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INTERDISCIPLINARY CHALLENGES AND BOTTLENECKS IN THE AQUATIC SCIENCES

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The utmost importance of aquatic ecosystems for humanity confers crucial relevance to research aimed at underpinning their sustainable use. Limnology and oceanography, the sciences that most directly address this need are, or rather should be, highly interdisciplinary endeavors, since water resources touch upon all aspects of life on the planet. Although this statement is currently undisputed, there is growing concern that putting in production truly interdisciplinary aquatic research is still a distant goal. We contend here that the insufficient development of interdisciplinary cooperation in aquatic sciences is due to two main reasons: (1) a deep crisis in the present scientific model that extends beyond aquatic sciences, and (2) a disparity of views as to what interdisciplinary really means. Progress beyond the present bottleneck requires serious actions to address both these issues.

Early research on aquatic ecosystems, such as the study of currents in the Mediterranean Sea or the prediction of tides, was done by "philosophers" who recognized no disciplinary boundaries in pursuing knowledge. Later efforts to catalog all knowledge divided intellectual activities into fields that, as progress took place, became increasingly narrow to the present segregation of science into multiple, largely unarticulated, disciplines. The UNESCO catalogue of major scientific disciplines, for example, lists 2177 sub-disciplines in 245 different areas, within 24 main branches of science, any one of them much broader than the field each individual scientist would recognize as his/her domain. This compartmentalization has spread over all aspects of research and is reflected in the design of university curricula, which obviously contributes to consolidating this *status quo*.

The fragmentation of science is a rudimentary way to cope with the vast amount of information already available. Moreover, this information proliferates at a pace that overruns any individual's capacity to process it. This "flood" of literature and our ability to cope with it are not new concerns. For instance, in Merton's (1968) review of the science reward and communication systems, he notes that less than 1% of the published papers in chemistry and psychology are ever read by a given chemist or psychologist, a record that is likely to be matched in the aquatic sciences today. Any attempt to keep track of developments in a broader range of fields will lead to frustration, not only because of the overwhelming volume of the published scientific literature (about 30 million papers annually), but also because the specific jargons that each discipline developed now render the understanding of their research very cumbersome for outsiders. This last phenomenon is, in fact, a very important cultural barrier that hinders the exchange of knowledge between fields.

The compartmentalized structure of scientific research can be understood as a pragmatic approach to overcome our limitations to assimilate the vast knowledge base accumulated in any one discipline. However, it is poorly suited to address those problems in nature that involve a large variety of interactions among living (humans included) and non-living components, linked across a range of spatial and temporal scales, which elude any ordered division of science into disciplines. Contemporary science has approached this kind of problem by piecing together the portions of information provided by the sub-disciplines in the hope that this would lead to the understanding of the whole. Unfortunately, there is mounting evidence of failure of efforts to understand the behavior of complex systems by reduction to the analysis of their constituents. Examples of complex problems defeating reductionism abound in the realm of aquatic sciences: fisheries science is still unreliable as a basis to manage natural stocks despite the growing sophistication of the available population models (Peters, 1993); the integration between the coastal and open ocean is only addressed by case-studies and is deliberately ignored by general circulation models; the accurate

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computation of the impact of the ocean on the global carbon budget is hindered by the multiple feedback processes involved; the behavior of aquatic food webs is open to complex interactions, etc.

The crucial bottleneck where the approach based on reductionism arrived at has elicited general awareness of the need for interdisciplinary strategies in research. However, while interdisciplinary research is now universally praised, it is still insufficiently implemented in practice. There are several factors accounting for the poor development of interdisciplinarity in aquatic science, including the striking disparity of meanings that different scientists attach to this term, for even the definition of a discipline is, to a large extent, subjective. There is consensus to consider interdisciplinary research as that spanning across the boundaries of the classical science compartments. In aquatic sciences many compartmental barriers arise from the variety of systems subject to study, including lakes, rivers, coastal, open ocean, as well as from the differentiated interests in their several components (e.g., plankton vs. benthos). The narrowing of scope that some scientific meetings, professional societies, and journals have been pursuing over the past 20 years strengthens these barriers. Fortunately, some societies, notably the American Society of Limnology and Oceanography, have provided forums to exchange and integrate results across these barriers. From a more objective point of view, the observation of coherent dynamics of physically distant systems such as lakes, oceanic systems, etc., phenomena that in absence of any reasonable explanation are referred to as "tele-connections", reinforce the idea that the separation of subjects is indeed artificial. Hence, these barriers should not represent major obstacles for interdisciplinary progress in the future.

Interdisciplinary research is sometimes understood as that conducted by teams of scientists pooled from different sub-disciplines (e.g., physical, chemical, and biological oceanography and/or limnology). The interaction within these teams often amounts to simply collecting information provided by the different disciplines. Such research is better qualified as *multidisciplinary* and whose outcome is a superposition of thematic layers that improve the understanding of the study subject only at a descriptive level. This approach has controlled disciplines such as oceanography for decades. We argue that in a truly interdisciplinary approach, knowledge and methods from different fields should be integrated so there is conceptual progress on problems reluctant to the treatment by each of the specific methodologies, thereby allowing the development of predictive models that would be unthinkable within the realm of each individual discipline. Examples of such interdisciplinary research, which is still insufficiently developed, include the integration of the physical and biological processes in the study of oceanic plankton (e.g., Rodriguez et al., 2001) and processes in benthic boundary layers (e.g., Boudreau and Jørgensen, 2001).

Interdisciplinary efforts have even led to the formulation of new research areas, such as biogeochemistry in the late 1980's (Schlesinger, 1991). Biogeochemistry was able to assimilate complex biological, physical, and chemical processes into simplified fluxes of elements between compartments. This simplification effectively removed barriers to communicating and integrating knowledge across disciplinary borders, thus rendering the problems amenable to interdisciplinary approaches. However, the price to pay is some degree of oversimplification implicit in the reduction of complex biological and chemical processes as an unarticulated application of the Ockham's razor principle. On the other hand, the biogeochemical approach often entails unbalanced levels of detail for the **bio**logical, the **geo**logical, and the **chem**ical components of the problems, because the actual research is seldom conducted by interdisciplinary teams. In addition, aquatic biogeochemistry has generally neglected the physical framework supporting the fluxes of elements between compartments, an issue that is now beginning to be addressed.

Interdisciplinary research in aquatic ecosystems remained confined within the realm of natural sciences for decades, but has progressively opened up to encompass social sciences as well, as in the coordinated efforts to address coastal management and water quality issues. Yet most attempts to reach beyond the natural sciences are actually multidisciplinary, where the integration is descriptive and typically verbal in nature, and does not lead to quantitative formulations and predictions. The path to integrate these different components into models will probably require an exercise of parsimonious reduction of details down to commonly accepted metrics for the intervening processes, similar to that successfully carried out by the

biogeochemical approach in aquatic sciences. In fact, even biogeochemistry should be broadened not only to better encompass the physical processes supporting the fluxes, but also to incorporate the socio-economic aspects driving the large anthropogenic influences on the elemental fluxes studied.

Aquatic scientists would do well to examine the concepts and tools for interdisciplinary research that emerged in the early 70's within the realm of condensed matter physics and subsequently within a more general body of problems usually referred to as nonlinear physics (or science). These have progressively evolved into a more or less articulated theoretical and experimental scientific framework often referred to as *complexity* (e.g., Waldrop, 1992; Kanadoff, 1993, 1999). The key notion that made a general theory for complex systems possible is *universality*, which was developed in the study of phase-transitions displaying similar quantitative features in very different systems (cf. Kadanoff, 1999). The term *critical phenomena* was later coined to refer to the study of this type of transformations in a broad range of systems (e.g., Ma, 2000), including problems in chemistry and biology, and disciplines as distant from physics as psychology and social sciences (Haken, 1983). Additional universal properties have been described, such as the so-called *fractals*, which are geometric objects displaying self-similarity, such as the shape of coastlines in a configuration in which gulfs engulf smaller gulfs and bays embay smaller bays (Mandelbrot, 1987). Fractals do not follow any quantitatively precise universal pattern, but share many qualitative features which make them amenable to common analytical tools (Kadanoff, 1986). *Chaos* also has many qualitative and quantitative universal features which can arise in very simple dynamical systems, and has been identified in problems studied by most of the sciences, including aquatic sciences, and also several of the arts (Cvitanovic, 1983). For instance, Lagrangian trajectories of fluid flows are often chaotic, and this chaos enhances the flow efficiency to mix suspended substances. This effect has been used successfully to characterize, explain, and predict transport phenomena in a range of aquatic systems, including the oceans, coastal areas, lakes, rivers, and estuaries. In this respect, a remarkable interdisciplinary study has been the European Science Foundation's Transport in the Atmosphere and Oceans program (www.esf.org/ftp/pdf/Lesc/TAO.pdf) which brought together oceanographers, atmospheric scientists, physicists, and mathematicians to approach problems such as the analysis of drifter buoys and balloon data, and the interaction of chemical reactions and population dynamics (e.g., plankton) with physical transport.

The interaction of a large number of system components has been shown to often yield universal qualitative properties, termed *emergent* properties, often encountered in complex systems (Kauffman, 1996; Holland, 1998). An important example is the phenomenon of self-organized criticality, characterized by the spontaneous emergence of critical states dominated by particular power-law scaling, as observed in a range of important phenomena such as the dynamics of building sand-piles, earthquake magnitude distributions, and the frequency of species extinctions (Bak, 1999). A relevant example is the size distributions of organisms in aquatic ecosystems, which display size-abundance relations similar to those of objects in systems of very different nature, each described by inherently equivalent discipline-specific (e.g., economics, astronomy, earth sciences, and semiotics) models (cf. Vidondo et al., 1997).

The emergence of cooperative behavior, auto-organized without external control, has been demonstrated in models representing abstract communities of agents or individuals in interaction (Axelrod, 1984), and has been used to explain problems in ecology, such as the organization of insect colonies, the altruistic behavior in evolution, and clonal growth. The emergence of patterns as a result of both deterministic and stochastic processes has been demonstrated in cellular biology, elemental physics, fluid dynamics, and aquatic sciences (Murray, 1991). Indeed, the structure of pelagic ecosystems has been proposed to arise as an *emergent* property of the interactions established within the individual organisms (Reynolds, 2001). The analysis of the fate of individual objects within systems, particularly their mortality, loss, or failure, is under active investigation in physics, astronomy, industrial processes, socio-demographics, and aquatic population ecology, where discipline-specific, but similar, models are used to study a universal phenomenon.

The discovery of universality in phase transitions, chaos, objects' geometry, and emergent properties, substantiates the hope of developing a general theory of complex systems, a goal that is now shared by scientists from many disciplines. Nonetheless, the search for universality guiding complex system theory should be pursued intelligently to avoid the tendency to oversimplify the individual problems often observed in this field. For example, the assumption that comparable behaviors observed in different systems imply the existence of similar underlying mechanisms is often unsubstantiated and sometimes very difficult or even impossible to validate. However with this warning in mind, universality can benefit interdisciplinary research since it offers convenient, adequately tested tools that can be applied across disciplinary boundaries, independent of the specific mechanisms driving the processes under study. Chaos theory, for instance, has yielded useful numerical techniques to separate the stochastic and the deterministic components of dynamic systems data, allowing prediction of a complex process. Analyses of this type could very well provide breakthroughs in the study of fisheries, global change, and other complex phenomena. An additional benefit of the application of universality concepts is the improvement of communication between fields by developing common vocabularies across disciplines, offsetting the negative effects of discipline-specific jargon.

Clearly, many important problems in aquatic sciences are common to other disciplines so that cross-application of developments within these fields should effectively accelerate progress through a more efficient use of intellectual resources. Thus, it is important to remark that incorporating aquatic scientists, with their own scope of problems and techniques, to the pool of researchers involved in understanding complex

systems also would be beneficial to the other participants. The efficiency increase would be, to use a metaphor, comparable to the power gained by replacing serial by parallel problem-solving approaches in computing science.

Unfortunately, while the search for universal properties occupies scientists working on complex systems of many kinds and leads to the cooperation of research teams from very distant disciplines, it has not yet developed enough within the domain of aquatic sciences, despite eloquent pleas to promote interdisciplinary research to a prominent position in the aquatic sciences agenda (Harris, 1999). Indeed, most critical issues in aquatic sciences involve the behavior of complex systems (e.g., Carpenter, 1988), and it is hard to think of an issue in aquatic sciences that is not related one way or another to complexity. It is, therefore, striking that developments from complex system theory have not received sufficient attention within aquatic sciences, although efforts to address complexity in ecological systems (e.g., Complexity in Ecological Systems Series, Columbia University Press), are now finding parallels in aquatic sciences (cf., Gardner et al., 2001).

Like the development of interdisciplinary research in general, applications in aquatic sciences must sort many internal and external difficulties such as the diversity of conceptions, communication barriers, the overwhelming volume of the scientific production, as well as the structural inadequacy of the scientific system. With respect to the latter, aquatic science suffers from its poorly developed interconnections with other useful disciplines, attributable to the traditional, focused structure of most university departments, research institutions, research programs, and venues for scientific communication. Moreover, since as indicated earlier, scientists are generally unable to keep track of the literature in their own areas of interest, their capacity to follow – even if overcoming the important communication barriers – the developments in other fields is meager at best. Redesigning research teams or networks to ensure that the necessary links are firmly established would facilitate interdisciplinary research in the broadest sense. However, effective efforts to promote research of this kind must be based on the cooperation between scientists with solid foundations in their own fields. Otherwise, the interdisciplinary activity may only result in exercises of euphemism or, at best, metaphor building, together with the trivialization of complex problems or even worse, the construction of sophisticated analyses to tackle trivial issues. The application of concepts and models derived from complex system theory to problems in any one discipline, such as aquatic sciences, therefore requires articulation with scientists who are themselves experts in their field.

An additional obstacle to the development of interdisciplinary research is the fact that the mechanisms supporting scientific research are still inherently inspired by reductionism. Frequently, for instance, interdisciplinary research is obliged to nest between the cracks of research programs and journal scopes, implying that properly judging its assessments becomes a severe challenge for reviewers and journal editors. The resulting publishing difficulties are often quite damaging for the career development of the committed scientists. Interdisciplinary research is, therefore, penalized by the inadequate scientific mechanisms of funding and evaluation.

The forthcoming ASLO 2002 Summer Meeting *INTERDISCIPLINARY LINKAGES IN AQUATIC SCIENCES* (Victoria, Canada, June 2002; www.aslo.org), should provide an important opportunity to further develop interdisciplinary efforts into aquatic sciences. While the benefits of interdisciplinary research are still not fully tangible from the products currently in existence, the cost of the reductionism-based approaches to complex problems in science are evidenced by a general failure to progress in several crucial topics. We contend here that these bottlenecks, present in fields as distant as human nutrition and health, climate and global change research, and biodiversity and ecosystem preservation, are conceptual, rather than resource driven, signaling a crisis with the present scientific model. Therefore, we contend that a major leap in scientific research could result from a revolution, *sensu* Kuhn (1970), modifying the structure of the science system, from higher education to funding programs, to promote interdisciplinary efforts at all possible levels. Because the key scientific challenges, those that directly impinge on human livelihood and the sustainability of the planet's ecosystems, are all complex, the gains from a commitment to interdisciplinary science are potentially large.

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FRESHWATER ECOSYSTEMS AND CLIMATE CHANGE: RECENT ASSESSMENTS AND RECOMMENDATIONS

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INTRODUCTION

The recent publication of the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC) marks another 5-year step in the broad international scientific community's building consensus on the causes and impacts of climate change. The IPCC is an organization of the World Meteorological Organization (WMO) of the United Nations. The report itself is comprised of several parts: large (1000 page) detailed volumes from the three working groups and various Technical Summaries, and Summaries for Policymakers. In the context of the aquatic science community, the publication of the TAR provides a stimulus to consider the future contributions of the sciences of limnology and oceanography to understanding climate change over the next 5 years. Oceanography is a prominent science in understanding and predicting the magnitude of potential climate change due to increases in greenhouse gases because of the important couplings between the oceans and atmosphere. Whereas limnology is not as critical to climate change predictions as is oceanography, limnology could become more prominent in understanding the impacts of climate change over the next five years. The great importance of the goods and services provided by freshwater ecosystems and their inherent vulnerability to a wide range of stresses are two reasons that limnology should become more prominent in climate change research. Another reason is that several recent reports making recommendations for future climate change research have included studies of freshwater systems in their plans. The goal of this article is to provide an overview of these developments and their potential to expanding research in limnology. In the past, scientific societies, including ASLO, have played an important role in promoting the science addressing climate change, and there may be opportunities for ASLO to serve in such a way again.

BACKGROUND

In the early 1990s, the public understanding of climate change in terms of the potential impacts on quality of life in North America was centered on the prediction of warmer temperatures. The consequences of hotter summers and milder winters were viewed in the context of the current climate regime in different regions. For example, here in Colorado where outdoor recreation is highly valued, hotter summers due to climate change were joked about as being one more

good reason not to move to south Texas. At this time, the US Global Change Research Program (USGCRP) supported important efforts to: 1) develop improved global circulation models (GCMs), and meso-scale models, in order to better project temperature changes and 2) understand and quantify the sources and sinks of the global carbon cycle. Hydrology was not central to either of these efforts. When addressed by the USGCRP, hydrologic research only was seen as relevant to improving the parameterization of hydrologic processes (e.g., clouds and precipitation) in order to improve GCMs.

By the late 1990s, the broader public became more interested in the potential consequences of changes in the hydrologic cycle as an impact of climate change in North America. This shift in public perspective may have been inevitable. Some numbers of hydrologic extreme events (floods and droughts) were bound to occur after the potential for climate change had become general knowledge, and these events naturally prompted speculation as to their potential connection with the accumulation of CO_2 and other greenhouse gases in the atmosphere. At the same time, the scope of the research within USGCRP expanded and large-scale hydrologic investigations became part of the activities of the global change research community.

ASLO and NABS (North American Benthological Society) contributed to an expanding perspective of the potential impacts of climate change through the jointly sponsored 1995 symposium "Freshwater Ecosystems and Climate Change in North America" and the two resulting publications from the symposium (special issues of *Limnology and Oceanography* and *Hydrologic Processes*). For example, there were numerous citations to papers in these publications in the two subsequent IPCC reports. In the regional overview papers published in *Hydrological Processes*, recommendations were presented for 1) improved monitoring of freshwater ecosystems in order to detect change and 2) more basic research to resolve the responses of freshwater ecosystems to climate and hydrologic variability. Partially because the limnological community and the agencies responsible for management of freshwater ecosystems were not major players among the scientific community and federal agencies involved in the USGCRP, these recommendations did not directly influence the scope of the USGCRP.

THE TAR OF THE IPCC AND FRESHWATER ECOSYSTEMS

One of the three major parts of the Third Assessment Report is that of Working Group II, entitled Climate Change 2001-Impacts, Adaptation and Vulnerability (McCarthy et al. 2001). This report assesses the potential impacts on freshwater ecosystems (lakes, streams, rivers and wetlands) in an overview chapter entitled "Ecosystems and their Goods and Services" and in the chapters for each of the major continents. A chapter entitled "Hydrology and Water Resources" discusses potential changes in hydrologic regime and the importance of integrated water resources management for adapting to change. One example of a change in hydrologic regime that would influence freshwater ecosystems is peak streamflow occurring in winter rather than spring in regions currently dominated by spring snowmelt. The overview ecosystem chapter emphasizes the inherent vulnerability of many freshwater ecosystems because of their small size, their dependence on catchment level hydrology, and their position downstream of many sources of pollutants, excess nutrients, and areas of accelerated erosion. Other highlights from the overview chapter include: 1) the high confidence in the observed trends in shorter duration of ice-cover on lakes and rivers in the Northern Hemisphere, 2) the high confidence in the poleward movement of fish distribution and the loss of habitat for coldwater and cool water fishes, 3) the potential displacement of extensive, seasonally inundated freshwater swamps due to sea level rise, which would result in a loss of habitats with high biodiversity, and 4) the important and poorly understood feedbacks between major wetland areas, such as northern peatlands, and the global carbon cycle. It is also noted that human adaptations to climate change may well have additional negative affects on freshwater ecosystems and that there will be interactions between direct climate effects on freshwater ecosystems and climate effects on land use and regional population growth.

The Working Group II report of the TAR has chapters describing current and projected climate trends and "Key Regional Concerns" for each continent, as well as for small island states. Among the common themes in these chapters, water resource issues are emphasized in all the chapters, and the impacts of water scarcity and flooding on freshwater ecosystems are highlighted in most of the chapters. For many regions, water resources are major problems now and these problems were found to be more likely to be exacerbated rather than alleviated by climate change in these continental chapters. Further, fragmentation of water resource management may reduce the "adaptability" to changes in the hydrologic regime associated with climate change. The political boundaries and multiple demands on water may be barriers to management of large river systems in a way that could protect large wetland and delta habitats. Finally, in some regions of the world the potential impacts on water resources are relevant to the viability of freshwater fisheries and aquaculture as important sources of food. For example, conversion of rice fields for expanding shrimp aquaculture is a factor influencing the future food supply in Asia.

For North America, the water resource issues were summarized on a regional basis (see Figure 1). This regional approach was derived from previous regional assessments, including the special issue from the ASLO/NABS symposium. For regions of North America where the hydrologic regime is snowmelt dominated, seasonal shifts to earlier snowmelt and reductions in summer flows are likely. Adverse impacts on stream and river ecosystems from reduced habitat in summer, higher water temperatures and degraded water quality may be difficult to avoid given the pressing demands on surface waters for water supply and irrigation. As a result, in-stream uses (e.g., for recreational fly-fishing in Colorado) may be seriously compromised.

ESA'S REPORT ON "WATER IN A CHANGING WORLD"

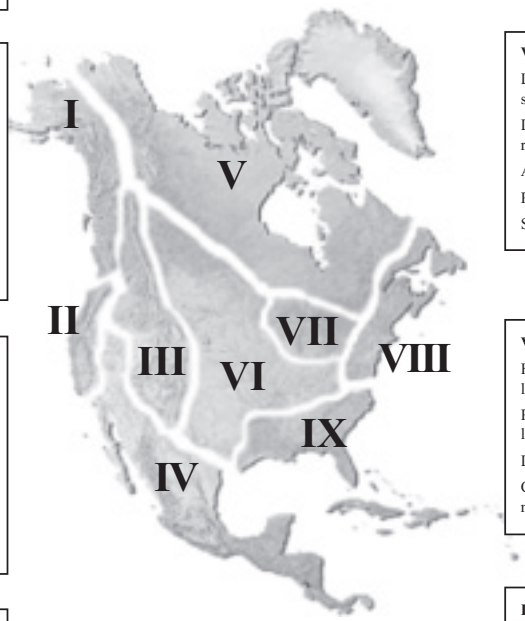
Simultaneously with the publication of the TAR, the Ecological Society of America (ESA) has published a report in their *Issues in Ecology* series entitled "Water in a Changing World" (Jackson et al. 2001). This report and a companion and more extensive report in *Ecological Applications* (2001; volume 11:1027-1045) provide a global scale overview of the current status of water resources. In the report's summary, one of the six conclusions is that, "Globally, 20 percent of freshwater fish species are threatened or extinct, and freshwater species make up 47 percent of all federally listed endangered animals in the United States." The reports highlight how the greater demand for water with expanding population may exacerbate the loss of aquatic biodiversity, diminish goods and services from freshwater ecosystems, and may cause greater fragmentation of freshwater ecosystems, reducing their long-term viability.

One important recommendation from the *Issues in Ecology* report is for improvement in water resource management in the United States. The report points out that in the United States there are six federal agencies with responsibilities in water resource management, in addition to the numerous state and municipal agencies. Greater coordination and cooperation amongst these agencies is therefore one of the keys to managing freshwater ecosystems under the future challenges associated with expanding populations and changing climate. Many of the agencies with responsibility for water resource management have not had support of basic research in limnology within their mission, or their research programs have been small relative to the extent of these problems and have included only limited support of external research at universities.

THE REPORT OF THE WATER SCIENCE AND TECHNOLOGY BOARD OF THE NATIONAL RESEARCH COUNCIL ON "ENVISIONING THE AGENDA FOR WATER RESOURCES RESEARCH IN THE 21ST CENTURY"

Another new report that addresses future issues in water resources, including freshwater ecosystems, is the recent report

Figure 1. Potential impacts of increased atmospheric carbon dioxide on freshwater ecosystems in North America. This figure was modified from Fig. 15-1 in Chapter 15, North America, in Climate Change 2001: Impacts, Adaptation, and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.



I. Alaska, Yukon and Coastal British Columbia

Lightly settled/ water abundant region.

Increased spring flood risks

Glacial retreat/disappearance in south; advance in north: impacts on stream ecology

Increased stress on salmon; other fish species

Flooding of coastal wetlands, changes in estuary salinity/ecology

II. Pacific Coast States (US)

Large & rapidly growing population; water abundance decreases north to south; irrigated agriculture; massive water-control infrastructure; heavy reliance on hydropower; endangered species issues.

More winter rainfall/less snowfall -earlier seasonal peak in runoff, increased fall/winter flooding, decreased summer water supply.

Possible summer salinity increase in coastal bays and estuaries Warm water fish species benefitting; damage to cold water species (e.g. trout and salmon)

III. Rocky Mountains (US and Canada)

Lightly populated in north & population growth in south; irrigated agriculture, recreation, urban expansion competing for water; headwaters area for other regions:

Rise in snow line in winter-spring, possible increases in snowfall, earlier snowmelt, more frequent rain on snow — changes in seasonal streamflow, possible reductions in summer streamflow, reduced summer soil moisture

Stream temperature changes affecting species composition; increased isolation of cold water stream fish.

IV. Southwest

Rapid population growth, dependence on limited groundwater and surface water supplies, water quality and endangered species concerns, vulnerability to flash flooding:

Possible changes in snowpacks and runoff

Possible declines in groundwater recharge- reduced water supplies

Increased water temperatures -further stress on aquatic species

Increased frequency of intense precipitation events - increased risk of flash floods

V. Sub-Arctic and Arctic

Sparse population- winter ice cover important feature of hydrologic cycle:

Thinner ice cover, 1-3 month increase in ice-free season, increased openwater

Increased lake-level variability, possible complete drying of some delta lakes

Changes in aquatic ecology, and species distribution due to warmer temperatures and longer growing season

VI. Midwest US &Canadian Prairies

Agricultural heartland - mostly rainfed with some areas relying heavily on irrigation

Possible large declines in summer streamflow

Increasing likelihood of severe droughts

Uncertain changes in irrigation demand, water availability, groundwater levels, streamflows, and water quality

VII. Great Lakes

Heavily populated and industrialized region; variations in lake levels/flows now affect hydropower, shipping, shoreline structures

Possible precipitation increases coupled with reduced runoff and lake-level declines

Decreases in lake ice extent -some years without ice cover

Changes in phytoplankton/zooplankton biomass, northward migration of fish species, extirpations of cold water species

VIII. Northeast US & Eastern Canada

Large, mostly urban population — generally adequate water supplies, large number of small dams heavily populated floodplains

Decreased snow cover amount and duration, possible large reductions in streamflow

Accelerated coastal erosion, saline intrusion into coastal aquifers

Possible elimination of bog ecosystems

Shifts in fish species distributions, migration patterns

IX. Southeast, Gulf and Mid-Alantic United States

Increasing population in coastal areas, water quality/non-point source pollution problems, stress on aquatic ecosystems

Heavily populated coastal floodplains at risk to flooding from extreme precipitation events, hurricanes

Possible lower base flows, larger peak flows, longer droughts

Major expansion of northern Gulf of Mexico hypoxic zone possible --other impacts on coastal systems related to changes in precipitation and pollutant loading

Changes in estuary systems and wetland extent, biotic processes, species distribution

of the Water Science and Technology Board (WSTB) of the U.S. National Research Council (WSTB 2001). The WSTB provides oversight to numerous studies on water resource issues that are conducted for federal and state agencies, including those involved in the USGCRP. The WSTB took the opportunity of the start of the new millennium to consider advances that will be needed in water science and technology in order to successfully manage water resources in the future. One of the three main chapters addresses "water availability" with the connotation of "availability" to include water quantity and quality, and the availability of water for a range of uses. The report emphasizes the need to improve the understanding of the coupling between hydrologic and biogeochemical processes in order to develop the regulatory framework to manage water quantity and quality in a coordinated manner. In the context of limnology, the report recognized the importance of the ecosystem goods and services provided by freshwater ecosystems, and the need for quantitative approaches to understand contaminant biogeochemistry in freshwater ecosystems and potential climate change responses of freshwater ecosystems. The report identified several specific research issues relevant to this general theme: "Understand physical, chemical, and microbial contaminant fate and transport; understand impact of contaminants on ecosystem services, biotic indices, and higher organisms; understand impact of land-use changes and best management practices on pollutant loadings to water; understand assimilation capacity of the environment and time course of recovery following contamination; develop new techniques for measuring water flows and water quality, including remote sensing and *in situ* techniques." Because this report was not prepared in response to a specific agency request, the discussion and recommendations are of a general nature. Agencies may choose to use the broad recommendations as they are consistent with the agency's mission. The report does echo the recommendations of the "Water in a Changing World" report in calling for greater agency coordination as a requirement for the future.

THE NEW WATER CYCLE SCIENCE PLAN FOR THE USGCRP

The international and North American scientific community has identified important potential impacts on freshwater ecosystems from climate change, which are expected to exacerbate the numerous other impacts from flow diversion, pollution, and land use change. In Washington D.C., the current administration has called for greater research on climate change. The question now for limnologists is how can advances in our field lead to stronger scientific understanding to support improved water resource management to sustain freshwater ecosystems in this "changing world"? As a practical matter, where are the opportunities for research support in limnology in the area of climate change? In addition to new programs of individual agencies, such as the Environmental Protection Agency, the USGCRP may be moving in the direction of including some questions involving freshwater ecosystems in their research plan.

The USGCRP Water Cycle Study Group has recently completed a report "A Plan for a New Science Initiative on the Global Water Cycle" which was prepared at the request of the agencies of the USGCRP (U.S. Global Change Research Program; Hornberger et al. 2001). This report is being considered by these federal agencies in preparing their plans and budgets for climate change research in the next few years. The report identifies three key science questions; one of these questions is "How are water and nutrient cycles linked in terrestrial and freshwater ecosystems?" Under this science question three main goals are described. These goals are: 1) develop observations and experiments that characterize the coupling of water, carbon, and nitrogen cycles, 2) develop a quantitative predictive framework for water, carbon, and nitrogen fluxes coupled to ecosystem responses, and 3) distinguish human-induced and natural variations in the coupling of water, carbon, and nitrogen cycles. The scientific gaps leading to these goals and proposed actions to address these goals are elaborated on in one of the five chapters of the report. In the final chapter, the goals related to each of the three main science questions are integrated into three proposed initiatives. The approaches for studying the coupling of water, carbon, and nitrogen cycles that are laid out in the report include development and use of *in situ* and remote sensors for water quality parameters, use of advanced information technology, as well as long term study of nested large scale catchments and the stream, lake, wetland and river systems within these catchments .

Whether or not these research recommendations for understanding the coupling of water, carbon, and nitrogen cycles are incorporated into the programs of the USGCRP agencies will depend on the agencies' understanding of how their missions relate to these recommendations, and the involvement and activity of the ecological and limnological communities. Now may be an opportune time for limnologists interested in these questions to interact with colleagues in hydrology in developing research programs. **We may lose this opportunity if limnologists do not become active in the programs as they develop.**

The U.S. National Science Foundation is one of the USGCRP agencies, and within the Geosciences Directorate, a new Hydrologic Science initiative is being organized which will address some of the science questions identified by the report. This initiative is being organized by the Consortium of Universities for Advancement of Hydrologic Science, Inc. (CUAHSI) and more information about this effort can be obtained at www.cuahsi.org, or by contacting Dr. Marshall Moss at memoss@worldnet.att.net. There may be colleagues at your university who have already become involved in the consortium and in the planning phase of this effort. One of the three main activities of the CUAHSI will be the establishment and operation of Long Term Hydrologic

Observatories (LTHOs). The science themes for these LTHOs will include the themes presented in the Water Cycle Science plan described above. Another activity will be development of measurement technology, potentially including *in situ* sensors for C and N species, for example.

SUMMARY

The aquatic science community, and ASLO in particular, have been effective in advancing the science related to understanding climate change and its consequences. However, limnology has not been a major player in the USGCRP up till now. Because of the greater recognition of water resource problems associated with climate change, there may be greater opportunities for limnologists to become involved in climate change research programs. The high value of the ecosystem goods and services provided by vulnerable freshwater ecosystems is strong justification for the inclusion of limnology in these research programs, but will not be compelling by itself unless the limnological community actively participates in these developments. Now is not the time to party on the dock while someone else launches the boat.

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Copies of "Water in a Changing World" can be obtained at http://esa.sdsc.edu/ or by contacting Ecological Society of America, 1707 H Street, Suite 400, Washington D.C. 20006 (202) 833-8773.

Copies of the USGCRP report can be obtained from U.S. Global Change Research Program, 400 Virginia Avenue, SW, Suite 750, Washington D.C. 20024 (202) 488-8630, fax: (202) 488-8681.

Copies of the WSTB report are available from the WSTB, National Research Council, 2101 Constitution Ave., N.W. Washington, D.C. 20418, or at www.nap.edu.

ASLO NEWS

MESSAGE FROM THE EXECUTIVE DIRECTOR

Jonathan T. Phinney, *ASLO, 1444 Eye St., N.W., #200, Washington, DC 20005 (Tel: 202-289-1972, Ext. 249, Fax: 202-628-1509), jphinney@aslo.org*

New Joint ASLO-AIBS Policy Representative in Washington, DC. I have great pleasure in announcing that Adrienne Froelich is the new policy representative in the Washington, D.C., office. Adrienne received her Ph.D. in Ecology, Evolution and Environmental Biology from University of Notre Dame with David Lodge. Her research focused on freshwater ecology and conservation. After graduation, she was a Knauss Sea Grant Fellow on Capital Hill for a year and is a wealth of information on the interaction between science and policy. (See her accompanying article in this issue on the travails of working in the trenches of science policy.) She is partially supported by other aquatic scientific societies including: American Fisheries Society, Estuarine Research Federation (ERF), North American Lake Management Society (NALMS), Society of Wetland Scientists, and Society of Environmental Toxicology and Chemistry (SETAC). These societies are members of AIBS (American Institute of Biological Sciences) who share the position with ASLO. In return for their generous support, the aquatic societies receive the monthly aquatic policy updates and can utilize her expertise on Capital Hill to arrange briefings or expedite sending position papers. She is also available to help with developing policy and outreach strategies in Washington, D.C.

Monthly Aquatic Policy Updates from Washington, D.C., and quarterly updates from Ottawa, Canada. After a year of repeating this item in the *Bulletin*, we are finally distilling the plethora of aquatic policy information from Washington, D.C., in the form of monthly updates. (See an abridged version below.) We will produce the inaugural quarterly update for Canada in December. All documents are on the policy section of the ASLO website (www.aslo.org/policy) and can be emailed directly to individuals who request them. In addition brief background pieces and links to other sites are available on the website and will continue to be developed as needed. To receive the updates directly, please alert Adrienne Froelich (afroelich@aslo.org).

European members and ESLO. The three Europeans on the ASLO Board of Directors (Carlos Duarte, Morten Søndergaard, and Peter J. Le B. Williams) provide a welcome European perspective to the board meetings. We are exploring imaginative (in other words, affordable) ways of delivering aquatic policy information from Europe similar to the monthly updates from the United States. No breakthroughs have occurred to date, but we have only started on the process. Suggestions on how to develop this area are always welcome. An inaugural scientific "Congress" of ESLO is scheduled in Rotterdam for 18 - 21 June 2003. For more information contact Dan Conley (dco@dmu.dk).

Jonathan T. Phinney, ASLO

AQUATIC POLICY UPDATE FROM THE LEGISLATIVE, EXECUTIVE AND JUDICIAL BRANCHES OF THE U.S. GOVERNMENT AS WELL AS NONGOVERNMENTAL ORGANIZATIONS

OUTLINE FOR OCTOBER 2001

LEGISLATIVE ACTIVITIES:

L1 HOUSE HOLDS SEVERAL HEARINGS ON AQUATIC POLICY ISSUES:

- Wetlands Mitigation Banking
- Marine Mammal Protection Act and Navy sonar testing.

L2 FARM BILL PASSES HOUSE; SENATE INTRODUCES THEIR VERSION

Funding increase for conservation programs affecting water quality and habitat Abundance-Conservation Reserve Program and the Wetlands Reserve Program.

L3 APPROPRIATIONS

- Interior appropriations gives USGS, USDA and Smithsonian slight increases
- Energy and Water Appropriations (Dept of Energy, Army Corp and Bureau of Reclamation, CAL-FED) passes, including Missouri River rider

L4 SENATE TAKES ACTION ON BUSH NOMINEES:

- Confirmed: John H. Marburger III to head the White House Office of Science and Technology Policy (OSTP).
- Pending: Vice Admiral Conrad C. Lautenbacher, Jr. (retired), to head NOAA, Kimberly Nelson to be Assistant Administrator of the Office of Environmental Information for EPA, Steven Williams to be Director of the U.S. Fish and

Wildlife Service in the Department of the Interior; Richard Russell to be Associate Director of OSTP.

EXECUTIVE ACTIVITIES:

E1 EPA NUTRIENT CRITERIA GUIDELINES FOR ESTUARIES RELEASED

E2 OCEAN COMMISSION ANNOUNCES EXECUTIVE DIRECTOR; WILL HOLD SECOND PUBLIC "LISTENING" MEETING NOV. 13 AND 14 IN WASHINGTON, DC.

E3 BUSH ADMINISTRATION TO ADOPT CLINTON ARSENIC STANDARD OF 10 PPB

NONGOVERNMENTAL ORGANIZATION ACTIVITIES:

N1 AAU, AAAS WORKSHOP ON 'PORK-BARREL' RESEARCH

N2 NATIONAL ACADEMY TO REVIEW SCIENTIFIC DECISIONS OF AQUATIC ENDANGERED SPECIES IN KLAMATH BASIN PROJECT

HYPOTHESIS: CONGRESS WOULD MAKE BETTER POLICY DECISIONS IF THEY HAVE ACCESS TO THE BEST SCIENCE AVAILABLE

Adrienne Froelich, *ASLO-AIBS Policy Representative, 1444 Eye St. NW #200, Washington, DC 20005, afroelich@aslo.org*

[Editor's Note: Adrienne Froelich was a Knauss Sea Grant Fellow in the office of Senator Ron Wyden (D-OR, Chair of the Senate Subcommittee on Science, Space and Technology) in 2000.]

In a profession where voicing an opinion without a p-value is heresy, it goes against the very heart and soul of a scientist to engage in policy debates. After all, we can hardly make a definite statement about issues in our own field – how can we possibly engage in debates that involve economic and social factors as well? The answer is – no one is asking for your opinion, they want your science.

As a former Sea Grant policy fellow in the U.S. Senate, I was inundated by an *overabundance* of "science" attached to an agenda. As Rep. Wayne Gilchrest (R-MD) recently said to the Association of Ecosystem Research Centers, "It's the science they [i.e., lobbyists] want us to see." I once spent several hours trying to track down an academic researcher who worked on the reproductive biology of Pacific rockfish. I wanted to know what information was out there and what was missing. I had heard from the fishing industry and conservation organizations, but wanted information without spin. Since I couldn't find anyone quickly, I had to use my best judgment. Although the scientist in me felt like an imposter for advising on a topic for which I had little professional knowledge, the fact that I was a scientist reassured my boss that we had a made a "scientifically-sound" decision.

In another instance, an organization attempting to weaken wetlands protection showed congressional staff a graph to illustrate how few wetlands were lost in the United States over the past 50 years. Basic scientific instinct kicked in, and I looked at the graph and realized that irregular axis intervals and the choice of measurement units (hectares versus proportionate loss) had distorted the true trend in the data. Following this discovery, I gave my colleagues graphs from scientific textbooks showing the same data, plotted in a less misleading manner. Now the staffers could clearly see the extensive loss of wetlands over the same time period.

Over time, I realized I could offer reliable advice on the quality or validity of some piece of scientific information, whether or not it was within my field of research experience. While expertise in the area of discussion is highly desirable, it is not a prerequisite to scientific contributions to policy. A lack of understanding of general biological concepts can have profound implications on both regulations and funding for research initiatives. In the case of a debate over stock assessment methods in the Pacific, I was able to explain to the senator and other staff the tremendous spatial and temporal variability in fish stock abundance, and therefore provided a scientific reason to devote more funding for more frequent surveys. (As a side note, the Senate nearly doubled the amount of research funding for Pacific groundfish last year and granted another large increase this year.)

During my year on Capitol Hill, I witnessed many debates about the "science" of an issue, yet scientists themselves were notably absent from these deliberations. In the absence of a solid understanding of the science behind an issue, policy-makers make decisions based on the variables they know best: economic, social, and political consequences. If we lament the lack of "scientifically-sound policies," we have only ourselves to blame. Legislation will be developed whether or not scientists step up to the plate.

Scientists are quick to point out the social value and management implications of our work in the pages of L&O. However, unless scientists become active in policy, that is exactly where the information stays. How do you know where your expertise is needed? Sign-up by email (afroelich@aslo.org) to receive monthly aquatic policy updates. Examples of past updates can be viewed on the policy section of the ASLO website (www.aslo.org/policy). For more ambitious ASLO members, please sign-up on the Aquatic Sciences database on the ASLO website so we in Washington, D.C., can develop a list of experts willing to QUICKLY respond to inquiries from Hill staffers on aquatic issues. And finally, one of the most effective ways of being involved is to simply let your representatives know who you are. At a minimum, write a letter to your congressional representative, describe your areas of expertise and provide contact information. Hold non-technical research symposia for congressional representatives and their staff. Invite the member or their staff to tour your field site. Even if they don't attend, they will remember you are out there.

So, will this make a difference? For those who doubt the importance of aquatic policy issues in the grand scheme of things in Washington, remember that the entire federal budget was held up for over a month last year over a debate about the foraging ecology of Steller's sea lions in Alaska. If you would like any assistance in contacting your Senators or representatives, or want to know other ways to get involved, do not hesitate to contact me at afroelich@aslo.org.

MESSAGE FROM THE BUSINESS OFFICE

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

Serving ASLO members is one of the key responsibilities for the business office. Think of us as your point of contact whenever you have questions about your membership, accessing on-line publications or the membership directory, upcoming meetings, purchasing the *Limnology and Oceanography* CD archive, etc. Just send an e-mail to business@aslo.org or call 800-929-ASLO.

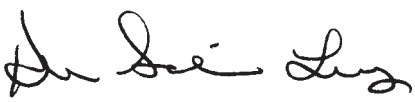
We are now in the membership renewal cycle for 2002. Your ASLO membership runs from January 1 through December 31 each year. It is important that you renew your membership prior to the end of 2001 so that your membership benefits will not be interrupted. We hope that we have made it easier for you to renew. You now can renew on-line, via fax, or through the mail. Choose the option that works best for you. As you renew your membership, be sure to let your colleagues know about ASLO. They can learn more about ASLO and about joining by visiting the web site at www.aslo.org.

You may not know that ASLO offers a sustaining member category for universities, corporations, and other organizations as a way to support ASLO. If you think your organization might be interested in becoming a sustaining member, please contact me at business@aslo.org for more information.

During 2002 you will notice a slight change in *L&O*. As noted in the *L&O* Status Report in this issue, the society will begin publishing six issues of *L&O* per year versus eight issues per year. Your subscription will include the same number of pages, but *L&O* will now come out every other month. This schedule should make it easier for you to keep track of your *L&O i*ssues whether you receive the electronic or the printed version.

If you are attending any of the upcoming ASLO meetings in Honolulu or Victoria, be sure to stop by the ASLO booth and introduce yourself to us. We would love to meet you, to talk about your membership, to answer your questions, and to learn more about what ASLO means to you.

From all of us in the ASLO business office, have a wonderful holiday season!



Helen Schneider Lemay, ASLO Business Office

STUDENT REPRESENTATIVE ON THE ASLO BOARD: MY PERSPECTIVE ON THE JOB AND ITS BENEFITS

Margaret Squires, *Dept. of Geography, Simon Fraser University, Burnaby, BC, Canada V5A 1S6, msquires@sfu.ca*

My term as the first voting student member (previous student representatives did not have voting privileges) elected to the ASLO board ends June 2002. As my replacement will be determined by the upcoming elections, I think it is appropriate to briefly describe "what board members and student representatives do." Because the opportunity to rub shoulders with seasoned professionals can benefit students, I will also relate how I have benefited by serving on the board.

The duties and responsibilities of ASLO's board members and support staff are described in the ASLO Operations Manual. Five executive officers, seven members-at-large, and two student members meet semi-annually with ASLO's executive director, business manager, editor-in-chief of L&O, journals manager, *Bulletin* editor, and ASLO's web editor. By staggering the yearly replacement of members elected for two-year terms (student reps serve for three years), the board is comprised of a mix of experienced and new members. The board guides the society in its scientific pursuits. This includes ASLO's Aquatic Sciences Meetings, the journal *L&O,* and other less visible activities such as public policy and education initiatives. Most activities are accomplished with the help of committees drawn from the ASLO membership. Such committees also periodically evaluate ASLO's activities and report to the board on new initiatives.

Two recent reports, the "Future of ASLO" (Hobbie et al 1996) and the "Challenges for Limnology in the United States and Canada" (Lewis et al 1995), presently direct many of the board's and student representatives specific activities. For instance "The Future of ASLO" report recommended finding ways, in addition to providing travel grants, of reducing the costs of attending ASLO meetings for students and scientists from developing countries. The web-based "Roommate Wanted" service is one way of facilitating attendance. The student reps recently surveyed student members and verified that many do not attend meetings because of insufficient funding. The funding requirements of national and international students were quantified to facilitate a match between funding and student needs. The survey suggested that significantly more students could attend meetings via further cost-reduction measures such as decreased registration fees. With respect to the latter, student funding will be on the agenda at the next board meeting.

In addition to participating in board meetings, student representatives are active at ASLO meetings. Student reps organize and execute the Career Link Program and the judging of student posters. The meeting services initiated by previously appointed student representatives, Cristina Takacs

and Karla Heidelburg, have been updated and expanded with the able assistance of ASLO's web editor Paul Kemp and business manager Helen Schneider. To ensure continuity, Cynthia Kicklighter (student rep, 2000-2003) and I have overseen the incorporation of a detailed description of the various student representative duties into the ASLO Operations Manual. The effectiveness of student programs should be evaluated from time to time, and new student reps should not feel limited to these duties. Additional opportunities for which students may be particularly well-suited include regular updating of the career information on the ASLO website, and contributing topical papers that will inspire high school students and others to pursue careers in limnology or oceanography.

I began my term aspiring to promote collegiality and camaraderie among ASLO student members and the participants in ASLO's Minority Program. One step towards this objective involved convening a student meeting at the 2001 Albuquerque Meeting. Feedback from this meeting indicated great interest among students in public policy and publishing strategies. These topics will be featured again at the student meeting in Victoria 2002. I hope these student meetings will continue to provide opportunities for students to connect with other students, board members, and other ASLO members. Such interactions facilitate the sharing of experiences that can promote careers in science, education and policy.

Board experience has provided me with valuable training in professionalism. Decisions by the board are not made without considerable discussion and debate, and occasionally delayed due to differences in opinions among board members. I participated in energetic and purposeful debate. This experience has and will continue to shape my interactions with colleagues and others. Complementing the service aspect of board work, I have enjoyed the numerous opportunities to link the names of respected limnologists and oceanographers with faces and personalities. Although members may express wide-ranging, and sometimes opposing, views, meeting spirits are consistently high and board members are genuinely warm and friendly.

In short, serving on the board offers valuable experience in debate and many opportunities to serve fellow ASLO student members. One reason for including students on the board is to bring the student perspective to bear when it is needed. From my experience and perspective, students could be more actively engaged in ASLO's governance. Younger students and those who may have worked and traveled extensively bring distinct perspectives to bear on public policy initiatives. To facilitate the student's transition to board membership, I suggest matching a new student representative with a board member "mentor" with similar or possibly contrasting interests, and placing students on active committees. I also feel that the level of commitment to ASLO by student members could be improved. Candidates nominated to run for student representative on the board are selected from a pool of volunteers. In the last two elections, this pool has been disappointingly small. Students strongly committed to ASLO, and a society strongly committed to students, can only be mutually beneficial and build a stronger ASLO in years to come.

I thank ASLO, the board, and the various board members whom have become my colleagues and friends.

L&O STATUS REPORT

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In 2001, new submissions continued to arrive at 2000's record rate (550 per year). Also unchanged during the past year were *L&O*'s high ISI® impact factor (3.0), the speed of our peer review system (the median time from manuscript submission to when the first decision letter is sent has been <2.5 months for the last 3 years), and our short "in press" time (the average time from receipt of a final accepted manuscript to appearance in print has been <4 months for the last 3 years).

The past year saw important growth in the electronic services that we offer to authors. Fifteen papers in Volume 46 (2001) contained Web appendices (three times more than in Volume 45). In January 2001 we began to accept manuscript submissions electronically (as PDF files); by October, the last complete month for which we have data, more than 70% of

new submissions were received this way. In May we also began to send proofs to authors electronically (again, as PDF files) rather than by airmail; this has dramatically reduced the turnaround time for proof corrections. In October, together with Paul Kemp, the ASLO web editor, we implemented a new service called Free Access Publication (FAP): for a nominal cost (the same as 100 hard-copy reprints), FAPs are made freely available for viewing and downloading from the *L&O* website. FAPs thus receive increased visibility over non-FAP papers, which can be viewed in full only by L&O subscribers; sending the Web address of an *L&O* FAP is quickly becoming the preferred way of responding to *L&O* reprint requests. Any paper published in Volume 44 (1998) or later can be made a FAP; authors interested in purchasing this service for their papers should contact the *L&O* Editorial Office for details.

September 15 was the deadline for submission of papers for the first *L&O* Special Issue (SI) that we have been involved in producing. This SI will represent a significant step forward in understanding the optical properties of shallow-water environments. Michael Lesser organized this SI, and the Guest Editors are Zvy Dubinsky and Marlon Lewis. Thirty-five papers were submitted and are now under review. We expect to print this SI in late 2002.

During the past year Don Canfield, Dave Caron, Jon Cole, Michael Landry, Gary Mittelbach, LeRoy Poff, and Alan Tessier rotated off the *L&O* Editorial Board. Evelyn Sherr, George Kling, Markus Huettel, Stephen Hamilton, and Thomas Kiørboe joined the Board during this time.

In the coming year there will be six (instead of eight) issues of *L&O*. The same total number of pages will be printed (~2000 per year), so the average issue size will increase from 250 to 333. This change was made primarily to even out workflow in the Editorial Office. The 8-issue schedule resulted in irregularly spaced press dates and some very tight time lines. Reducing the number of issues will also slightly reduce hard copy costs (printing covers and mailing).

ASLO WEB EDITOR'S REPORT

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The *L&O* Status Report mentions two new services added to the ASLO website in 2001: Free Access Publication and web appendices. Both services have been well received, and nearly one-half of new papers are being published as FAP papers. Another way we are increasing access to *L&O* papers is to allow electronic access from subscribing libraries, starting with the 2002 subscription year. We are also implementing a "pay per view" service. Non-subscribers who need a password-protected paper will be able to purchase and download a PDF copy. These new services follow a growing trend in electronic publishing in which publishers and science societies seek new ways to increase the accessibility of research papers while maintaining revenues.

A question that comes up regularly is "How often was my paper downloaded?" The most frequently downloaded papers in *L&O* are downloaded hundreds to thousands of times; the top ten papers were each downloaded over 500 times during January-June 2001 alone. In total, *L&O* papers were downloaded approximately 58,000 times during the first 6 months of 2001, compared to 70,000 times during all of 2000, and 31,000 times during all of 1999. This continues a trend toward increasing use of the online version of *L&O*, as well as increasing accessibility of papers through programs such as Free Access Publication.

Another common question is "How many 'hits' does the website get?" The website's pages are viewed well over a million times each year, by more than a thousand people each day. It's a little game each year, predicting the day on which the one-millionth access will happen. In 2000, it was November 23rd. This year, we passed the 1,000,000 mark on November 1st, and web accesses are still picking up speed.

Several new sections have been added to the website this year. The new **Science Shorts** section features brief synopses of papers in the aquatic sciences that are of special interest to the general public. The purpose is to increase the visibility of aquatic science research, and articles from any journal may be nominated. The ASLO Executive Director's office will issue a press release to print media outlets in Washington, DC, including the international wire services, summarizing the significance of **Science Shorts** papers featured on the ASLO website. A new **Public Policy** section on the website is aimed at the general public, as well as aquatic science professionals. This section features synopses of events and decisions that affect science policy in the U.S. and Canada and is intended to increase awareness of the scientific and political process by which science policy is determined. The U.S. policy section will be updated monthly, and the Canadian section on a quarterly basis.

The ASLO website also has two new or expanded programs to increase communication amongst aquatic science professionals. The **Aquatic Science Database** is intended to facilitate interactions within the aquatic sciences community by allowing individuals to search and locate others working in similar areas. Participation is entirely voluntary and participants are able to update their own entries at any time. The **Programs for PhDs** section of the website offers two separate programs for recent PhDs, both under the supervision of Dr. C. Susan Weiler (Whitman College). The DIALOG program goals are to catalyze interdisciplinary understanding, research, and networking across the full range of aquatic systems and disciplines. DISCCRS is a new program to bring together recent PhDs across the atmospheric, terrestrial, and aquatic sciences who are interested in climate change. Both programs include dissertation registries in which participants publish their dissertation abstracts on the ASLO website. Over 700 dissertation abstracts are already registered on the ASLO website!

The website consistently comes up at or near the top of any search of limnology or oceanography websites and is a primary source of information to the public as well as aquatic science professionals. We hope that these new services and features will continue to increase the usefulness of the website, and we welcome any suggestions.

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.

JEAN-PIERRE GATTUSO

Jean-Pierre Gattuso is senior research scientist with Centre National de la Recherche Scientifique (CNRS) and leader of the group "Diversity, Biogeochemistry and Microbial Ecology" at the Laboratoire d'Océanographie de Villefranche, Université de Paris VI, France. His research interests are broad and include the cycles of carbon and carbonate in coastal ecosystems as well as the response of marine organisms to environmental changes. Early on, he worked on coral reefs, but now focuses on European temperate systems. Jean-Pierre is currently involved in EUROTROPH, a European Union-funded project which investigates the trophic status of coastal sites and their response to human perturbations and management.

SAMANTHA B. JOYE

Samantha Joye is an associate professor of Marine Sciences at the University of Georgia in Athens. Research conducted by Joye's group examines the biogeochemical cycling of nutrients (nitrogen and phosphorus), dissolved gases (N_2, methane, and oxygen), carbon, and sulfur in a variety of systems, ranging from saline lakes to temperate and tropical coastal environments to deep ocean sediments. Several projects include parallel studies of biogeochemical and molecular ecological dynamics with the aim of identifying fundamental links between environmental variables, bacterial community composition, and bacterial activity.

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*. Starting with this issue of the *Bulletin*, ASLO acknowledges the important work that these people do for the society; two AEs will be featured per issue.

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.

HANS W. PAERL

Hans W. Paerl is Kenan Professor of Marine and Environmental Sciences at the UNC-Chapel Hill Institute of Marine Sciences, Morehead City, NC. His research interests includes; microbial ecology, nutrient cycling and production dynamics of freshwater and marine ecosystems. Current research focuses on environmental controls of algal production and community structure, and assessing the causes and consequences of eutrophication. His recent studies have included identifying the importance and ecological impacts of atmospheric nitrogen deposition in estuarine and coastal environments and the development and application of bioindicators used to assess human- and climate-induced ecological change in estuarine and coastal waters. Manuscripts handled by Hans include: Aquatic microbial ecology; nutrient (with an emphasis on nitrogen) cycling; primary production, eutrophication and algal bloom dynamics; watershed and airshed nutrient processes and their impacts on biogeochemical cycling and water quality.

MARY I. SCRANTON

Mary Scranton is a professor of Marine Science at the Marine Sciences Research Center of Stony Brook University in Stony Brook, New York. Mary's research interests include the geochemistry of a number of biologically important gases such as methane and hydrogen in the open ocean, coastal zone and in estuaries, and the cycling of carbon in suboxic and anoxic environments. She recently has been studying carbon fluxes in the Cariaco Basin, Venezuela, as a part of the CARIACO program, and fluxes of methane from the continental margin of the Mid-Atlantic Bight. As an associate editor of *L&O* she usually handles manuscripts on the biogeochemistry of nutrients, trace elements, and gases.

MEMBER HIGHLIGHTS

DAVID SCHINDLER NAMED 2001 HERZBERG WINNER

Excerpted from a Natural Sciences and Engineering Research Council of Canada press release of Nov. 2001

The Hon. Dr. Gilbert Normand, Secretary of State (Science, Research and Development), announced on 5 Nov. 2001 that the University of Alberta's David Schindler has won the 2001 Gerhard Herzberg Canada Gold Medal for Science and Engineering. The prize guarantees that Dr. Schindler - one of the world's leading environmental scientists - will receive a million dollars from the Natural Sciences and Engineering Research Council (NSERC) for his research over the next five years. For Dr. Schindler, that means an additional $509,125 on top of NSERC's existing investment in his research. Schindler is a pioneer in the study of freshwater lake systems who convinced governments in many countries to legislate controls on acid emissions and phosphorus detergents. He was the first researcher to understand how pollution changes lakes and his work has made it possible to reverse the process in thousands of lakes around the world.

The Medal selection process involves both international peer review of the nominees and adjudication by a distinguished NSERC jury. This year's panel was chaired by Dr. Christopher Beaumont, a Dalhousie University researcher and member of NSERC's Council. The medal was presented to Dr. Schindler at the National Gallery of Canada. "David Schindler is the epitome of the active and engaged scientist. He is passionate about his research and about conveying to Canadians the importance of science in guiding decisions about the natural world," said Dr. Normand, who spoke on behalf of the Honorable Brian Tobin, Minister of Industry and Minister responsible for NSERC. "The Government of Canada applauds his outstanding scientific career and we extend our best wishes to him as the winner of the 2001 Gerhard Herzberg Canada Gold Medal for Science and Engineering." "David Schindler is a role model for many young scientists the world over," said Tom Brzustowski, President of NSERC. "He has had an enormous influence beyond his field. Through this award, we hope he will inspire, as does Gerhard Herzberg, future generations of young science students."

The membership of ASLO congratulates Dave, a longtime member, former ASLO President (1982-1983), and recipient of ASLO's Hutchinson Award in 1985.

DIALOG IV SYMPOSIUM REPORT: WHAT'S UP WITH THIS NEW GENERATION OF AQUATIC SCIENTISTS?

C. Susan Weiler, *DIALOG Program Director, Whitman College, Walla Walla, WA 99362, weiler@whitman.edu*

The DIALOG IV symposium took place October 14-19, 2001 at the Bermuda Biological Station for Research (BBSR). Forty-four recent PhDs of 14 nationalities (Australian, Austrian, British, Canadian, Chinese, Dutch, German, Israeli, Japanese, Jordanian, Spanish, Ukrainian, U.S., and Venezuelan) met shortly after Hurricane Karen blew through leaving the station on reduced power and water for the first two days. Rather than relying on the usual slides and PowerPoint for introductions, participants improvised with flip charts. If anything, this just intensified group camaraderie. Participants were selected by committee through a process that ensured a broad range of expertise, from freshwater streams to the deep sea, from chemistry and physics to ecological theory, and from picoplankton to seabirds. In addition to the usual activities (oral and poster presentations, working-groups, shared meals, and informal networking) participants spent 8 hours with communication consultants to gain experience in team building. Below are some of the highlights. Working group reports mentioned below will be published on the DIALOG webpage—go to http://aslo.org and click on the Programs for PhDs folder, then on the Publications folder.

The informal atmosphere provided by the BBSR enhances collegial interactions. Participants share meals and lodging, as well as the formal symposium activities.

An excellent job is hard to find! Uncertainty about jobs weighs particularly heavy on most minds. A full 72% of the American participants at DIALOG IV were on postdocs or other temporary positions. Despite the uncertainty, overall job satisfaction was at 1.7 on a scale with 1.0 as "very satisfied" and 5.0 as "very dissatisfied." They were less enthusiastic about the overall job market, rating it 2.7. Participants with permanent jobs are putting together some tips based on their experience.

Have you been nice to a postdoc lately? We all know the many advantages of postdocs. But if you ask a postdoc what the worst part of the job is, you might be surprised by the answer. Many at the recent DIALOG symposium expressed a sense of isolation. Having left behind the support network and friendships generated as grad students through shared classes, many felt shunned by students at their new institution. Many students seem to assume postdocs are tied up with family or other relationships, or perhaps simply assume they no longer have shared interests. On the other hand, postdocs are generally not part of the activities that draw new faculty into the fold. All this is further compounded by the sense that postdocs are transients who will not be around long enough to build relationships. Fortunately this seems an easy thing to remedy—invite a postdoc to lunch, a Frisbee game, or whatever is on!

Time is an issue. "Time, Time, Time – Never enough!" was a common complaint. If in permanent relationships, there was too little time for partners or family. The singles felt they had no time to establish relationships or even for hobbies. Much time was spent discussing how to allocate that precious commodity so that neither work nor family was cheated. Sadly, no solution was found! One participant remarked, "Professional science seems to demand 80-hour work days and has little respect for other aspects of personal development." Another quipped, "You can't work enough." A new faculty member added, "I need to clone myself." My personal sense is that the situation, unfortunately, does not improve with time….

Know thyself (and others!) Communication consultants Chris Olex and Michelle Walker helped participants identify their leadership style and use it effectively in a team setting. Despite widespread belief that science PhDs would most likely end up in the most aggressive, controlling/driven category, only 36% of the DIALOG IV group did so. The most important take-home lesson was that all of us have much to offer, even we driven personalities! The trick is to identify and use your personal traits effectively, and learn how to get the most out of a team with mixed styles. Whatever their style, the best leaders and participants bring out the best in others.

Working Group reports. Once basic team-building skills had been honed, participants broke into various groups to discuss topics of interest and make recommendations. Several reports are in preparation and will be posted on the DIALOG webpage as they become available. Reports "in prep" include finding and getting that first job, identifying a "hot topic" (and knowing when, and when not, to jump on the bandwagon, and recommended readings).

Proposal writing tips. Deneb Karentz, NSF Associate Program Manager for Antarctic Biology and Medicine at NSF, compiled information provided by Philip Harriman, Pamela Talalay, Dennis Peacock and the NSF webpage to provide a very informative 4-page set of guidelines for proposal writers. This has been posted on the DIALOG webpage in the Publications folder, under "proposal-writing tips."

Several new symposia are coming up. If you received your Ph.D. after January 1, 2000, you should be eligible for at least one. Read and then post the DIALOG flyer included with this *Bulletin* mailing. Visit http://aslo.org/phd.html for details and be sure to **register your PhD** using the interactive form! Once registered, you will automatically be placed on an e-mail distribution list to receive program updates.

Acknowledgments. DIALOG is made possible through funding from the U.S. National Science Foundation # 9813932 and Office of Naval Research #N00014-98-1-05 with interagency transfers from the National Aeronautics and Space Administration and National Oceanic and Atmospheric Administration. Symposium participant travel support is provided by the above agencies and the European Commission (MAS3 CT986386). The DIALOG V program is in progress, with a symposium contingent on continued funding.

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

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On behalf of the DIALOG Program and ASLO membership**,** congratulations and best wishes to the following new Ph.D. recipients! The citations below represent graduates who registered with the DIALOG Program between August 1 and October 1, 2001. **We encourage ALL recent Ph.D. recipients to register their Ph.D. dissertation**. It's a great form of individual recognition, and the resulting compilation provides a global overview of emerging aquatic science research. Citations and 1-page dissertation abstracts are available at http://aslo.org/phd.html in a fully searchable format, along with a convenient interactive registration form. Recent grads are placed on an e-mail distribution list as soon as they register with DIALOG. Please send job and other announcements to phd@whitman.edu for distribution to all participants.

In addition to the Dissertation Registry, the DIALOG program includes symposia designed to foster early career development, interdisciplinary understanding and collegial networking. The next symposium is planned for October 2002 in Puerto Rico. The deadline for applications is May 1, 2002. Visit the above website for details.

Almeida, João F. 2000. Physiological ecology of a solar saltern yeast population. Universidade Nova de Lisboa (Portugal), 254 pp. (jmfa@mail.fct.unl.pt)

Amat, Alexandra 2000. Coral growth and CO_2 variations: Biological and climatological implications. Universite Pierre et Marie Curie (France), 321 pp. (amat@bbsr.edu)

Brock, Robert J. 2000. Assessment of aquatic food web alterations in the presence of the exotic clam, *Corbicula fluminea*, and Cichlid, *Oreochromis aureus.* University of Florida (USA), 231 pp. (Robert.Brock@noaa.gov)

Cooper, John E. 2000. Comparative development and ecology of northern pike *Esox lucius* and muskellunge *E. masquinongy* eggs and larvae in the upper St. Lawrence River and the implications of changes in historical spawning habitat. State University of New York, College of Environmental Science and Forestry (USA), 208 pp. (coopres@gisco.net)

De Robertis, Alex 2001. Small-scale spatial distribution and swimming behavior of euphausiids in relation to visual predation risk. University of California at San Diego (USA), 242 pp. (Alex.DeRobertis@noaa.gov)

Diaz, Frederic F. D. 2000. Seasonal evolution of primary production and of nitrogen assimilation regeneration processes in the Gulf of Lions. Estimation of a carbon budget. In situ and modelling approaches (Two parts). Université de la Méditerranée (France), 542 pp. (diaz@com.univ-mrs.fr)

Dommisse, Michaela 2001. The potential nutritional value of detritus depositing onto coral reefs. James Cooke University (Townsville), 231 pp. (michaela.dommisse@arts.monash.edu.au)

Duis, Karen 2001. Acid tolerance of early life stages of indigenous fish species under the hydrochemical conditions of Lusatian post-mining lakes. Humboldt-University Berlin (Germany), 85 pp. (k-duis@ect.de)

Froelich, Adrienne J. 2001. Waterfowl-macrophyte interactions: Implications for conservation of freshwater ecosystems. University of Notre Dame (USA), 214 pp. (afroelich@aslo.org)

Gerken, Sarah A. 2000. The Gynodiastylidae. University of Maine at Orono (USA), 609 pp. (gerkensa@jmu.edu)

McCray, Arja T. 2001. Halophyte responses to soil variation and interspecific competition in Southern California salt marshes. University of California at San Diego (USA), 237 pp. (amccray@ucsd.edu)

Mikkelsen, Ole A. 2001. Marine aggregates and suspended matter in coastal waters: Variation in time and space. University of Copenhagen (Denmark), 141 pp. (oam@geogr.ku.dk)

Mohr, Silvia 2001. Trophic interactions between two Brachionus species and protozoans. University of Potsdam/ Institute of Freshwater Ecology and Inland Fisheries (Germany), 79 pp. (silvia.mohr@uba.de)

North, Elizabeth W. 2001 Transport and retention of fish early-life stages in Chesapeake Bay: Mechanisms and implications for recruitment. University of Maryland at College Park (USA), 305 pp. (enorth@hpl.umces.edu)

Paris, Claire B. 2001. Transport dynamics and survival of the pelagic larval stages of a coral reef fish, the bicolor damselfish, *Stegastes partitus* (Poey). State University of New York at Stony Brook (USA), 246 pp. (cparis@rsmas.miami.edu)

Peres, Mônica B. 2000. Fishery and population dynamics of southern Brazil wreckfish *Polyprion americanus* (Bloch and Schneider, 1801) (Teleostei: Polyprionidae) Universidade do Rio Grande (Brazil), 151 pp. (peresm@terra.com.br)

Persich, Graziela R. 2001. Growth conditions, genetic identification and toxicity of the dinoflagellate *Alexandrium tamarense* (Lebour) Balech from southern Brazil. Universidade de Rio Grande at Rio Grande (Brazil), 100 pp. (gpersich@hotmail.com)

Piniak, Gregory A. 2001. The effects of symbiotic condition and nutritional history on prey capture and use by anemones and corals. Duke University (USA), 179 pp. (gap1@duke.edu)

Sagarin, Raphael D. 2001. Evaluating the effects of climate change on biological communities: Integrating historical science with biogeography and physiology. University of California at Santa Barbara (USA), 292 pp. (sagarin@stanford.edu)

Shaw, Stephanie L. 2001 The production of non-methane hydrocarbons by marine plankton. Massachusetts Institute of Technology (USA), 169 pp. (slshaw@mit.edu)

Warner, Kimberly A. 1999. Reductive dechlorination of the model compound 2,4-dichlorophenol in Chesapeake Bay sediments: Effects of sulfur biogeochemistry. University of Maryland at College Park (USA), 262 pp. (kwarner@biology.as.ua.edu)

DIALOG

Dissertations Initiative for the Advancement of Limnology and Oceanography

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

The DIALOG Program reduces the barriers that limit the exchange of information across the aquatic sciences.

Ph.D. DISSERTATION REGISTRY

Dissertation abstracts are collected and posted on the ASLO webpage in a searchable format, providing a concise overview of the field and highlighting individual accomplishments. The Registry is linked to co-sponsoring society websites.

Graduates completing PhD requirements after January 1, 2000 and whose work in biology, chemistry, geology, mathematics/modeling or physics is relevant to biologically oriented limnology or oceanography are encouraged to register. Demographic information for population characterization is collected confidentially along with PhD dissertation abstracts.

At the end of the 2-year program cycle, participants receive an abstract book, peer directory and demographic report.

ELECTRONIC COMMUNICATION

Once registered with DIALOG, graduates are included on an e-mail list to foster cross-institutional communication and distribute information.

Submit job and other announcements to

dialog@whitman.edu

SYMPOSIA

The biennial DIALOG symposia are international events that catalyze early career development and interdisciplinary understanding and collaborations across the full spectrum of aquatic sciences. These forums foster lasting collegial ties.

DIALOG V will be held
October 19-24, 2003
Bermuda Biol. Station for Research

NOAA's Coastal Ocean Program will support a related symposium in 2002. The Dissertations Symposium for the Advancement of Coastal, Estuarine and Great Lakes Science, **DIACES,** will catalyze early career development and collaborations leading to interdisciplinary understanding of these unique environments, including human impacts.

DIACES will be held
October, 2002 in **Puerto Rico**

During the DIALOG and DIACES symposia: Participants will present and discuss their Ph.D. and current pursuits; Working groups will discuss emerging aquatic-science research, education, career and policy issues; and Funding-agency representatives will describe interdisciplinary and international aquatic science research opportunities.

Symposium Eligibility

DIACES is open to PhDs completed
January 1, 2000 - March 31, 2002
and whose work in biology, chemistry, geology, mathematics/modeling or physics is relevant to coastal, estuarine or Great Lake environments. Selection will favor those who plan to pursue careers dedicated to better understanding or management of these systems.

DIALOG V is open to PhDs completed
January 1, 2001 - March 31, 2003
and whose work in biology, chemistry, geology, mathematics/modeling or physics is relevant to biologically oriented limnology or oceanography. Selection will favor those who plan to pursue careers focused on interdisciplinary aquatic science research.

Individuals from all nations are eligible. Committees will select 40 participants based on the application materials submitted. Travel subsidies are provided through grants from the agencies acknowledged below.

HOW TO PARTICIPATE

Abstract Registration Forms
•
Symposium Application Instructions
•
PhD Dissertation Registry
at

http://aslo.org/phd.html

Participation in the DIALOG Dissertation Registry is required for DIALOG and DIACES

Symp. Appl. DEADLINES

DIACES	**May 1, 2002**
DIALOG V	**May 1, 2003**

Questions

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DIALOG is sponsored by the American Society of Limnology and Oceanography (ASLO) and Whitman College. Co-sponsoring societies: Ecological Society of America (ESA), Estuarine Research Federation (ERF), International Society of Limnology (SIL), Society of Canadian Limnologists (SCL), The Oceanography Society (TOS). DIACES symposium is sponsored by ERF and Whitman College. Supporting agencies: NSF, NASA, NOAA, ONR and the European Commission. DIALOG V is contingent on new funding.

L&O BULLETIN

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ASLO