

Gulf of Maine NEWS

Regional Association for Research on the Gulf of Maine

Winter 1996

Land-Ocean Interactions in the Coastal Zone (LOICZ): An International Science Program with Relevance to the Gulf of Maine

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This article briefly reviews the recently launched Land-Ocean Interactions in the Coastal Zone (LOICZ) project which is highly relevant to the Gulf of Maine. Regional scientists from both the United States and Canada could make valuable contributions as well as derive substantial benefits from participation.

LOICZ is one of the seven core projects which comprise the International Geosphere-Biosphere Program: A Study of Global Change (IGBP). The other core projects are:

Biospheric Aspects of the Hydrological Cycle (BAHC),
Global Change and Terrestrial Ecosystems (GCTE),
International Global Atmospheric Chemistry Project (IGAC),
Joint Global Ocean Flux Study (JGOFS),
Past Global Changes (PAGES), and
Land Use and Cover Change (LUCC).

In addition, the Global Ocean Ecosystem Dynamics (GLOBEC) program (which has a US/Canadian project focused on Georges Bank) has recently become an IGBP core project. The IGBP also supports three frame work activities which are: the IGBP Data and Information System (IGBP-DIS), Global Analysis, Interpretation and Modelling (GAIM), and the System for Analysis, Research and Training (START). The overall aim of the IGBP is to describe and understand the interactive physical, chemical and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in the system and the manner in which they are influenced by human activities.

As the name implies, LOICZ is that component of the IGBP which focuses on the area of the earth's surface where the land, ocean and atmosphere interact. The coastal zone is broadly defined to extend from coastal plains to the outer edge of the continental shelves, approximately matching the region that has been alternatively flooded and exposed during the sea level fluctuations of the late Quaternary period.

The overall goals of LOICZ are:

- To determine at global and regional scales:
 - a) The fluxes of materials between land, sea and atmosphere through the coastal zone
 - b) The capacity of coastal systems to transform and store particulate and dissolved matter
 - c) The effects of changes in external forcing conditions on the structure and functioning of coastal ecosystems
- To determine how changes in land use, climate, sea level and human activities alter the fluxes and retention of particulate matter in the coastal zone, and affect coastal morphodynamics.
- To determine how changes in coastal systems, including responses to varying terrestrial and oceanic inputs of organic

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matter and nutrients, will affect the global carbon cycle and the trace gas composition of the atmosphere.

- To assess how responses of coastal systems to global change will affect the habitation and usage by humans of coastal environments, and to develop further the scientific and socio-economic bases for the integrated management of the coastal environment.

Because of its association with the IGBP, LOICZ has a very strong biogeochemical focus and seeks to improve the scientific understanding of the cycling of carbon, nitrogen and phosphorus in the coastal zone and the importance of coastal processes in the total Earth system. Coastal biogeomorphology and sediment dynamics are also important aspects of LOICZ. However, LOICZ is more than just natural science. Because of the importance of the coastal zone to the human population and the pronounced effects of the human population on watershed and coastal processes, socio-economic considerations are a critical and unique component of LOICZ. LOICZ is seeking new ways of integrating the disciplines of natural and social sciences in order to develop more effective tools for managing coastal change whether it be natural or human in origin.

LOICZ formally began in 1993 with the publication of the LOICZ Science Plan (Holligan and de Boois 1993) and with the establishment of a Scientific Steering Committee (SSC) and Core Project Office (CPO). Patrick Holligan from the UK has served as Chair of the SSC until October 1995. Ed Gomez from the Philippines is the new chair. US and Canadian scientists currently serving on the SSC are John Milliman (College of William and Mary), Jeff Richey (University of Washington), Steve Smith (University of Hawaii) and Don Gordon (Bedford Institute of Oceanography). Bob Buddemeier (University of Kansas) is about to join. The CPO is funded by the Government of the Netherlands and is located at the Netherlands Institute for Sea Research (NIOZ) in Texel. John Pernetta is Core Project Director and Paul Boudreau (on extended leave from the Bedford Institute of Oceanography) is currently serving as Core Project Scientist.

The initial task of the SSC and CPO, once the project was formally established, was to develop an Implementation Plan which was subsequently published by the IGBP in early 1995 (Pernetta and Milliman 1995). This 215 page document outlines in considerable detail the plans for both research and project management.

The research planning identifies three different categories of activity:

1. Framework Activities

Since the overall perspective of LOICZ is global, it is necessary to establish strong coordination mechanisms at the start of the project to ensure that the results of local studies around

the world can be ultimately integrated into global models. Therefore a number of framework activities have been identified which are being implemented in top-down fashion by the CPO and SSC. These include scientific networking; development of a global coastal zone typology; development of a data system plan; measurement standards, protocols and methods; and modelling.

2. Focus Research

While global in scope, LOICZ is necessarily dependent on research conducted at smaller spatial scales and therefore relies heavily on nationally funded research to achieve its program goals. The recommended research is presented under four foci which correspond to the four long term goals of LOICZ.

They are:

Focus 1: The effects of changes in external forcing or boundary conditions of coastal fluxes.

Focus 2: Coastal biogeomorphology and global change.

Focus 3: Carbon fluxes and trace gas emissions.

Focus 4: Economic and social impacts of global change in coastal systems.

Numerous diverse research activities are proposed in considerable detail under each foci in the Implementation Plan.

3. Integrative Activities

Even with a considerable investment in the framework activities outlined above and having available the results of numerous nationally funded projects from around the world, LOICZ will not necessarily be able to meet its long term global goals. The mere compilation of results from local studies will not provide all the insight needed to understand integrated biogeochemical and socioeconomic processes at the global level. Therefore, a number of integrative activities will be developed by the SSC and CPO in top-down fashion which address in a cross-cutting manner multiple activities from two or more research foci. The initial topics identified in the Implementation Plan are the role of coastal seas in the global carbon cycle and integrated approaches to assessing the economic and social impacts of global change on coastal ecosystems. However, it is anticipated that additional integrative activities will be added as LOICZ develops. It is unlikely that these integrative activities would be funded at the national level so the investment of substantial new research funds will be needed.

The Implementation Plan calls for a very ambitious program to be carried out over a ten year time period. How much will be actually accomplished depends heavily upon the amount of funding that can be procured for the framework and integrative activities as well as the extent that nationally funded programs are developed around the world to provide the data required by LOICZ.

Considerable priority has been given initially to the development of framework activities and several products are already available. For example, a global river discharge data base called GLORI has been developed and is available in hard copy (Milliman et al. 1995). A draft global coastal typology has been developed (LOICZ 1995a) and is under continued development. The purpose of this typology is to categorize the world's coastal zone into a realistic number of geographic units on the basis of both natural and socioeconomic features. Guidelines for the assessment of coastal zone resources have been drafted (LOICZ 1995b). They provide some general guidance on the application of socioeconomic methods and techniques in the context of coastal zone resource assessment and management problems. Guidelines for the development of biogeochemical models (i.e. carbon, nitrogen and phosphorus fluxes) in the coastal zone have been developed during a series of workshops and will be published in early 1996.

The planning and progress of LOICZ are reviewed at a regular series of Open Science Meetings. The first was held at Raleigh, NC in May 1993 (Hopkins and Kinder 1993) and the second was held at Manila in the Philippines during April 1995 (LOICZ 1995c). Reports of both are available. A third is tentatively scheduled for late 1996 in Africa.

Canada has established a national LOICZ committee under the chair of Grant Ingram of McGill University. A national workshop was held in Montreal in the fall of 1994 and one of the recommendations was that a new LOICZ-oriented Canadian project should be developed for either Hudson's Bay or the Mackenzie Delta/Beaufort Sea region. Planning is still underway with the goal of having a proposal ready to submit to funding agencies by fall 1996. The extent and design of a potential US contribution to LOICZ is uncertain at this time.

The Gulf of Maine scientific community can contribute to LOICZ in various ways, both formally and informally. The Gulf of Maine is a data-rich region which is home to a large number of highly experienced natural and social scientists. On a global scale, few other coastal regions can match the knowledge base that is available for the Gulf of Maine. Using existing data, or data currently being collected, local and regional scale models of coastal processes could be developed following the guidelines recommended by LOICZ. These models could be compared with models of similar coastal systems elsewhere in the world to improve scientific understanding of how the Gulf of Maine system functions and how natural processes interact with human activities. The Gulf of Maine scientific community could also play a leadership role in developing procedures for scaling up local and regional models into the global models ultimately required by LOICZ. In addition, the Gulf of Maine scientific community could also use its extensive expertise to help develop new coastal zone research programs in the developing nations of

the world. And finally, there also is the potential for developing new data collection programs within the Gulf of Maine to help fill any important data gaps that may remain in the region.

Anyone wishing to obtain further information on LOICZ should contact one of the US or Canadian members of the SSC or the CPO. Copies of LOICZ documents can be requested from the CPO:

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A LOICZ Home Page is in the process of being established on the World Wide Web.

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Canada GLOBEC Atlantic Program

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The Atlantic component of Canada GLOBEC will investigate environment-plankton-fish interactions in a broad, strongly seasonal, and predominately demersal (in terms of harvested finfish) continental shelf ecosystem. The target species - gadoid finfish (primarily cod and haddock) and copepods (primarily *Calanus finmarchicus* and *Pseudocalanus* sp.) - will be examined in relation to their environment, their prey and co-occurring species in several areas. The research will focus on two broad mechanisms for environmental regulation of fish stock production and structure: direct influences of the physical environment on the distribution, growth and survival of fish at various life stages, and indirect influences of the environment through its mediation of planktonic food supply.

The Atlantic program will have three complementary and interconnected elements: numerical modeling of existing and new observational data, field studies in key areas, and laboratory experiments. The investigations of direct environmental influences on fish abundance and distribution will be focused on the Scotian Shelf where there are competing large-scale effects from continental runoff (St. Lawrence system) and the North Atlantic subpolar (Labrador Current) and subtropical (Gulf Stream) gyres, and local effects from winds, tides and fronts. The emphasis of these investigations will be on advective, temperature and turbulence influences on early life gadoid stages in major spawning and nursery areas over Browns, Western and Banquereau Banks. This will provide a national complement to U.S. GLOBEC investigations on Georges Bank - a "downstream" extension of the same ecosystem. The early-life stage investigations will be complemented by evaluations of associated changes in adult populations and of direct hydrodynamic influences on adult distributions (e.g. effects on migration).

The investigations of indirect environmental influences through the food chain will focus on zooplankton population variability and the transfer of food energy from plankton to early life fish stages. The proposed investigations will have broad geographic coverage, from the Labrador Sea and Gulf of St. Lawrence to the Scotian Shelf, over which there is a wide range of oceanographic conditions that directly influence the living marine resources of the entire east coast of Canada. The ultimate goal is to relate variability in secondary production (zooplankton food supply), as controlled by the physical environment (e.g. circulation, turbulence, and stratification effects on the match or mismatch of predators with prey) to the growth and survival of early life fish stages - the immediate precursor to recruitment. Enhanced growth leads to enhanced survival and hence increased recruitment to exploitable biomass.

Particular emphasis will be given to the factors controlling temporal variability in the abundance of the predominant zooplankton species *C. finmarchicus*, the extent of inter-regional

Figure 1. Location map of the Gulf of St. Lawrence, Scotian Shelf and Gulf of Maine regions with 200-m isobath.

coupling of *Calanus* populations through the large-scale shelf current systems, the supply and retention of zooplankton prey in typical gadoid nursery areas, the relative importance of physical factors (e.g. turbulence) and prey to the feeding success and growth of zooplankton and ichthyoplankton, themselves a function of shelf-scale changes in primary production associated with climatic variability.

The spatial focus covers a hierarchy of scales ranging from coarse coverage of the large-scale northwestern Atlantic in concert with, and paralleling, GLOBEC International and TASC, to moderate resolution of the St. Lawrence estuarine system extending onto the Scotian Shelf, and finally to high resolution of regional bank-scale gadoid nursery regimes. With the next phase (1996-1999) of the US GLOBEC Georges Bank program focusing on "sources, retention and losses" in an adjacent gadoid nursery regime, and the tight connection of our programs in approach, methodology, space, time and planned coordination, the hierarchical spatial focus of Atlantic GLOBEC provides unique opportunities for both inter-regional comparisons (e.g. gadoid stocks) and the evaluation of large-scale environmental influences.

Study Structure

Within GLOBEC Atlantic, we propose to investigate the physical-biological mechanisms determining variability in the abundance and distribution of *C. finmarchicus* in the Atlantic Ocean. At the largest scale in the program, that of the North Atlantic, GLOBEC Atlantic first seeks to address variations in Calanus populations through numerical modeling in an effort directed at determining the influence of the physical environment and its variability on zooplankton population dynamics (deYoung et al.).

At the regional scale the role of the physical environment, particularly advection, will be modeled for the entire Gulf of St. Lawrence and Scotian Shelf (Runge et al.). This work builds upon recent advances in the quantitative understanding of the physical processes controlling the circulation and the hydrography of shelf systems.

At the shelf scale, there will be a dual trophic-level emphasis on zooplankton and early life gadoid stages. The importance of direct environmental influences and indirect influences through zooplankton food supply to fish early life stages on Browns, Western and Banquereau Banks will be studied on the shelf through both modeling (Loder et al.) and direct field measurements and monitoring (Taggart et al., Ruddick et al., Herman et al., Fortier et al.). Loder et al. will use a 3-d high-resolution hydrodynamics model to evaluate the environment and its influences in the vicinity of these major gadoid spawning banks during the period of several field investigations. Direct influences of circulation and temperature on gadoid fish, as well as indirect influences of circulation and hydrography on the food supply from lower trophic levels will be examined. The resulting characterization of these gadoid regimes will be compared with that for Georges Bank, in collaboration with the US GLOBEC program.

The modeling studies propose to provide the quantitative framework for the interpretation of the directed field programs. The field work by Fortier et al. is designed to dovetail with recent work which indicates significant influences of temperature and feeding success on the growth of larval fish. For the purposes of understanding and predicting recruitment variations, interannual differences in early growth may be critical and require multi-year observational data sets. Ichthyoplankton samples collected along several lines will be used to assess whether the interannual growth anomalies detected to date on banks are a general phenomenon on the Scotian Shelf.

Herman et al. propose to measure the abundance of zooplankton being transported through the Cabot Strait and along the Scotian Shelf. In addition, the role of the outer Scotian Shelf banks in concentrating and retaining larval fish and their food prey will be characterized. A series of cruises occupying lines along and across the shelf will yield data to determine the relationships between larval fish, their food prey, and their environment.

Two closely-integrated field programs will focus on Western Bank, chosen for a combination of scientific and logistic reasons. Taggart et al. propose to address several questions about the key processes involved in the interplay between circulation, hydrography and mixing that provide for enhanced primary and secondary production and on-bank concentrations of zooplankton and ichthyoplankton. In particular, what processes maintain the closed gyre on the crest of Western Bank and what conditions lead to bank-clearing events?

At the micro-scale, the team of Ruddick et al. propose to critically evaluate hypothesized effects of turbulence on the feeding behavior of larval fish. This group of biological and physical oceanographers will make field measurements on Western Bank in close collaboration with Taggart et al. Turbulence distributions and their variability across the gyre will be surveyed in conjunction with measurements of larval distributions, gut contents, growth history and condition.

The final component of the GLOBEC Atlantic program, by Deibel et al., involves controlled laboratory studies on feeding of zooplankton and gadoid larvae. The goal of the zooplankton studies is to determine the assimilation, egg production, hatching and survival rates of naupliar stages of copepods in relation to the quantity and quality of food, and the character and intensity of turbulence. For larval fish, the goal is to determine the ontogeny of selection, ingestion and assimilation rates in relation to similar conditions as for the copepods.

Timetable

The program will start with the analysis and model interpretation of existing data sets, together with the laboratory experiments, in Year One. These will continue and provide decision making input to the field programs in Years Two and Three, culminating with a strategically designed field study in the fall of Year Three. The program will conclude in Year Four with analysis and model interpretation of the extended observational database, addressing the study objectives.

GLOBEC Canada consists of two components, one in the Atlantic and one in the Pacific. Only the east coast program is described in this summary. The joint proposal will be submitted for funding by early January 1996. We hope to receive funding by the spring of 1996.

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Polynuclear Aromatic Hydrocarbons (PAH) in the Gulf of Maine Sediments Visualized by Principal Component Analysis (PCA)

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The data of Johnson et al. [1985] and of Larsen et al. [1986] are used to demonstrate the application of Principal Component Analysis (PCA) to a preliminary examination. The combined set forms a table with 145 rows (49, and 96 samples, respectively), and 11 columns (variables, individual PAH). Such a large table is difficult to comprehend. PCA transforms the data so that they can be conveniently presented graphically. The data can be then examined visually for the presence of similarities, differences, 'outliers', groups, trends, etc.

Compositional data, such as the concentrations of PAH in sediments, can be pre-processed by expressing the individual

values as percents, or by scaling to a maximum of 1. These transformations eliminate the effect of concentration and show the changes in the 'profile' of the samples. Before PCA the data are usually centered and scaled by subtracting the mean row and by dividing the data in the columns by the respective standard deviations. As a result of the latter, each column (variable) carries the same weight.

PCA reduces the dimensionality of the data, given by the number of the columns. The reduction is achieved by selecting new axes in the direction of successively decreasing variances. The new axes are linear combinations of the original variables and their directions are given by the so-called 'eigenvectors'. The relation of the new axes to the original variables can be seen in 'loading' plots. A high value of an original variable results in high values of the new coordinates on the axes on which the original variable has high loadings.

The similarities and differences among the samples can be

Figure 1. Centered (mean 0) and scaled (standard deviation 1) data of Johnson et al. [1985] and Larsen et al. [1986], projected on the plane of the first two principal components pc-1 and pc-2 (a 'score' plot). Proportions of the original variance accounted for by the principal components are given in brackets. Sample positions are indicated by sample numbers (Johnson et al. 1-49, Larsen et al. 50-145). The distance between samples is indirectly proportional to their similarity. The large variance in the direction of pc-1 is caused by differences in the concentrations of PAH.

Figure 2. 'Loading' plot for the data in Figure 1. The eigenvectors ev-1 and ev-2 are the axes for the principal components pc-1 and pc-2, respectively. The effects of the individual PAH ('loadings') on the eigenvectors are indicated by symbols:

Ph = phenanthrene,

Fl = fluoranthene,

Py = pyrene,

BaA = benzo[a]anthracene,

Chr = chrysene,

BbFl = benzo[b]fluoranthene,

BkFl = benzo[k]fluoranthene,

BaP = benzo[a]pyrene,

DbahA = dibenzo[ah]anthracene,

BghiPer = benzo[ghi]perylene, and

Ind123Py = indeno[1,2,3,c,d]pyrene.

seen in 'score' plots, which give the positions of the samples in the new coordinates. Similar samples are located close together.

Figure 1, a score plot, is a projection of the data on the plane of the first two principal components, pc-1 and pc-2. These account for 94 and 2.4 % of the original variance, respectively. The largest variance is along the pc-1 axis and is caused by differences in concentration. Samples with high PAH levels are located farther on the right hand side of Figure 1. From the loading plot in Figure 2 one expects that samples with high concentrations of phenanthrene, fluoranthene, or pyrene will be located closer to the top of Figure 1, since these PAH have relatively high loadings on pc-2. On the other hand, samples with elevated levels of benzo[b]fluoranthene, dibenzo[a,h]anthracene or chrysene, will be closer to the bottom of Figure 1, because these PAH have high negative loadings on pc-2. These conclusions can be verified by the examination of the original data, some of which is given in Table 1. The differences in the

composition among the samples are even better visible in the 2pc-2 and pc-3 plane (Figure 3). The reasons for the differences can be seen from the ev-2 and ev-3 loading plot (Figure 4).

When the data are expressed on a percentage basis, the score plot (Figure 5), detects immediately the sample 115 as an outlier. PCA carried out after the elimination of this sample shows a systematic difference between the data of Johnson et al. (samples 1-49) and Larsen et al. (samples 50-144), Figure 6, caused primarily by differences in the fluoranthene percentage, as can be also seen from the loading plot (Figure 7, fluoranthene has a negative, other PAH have positive loadings on pc-1). Looking at more subtle differences, the sample 103 contains a much higher proportion of pyrene than sample 104 (see Table 1). At the same time, the sample 104 contains a much higher proportion of benzo[k]fluoranthene and dibenzo[ah]anthracene.

In comparison to PAH profiles in sediments from other parts of the world, PAH from the Gulf of Maine contain a higher
(continues on page 8)

Figure 3. Centered (mean 0) and scaled (standard deviation 1) data of Johnson et al. [1985] and Larsen et al. [1986], projected on the plane of the principal components pc-2 and pc-3. In this projection, the differences among the samples are caused primarily by relative differences in the concentrations of the individual PAH.

Figure 4. 'Loading' plot for the data in Figure 3. The eigenvectors ev-2 and ev-3 are the axes for the principal components pc-2 and pc-3, respectively. For PAH symbols see Figure 2.

("PAH" continued)

Sample Num	ug/kg										
	Phe	Flu	Pyr	BaA	Chr	BbFl	BkFl	BaP	DahA	BghiP	Ind123Py
3	252	3700	502	512	276	601	402	376	37	610	198
6	207	2700	426	374	248	656	404	540	76	328	180
7	86	1220	178	184	108	264	147	222	27	294	96
8	121	2040	285	306	237	310	263	218	23	384	185
9	232	3110	539	370	205	206	275	346	43	486	126
10	223	2580	525	517	285	485	515	408	44	652	145
11	130	1960	296	279	174	490	302	327	58	252	120
12	217	3530	515	540	578	1000	696	497	120	856	213
						%					
103	8.04	30.2	15.8	6.75	1.93	9.32	5.14	8.04	0.64	9.00	5.14
104	6.87	9.92	9.92	7.63	8.40	5.34	9.92	13.0	2.29	19.1	7.63

Figure 5. Data of Johnson et al. [1985] and Larsen et al. [1986] expressed as percents, centered (mean 0) and scaled (standard deviation 1), and projected on the plane of the first two principal components pc-1 and pc-2. Note the 'outlier' sample 115.

Figure 6. Data of Johnson et al. [1985] and Larsen et al. [1986], without sample 115 (see Figure 5), expressed as percents, centered (mean 0) and scaled (standard deviation 1), and projected on the plane of the first two principal components pc-1 and pc-2. Note that the two data sets form separate clusters, with only a few exceptions.

proportion of fluoranthene, which may be typical of less contaminated sediments (Zitko [1993] and unpublished, Figure 8). The data in Figure 8 are based on only 6 PAH (phenanthrene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, and benzo[a]pyrene), common to the reviewed publications.

The above examples serve as an illustration that PCA is a convenient tool to examine multivariate data. They also indicate systematic differences between the data from the Gulf of Maine and from elsewhere. It is not known whether these differences are real or whether they are caused by an analytical bias. In any case, PCA is a fast and convenient technique to detect such patterns in the data.

There are many publications on environmental applications of PCA. Some of the references as well as a description of software are given in Zitko [1994].

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Figure 7. 'Loading' plot for the data in Figure 6. The eigenvectors ev-1 and ev-2 are the axes for the principal components pc-1 and pc-2, respectively. For PAH symbols see Figure 2.

Figure 8. The concentrations of 6 PAH (phenanthrene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, and benzo[a]pyrene) in sediments from various parts of the world, scaled to a maximum of 1, centered (mean 0) and scaled (standard deviation 1), and projected on the plane of the first two principal components pc-1 and pc-2, from Zitko [1993] with some additional points. Data of Johnson et al. [1985] and Larsen et al. [1986] indicated by 'x'.

Health of the Gulf of Maine Ecosystem: Cumulative Impacts of Multiple Stressors

A scientific workshop was convened by the RARGOM at Dartmouth College on 18-20 September, 1995. The goals were to assess the human-caused factors affecting the health and stability of the Gulf of Maine marine ecosystem and to identify research and management options to restore and/or maintain the environmental quality of the ecosystem.

Workshop participants discussed the status of key ecosystem components that characterize the Gulf of Maine, from three perspectives: Anthropogenic Impacts/Natural Environment, Fisheries Harvesting, and Marine Mammal/Protected Species. In each category, the state of knowledge was surveyed; individual stressors (direct and indirect) were identified, and their cumulative impacts described. The themes of habitat, biodiversity, and ecosystem function were emphasized throughout. The workshop focused on problem identification and on the pros and cons of possible alternative research and management strategies.

Invited participants were selected from the research community, resource users, and state/federal managers with expertise in the fields of marine biology, ecology, and the various branches of oceanography. Participation by the broader public was encouraged through initial plenary presentations. Total attendance was 63 people.

The human-caused factors affecting the health and stability of the Gulf of Maine ecosystem and its constituent parts are summarized below. With the exception of migratory species, the major perturbations are internal, rather than external to the system, and were grouped in the following categories:

- Over fishing and related impacts,
- Contaminant introduction, primarily in the near shore coastal zone (toxins, nutrients, and pathogens), but via atmospheric input as well,
- Physical alteration and loss of critical habitat especially for sensitive or key species (in riparian, coastal and offshore regions),
- The effects of human activities on endangered or threatened species such as right whales; (although these effects on endangered or threatened species may be of relatively minor significance to overall ecosystem dynamics, the effects on these populations are very important);
- Factors external to the Gulf of Maine which affect seasonally resident and resident populations (including atmospheric deposition, global warming, effects on migratory populations in other ecosystems or regions), and
- Decision-making practices which can best be characterized as based on local, site specific, short-term, crisis-oriented decision-making, need to be replaced by regional, long-term, information and risk based management.

The Workshop Steering Committee included David Dow, NMFS (Chair), Solange Brault, UMass. Boston, Ned Cyr, NMFS, Joseph DeAlteris, URI, Wendy Gabriel, NMFS, Ramona Haebler, EPA, Robert Hofman, MMC, Charles Hopkinson, MBL, David Townsend, U.Maine, RMRP, Jon Witman, Brown Univ., Gordon Wallace, RARGOM. Jack Pearce, NMFS, Woods Hole, served as the workshop chair.

A 12 page Executive Summary is available now. Full working group reports and plenary papers will be presented in the workshop proceedings, RARGOM Report 96-1, due to be completed this winter.

Jack Pearce, Deputy Director, Northeast Fisheries Science Center, Retires

Serving as the chair of the Gulf of Maine Ecosystem Health Workshop was the culminating event for Dr. Jack Pearce as a federal employee. With 31 years experience in public service as a marine scientist, Pearce played a key role in the workshop, articulating the rationale and goals, identifying participants, and summarizing the results.

During his federal career, Pearce worked on several projects of national and international scope, serving with ICES, NOAA's National Estuarine Program, and the U.N. Environmental Program Committee. He is a fellow of the AAAS. Pearce currently serves as the scientific editor of *Fishery Bulletin*, and as the N. American editor of *Marine Pollution Bulletin* and *Fisheries Research*. He also remains active with the RMRP as a board member. His commitment to science education is reflected in many other volunteer activities, locally, in the Falmouth area schools, and regionally, with the New England Aquarium.

Dr. John Boreman, director of the NEFSC's cooperative research and education program at UMass Amherst, is serving as deputy director until someone is selected for the post.

Regional Marine Research Program News

Principal Investigators and Board Meeting

An annual principal investigators and board meeting was held at the University of Maine, Orono, on 23-24 October 1995. During the initial day and a half, nineteen investigators presented their research activities. That portion of the program was followed by a discussion period concerning the status of the RMR Program and possible participation in the planned Gulf of Maine Scientific Symposium in September 1996. An Ecosystem Modeling workshop, hosted by Xuijie Xue et. al., was held during the afternoon of Oct. 24th and on Oct. 25th.

For a report, contact David Townsend, Executive Director, RMRP, (207) 581-1435, davidt@maine.maine.edu

U.S. GLOBEC Georges Bank Program News

Scientific Investigators' Workshop

Following the completion of the second field season, the third U. S. GLOBEC Georges Bank Program scientific investigators' workshop was held at Woods Hole Oceanographic Institution on 16-18 October 1995. The objectives were to enable the scientific investigators to describe their research activities to one another, to exchange data and information, and to work together toward developing the scientific products that will fulfill the program's goals and objectives.

The workshop was organized around four major themes:

- Bank-wide physical and biological structures.
- Water column stratification and its effects on biological distributions and processes.
- The population dynamics of the target species.
- Hot topics: unexpected findings/discussions or interesting tidbits.

Each of the sessions was a blend of physics, biology, and modeling work. Presentations and discussions were designed to improve our understanding of the coupling of physics and biology of the region. For each session there was a session chairman and two rapporteurs. After each session, an open discussion was held. These were guided by the Chairman of the session who asked particular investigators to summarize ideas or findings that were particularly pertinent to topics presented in the sessions. In addition, there was a final talk which focussed on the data management system and its role in providing a mechanism for program information, data access, and investigator interaction. A total of 58 presentations were made over the two days of the workshop. For a workshop report, contact Bob Groman, Woods Hole Oceanographic Institution, rgroman@gb1.who.edu

U.S. GLOBEC Georges Bank 1996 Field Program Schedule

The 1996 ship schedule is planned with six broad-scale studies and four mooring/drifter cruises.

dates	vessel	purpose, chief scientist
January		
9-21	R/V Endeavor	broad scale survey, Charlie Miller (508) 737-4524
February		
11-23	R/V Endeavor	broad scale survey, Peter Garrahan / Erich Horgan (508) 457-2169
March		
11-23	Oceanus	broad scale survey, Peter Weibe (508) 457-2000 x2313
29-Apr. 13	Oceanus	long term mooring cruise, Jim Irish (508) 548-1400 x.2732
April		
8-20	R/V Endeavor	broad scale survey, John Sibunka (908) 872-3064
May		
8-19	R/V Albatross IV	broad scale survey, Jack Green (401) 782-3201
June		
3-14	R/V Albatross IV	broad scale survey, David Mountain (508) 548-5123
September		
6-16	R/V Endeavor	long term mooring cruise, Jim Irish (508) 548-1400 x.2732
October		
24-Nov. 4	Oceanus	long term mooring cruise, Jim Irish (508) 548-1400 x.2732
November		
10-12	R/V Endeavor	drifter deployment, Dick Limeburner (508) 289-2539

Gulf of Maine Ecosystem Dynamics Scientific Symposium-St. Andrews-September 16-19, 1996

The dual objectives of the symposium are to present and synthesize scientific research conducted since the 1990 Woods Hole Gulf of Maine scientific workshop and make future research recommendations. This program will be designed to bring together a large group of scientists to report on their results, with the goal of shaping a regional research agenda of both basic and applied research, needed to solve problems of particular significance to the Gulf of Maine region.

Members of the Steering Committee met on December 11 at the NMFS office in Gloucester, MA. At the meeting, the program structure and content continued to develop; there was lengthy consideration of the structure and purpose of the plenary session (the most effective way to integrate specific project results into synthesis presentations of overarching themes), the integration of management issues into the symposium's scientific focus, and the need to provide greater opportunity for oral presentations at the conference. The symposium will open with an evening panel discussion by top level representatives of the environmental

agencies of each of the states and provinces bordering the Gulf of Maine region, as well as appropriate federal representation; these participants will be asked to identify the three principle issues they feel need additional scientific data and information.

The next steering committee meeting, to finalize the structure and format of the symposium, will take place on February 1st at Dartmouth College in Hanover, NH.

An announcement of the conference will be sent out in February. A mailing list is being compiled from recent workshop events; to ensure that you receive this announcement, please contact the Association headquarters (braasch@dartmouth.edu), by February 9th, indicating your research interest, current mailing address, and e mail address, phone and fax numbers.

Resources

Grants / Sponsored Research

ENVIRONMENTAL PROTECTION AGENCY

Contracts Management Division, Cincinnati, OH 45268-7001; Attn: Sandra V. Savage, (513) 366-2046

Economic and Regulatory Analytical and Evaluation Support (Sol. C600025T1) The U.S. EPA, Office of Water, requires a contractor to provide technical and analytical support in performing economic, financial, and regulatory analyses and in support of program decisions, actions, and regulations development, review, and implemented under provisions of the Clean Water Act (CWA). These tasks will require the application of sophisticated economic, financial, statistical, benefit-cost, and risk assessment methodologies, the formulation and implementation of solutions to complex regulatory problems, and the adaptation of economic theory and financial analysis to solve nonstandard applied problems. The contract will require long-term as well as quick turnaround responses to specific analytical tasks. A cost-plus-fixed-fee, level of effort, term type contract is contemplated with a 15-month base period, three twelve-month and one nine-month option periods. **Due: To be Announced.**

NASA

c/o Michael Dolan, Planetary Biology Internship, Dept. of Biology, Univ. of Massachusetts, Box 3-5810, Amherst, MA 01003-5810, (413) 545-3223, e-mail: pbi@bio.umass.edu, **Deadline: March 1**

NASA Planetary Biology Internships. The Marine Biological Laboratory, Woods Hole, MA, invites applications from graduate students and seniors accepted to graduate programs in biology or related sciences for internships in planetary biology, the study of life, its chemical precursors, and its effects on the chemistry of the Earth's surface. Interns receive stipends of \$2,200 plus travel (\$1,100 limit on travel) to participate in research at NASA centers and collaborating institutions for approximately eight weeks. Typical intern programs include: global ecology, remote sensing, microbial ecology, biomineralization, closed ecological life support systems, and origin and early evolution of life.

NATIONAL SCIENCE FOUNDATION

4201 Wilson Boulevard, Arlington, VA 22230.

For NSF publications, send request to: pubs@nsf.gov or fax to (703) 644-4278 or call (703) 306-1130.

Directorate For Biological Sciences

Dr. Deborah Joseph, (703) 306-1469, **Deadline: None**

Computational Biology Activities in the Biological Sciences

This program promotes, supports, and facilitates the development and use of computational tools, algorithms, community software, and related research that will enhance biological sciences research and infrastructure. Toward this stated goal, the computational biology activity will encourage collaborations of biological scientists with computer, computational, and mathematical scientists and engineers, in the form of research, workshops, and training at all levels. To be supported, a research project would be expected to have a large impact on the biological sciences by providing tools for this community or by developing novel computational or mathematical approaches, especially those involving high-performance computing environments and techniques, to biological problems. For additional information, see NSF 92-62.

Directorate For Biological Sciences

Div. of Biological Instrumentation and Resources. Dr. James T. Callahan, (703) 306-1469, **Deadline: March 1**

Biological Field Stations and Marine Laboratories

The Directorate for Biological Sciences, in collaboration with the Directorate for Geosciences, supports this special competition for the improvement of research facilities and the acquisition of research equipment at U.S. biological field stations and marine laboratories. Proposals should focus on specific projects for facility improvement, and the high quality research and education that will be enabled as a result of an award. Facility improvement may include: acquisition of new multi-user research equipment; new construction of laboratories or living accommodations for visiting scientists; building refurbishment, rehabilitation, enhancement, or renovation; and building modifications to facilitate use by scientists with disabilities. Proposals will be accepted from U.S. colleges, universities and other organizations with formally constituted research programs at field stations or marine laboratories. The maximum award amount will be \$500,000 per facility, and submitting institutions will be expected to provide appropriate cost sharing. Award durations will normally be two years. Requests for up to \$25,000 may also be submitted for support of planning and/or design activities. See NSF 91-8 for additional information.

Directorate for Geosciences, Div. of Ocean Sciences

Ocean Sciences Research Section, Dr. Michael R. Reeve, (703) 306-1582, **Target Dates: Feb. 15, Aug. 15**

Ocean Sciences Research. Grants are awarded to highly qualified individuals and groups of scientists to improve understanding of the sea and ocean basins. See NSF 95-27 for descriptions of the program areas:

Biological Oceanography Program:

Phillip Taylor, (703) 306-1587

Chemical Oceanography Program:

Rodger Saier, (703) 306-1589

Marine Geology and Geophysics Program:

Bilal Haq, (703) 306-1586

Physical Oceanography Program:

Richard Lambert, (703) 306-1583

Ocean Technology and Interdisciplinary Coordination Program

(includes instrument development):

Larry Clar, (703) 306-1584.

Div. of Ocean Sciences, Oceanographic Centers and Facilities Section, Dr. Bruce T. Malfait, (703) 306-1581, **Target Dates: Feb. 15, Aug. 15**

Ocean Drilling Program.

This is an international program dedicated to the exploration of the ocean crust and the sediments of the ocean basins and margins. The NSF/ODP is interested in funding the following types of unsolicited proposals: regional geological and geophysical field studies well in advance of drilling; Downhole geophysical or geochemical experiments related to a specific drilling leg or drilling program; New methods, techniques, or concepts that will improve drilling or the collection and analysis of drilling data; and Synthesis research projects that have scientific merit and are directed to profiling new insight toward future drilling goals. The program includes regional or topical workshops, shipboard participation by U.S. scientists and a fellowship program.

Div. of Ocean Sciences, Dr. Phillip R. Taylor, (703) 306-1587, **Target Date: Feb. 15**

Land-Margin Ecosystems Research. In a joint venture, NSF's Division of Environmental Biology and Ocean Sciences support research on major ecological questions that stress linkages between terrestrial and lang-margin ecosystems. Studies of the ways in which changes on land cause changes in land-margin ecosystems should be a part of the proposed research. The research should be interdisciplinary; include a strong mathematical modeling component; and make appropriate use of advanced technologies. Investigators may request up to six years of

funding, not to exceed \$500,000 annually. For additional information see NSF 95-45.

Div. of Ocean Sciences. Dr. David Epp, Marine Geology and Geophysics Program, (703) 306-1586, Dr. Phillip R. Taylor, (703) 306-1587, **Target Dates: Feb. 15, Aug. 15**

Ridge Interdisciplinary Global Experiments. The primary objective of RIDGE relative to global change is to understand the geological, chemical, biological, and physical oceanographic interactions between the oceans and hydrothermal circulation of seawater through the ocean crust. Proposals are invited to address temporal variability, biological studies, and technology development, material properties, and database activities. For additional information see NSF 95-45.

Div. of Ocean Sciences, Dr. Richard B. Lambert, Jr., (703) 306-1583, **Target Date: Feb. 15**

World Ocean Circulation Experiment. The Division of Ocean Sciences will consider proposals for various activities of the World Ocean Circulation Experiment (WOCE). WOCE is a study of the general circulation of the ocean and its role in climate and is scheduled to take place during 1996 to 1998. Two primary areas of interest are: 1) Atlantic Circulation and Climate Experiment; and 2) Analysis, Synthesis, and Modeling. Additional information and applicable program announcement 95-85 can be obtained from Dr. Lambert.

Div. of Atmospheric Sciences, Dr. Sankar Rao Mopidevi, (703) 306-1527, **Target Dates: Feb. 15, Aug. 15**

Climate Variability and Predictability. The Divisions of Atmospheric and Ocean Sciences will consider proposals for participation in studies of the seasonal to centennial variability and predictability of the coupled ocean-atmosphere-land system. CLIVAR is organized around three science thrusts to 1) study seasonal to interannual climate variability and predictability; 2) examine the role of the ocean in decadal to centennial climate variability; and 3) model and detect anthropogenic climate change. For additional information see NSF 95-45.

UNIVERSITY CORP. FOR ATMOSPHERIC RESEARCH
UCAR Visiting Scientist Programs, P.O. Box 3000, Boulder, CO 80307-3000, Meg Austin, Program Manager, (303) 497-8649

Deadline: March 1

NOAA Postdoc. Prog. in Climate and Global Change

This program offers up to a two-year visiting research appointment to recently graduated postdoctorals who are paired with host scientists in an area of mutual interest in climate studies. The overall goal of the NOAA Climate and Global Change program is to provide predictions and assessments of global climate change on seasonal to centennial time scales. On seasonal to international time scales, the program currently supports studies to improve understanding of the variability of the ocean, atmosphere and land system, their relationship to the global atmosphere, and the potential use and value of improvements in predictability. Applications are solicited from both postdoctoral candidates and host scientists. Appointments will be announced by late spring 1996. Additional information is available from Ms. Austin.

WOODS HOLE OCEANOGRAPHIC INSTITUTION

The Fellowship Committee, Education Office, Clark 223, MS 31, 360 Woods Hole Road, Woods Hole, MA 02543-1541, (508) 457-2000, Ext. 2219, FAX: (508) 457-2188 **Deadline: March 1**

Summer Program in Geophysical Fluid Dynamics

Up to ten pre- or postdoctoral fellowships are available for a ten-week (June 17 to August 23, 1996) study program on geophysical fluid dynamics. The 1996 summer study program will consider double-diffusive processes. Stipend is \$3,900.

Reports Received

The following reports have been received at the Association office and are available for distribution by contacting the author.

“Improving Interactions Between Coastal Science and Policy” Proceedings of the Gulf of Maine Symposium, Ocean Studies Board Committee on Science and Policy for the Coastal Ocean, and National Research Council Commission on Geosciences, Environment, and Resources, National Academy Press, Washington, D.C., 1995 (note: the Executive Summary of the report is available in the National Academy Press/On-line Reports section of the NAS world wide web home page <http://www.nas.edu>).

Mooney-Seus, M., and Stone, G., “Pinniped Populations in Gulf of Maine: Status, Issues and Management” New England Aquarium Aquatic Forum Series, Report 95-1, June 14-15, 1995

Review of EPA’s Environmental Monitoring and Assessment Program: Overall Evaluation, National Research Council Board on Environmental Studies and Toxicology, and Water Science and Technology Board, National Academy of Sciences, National Academy Press, Washington, D.C., 1995

Sea Grant’s Guide to Coastal Science Experts, 1995-96, The National Sea Grant Media Relations Office, College Park, MD, (note: for stories about various Sea Grant projects around the nation, visit the world wide web home page, <http://www.mdsg.umd.edu/seagrantmediacenter/>).

“Science, Policy, and the Coast: Improving Decision making”, Ocean Studies Board Committee on Science and Policy for the Coastal Ocean, and National Research Council Commission on Geosciences, Environment, and Resources, National Academy Press, Washington, D.C., 1995 (note: the Executive Summary of the report is available in the National Academy Press/On-line Reports section of the NAS world wide web home page <http://www.nas.edu>).

Smith, P., “C.S.S. Parizeau Cruise 95-010 to Scotian Shelf and Georges Bank”: U.S. GLOBEC NW Atlantic *Georges Bank Study*, June 6-13, 1995

Smith, P., “C.S.S. Parizeau Cruise 94-018 to Scotian Shelf and Georges Bank”: U.S. GLOBEC NW Atlantic *Georges Bank Study*, June 24-30, 1994

Smith, P., “C.S.S. Parizeau Cruise 93-032 to Scotian Shelf and Georges Bank”: U.S. GLOBEC NW Atlantic *Georges Bank Study*, October 11-16, 1993

AMERICAN GEOPHYSICAL UNION

2000 Florida Avenue, NW, Washington, DC 20009, (202) 462-6903, FAX: (202) 328-0566, **Deadline: March 1**

The Horton Research Grant

This annual grant supports research projects in hydrology and water resources by Ph.D. candidates. Its objective is to foster graduate student research leading to the completion of doctoral dissertations. Appropriate topics may be in hydrology (including its physical, chemical, or biological aspects) or in water resources policy sciences (including economics, systems analysis, a sociology and law). The grant ranges from \$8,500 to \$10,000.

Internet Corner: Internet Site Tour

Jim Waugh, Dartmouth College

The four preceding "Internet Corner" articles have introduced RARGOM members to the history of the Internet, popular Internet software utility programs such as email, telnet, and gopher, the World Wide Web (WWW) and writing HTML documents for publication on the WWW. This issue of the newsletter tours an Internet site which has applied these network technologies to better serve its clientele, who are scientists and researchers at Woods Hole Oceanographic Institute and its affiliates.

The Marine Biological Laboratory / Woods Hole Oceanographic Institute (MBL/WHOI) library is a research facility serving the Woods Hole scientific community, and it is physically and electronically accessible to other scholars on a self-serve basis. Under the direction of Catherine Norton, MBL/WHOI publishes a WWW Home page which is but one entrance to an electronic, virtual library far larger than the physical institution itself.

Figure 1 illustrates a small subset of the substantial collection of information resources offered to persons connecting to the MBL/WHOI Home page (<http://www.mbl.edu/html/LIBRARY/libweb.html>) with a WWW browser utility like Mosaic.

Each underlined block of text represents a "hyperlink" to further information. The first three links (Library and its staff, Use Aids, and Recent Accessions Lists) all point to static, HTML, textual documents. However, the next three links (Library gopher, Library catalog on CLAMS, and Uncover Table of Contents Service) direct attention to other, interactive networked services. A mouse click on any of these links will connect to the service.

People without WWW browser service can still enjoy networked library access. Internet users with the gopher client program can connect directly to the MBL/WHOI gopher server by typing the computer command "gopher hoh.mbl.edu 71". (71 is the "port" number which uniquely identifies this gopher service on the hoh.mbl.edu computer). Figure 2 illustrates the entry menu returned by the MBL/WHOI gopher.

Figure 1

Compare figures 1 and 2, and notice that access to CLAMS (Cape Libraries Automated Materials Sharing) is available to both WWW and gopher users. CLAMS is a networked service providing on-line catalog access of library materials. People wishing to browse the Cape Libraries' catalogue can follow the link from the MBL/WHOI Home page, or they can telnet directly to the service by typing the computer command "telnet clams.mbl.edu". Figure 3 illustrates the MBL/WHOI main menu for CLAMS.

Figure 3

The telnet Internet service commonly provides interactive log-ins to a computer over a network as though a user's terminal were attached directly to the computer. However, here telnet supports a "captured" service (CLAMS) wherein only a limited selection of capability (on-line catalog searching) is available. Another captured information service, the UnCover Table of Contents Service, can be entered for WHOI users from the MBL/WHOI Home page shown in figure 1, or by selecting the fourth menu item on the MBL/WHOI gopher menu shown in figure 2. Users outside the MBL/WHOI system can telnet directly to the UnCover service by typing the computer command "telnet database.carl.org". Figure 4 illustrates the UnCover entry menu.

Figure 4

(CARL Corporation is affiliated with Knight-Ridder Information, Inc., a provider of library automation services).

Other noteworthy examples of MBL/WHOI's networked access to information include the Library photocopy request form, shown hyperlinked in figure 1, that is automatically emailed for processing, and a connection to the Boston Library Consortium service through gopher menu item four shown in figure 2.

RARGOM's first "Internet Corner" column described how the Internet evolved from an experiment by the U.S. Defense Department. The practical utility of information access motivated further network development by the National Science Foundation and ultimately catalyzed the explosive growth of the Internet and its usage. To the benefit of its patrons, MBL/WHOI well-exemplifies the fundamental Internet goal of making information accessible.

Calendar

January

- 12 Fisheries Forum
New England Aquarium
contact: Maggie Mooney-Seus (617) 973-6587
- 23 Modeling Nitrogen in Coastal Ecosystems
Workshop, MIT
contact: Christine Hardiman (617) 253-7092
- 29-Feb. 1 Fundy Marine Ecosystem Science Project
workshop, Acadia University
contact: Alison Evans (902) 542-2201 ext.
1311

February

- 1 Gulf of Maine Scientific Workshop Steering
Committee meeting, Dartmouth College
contact: Genie Braasch (603) 646-3480
- 1 GLOBEC Georges Bank Proposal
for details, see Summer 1995 GoM NEWS
contact: Bob Groman (508) 289-2409
- 2 **RARGOM meeting**
Dartmouth College
contact: Genie Braasch (603) 646-3480
- 8 Exotic Species Workshop: Issues Relating to
Aquaculture and Biodiversity, MIT
contact: Christine Hardiman (617) 253-7092
- 12-16 AGU / ASLO meeting, San Diego, CA (special
session on "Physical/Biological Interactions on
Georges Bank and the Gulf of Maine")
contact: Kristen Hansen (202)462-6900ext.382

March

- 13-14 Council on the Marine Environment
Working Group meeting
Boston, MA
contact: Beth Dellavalley (207) 287-1482

Regional Association for Research on the Gulf of Maine
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Gulf of Maine NEWS

Winter 1996
Volume 4 Number 1
Issued four times a year
Editor: Eugenia F. Braasch

printed on recycled paper

Call for Papers

"Open-Ocean Aquaculture"

The UNH/UMaine Sea Grant College Program, UNH Cooperative Extension, and National Marine Fisheries Service are sponsoring a conference on May 8-10, 1996 in Portland, Maine.

Marine aquaculture in the Northeast United States is currently limited by the availability of nearshore grow-out areas. Continued growth of the aquaculture industry will require development of off-shore facilities to grow-out. Engineering, regulatory, economic, and social issues will need to be addressed before offshore, open-ocean aquaculture becomes a reality.

Topics of this conference include: latest developments in cage design for high-energy environment, suitability of various species for offshore culture, economic feasibility, regulatory and environmental considerations, reports from existing offshore operations in Israel, Norway, and other sites.

Abstracts are due on January 15th.

For further information, contact:

Rollie Barnaby, UNH Cooperative Extension/Sea Grant,
603-679-5616, (rollie.barnaby@unh.edu)