborus americanus* larvae in the sediments of a lake imply the absence of fish, since the larvae, which are large and do not undertake diurnal vertical migrations, rarely coexist with fish (Uutala et al. 1994). While the extirpation of fish due to lake acidification may lack the appeal of case studies chronicled in the works of Sir Arthur Conan Doyle, the insightful use of deductive logic to infer past events and circumstances based on information that would appear uninteresting and irrelevant to an amateur has a certain appeal.

The book has several faults. First, the treatment of subject matter is uneven. A total of 38 pages are devoted to eutrophication, 27 to acid deposition, 13 to persistent organic pollutants, and nine to mercury. Why, for example, is there so little discussion of mercury? World production of mercury has declined by about 70% since 1970, largely due to recognition of its extreme toxicity. One of the most serious instances of mercury pollution in North America was caused by the discharge of mercury by the Dow Chemical chlor-alkali plant at Sarnia, Ontario, into Lake St. Clair. Oddly, there is no mention of Lake St. Clair in the chapter on mercury pollution. Second, in some cases, the use of figures is appalling. The book contains more than a few greatly detailed but largely uninformative figures. For example, Fig. 7.9 shows sedimentary profiles of valves, scales, and mandibles of 26 species of diatoms, chrysophytes, and *Chaoborus*, respectively, in an Ontario lake. The text makes reference to only one of the 26 species, *C. americanus*. The caption to the figure says that the diatom and chrysophyte record indicates a slight acidification trend beginning in the 1930s and increased acidification and elevated monomeric aluminum concentration in the 1960s. There is no way that the reader can make any connection between the 26 profiles and either acidity or aluminum concentrations. No information is provided about the tolerance or sensitivity of the 26 species to either acid or aluminum. This is an obvious case where some synthesis of the data is badly needed.

Although logical reasoning is obviously required to intelligently interpret the sedimentary record, the book contains several remarkable non sequiturs. For example, the first few sentences of a section concerned with the effect of phosphorus reductions on eutrophication in the Great Lakes read as follows: "In 1969, the Cuyahoga River (Cleveland, Ohio) caught fire and burned uncontrollably! It became clear to residents, and then politicians, and eventually (with legislation) to industrialists that it was time to take serious action on water quality. One of the major mitigation efforts instigated was reductions in the amounts of nutrients entering the lakes." Since when are nutrients flammable? It is true that there was a serious fire on the Cuyahoga River on June 22, 1969, but what burned was an oil slick, apparently ignited by sparks from a train. The fire had nothing to do with eutrophication. On pages 229-230 Smol states, "Because of their high fat content, salmon may also be vectors for carrying a variety of bioaccumulated and bioconcentrated pollutants, such as POPs . . . and mercury." It is true that many POPs tend to be stored in lipid tissue, but fish accumulate mercury in their muscle tissue. The fish with the highest levels of mercury are tilefish, swordfish, king mackerel, and sharks. The average concentration of mercury in salmon is below the limit of detection (http://www.cfsan.fda.gov/~frf/sea-mehg.html).

Despite such shortcomings, is this book worth using in courses taught to upper division undergraduates and M.S. students? I would say that the answer is yes. The subject matter is organized in a logical way, and the level of presentation is appropriate for the target audience. Yes, there are some mistakes, but in a book with almost 250 pages of text, I found relatively few. Most instructors would probably supplement the written material with figures of their own choosing. Hence the lack of synthesis in some of the figures, while unfortunate, is not a fatal shortcoming. There is more than enough information in this book to form the basis of a good course on the subject matter.

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FINDLAY, STUART AND ROBERT SINSABAUGH. 2003. **Aquatic Ecosystems: Interactivity of Dissolved Organic Matter.** Academic Press. ISBN 0-12-256371-9 (hardback). 512 p. US $99.95

*Reviewed by **Deborah Bronk**, Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, Virginia 23062 USA; bronk@vims.edu*

The study of dissolved organic matter (DOM) has undergone a renaissance over the past two decades. The results include improved analytical methods, an explosion of information on composition, sources, and sinks, and a greater appreciation for the central role DOM plays in global cycles of carbon, nitrogen, and phosphorus. By its very nature, the study of DOM is interdisciplinary, which makes keeping up with the current literature a constant challenge. As a result, a well-written review chapter can be a godsend, and those interested in DOM will find many of them in the new book, *Aquatic Ecosystems: Interactivity of Dissolved Organic Matter*, edited by Stuart Findlay and Robert Sinsabaugh. The book deals primarily with DOM produced at the interface of terrestrial and estuarine ecosystems. Its focus on fresh- and brackish water environments makes it a wonderful companion to another recent review volume that covers DOM cycling in marine systems, *Biogeochemistry of Marine Dissolved Organic Matter*, edited by Dennis Hansell and Craig Carlson. Those with a more marine bent should take special note of the Findlay and Sinsabaugh book. Chapters often contained references pertinent to my own work, but from freshwater literature I do not regularly read; in that respect I found it especially useful.

There are 20 chapters, many of which are short and very focused in subject. As such, this book would make a great basis for a graduate-level reading course where topics must be covered in a relatively short time. The book, which has a sufficiently detailed index, is divided into three sections: sources and composition, transformation and regulation, and approaches to synthesis.

The first and largest section of the book starts with two well-written chapters by Bertilsson and Jones and Aitkenhead-Peterson et al. These chapters focus on sources of autochthonous and allochthonous DOM, respectively. An excellent follow-up to these chapters is a discussion by Mulholland of large-scale patterns in DOC concentrations. The remainder of the first section consists of several well-written chapters of more narrow focus that largely describe aspects of the chemical characteristics of individual DOM fractions.

The second section focuses on transformations of DOM and contains a number of excellent chapters on various aspects of DOM cycling, including bacterial utilization of low molecular weight organic compounds (Kirchman), photochemistry (Moran and Covert), biofilms (Fischer), and the roles played in DOM turnover by enzymatic processes (Arnosti) and bacterial community composition (Foreman and Covert). Findlay concludes the section with an overview of bacterial responses to many of the variables discussed earlier. Overall, this section focuses almost exclusively on heterotrophic processes. The ultimate source of DOM, however, is primary production, and the book would have benefited from a more thorough coverage of the many roles autotrophs and mixotrophs play in DOM cycling.

The final and most interesting section presents a number of chapters that synthesize information presented earlier in the book. Within this section, DOM cycling is considered over a wide range of spatial and temporal scales. Thingstad starts at the cellular level with a discussion of parameters affecting bacterial physiology and in turn, DOM cycling. At the other end of the spectrum, del Giorgio and Davis offer a cross-system comparison of DOM lability. The final chapters by Sinsabaugh and Foreman, Wetzel, and Sinsabaugh and Findlay present a range of modeling approaches and conceptual views to bring what is known to date into a more synthetic whole.

Though I liked the book overall, there were a number of things I wish had been done differently. In bringing forth these points, I acknowledge the role the publisher may have had in some of the decisions. First, the chapters are not cross-referenced. Authors often note subject areas they exclude from consideration, but do not direct the reader to other chapters that cover the material. Second, there are disappointingly few references from the last three years (2000-2002) and when they do appear, they are often only recent publications of the chapters' author(s). Third, few of the chapters explicitly discuss research needs in the future (notable exceptions are the works of Bertilsson and Jones, Mulholland, Kirchman, Arnosti, and Foreman and Covert). As review chapters in books are often a student's first foray into the literature, some guidance on what's hot and what's not is always helpful. Fourth, the book is decidedly carbon-centric, yet dissolved organic nitrogen and phosphorus pools are now recognized as key components in carbon and nutrient cycles. As a nitrogen researcher, I found this perspective lacking. Only the chapter by Caraco and Cole deals specifically with nitrogen, and it is narrowly focused on a cross-system comparison using a model to predict heterotrophic nitrogen formation. There is even less depth and breadth accorded phosphorus. In fairness, I note that some authors do discuss dissolved organic nitrogen and sometimes dissolved organic phosphorus, specifically chapters by Aitkenhead-Peterson et al., Kirchman, McKnight et al., Moran and Covert, Thingstad, and Sinsabaugh and Foreman. Nonetheless, chapters devoted to nitrogen and phosphorus would have been welcome additions to the text.

In summary, Findlay, Sinsabaugh, and colleagues have produced a very useful addition to the literature. Particularly beneficial to students as an introduction to the field, there is enough depth here to challenge even seasoned researchers. Though the book is focused on freshwater systems, I hope ASLO's marine members will take to heart the society's call for more integration between disciplines and read this book. They have much to gain.

LETTERS TO *THE BULLETIN*

ONE MORE REPLY BY KARL BANSE ABOUT MEASUREMENTS OF ^{14}C-UPTAKE DURING THE NEXT 50 YEARS

Recall that in the first paragraph of Banse (2002a) I had written, "A principal goal of ecology … is to understand … the abundance of organisms and the rate of temporal change. Can we achieve this goal for the phytoplankton by *only* [now emphasized] measuring photosynthesis? My answer is NO. … I do not address the great utility of ^{14}C-uptake data for, as examples, physiological or grazing studies." Also, I had restricted myself to time scales of $\geq$ 24 h to avoid discussions of day-night changes, etc. and had noted in passing that even during exponentially increasing phytoplankton blooms, the CO_2 draw-down is much smaller than the cumulative ^{14}C-uptake because of the large grazing losses and regeneration (see Banse 2002b).

The four comments by Parsons and Sherr and Sherr (*L&O Bull.* 11[4], 2002) and Marra and Hobson (*L&O Bull.* 12[1], 2003) did not take up my challenge of "A principal goal of ecology … ." Also, none drew attention to the question (set aside by me) of why in more than half of the oceans with little seasonal change of phytoplankton, the average concentrations are not, e.g., three times or one-third of those being observed, or why the pigment concentrations in the subarctic Pacific or the sub-Antarctic water ring are about the same during winter (and quite high, for that matter) as during summer in spite of the greatly changing underwater irradiance and, hence, photosynthetic rates. (These intermediate-latitude HNCL regions comprise about one-sixth of the oceans. Obviously, I infer phytoplankton cell concentrations from pigment values, as I did in the 2002a note.)

Instead, the commentators principally addressed the utility of ^{14}C-measurements during < 24 h for more physiological observations, etc., and I largely do not disagree with their opinions. I note, though, that POC changes over 24 h are not the same as changes of abundance of phytoplankton, and arithmetic POC/chlorophyll ratios are not a good measure of the C/chlorophyll ratio of the phytoplankton (cf. Banse 1977). Principally, however, I wish to question here whether continuing sort-of worldwide measurements of ^{14}C-uptake (mg C m^{-3} d^{-1}) for another 50 years would be a useful exercise toward assessing temporal change in the global ocean, as implied or urged in three of the four comments. My premise is that outside of possibly shifting major current systems or upwelling regions, any average change will be relatively small, and the signal-to-noise ratio will be unfavorable. By noise I mean the variable accuracy of the, I am sure, continuing slightly variable methodologies of our ^{14}C-measurements. Moreover, even if, say, 10 years hence an absolutely fixed ^{14}C-methodology were to be applied on all ships, remember that temporal change can be found only by comparing at least two time points. The mean ^{14}C-rates for the past 50 years, however, are not known with great accuracy, quite apart from the greatly inadequate regional coverage noted by one comment.

Possibly, global oceanic change for phytoplankton will come about as an advance of the onset of the spring bloom rather than as a general shift of average photosynthesis per m^3 or chlorophyll-normalized rates. But, as I had written in the last sentence of my 2002a note, "… think about the data ….before you gather them." Would such a change of timing not much better be assessed via satellite pigment? Therefore, unless specific regional questions are to be answered, should we add another half-century of ^{14}C-measurements?

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Regards,

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ASLO NEWS

MESSAGE FROM THE PRESIDENT

Peter A. Jumars*, Darling Marine Center, University of Maine, 193 Clark's Cove Road, Walpole, ME 04573-3307 USA; jumars@maine.edu*

I am pleased to report that even while planning for the TOS-ASLO '04 Ocean Research Conference is tapering off and the implementation phase is beginning, ASLO's talks with AGU have resumed for producing a more broadly integrative Ocean Sciences Meeting than ever before for '06 in Hawaii. Although we are in the very preliminary stages, it looks as though the 2006 Ocean Sciences Meeting will combine the talents and resources of AGU, TOS, ASLO and possibly the Estuarine Research Federation. The draft agreement recognizes the long lead times required to plan and schedule such events and takes aim toward a very successful meeting. Oceanographers from each of these societies have been working hard to develop a shared vision of one inclusive, biennial meeting. I particularly thank John Orcutt and Mike McPhaden of AGU and Eric Hartwig of TOS for their efforts to make it work. I sincerely hope to be able to report a firm agreement in the next *L&O Bulletin*.

I also want to engage more of you in observing and participating more consciously in the rapidly morphing face of scientific publishing. ASLO this year lost about $50,000 in revenue when RoweCom, a journals reseller to libraries, went bankrupt. Some individual associations and societies may lose as much as $700,000. Many libraries find it more convenient to purchase multiple titles from a single source than to deal with each journal. RoweCom collected the libraries' funds and then declared bankruptcy without delivering. It alleges that its parent company, Divine, Inc., mishandled over $73.7 million, forcing the defaults and bankruptcy. The issue is still under litigation, but we have little prospect of recovering the funds due to ASLO. We produce journals because we want the science in them widely distributed, and so we cannot leave these unfortunate libraries in the lurch. Helen Schneider, ASLO's business manager, has been developing arrangements to deliver the journal in print or electronic form to these libraries on terms worked out with each of them individually.

Rapid changes have most society boards in continual review of their publications and subscriptions policies. For-profit publishers in the science area have dwindled in number and grown to monopoly proportions in the number of titles held. They agglomerate titles, and those holding dominant market share sell these bundles to libraries at exorbitant prices. They follow similar practices in enticing authors with various perks (notably many "free" copies) to sign book and symposium-volume contracts and pay for these perks with proceeds from high per-volume prices charged to libraries. If you have not thought about these issues, I highly recommend a slightly dated web piece at http://www.biomedcentral.com/1471-8219/1/1 and updates from the Scholarly Publishing and Academic Resources Coalition http://www.arl.org/sparc/home/index.asp?page=0

A fundamental question is what readers want (value) and get. Both are changing rapidly. Fundamentally, a reader wants the value added by the process of review and editing. In the past, one means of recognizing this kind of value was by recognizing the color and pattern of a cover, such as the reliable, never glossy, blue and gray of *L&O*. Fewer and fewer journal users ever see the cover of a journal. Readers want easy, inexpensive, electronic access to well-reviewed and edited material, and increasingly they want connectivity in the form of embedded links to related material. To provide such services, and to compete in kind with major for-profit publishers, scientific societies are turning to electronic agglomerations among multiple societies and journals. The ASLO board is reconsidering the options of joining BioOne <http://www.bioone.org/bioone/?request=index-html> and a fledgling geosciences agglomeration called GeoScienceWorld (no website yet). The board is eager to hear your opinions on the subject.

Even if you choose not to join this discussion, I hope that you will take the time to think about your review priorities, where to submit your next paper and with what press to publish your next book. When you review papers, you add value to the journal for which you review. When pressed for time, I have begun consciously to decline review requests from for-profit journals, but I have never declined such a request from a society-sponsored, non-profit journal. My reason is to help keep high-quality scientific publications affordable.

Peter A. Jumars
University of Maine

MESSAGE FROM THE BUSINESS OFFICE

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

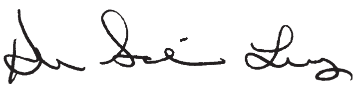
Following is a quick recap of some milestones and upcoming events and activities going on in ASLO:

- We are very close to posting the first article for ASLO's new journal, Limnology and Oceanography: Methods. Check it out at http://www.aslo.org/lomethods/free/2003/index.html. The purpose of this new journal is to provide a

central point for new and innovative methods in the aquatic sciences. Remember to check the web site often to see what's new.

- The Call for Special Sessions for the ASLO 2004 Summer Meeting in Savannah, Georgia, will go out soon. Be sure to submit your special session topics by the August 15 deadline.
- The abstract submission deadline for the 2004 Ocean Research Conference in Honolulu, Hawaii, is October 1, 2003. If you plan to participate, or if you would like more information on this inaugural meeting jointly sponsored by ASLO and The Oceanography Society, please visit the web site at www.aslo.org/honolulu2004.
- Other plans are in the works for the membership in 2004, including future meetings and additional services for you. As you are off on your summer activities, be assured that the ASLO Business Office is here working for you. If there is anything we can do to be of assistance, just let us know.

Have a great summer!



Helen Schneider Lemay
ASLO Business Office

2003 ASLO AWARDS

Five ASLO members received awards from the society this past February at the 2003 Aquatic Sciences in Salt Lake City, Utah. Following are citations for the award presented:

Citation for Scientific Excellence: **John I. Hedges, posthumous; Accepted on his behalf by his wife, Joyce**
Citation: For his many contributions to aquatic organic chemistry - particularly where oceans intersect the terrestrial world; for his stewardship as a long-time Associate Editor of Limnology and Oceanography; for his fine mentorship of many students and post-docs; and, for his ability to make us all enjoy science a bit more.

Lifetime Achievement Award: **John J. Gilbert, Dartmouth College, Hanover, New Hampshire**
Citation: For developing and sustaining the field of rotifer ecology and biology; for successful mentorship for more than a quarter century; and for vital service contributions to the national and international communities of limnologists and oceanographers.

Ruth Patrick Award: **Claire L. Schelske, Land Use and Environmental Change Institute, Department of Geological Sciences, University of Florida, Gainesville, Florida**
Citation: For elucidating the biogeochemical consequences of cultural eutrophication in large lakes and developing a comprehensive understanding of the recovery of anthropogenically disturbed aquatic ecosystems.

Raymond L. Lindeman Award: **Jules M. Blais, Biology Department, University of Ottawa, Ottawa, Ontario, Canada**
Citation: For Blais, J.M., D.W. Schindler, M. Sharp, E. Braekevelt, M. Lafreniere, K. McDonald, D.C.G. Muir, W.M.J. Strachan. 2001. Fluxes of semivolatile organochlorine compounds in Bow Lake, a high-altitude, glacier-fed, subalpine lake in the Canadian Rocky Mountains. Limnology and Oceanography 46:2019-2031.

G. Evelyn Hutchinson Award: **Hans W. Paerl, Institute of Marine Sciences, University of North Carolina –Chapel Hill, North Carolina**
Citation: For contributing to understanding of aquatic microbial processes; for documenting linkages among the atmospheric deposition of nitrogen, coastal eutrophication, and harmful algal blooms; and for crossing traditional research boundaries delineating organism- to system-level perspectives within freshwater, estuarine and marine ecosystems.

MEETING HIGHLIGHTS

2003 ASLO AQUATIC SCIENCES MEETING

ACCEPTANCE SPEECH FOR THE 2003 ASLO LIFETIME ACHIEVEMENT AWARD

John J. Gilbert*, Dept. of Biological Sciences, Dartmouth College, Hanover, NH 03755 USA; john.j.gilbert@dartmouth.edu*

I am extremely pleased to receive this award and consider it a great honor to join those who have received it in the past. I will value it for the rest of my life. I am most grateful to the person who nominated me, those who supported my nomination, and the awards committee. The award reminds me that I have much to be thankful for in my professional career. I have had the good fortune of associations with wonderful people and excellent academic institutions.

I am indebted to two mentors who inspired me with their integrity, wisdom, creativity, enthusiasm for science, and exceptional knowledge of limnology and plankton biology. Shortly after going to Yale University for graduate study in 1959, G.E. Hutchinson opened my eyes to the world of rotifers and encouraged my interest in their life cycle and phenotypic plasticity. On his recommendation, I spent a year of postdoctoral study in the laboratory of his former student, W. T. Edmondson, at the University of Washington. Both of these renowned ecologists provided important support throughout much of my career.

For the next four decades, questions about the biology and ecology of rotifers and other freshwater organisms (ciliates, notonectids and sponges) provided many opportunities for research. A favorite approach with rotifers and other zooplankton has been to examine interactions involving behavioral and developmental responses in the laboratory using experiments and direct observations, and then to extend these studies to the field by conducting enclosure experiments and determining if patterns of abundance support predictions. A guiding philosophy has been that interactions, and mechanisms of interactions, discovered in the laboratory under appropriate conditions probably also occur in nature. Detailed knowledge of these interactions can be useful in understanding population dynamics, and also can suggest previously undetected patterns of abundance and distribution in natural communities.

The diversity of studies with which I have been involved at Dartmouth would not have been possible without collaborations with graduate students and postdoctoral associates and without generous support from the National Science Foundation, National Institutes of Health, and Environmental Protection Agency. I am particularly grateful to my graduate students and other research colleagues for their friendship and for making the search for knowledge such a stimulating and enjoyable adventure. In addition, faculty colleagues have freely given assistance and have provided a pleasant, stimulating environment for learning and research. Finally, I thank my wife, Cally, for supporting my interests since the very beginning of graduate school.

ACCEPTANCE SPEECH FOR THE 2003 ASLO G. EVELYN HUTCHINSON AWARD

***Hans W. Paerl**, Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, NC 28557 USA; hans_paerl@unc.edu*

It is with tremendous gratitude, appreciation and respect for my colleagues in ASLO that I accept the G. Evelyn Hutchinson Award. Many thanks and appreciation go to the nominator, my wife (Barbara) and children (Jessica and Ryan), students, technicians, post-doctoral researchers and co-workers, who provided boundless inspiration, enthusiasm, perspective, support and guidance over the years.

G. Evelyn Hutchinson's pioneering work and insights on the roles physical-chemical-biotic interactions play in determining the structure and function of aquatic ecosystems continue to inspire and guide researchers, especially those crossing disciplinary boundaries to clarify environmental controls of ecosystem biogeochemical and trophic processes. It is a particular honor and pleasure to share this prestigious award with numerous limnological and oceanographic colleagues, students, and technicians who have participated in a wealth of interdisciplinary, cross-cutting and multi-media research addressing these processes.

Our collaborative research has canvassed a spectrum of aquatic ecosystems ranging from oligo- to hypereutrophic lakes, extreme environments (including tropical hypersaline lakes, permanent, ice-covered lakes of Antarctica's Dry Valleys), temperate and tropical estuarine and coastal waters, to the ultra-oligotrophic open ocean. A bulk of this research has focused on the roles biogeochemical gradients and marginal environments play in controlling production and nutrient cycling processes of these aquatic ecosystems. This includes investigations of the interfaces and linkages between freshwater and marine ecosystems, including estuarine, coastal and intertidal macro-environments as well as smaller-scale microenvironments, such as interstitial and surficial microzones, benthic microbial mats and suspended aggregates. The G. Evelyn Hutchinson Award is in recognition of collaborative cross-disciplinary research shared with many colleagues who have tirelessly worked to unify limnology and oceanography into a "seamless" and functional continuum coupling freshwater and marine domains, as well as their many environmentally-sensitive processes. The dynamic interactions of these domains with major sources and sinks of water, namely the atmosphere, soils and the subsurface environment, often are controlled at these interfaces. Geophysical, biogeochemical, and trophic change are also strongly modulated at these interfaces, which represent some of the most diverse and productive habitats on Earth.

Having examined these habitats using microbes as indicators and catalysts of ecological condition and change has provided the opportunity and privilege of working with and learning from numerous colleagues having expertise in applied aspects of microbiology, phycology, molecular biology and biogeochemistry. These interactive disciplines have played pivotal roles in elucidating the structure, function and synthesis of "marginal" environments. On the "micro" end of this spectrum, early mentors and coworkers in environmental and applied microbiology and phycology, including Angelo Carlucci, Osmund Holm-Hanson and Ralph Lewin (Scripps Institution of Oceanography), Holger Jannasch (Woods Hole Oceanographic Institute) and John Hobbie (then at North Carolina State University, now at the Marine Biological Laboratory), and Kevin Marshall (University of New South Wales, Australia), were instrumental in showing me ways and means to identify, assess and diagnose "players" and their interactions crucial to interfacial processes and ecological change. In addition, these scientists helped many of us microbial ecology "upstarts" appreciate the immense biological complexity mediating these interactions, as well as the critical range of scales over which these processes are translatable, relevant and manageable on ecosystem and regional levels.

On the "macro" end of this spectrum, multidisciplinary "big-picture" colleagues (a list too long to recite, but including limnologists, estuarine ecologists, hydrologists, atmospheric scientists, modelers and oceanographers) provided crucial insights and guidance enabling me to place micro- and mesoscale processes in their most appropriate and effective context for assessing ecosystem-level biogeochemical and trophic processes, responses, impacts and change. I am thankful for having had the opportunity to work with atmospheric scientists, hydrologists and ecosystem-level ecologists who, early in my graduate career, helped me look beyond water bodies and up into the watershed and sky for identifying physical-chemical sources and drivers of biological processes in aquatic ecosystems. In particular, interactions with Gene Likens, a visiting scholar at the University of California-Davis during the early 1970's, helped me develop an appreciation for the importance of the "airshed" as a major source of nitrogen; the nutrient limiting primary production in Lake Tahoe at the time. Interestingly, increases in man-made atmospheric and terrestrial inputs of nitrogen since then appear to have caused the lake to "shift" into a more phosphorus-limited mode; a remarkable short-term biogeochemical change considering the lake's tremendous volume, residence time (at least 300 years) and age (at least 5 million years)! Subsequently, the "connection" between atmospheric nitrogen inputs, estuarine and coastal eutrophication has also been established, serving as another example of the fundamentally important roles and importance of cross-boundary processes driving nutrient-enhanced primary production and ultimately, aquatic biogeochemical and ecological change.

Although research which crosses the scales of interactions and interfaces of aquatic ecology has been fascinating, stimulating, rewarding and "down-right fun," it has also been quite challenging and by no means an easy ride. There were times when few colleagues were interested in listening, let alone willing to "buy in," to this type of research. Similarly, there were many occasions when "marginal" research couldn't find a home with funding agencies. Fortunately, the complex interfacial nature of contemporary environmental issues requires multi- and interdisciplinary, cross-media, solutions that in turn, requires crossing interactive scales. Today, limnologists, aquatic ecologists, estuarine and marine scientists are actively engaged in research linking atmospheric with terrestrial (including sub-surface) and aquatic processes across ecosystems, climatic regions, continents, and ocean basins. The need for encouraging and supporting cross-cutting, multi-media research is now firmly emphasized and broadly funded by NSF, EPA, NOAA, NASA, USDA, USGS, Environment Canada, European Union, Japanese, and other national/international environmental science programs, state and provincial-level agencies as well as global cooperative programs such as the Coastal Global Ocean Observing System (GOOS), and the Global Harmful Algal Bloom Program (GEOHAB).

Although these evolving programs stress the importance of interdisciplinary research at atmosphere-terrestrial-aquatic interfaces, it has not necessarily been to the detriment of smaller-scale, subcellular, organismal, population, single-process or phenomena-based research. Interactions at these small scales often represent the "glue" that connects larger-scale ecosystem and regional research thrusts and challenges. No

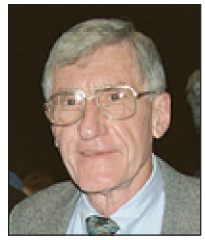
From left, Joyce Hedges accepted the Citation for Scientific Excellence on behalf of her late husband, John Hedges; Jules Blais received the Raymond L. Lindeman Award; Claire Schelske received the Ruth Patrick Award; John Gilbert received the Lifetime Achievement Award; and Hans Paerl received the G. Evelyn Hutchinson Award.

matter what scale one operates on, the real "trick" is asking the right question at the appropriate point in time and space. There always will be a pressing need for inquiry and problem solving over the entire range of scales. This is proving ever so true in today's world where anthropogenic and naturally-induced change increasingly interact to impact virtually every aquatic environment ranging from alpine streams to the open ocean. To address such complex issues, much will depend upon the effective application and synthesis of research and teaching tools over the range of relevant scales and the cohesive interactions of disciplines essential for problem solving. Often, this forces a researcher to involve oneself within a scientific discipline that they/she/he is not necessarily trained in. This brings scientists to yet another "margin;" the real or perceived distance that exists between traditional scientific disciplines. My experience has been that asking questions that initially may appear naïve or simplistic to colleagues from allied disciplines is well worth the risk. Well-timed, "pithy" questions often are the catalyst for rewarding and productive collaborations, may initiate new research directions and solutions and even lead to theoretical and technological advances in the field. Openly inquisitive communication across "margins" is an essential ingredient for developing giving and long-lasting friendships that to me, has been the most rewarding aspect of being a "marginal" aquatic scientist.

Finally, it gives me great pleasure and pride to thank my graduate mentor and lifelong friend Charles R. Goldman, who has served a multi-purpose role as scientific mentor and supporter of cross-disciplinary research. Charles constantly and enthusiastically conveyed insights on how to pursue ecological and environmental problem-solving in an imperfect world of limited data, details and resources, by asking pertinent questions and pursuing realistic objectives at the most-opportune and appropriate times, and equally-important, enjoying it! He also provided key personal and professional perspectives and advice, including not taking oneself too seriously, to live life fully, and to value friendships at all levels of scientific pursuit. In addition, many prior G. Evelyn Hutchinson awardees have served as intellectual and personal role models, sources of advice, and inspiration. These include Farooq Azam, Richard Dugdale, John Hobbie, Louis Legendre, Gene Likens, Timothy Parsons, Lawrence Pomeroy, Robert Wetzel, and others. It is with tremendous satisfaction that I accept this award and join this prestigious group. I hope to continue the established ASLO tradition of providing essential new research and teaching perspectives that have made limnology and oceanography indispensable disciplines for improving our understanding, management and preservation of Earth's precious aquatic resources.

ACCEPTANCE SPEECH FOR THE 2003 ASLO RUTH H. PATRICK AWARD

Claire L. Schelske*, Land Use and Environmental Change Institute, Dept. of Geological Sciences, Univ. of Florida, Gainesville, FL 32611-2120 USA; schelsk@ufl.edu*



It is indeed an honor and a privilege to be recognized by ASLO and selected for the Ruth Patrick Award. I regret that among the many who should be acknowledged for aiding and guiding me over the years only a few can be mentioned today.

David C. Chandler played an important role in my career, first as my major professor at the University of Michigan and later as the director of the Great Lakes Research Division when I returned to Michigan as a research faculty member. Although committed to developing an academic research program on the Great Lakes, he encouraged students to pursue their own research interests. Therefore, my dissertation was on "Availability of iron as a factor limiting primary productivity in a marl lake." That iron was a limiting nutrient was actually verified through a whole-lake experiment. The logistics of small lakes that could be sampled with a rowboat suited me very well because I had come to Michigan from the plains of Kansas and encountered seasickness for the first time on Lake Huron. My interest and love for Great Lakes research developed only after my return to Michigan in 1967.

One of the reasons I am here today is the silica depletion hypothesis. I would like to remind you that diatoms utilize soluble silica by precipitating it as amorphous silica during frustule formation. Silica depletion was identified by Schelske and Stoermer in 1971 as a biological consequence of eutrophication in Lake Michigan. We hypothesized that an observed decrease in silica resulted from increased diatom production driven by increased phosphorus loading in this phosphorus-limited system. Silica depletion was eventually identified in three of the five Laurentian Great Lakes at relatively low levels of phosphorus. As points of reference, silica depletion in Lake Michigan developed in the late 1960s when the total phosphorus (TP) concentration was <10 μg/L, (ca. 0.3 μM. Based on paleolimnological evidence it also developed in Lake Erie and Lake Ontario in the early to mid 1800s when the TP concentration was no greater than 10 μg/L. This early eutrophication was the result of phosphorus loading associated with land clearance and settlement by Europeans. For comparison, silica depletion did not occur in either Lake Superior or Lake Huron where the mean TP concentration ranged from 4 to 5 μg/L. The take home message is that this ecosystem response manifested by silica depletion is very sensitive to changes in phosphorus loading.

I would be remiss in stating that good science is the sole reason you see me here today. Serendipity, good fortune or blind luck played an important role in events leading to the silica depletion hypothesis in Lake Michigan. When I enrolled at UM as a graduate student in 1955, silica was replete and research on silica depletion would not have been a timely topic for a dissertation. However, by good fortune, it was very timely in 1969, my first year of research on the Great Lakes because in the intervening 14 years silica depletion had run its course in Lake Michigan.

Silica depletion in Lake Michigan was discovered primarily with support from the U. S. Atomic Energy Commission, another fortunate circumstance. Strangely enough in today's world, the contract was solicited by the government agency, a forerunner of the present Department of Energy, as one means of acquiring environmental data in anticipation of siting nuclear power plants on Lake Michigan. Silica was included in the project to appease Gene Stoermer who kept insisting it was important.

The silica depletion hypothesis was questioned on several grounds. George Saunders, a long-term friend from graduate school, pointed out that silica depletion in Lake Michigan was only epilimnetic silica depletion because a large reservoir of silica not utilized by diatoms occurred in hypolimnetic waters during thermal stratification. Nutrient enrichment experiments conducted by Gary Fahnenstiel and Mark Haibach showed that diatoms utilized silica while growing at low light and temperature and that diatom growth was stimulated at low phosphorus concentrations. The resulting conclusion published in 1986 was that diatoms growing at low light and temperature could utilize silica and eventually induce water-column silica depletion during winter mixing if supplies of phosphorus were adequate. This paper provided a mechanism to explain water-column silica depletion that characterized Lake Erie and Lake Ontario in the 1970s.

A more serious line of criticism questioned whether silica actually decreased in Lake Michigan. This skepticism arose partly because silica changed so rapidly from 1955 to 1969, and no long-term sampling program existed on the lake. In fact, few data were available for the years between 1955 and 1969. As more data became available in the 1970s, it was obvious to all that silica depletion had occurred. In retrospect, this debate followed the pattern outlined by Thomas Kuhn (1970) in "The structure of Scientific Revolutions." Simply stated, skepticism in an emerging paradigm is eventually replaced by "What's the big deal, we knew it all the time." Silica changes in the water column were documented in a paper published in 1988.

Another critical point was raised in a question at the Limiting Nutrient Symposium in 1972. If silica depletion resulted from increased production of diatoms has there been increased sedimentation of diatoms? Today the answer seems to be quite naive. I stated that we had no evidence of this sort, which was true. Fortunately, an inappropriate sampling design explained the lack of diatoms in sediment cores. Eventually, diatom graveyards were found in depositional zones identified by the Canada Center for Inland Waters. With the collaboration of Gene Stoermer (diatom microfossils) and Dan Conley (biogenic silica), the silica depletion hypothesis was verified with paleolimnological data.

I will conclude with an anecdote about my mother. My parents never attended high school, but were fluent in two languages, liked to read and were well informed about current affairs. Both believed in hard work and stressed the importance of education. My mother had a canny approach for keeping things in perspective. At a family dinner, my cousin asked her if she was proud of Claire's scientific accomplishments. Her first, somewhat indignant reply was "Of course, I'm proud," but that was followed quickly by "But I remember when I wondered if he would ever be able to cross the street by himself." Yes, Mom, I did learn to cross the street even if it was only a dirt road in Peabody, Kansas, and with a lot of help from others also learned to circumvent some of the hurdles that one finds on the other side of the road.

OUTSTANDING STUDENT POSTER AWARDS FOR THE 2003 AQUARTIC SCIENCES MEETING

The society recognizes the following students with outstanding poster awards:

Yokokawa, Taichi, Kyoto University, Otsu, Japan
Abundance and Growth Rate of Phylogenetically Distinct Subpopulations of Bacterioplankton in Otsuchi Bay, Japan

Swan, Brandon K., San Diego State University, San Diego, California
Bioturbation and Its Role in Sediment Phosphorus Regeneration in the Salton Sea

Rossberg, Marcelo Claudio, University of Cologne, Cologne, Germany
Ciliate Vertical Migration in Lake Speldrop, Germany

Ogbebo, Fortune E., University of Mississippi, University, Mississippi
An Empirical Study of Limnological Relationships in Lakes and Ponds of North Mississippi

Stone, Jeffery R., University of Nebraska-Lincoln, Lincoln, Nebraska
Modeling Changes in Lake Level and Its Application to Planktic:Benthic Diatom Ratios

Yates, Marissa, University of Maryland Sea Grant, REU, Cambridge, Maryland
Characterizing Suspended Sediments in the Estuarine Turbidity Maximum Zone of the Chesapeake Bay

Testa, Jeremy M., Boston University Marine Program, REU, Woods Hole, Massachusetts
Dissolved Iron Cycling in the Subterranean Estuary of a Coastal Bay: Waquoit Bay, Massachusetts

Streble, Laurie, Western Washington University Shannon Point Marine Center, REU, Anacortes, Washington
Solar Radiation and Marine Invertebrate Larvae in Puget Sound

Wason, Christopher J., University of New Hampshire, Durham, New Hampshire
Project Lake Watch: On Golden Pond for Lake Truthing Landsat and Modis

Wilborn,Ursula S., Georgia Institute of Technology, Atlanta, Georgia
Savannah (Georgia) Estuary Sediment Geochemistry

Needoba, Joseph A., University of British Columbia, Vancouver, British Columbia, Canada
The Influence of Nitrogen, Silicon, and Iron Limitation on the Elemental Composition of a Marine Diatom

Liess, Antonia, University of Uppsala, Norrtalje, Sweden
Experimental Test of Ecological Stoichiometry in Benthic Food Webs

McCarren, Jay W., Scripps Institution of Oceanography, La Jolla, California
Gene Clusters Required for Swimming Motility in Marine Synechococcus

Hansen, Aviaja Anna, University of Aarhus, Aarhus, Denmark
Mars Simulation Facility for Microbiological Experiments

Freytag, John K., Pennsylvania State University, University Park, Pennsylvania
Different Sulfide Acquisition Strategies Allow Co-Occuring Hydrocarbon Seep Tubeworm Species to Exploit Different Sulfide Sources

Cordes, Erik E., Pennsylvania State University, University Park, Pennsylvania
Steady-State Diagenetic Model of Hydrogen Sulfide Supply to Aggregations of the Hydrocarbon Seep Vestimentiferan Lamellibrachia Luymesi

2003 ASLO MINORITIES PROGRAM STUDENT AWARDS

*Contributed by **Benjamin Cuker**, Dept. of Marine and Environmental Science, Hampton University, Hampton, VA 23668 USA; benjamin.cuker@hamptonu.edu*

The ASLO Minorities Program is pleased to announce the winners of the 2003 Southern Association of Marine Laboratories Student Awards. Awards were given for the three best posters and three best platform presentations at the Salt Lake City meeting as judged by mentors in the ASLO minorities program. We thank SAML for their support.

First Place Posters ($250): Braxton, John, Savannah State Univ., 8000 Waters Ave., #115, Savannah, GA 31406

"The use of RNA to identify marine and freshwater bacteria"

Second Place Posters ($150): Cruz, Delia, Univ. of Texas, El Paso, 500 West University Ave., El Paso, Texas 79968

"Genetic variation in tadpole shrimp egg banks"

Third Place Posters ($100): Nimrod, Marina, Savannah State Univ., PO Box 20554, Savannah, GA 31404

"Effects of filtration, aquamats, and stocking density on net ecosystem production in a Pacific white shrimp (*Litopenaeus vannamei*) culture system"

First Place Oral Presentations ($250): Malone, Shanique Tahera, Morgan State University, 4907 Goodmow Rd. , Apt. T, Baltimore, MD 21206

"Study of the salinity and temperature growth ranges of *Bdellovibrio* isolates"

Second Place Oral Presentations ($150): Sexto, Marielis, Univ. of Puerto Rico, Mayaguez, PO Box 1296, Jayuya, PR 00664-2296

"Evaluation of the linkage between land use and human health issues in tidal creeks in South Carolina"

Third Place Oral Presentations ($100): Deonarine, Sarah, Southampton College, Campus Box 1391, 239 Montauk Hwy. Southampton, NY11968

"Ecology of phytoplankton communities dominated by *Aureococcus anophagefferens*: Importance of nutrients, viruses, and microzooplankton"

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.

JAMES L. PINCKNEY

Dr. James L. (Jay) Pinckney is an assistant professor in the Department of Oceanography at Texas A&M University in College Station. He received his Bachelor of Science degree in biology (1983) and Master of Science degree in marine biology (1987) from the College of Charleston in Charleston, SC. In 1992, he received his Doctor of Philosophy degree in ecology from the University of South Carolina in Columbia, SC. From 1992 to 1998 he was a research assistant professor at the University of North Carolina at Chapel Hill, Institute of Marine Sciences in Morehead City, NC, and has been at TAMU since 1998.

Estuarine and coastal studies form the core of research activities performed by Dr. Pinckney. General areas of interest include marine ecology, microbial ecology, microalgal ecophysiology, phytoplankton-nutrient interactions, harmful algal blooms, and ecosystem eutrophication in estuarine and coastal habitats of Texas. Specific interests are centered around the ecophysiological factors and processes that influence carbon partitioning, allocation (growth), and interspecific competition in multispecies assemblages. Most of Dr.

Pinckney's work over the past 20 years has emphasized investigations of the ecophysiology of benthic and phytoplanktonic communities and their contribution to ecosystem function. Analytical approaches involve manipulative field and laboratory experiments for examining the ecological physiology and responses of microalgal communities.

JOTARO URABE

Jotaro Urabe moved from CER, Kyoto University to Tohoku University as a full professor of ecology and evolutionary biology in the Graduate School of Life Sciences in April 2003. He started his career as a plankton ecologist but his interests range from paleolimnology to physiological and ecosystem ecology. Current projects in the Urabe's lab include stoichiometric impacts of light, nutrients and carbon dioxide on mass transfer efficiencies and trophic dynamics in aquatic communities, Daphnia genetics, and reconstruction of the food web in the past of Lake Biwa the largest lake in Japan.

GETTING TO KNOW YOUR L&O ASSOCIATE EDITORS

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

The next time that you pick up an issue of *L&O*, I hope that you will take a moment to peruse the list of Associate Editors (AE) on the inside of the front cover. These are the people who decide what is published in L&O. ASLO acknowledges the important work that these people do for the society; two AEs are featured in each issue of the *L&O Bulletin*.

The role of the AE is that of an impartial judge — to fairly assess the reviewers' comments and guide the author's next steps. About every two weeks an AE is assigned a new manuscript. His or her first task is to select reviewers; this delicate job requires profound knowledge of both science and politics (the often conflicting relationships among people in a society). When the reviews are received, the AE digests that input along with his or her own assessment of the manuscript to arrive at a decision. It is unfortunately quite common for reviewers to recommend very different fates for a paper, which puts the AE in the uncomfortable position of having to make at least one of the reviewers and perhaps the author unhappy. If a paper is accepted, the AE's final job is to edit the manuscript, suggesting wording and organizational changes to improve clarity.

L&O AEs work at the highest level of our profession. Being an AE is a very demanding job, and we are extremely fortunate that these people devote so much time to the ongoing challenge of making *L&O* the leading journal in the aquatic sciences.

LAUREN S. MULLINEAUX

Lauren Mullineaux is a benthic ecologist interested primarily in invertebrate larval dispersal and its effects on population dynamics and community structure in the sea. Presently, her laboratory is involved in projects at deep-sea hydrothermal vents, Atlantic seamounts, and coastal embayments. In each of these habitats they are investigating how dispersal connects geographically disjunct populations, both ecologically and genetically. Her focus is on field-based ecological approaches, but these studies require close collaboration with theoreticians and physical oceanographers. The types of manuscripts she handles as an AE include coastal and deep-water papers on benthic ecological processes - mostly feeding, growth, reproduction, dispersal/recruitment and predation.

MICHAEL J. VANNI

Mike Vanni is a professor in the Department of Zoology at Miami University, Oxford, Ohio. His research interests include food webs, ecosystem processes and watershed-lake interactions, and they are currently focused on the role of animals in nutrient cycling in freshwater ecosystems. This research encompasses a food web perspective (i.e., the role of nutrient cycling by animals compared to trophic effects of animals) as well as an ecosystem perspective (i.e., the importance of consumer-mediated nutrient cycling compared to other nutrient fluxes). Dr. Vanni also teaches courses in general ecology, limnology and ecosystem ecology. As an AE, he handles manuscripts on food web interactions, nutrient cycling, and fish ecology.

FROM THE EDITOR'S IN-BOX

2003 ASLO SCIENCE JOURNALISM WORKSHOP

*Submitted by **Cheryl L. Dybas**, Workshop Organizer, Media and Public Information Section, National Science Foundation, Room 1245S, 4201 Wilson Blvd., Arlington VA 22230 USA; cdybas@nsf.gov*

Aquatic ecosystems, many believe, are the landscape's most beautiful and expressive features. They are the Earth's eyes, looking into which the beholder measures the depth of his (or her) own nature, wrote Thoreau in "The Ponds" (Walden). Participants in the Popular Science Communication workshop held in conjunction with the 2003 ASLO Aquatic Sciences Meeting had an opportunity to measure the depths of their natures, by discovering whether their experience in writing scientific research papers might translate to writing popular articles about aquatic sciences. Some 40 people attended the workshop, including the presidents of ASLO and ERF, executive directors of scientific societies, faculty members at institutions around the country, post-docs, and graduate students. Participants learned how to present science in an interesting way while retaining factual accuracy, the key to good science communication with a popular (general public) audience. Popular science communication aims to change scientific concepts and results from jargon-based language often understandable only to scientists, to news relevant to the lives of a general audience.

The workshop explored science communication, specifically science writing, in language understandable to non-scientists. Examples of good science writing were reviewed, the structures of science news and feature articles were "dissected," and changes in popular science news coverage over time were discussed. Attendees were offered the opportunity to try their hands at writing a popular article about research being presented at the conference. Below are the writings of three workshop participants who researched and wrote articles about newsworthy findings presented at the 2003 ASLO Aquatic Sciences Meeting. Their efforts resulted in a wonderful update from Salt Lake City on aquatic sciences.

Pulsating Predators: Jellyfish Ecology in the California Current

By ***K. Alexandra Curtis*** *(Scripps Institution of Oceanography)*

Our knowledge of gelatinous zooplankton is still woefully inadequate, scientists believe, despite the potential of these zooplankton to influence and sometimes control recruitment processes and patterns of trophic energy transfer in marine ecosystems. The sea nettle (*Chrysaora fuscescens*) and the moon jelly (*Aurelia labiata*) have been identified as potentially important predators on euphausiid eggs in the California Current upwelling system. Euphausiids, close relatives of shrimp, are a key trophic link between smaller plankton and numerous commercial fish species in upwelling systems. Annual variations in the distributions and abundances of these medusae could have cascading effects both on higher and lower trophic levels by regulating annual recruitment of euphausiids.

Scientists Cynthia Suchman and Richard Brodeur of NOAA's Northwest Fisheries Science Center in Newport, Oregon, are studying the distributions, abundances, and feeding ecologies of these jellyfish and two other species of large medusae in the California Current region.

Over the last decade, fishers, tourists, and scientists have noted a trend toward increasing abundances and spreading distributions of both invasive and native ctenophores, medusae, and siphonophores, particularly in ecosystems in which overfishing or eutrophication is a problem. The basic ecology of these predators must be addressed to assess whether the perceived changes are real, what is causing them, and what they portend, marine researchers say.

Suchman and Brodeur are investigating the distributions and abundances of four medusae sampled in the northern California Current region during June and August 2000 and 2002, the time of year at which the medusae populations generally peak. The medusae were collected in transect trawling surveys for juvenile fish as part of the GLOBEC (Global Ocean Ecosystem Dynamics) Northeast Pacific Program. In addition, individual specimens were hand-dipped for gut content analysis, and the mesozooplankton community was sampled with concurrent vertical net hauls.

All four species tended to be most abundant over the continental shelf, said Suchman, but the distributions differed from species to species. *C. fuscescens* was more abundant inshore and farther north than *A. labiata*, which extended well across the shelf break, confirming previous work. In most areas, numbers were less than one per thousand cubic meters, but the distributions were highly patchy, reaching such abundances at some inshore stations that the trawl could not be deployed without filling it beyond capacity almost immediately. In fact, the total number of jellyfish caught during the cruise was greater than the number of juvenile fish, which the trawls were designed to target, said Suchman. But the data on the diets of the medusae proved to be most interesting, she said. Given the observed abundances of medusae and other categories of zooplankton, the medusae fed disproportionately on euphausiid eggs relative to other mesozooplankton and had the potential to consume a large fraction of their standing stock.

Suchman plans to extend the work geographically and to perform experiments to better quantify the potential effects of medusoid predators. She hopes that the results of this study will be incorporated into future modeling efforts to improve the understanding of the trophic pathways and processes that control production in the northeast Pacific.

By land or sea: Divining the origins of underground water flowing to the coast

By ***Carolyn Gramling*** *(Woods Hole Oceanographic Institution)*

Groundwater seeping into estuaries or into the coastal ocean can transport with it nutrients, metals, or organic substances, often at much higher concentrations than found in rivers. However, the flow of groundwater is often ephemeral, making it difficult to quantify. "It's an underestimated, or unknown, in coastal hydrologic budgets…and it's a missing link for biogeochemical budgets, which can cascade through the whole ecosystem," said Jaye Cable, a chemical oceanographer at Louisiana State University.

Cable and her colleague Jon Martin of the University of Florida are working on the quantification of groundwater discharge to the Indian River Lagoon, part of a 250-kilometer-long coastline ranging from the relatively pristine Cape Canaveral National Seashore to highly urbanized West Palm Beach, Florida. Quantifying these fluxes can become complicated when different methods used to track groundwater at the coast produce different results. As part of their research into the relative importance of the contribution of groundwater and its chemical constituents to the lagoon, Cable and Martin have taken a combined-technique approach to the problem, comparing fluxes derived from the radioisotopic tracers ^{222}Rn and ^{226}Ra, from seepage meters, and from chloride-derived pore-water advection models.

While seepage meters can measure direct fluxes across the sediment-water interface, geochemical tracers such as radon and chloride, both chemically inert, can be used to measure the degree of seawater circulation within the sediment pore waters. Radon, with a half-life of about four days, can also help to determine the time scale of that mixing.

Though expecting to see similar groundwater flux estimates from the different techniques, Cable and Martin instead uncovered a puzzle. "We were confounded at first when the seepage meters and the radon came out the same, and the chloride was different," Cable said. In fact, the chloride-derived flux estimates were roughly one-tenth of the fluxes calculated from other methods. "But when we started digging around more into the literature and found a hydrologic model for the lagoon that gave a similar number to the chloride, our story started to develop more."

Cable and Martin now postulate two different sources of groundwater discharging into the lagoon, each with a different potential impact on coastal water quality. While the chloride-based pore water advection models tracked "aquifer-derived groundwater" originating from the distant, freshwater Floridan aquifer, the other tracers measured the flux of "seep water," which includes seawater circulating through the sediments.

Knowing the relative contributions of each to coastal waters is an important step to determining their impact. "It really depends on what's in your groundwater," said Cable. If the aquifer itself is fairly clean, but the lagoon sediments are nutrient-enriched because of surface water loading, wind-enhanced seawater recirculation can oxygenate and release the nutrients from the sediments and into the water column. In other areas, said Cable, "the [aquifer-derived] groundwater flux can be very important. In an urbanized area, like the northeast [United States], there's a high potential for impact even if the groundwater flux is low, because the concentration of constituents may be higher."

Is Life on Earth Just a Balanced Chemical Reaction? Or is it Ecological Stoichiometry?

*By **Ione Hunt von Herbing** (Univ. of Maine)*

The Academic Press "Dictionary of Science and Technology" defines stoichiometry as "the science or study of the proportional relationships of two or more substances during a chemical reaction." In the developing field of ecological stoichiometry these substances are *just* chemical elements, organisms are *just* bags of chemicals and life is *just* a balanced chemical reaction. According to biologist James Elser of Arizona State University (co-author with ecologist Robert Sterner of the University of Minnesota of "Ecological Stoichiometry"), there is no *just* about it. Organisms *are* chemical entities and *are* the result of chemical reactions which form complex networks produced by evolution.

Elser and Sterner maintain that all life is chemical and that biochemical exchange is predictable, regulates all processes from metabolism to global change, and operates at all levels of organization, from microbes to metazoans. In using this simple abstraction they believe that ecological stoichiometry links molecules to ecosystems and comes close to defining a biological law that explains how simple mechanisms can produce surprisingly complex outcomes. Elser and Sterner cite evolution by natural selection as a prime example of a simple mechanism, and see stoichiometry as playing a large part in creating variation, the substrate of evolution.

Ecological stoichiometry relies on a universal law important to all life, the law of conservation of energy, or the First Law of Thermodynamics. This law states that energy can neither be created nor destroyed. Energy must, however, be balanced when energy content changes (through work done or heat transferred) between the thermodynamic system and its surroundings. The thermodynamic system can be a chemical reaction, an organism, an engine, an ecosystem or a solar system. In "ecological stoichiometry" the thermodynamic system includes all biological levels, from RNA to entire communities and ecosystems. The work done is a function of the balance of the ratios of fundamental chemical elements within the system compared to the ratios of these elements in the surrounding system (the environment).

According to Elser and Sterner, all systems should no longer be considered from a hierarchical perspective. Neither "top-down" nor "bottom-up" approaches will work. As chemical elements are neither created nor destroyed, but instead are rearranged and transformed to conserve energy, stoichiometry predicts patterns and outcomes based on the ratio of chemicals in the individuals or systems being considered.

The idea of chemical conservation is simple, but its implications are profound and will challenge our understanding of how life works at the most basic or "elemental" level, as well as at more complex levels, these scientists think. In a striking example, Elser and Sterner show how environmental phosphorous—key to a cell's "turbine engine" and present in all nucleotides—has a causal relationship between phosphorus-rich demands of ribosomal RNA and high specific growth rates, thus linking proliferation of biota to high levels of phosphorus in eutrophication of both freshwater and marine ecosystems.

If life on the earth is based on conserved stoichiometric relationships, is all life everywhere regulated by ecological stoichiometric principles? Could ecological stoichiometry be a universal biological law? The scientists' continued research may provide an answer.

ECOHAB PNW, A NEW WEST COAST MULTIDISCIPLINARY PROGRAM

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ECOHAB PNW (Pacific Northwest) is a new project whose goal is to study the physiology, toxicology, ecology and oceanography of toxic *Pseudo-nitzschia* species off the Pacific coast of Washington (WA) and British Columbia (BC). The project is funded jointly by NSF's Division of Ocean Sciences and NOAA's Coastal Ocean Program. Recent studies suggest that the seasonal Juan de Fuca eddy, a nutrient-rich retentive feature off the WA-BC coast, serves as a "bioreactor" for the growth of phytoplankton, including diatoms of the genus *Pseudo-nitzschia* (Fig.1). Specific study objectives are: 1) To determine the physical/biological/chemical factors that make the Juan de Fuca eddy region more viable for growth and sustenance of toxic *Pseudo-nitzschia* than the nearshore upwelling zone; 2) To determine the combination of environmental factors that regulate the production, accumulation, and/or release of domoic acid (DA) from *Pseudo-nitzschia* cells in the field; and 3) To determine possible transport pathways between DA initiation sites and shellfish beds on the nearby coast. A summary of results leading to the formation of this new program and a description of the research plans are given below.

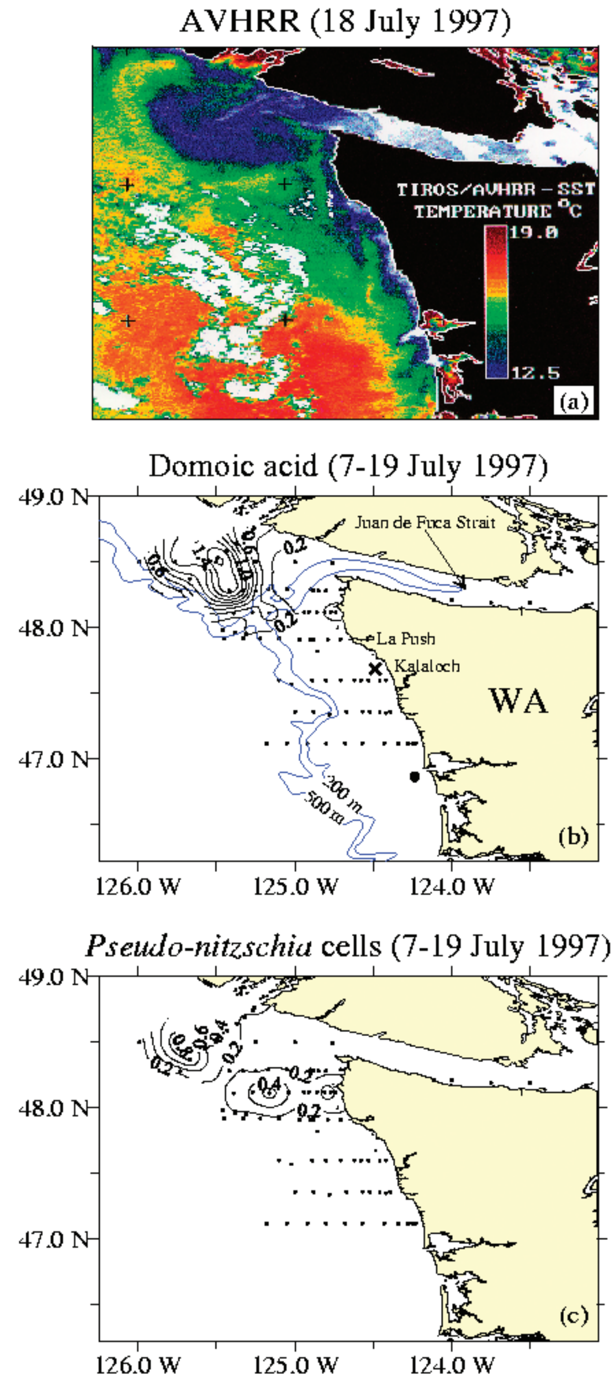
BACKGROUND

While DA poisoning was first recognized in an outbreak on Prince Edward Island, Canada (Wright et al. 1989), most of the known toxic events since that time have occurred on the U.S. west coast. Beach and harvest closures resulting from the toxigenic *Pseudo-nitzschia* blooms have a severe economic impact on both coastal economies and on tribal communities in the U.S. Pacific Northwest. In 1991, the closure of Washington State beaches to recreational and commercial shellfish harvesting resulted in a \$15-20 million revenue loss to local fishing communities (Horner and Postel 1993). The commercial Dungeness crab industry on which Washington's Quileute tribe depends for employment lost 50% of their income in 1998 due to harvest closures. The entire razor clam harvest of the Quinault tribe, on which they depend for both subsistence and commercial revenue, was also lost in the fall of 1998. Razor clam beaches have again been closed this winter and spring (2003) and devastating economic impacts have resulted in an estimated \$10 million loss to the recreational razor clam industry alone. With sufficient warning, tribal fishers could seek alternative buyers for eviscerated crab, and shellfish managers might have longer lead times to schedule closures.

Both the species of *Pseudo-nitzschia* (including *P. multiseries*, *P. australis* and *P. pseudodelicatissima*) and the relative levels of toxicity (e.g., Scholin et al. 2000) vary in time and space along the west coast of North America. Moreover, it is not uncommon for potentially toxic *Pseudo-nitzschia* cells to be present without detectable DA (e.g., Maldonado et al. 2002). The environmental regulation of DA production by *Pseudo-nitzschia* has not been determined in field populations due primarily to the ephemeral nature of these toxic events. Based on laboratory studies of unialgal cultures (primarily *P. multiseries*), two predominant triggers for the production of DA have been suggested: 1) the degree of cellular stress based on Si and P availability (e.g., Bates et al. 1991), and 2) the effects of micronutrient (Fe, Cu) conditions (e.g., Rue and Bruland 2001).

A survey of DA along the entire U.S. west coast continental shelf in summer 1998 suggests a strong relationship between DA concentration and mesoscale topographic features. Off

Figure 1. Satellite-derived sea surface temperature, particulate domoic acid (DA, μg/L) and total *Pseudo-nitzschia* cell numbers (10^6 cells/L) in surface seawater in July 1997 (Trainer et al., 2002). Dots represent all sampling stations where DA measurements and *Pseudo-nitzschia* cell counts were made. Spatial patterns show a coincidence of colder temperature, higher DA and greater numbers of *Pseudo-nitzschia* cells offshore of Juan de Fuca strait. The colder offshore water is indicative of the Juan de Fuca eddy. Colder water next to the Washington coast is indicative of local upwelling at the coast.



northern California where large coastal promontories and hence rapid offshore transport occur, DA levels are low. However, at more retentive sites along the coast, such as offshore of the Strait of Juan de Fuca, over Heceta/Stonewall Bank in Oregon, offshore of Monterey Bay (inshore of the Farallon Islands) and near the Santa Barbara Channel, DA levels are higher. Recent studies suggest that the seasonal Juan de Fuca eddy is an initiation site for toxic blooms of *Pseudo-nitzschia* that impact shellfish on beaches along the Washington coast. Measurements made during cruises and beach sampling of seawater and shellfish are all consistent with the possibility that during some years DA from this eddy appears to move southward in prolonged upwelling events and then onshore during the first major storm of the fall season, where it results in high levels of DA in razor clams on coastal beaches (Trainer et al. 2002).

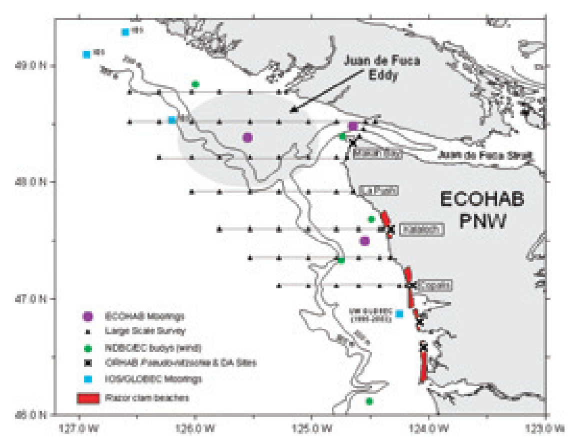
STUDY STRATEGY

To test our hypotheses on the origin of toxic blooms, multidisciplinary field surveys and drifter deployments will be performed in the region of the Juan de Fuca eddy and the nearshore coastal upwelling region (Fig. 2). The temporal context for observed variability as well as seasonal changes will be provided by an array of moored sensors measuring PAR and *in vivo* fluorescence, currents, winds, temperature, conductivity as well as time-dependent water samplers (preserved plankton and DA) deployed in both eddy and coastal environments as well as in the mouth of the strait. Results from the field studies will be used to configure and test numerical physical and biophysical models to determine bio/chem/physical conditions conducive to bloom and/or toxin production as well as transport pathways of *Pseudo-nitzschia* or toxic *Pseudo-nitzschi*a to the coast.

The backbone of this project will be six three-week cruises scheduled in June/July and September of 2003, 2004 and 2005. The length of the cruises was selected to ensure that a variety of growth regimes, including both upwelling and relaxation or downwelling, will be studied. *In situ* process studies will be made both in the eddy and coastal upwelling regimes as well as following aging water from each of these areas. Coastal *Pseudo-nitzschia* and DA data from the ORHAB (Olympic Region Harmful Algal Bloom) program and related state monitoring programs will be used to determine when and where toxic *Pseudo-nitzschia* arrive along the Washington coast resulting in toxification of razor clams. The field sampling plan, moored sensor arrays at key locations and drifter deployments, will allow us to:

1. Contrast characteristics of the nutrient-rich eddy with nutrient-rich nearshore upwelling areas. We will determine whether physical and biological factors that control DA production differ significantly in the two regimes.

Figure 2. Schematic large scale survey and locations of three interdisciplinary moored arrays. Locations of existing moorings, wind measurement buoys, razor clam beaches, and ORHAB sampling sites are also shown. The approximate location of the Juan de Fuca eddy is drawn as a lightly shaded area. Institute of Ocean Sciences (IOS) moorings are instrumented with current, salinity and temperature sensors at 3-4 depths between about 25 m and the bottom. ECOHAB PNW moorings will be instrumented with T, S, ADCP profilers and other current meters, time-dependent water samplers, PAR, wind, and fluorescence.



2. Contrast healthy and aged natural assemblages of *Pseudo-nitzschi*a to compare and contrast the environmental controls on DA production in cells at different stages of growth *in situ*.
3. Determine the biophysical mechanisms of *Pseudo-nitzschia* advection to the coast, resulting in shellfish toxification. Possible mechanisms include the following scenarios: a) a healthy *Pseudo-nitzschia* population is advected directly from the offshore eddy to coastal shellfish during a storm event; b) an aged *Pseudo-nitzschia* population is advected from the eddy to the coast where it becomes a "seed" population that becomes toxic only when later supplied with nutrients from local coastal upwelling; or c) the nearshore, "seed" population toxifies the coastal shellfish directly after local upwelling followed by a storm.

The integrated field and modeling studies of ECOHAB PNW described above will make significant strides toward satisfying our long-term goal—to develop a mechanistic basis for forecasting toxic *Pseudo-nitzschia* bloom development here and in other similar coastal regions in Eastern Boundary upwelling systems. The ECOHAB PNW team [B. Hickey, E. Lessard (U. Washington), V. Trainer (NOAA Fisheries), M. Foreman, E. Peña, R. Thomson (Institute of Ocean Sciences), W. Cochlan (San Francisco State U.), M. Wells, L. Connell (U. Maine) and C. Trick (U. Western Ontario)] welcomes collaboration with other interested scientists. For more detailed information about our program please visit our website at http://www.ecohabpnw.org.

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NSF BIOGEOSCIENCES PROGRAM: OPPORTUNITIES AT MULTIPLE LEVELS

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Recognizing the growing research and educational challenges posed by bridging the Earth and life sciences, the U.S. National Science Foundation has begun a new program in biogeosciences. Biogeosciences is the study of the fundamental interactions between life and the Earth's atmosphere, hydrosphere, and geosphere potentially including such life on other planets. The new program is housed in the Division of Earth Sciences, but cuts across all the divisions in NSF's Geosciences Directorate and will likely interface with other directorates as well. This is in clear recognition of the fundamental interdisciplinary nature of biogeosciences. The first program announcement was issued in Fall 2002 with a December 2002 deadline and focused on geomicrobial processes, a subset of the biogeosciences.

An outside working group has been formed to examine how the biogeosciences program might further develop within NSF. In this respect, the group needs input from the community on a variety of issues that they will be considering, including the following broad "categories":

1.) Scientific (e.g., What aspects of biogeosciences should be addressed by the new NSF program? What new or existing approaches can be applied? How does one accurately link paleo and modern studies?)

2.) Pedagogic (e.g., Is the U.S. system prepared/able to educate students to undertake rigorously interdisciplinary research? Can biogeosciences provide a framework for scientific inquiry/education at the K-12 levels?)

3.) Infrastructure (e.g., How can efforts with various funding agencies be combined and enhanced? Can panels and reviewers be found to evaluate interdisciplinary research? What are the communication venues, publications and meetings, for biogeoscience research?)

Members of the Biogeosciences Working Group are: Greg Cutter, Chair (gcutter@odu.edu); Sherry Cady (cadys@pdx.edu); Tim Lyons (lyonst@missouri.edu); Katrina Edwards (kedwards@whoi.edu); Rob Jackson (jackson@duke.edu); Ken Nealson (knealson@usc.edu); Charles Rice (cwrice@ksu.edu); (Sybil Seitzinger (sybil@imcs.rutgers.edu); Roger Summons (rsummons@mit.edu); and Susan Trumbore (setrumbo@uci.edu). We encourage you to contact any of these members to give your feedback on the evolving biogeosciences program (i.e., three categories above, not specific research projects), particularly since NSF will be issuing another announcement in the Fall of 2003. In this respect, the cognizant NSF program manager is Rachael Craig (rcraig@nsf.gov) and she also would be pleased to receive feedback on the new program.

DIALOG V PROGRAM UPDATE AND CONGRATULATIONS TO RECENT PH.D. RECIPIENTS

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Due to the expanding nature of the *L&OBulletin* and increasing costs, the ASLO board has decided it can no longer publish the quarterly reports on new Ph.D. recipients. So, this is the last time that names and dissertation citations will appear in the *L&O Bulletin*. However, the newly reorganized ASLO web page makes it easier than ever to identify recent Ph.D.s electronically—see http://aslo.org/phd.html.

Program reports will continue to be available on the DIALOG web page. In fact, a new article on mentoring has just been added. Students, recent Ph.D.'s and anyone who directs other people is encouraged to read this new resource.

Thanks to support from NASA, NSF, NOAA and ONR, funds are already in place for the DIALOG VI Program. DIALOG VI will highlight grads who completed their last Ph.D. requirement between May 1, 2003 and April 31, 2005. The DIALOG VI symposium will be held in October 2005. I am still hopeful that we will be able to raise funds for a symposium in October 2004, though support is still elusive. All aquatic science Ph.D.s are encouraged to register as soon as they complete their Ph.D. dissertation requirements. The dissertation registration form is posted at http://aslo.org/phd.html.

Please send job and other announcements to phd@whitman.edu for distribution to this network of recent grads. Once registered with the program, participants receive a weekly electronic newsletter with job and other announcements of interest to recent grads. Participants also receive symposium updates and other program information.

Finally, on behalf of the DIALOG Program and ASLO membership**,** congratulations and best wishes to the following new Ph.D. recipients!

Bastidas, Carolina 2003. Population dynamics and genetic structure of locally dominant species on coral reefs: A case study of the soft corals *Sinularia flexibilis* and *Clavularia koellikeri*. James Cook University (Australia), 167 pp. (cbastidas@usb.ve)

Benoit-Bird, Kelly J. 2002. Dynamics of the Hawaiian mesopelagic boundary community and their effects on predator foraging. University of Hawaii at Manoa (USA), 272 pp. (benoit@hawaii.edu)

Bernot, Randall J. 2003. Ecological consequences of *Daphnia* phenotypic plasticity in a Great Plains reservoir. Kansas State University (USA), 127 pp. (bernot.1@nd.edu)

Bischoff, Antje 2002. Juvenile fish recruitment in the large lowland river Oder: Assessing the role of physical factors and habitat availability. Humboldt University Berlin (Germany), 192 pp. (bischoff@igb-berlin.de)

Brooke, Sandra D. 2002. Reproductive ecology of a deep-water scleractinian coral, *Oculina varicosa* from the south-east Florida shelf. University of Southampton (United Kingdom), 160 pp. (sbrooke@oimb.uoregon.edu)

Damar, Ario 2003. Effects of enrichment on nutrient dynamics, phytoplankton dynamics and productivity in Indonesian tropical waters: A comparison between Jakarta Bay, Lampung Bay and Semangka Bay. Christian Albrechts University Kiel (Germany), 196 pp. (ariodamar@hotmail.com)

deBruyn, Adrian M.H. 2002. Sewage and the ecology of the St. Lawrence River. McGill University (Canada), 205 pp. (adebruyn@sfu.ca)

Donner, Simon S. 2002. The impact of climate and land use on nitrate export by the Mississippi River. University of Wisconsin at Madison (USA), 276 pp. (sddonner@princeton.edu)

Etheridge, Stacey M. 2002. Ecophysiology and optical detection of harmful algal blooms. University of Connecticut (USA), 182 pp. (Stacey.Etheridge@cfsan.fda.gov)

Hadwen, Wade L. 2003. Effects of nutrient additions on dune lakes on Fraser Island, Australia. Griffith University (Australia), 150 pp. (w.hadwen@griffith.edu.au)

Hertler, Heidi 2002. The implications of resource management in La Parguera, Puerto Rico. Drexel University (USA), 164 pp. (hertler@acnatsci.org)

Gielazyn, Michel L. 2003. DNA damage and reproductive effects in estuarine bivalves exposed in vivo and in vitro to genotoxic chemicals. University of South Carolina at Columbia (USA), 152 pp. (michel.gielazyn@noaa.gov)

Hinchey, Elizabeth K. 2002. Organism-sediment interactions: The role of seabed dynamics in structuring the mesohaline York River macrobenthic community. College of William and Mary (USA), 245 pp. (hinchey.elizabeth@epa.gov)

Kitidis, Vassilis 2002. CDOM dynamics and photoammonification in the marine environment. University of Newcastle (United Kingdom), 180 pp. (vassilis.kitidis@ncl.ac.uk)

Knowlton, Ann L. 2002. Sponges dominant in the Alaska intertidal: Biology, ecology, and genetic diversity. University of Alaska Fairbanks (USA), 211 pp. (ftalk@uaf.edu)

Laval, Bernard E. 2002. Modeling transport in lakes and estuaries. University of Western Australia (Australia), 167 pp. (Did not enter an e-mail address)

Loh, Ai Ning 2002. Chemical, isotopic and microbial characterization of dissolved and particulate organic matter in estuarine, coastal and open ocean systems. College of William and Mary (USA), 196 pp. (anloh@fgcu.edu)

McCallister, Leigh 2002. Organic matter cycling in the York River estuary, Virginia: An analysis of potential sources and sinks. College of William and Mary (USA), 220 pp. (leigh@vims.edu)

Mock, Thomas 2003. Photosynthesis in Antarctic sea-ice diatoms. Bremen University (Germany), 101 pp. (tmock@awi-bremerhaven.de)

Nayar, Sasi 2003. Nutrient and biotic fluxes in relation to dispersal of pollutants in Ponggol river. National University of Singapore (Singapore), 416 pp. (sasidiver@yahoo.com.sg)

Nunez-Nogueira, Gabriel 2002. Accumulation of Zinc and Cadmium in a tropical prawn *Penaeus indicus.* University of London (United Kingdom), 213 pp. (nunezng@yahoo.com.mx)

Ohi, Nobuaki 2003. Diel patterns in light absorption of phytoplankton: Package effects and pigmentation. Soka Universtity (Japan), 108 pp. (nooi@edu.t.soka.ac.jp)

Rember, Robert 2002. Composition of dissolved and suspended matter transported by the Sagavanirktok, Kuparuk and Colville Rivers in the Alaskan Arctic. Florida Institute of Technology (USA), 150 pp. (rrember@fit.edu)

Rynearson, Tatiana A. 2003. Clonal diversity, population differentiation and bloom dynamics in the centric diatom *Ditylum brightwellii*. University of Washington (USA), 159 pp. (trynear@ocean.washington.edu)

Short, Steven M. 2002. The molecular analysis of marine algal virus communities. University of British Columbia (Canada), 110 pp. (sshort@es.ucsc.edu)

Spänhoff, Bernd 2002. Submerged wood in a sandy lowland stream: Habitat traits, spatio-temporal colonization patterns of xylobiont invertebrates, and epixylic biofilm development. University of Muenster (Germany), 122 pp. (spanhof@uni-muenster.de)

Weiss, Johanna V. 2002. Microbially-mediated iron cycling in the rhizosphere of wetland plants. George Mason University (USA), 166 pp. (weisskarlsen@hotmail.com)

DIALOG VI

Dissertations Initiative for the Advancement of Limnology and Oceanography

Program for Recent Ph.D. Recipients

across the Aquatic Sciences and Related Disciplines

The DIALOG goal is to catalyze interactions and understanding across the aquatic sciences. Recent PhDs are targeted to introduce new graduates to the community, forge lasting collegial bonds across peer groups and foster early career development.

Ph.D. DISSERTATION REGISTRY

The registry encompasses *all* aquatic science disciplines. Dissertation abstracts are posted on-line in a fully searchable format, providing a concise overview of the field and highlighting individual accomplishments.

Graduates completing PhD requirements after April 1, 2003 are invited to register. Citations submitted within 3 months of PhD will be published in the *L&O Bulletin*. Participants will receive an abstract book, peer directory and a demographic report on their 2-year cohort.

ELECTRONIC COMMUNICATION

Once registered with DIALOG, graduates are placed on an e-mail list to foster cross-institutional communication and distribute job and other information. Anyone may submit job and other announcements for posting. Submissions should be sent to **dialog@whitman.edu**. Brief summaries are encouraged, with web addresses for details. Please do not send attachments.

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SYMPOSIUM

"I suspect that, in years to come, the familiarity with distant specialties and connection to the top young scientists in diverse fields will greatly impact my own research and teaching."
Past DIALOG participant

The DIALOG symposia catalyze early career development with a focus on interdisciplinary understanding and peer networking across the full spectrum of aquatic sciences.

DIALOG VI will bring together 40 recent grads from around the world. Both oral and poster sessions will be used to relate each participant's dissertation research and current interests. Working groups will discuss emerging aquatic-science research, education, career and societal issues. Agency representatives will describe interdisciplinary and international aquatic science research opportunities. While the format is intense, there will be time for informal as well as formal interactions. Past participants agree this opportunity for information exchange and developing an international peer network should not be missed:

"I am positive that my perspective of science was changed by this meeting. It has already proven to be a milestone in my career."

"This is exactly the sort of thing we need to bring the newest generation of aquatic scientists together."

Symposium Eligibility

DIALOG VI+ is open to PhDs completed
April 1, 2003 - March 31, 2005
in any subject *within* or *relevant to* the biologically oriented aquatic sciences. Selection will favor applicants who plan to engage in interdisciplinary aquatic science research. Graduates from all nations are eligible. A committee will select 40 participants based on the application materials submitted. Travel subsidies are available for most countries

SYMPOSIUM Dates & Location

Fall, 2005
Check website below for details

Application Deadline

May 1, 2005

HOW TO PARTICIPATE

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Questions

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