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WOODS HOLE OCEANOGRAPHIC INSTITUTION

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GLOBEC Researchers Aim to Understand Causes and Impacts of Climatic Variability on Georges Bank

Major fish stocks worldwide are severely overfished, leading to declining catches, economic hardships, international conflicts, and long-term ecological damage. Survival of fish populations depends on natural physical and biological forces, whose interactions are not well understood. Thus, long-term management of fish stocks needs to be based on understanding the natural ecology of the fishery habitat as well as on the performance of the fishery. Global climate changes may have severe or unexpected effects on fishery environments such as the continental shelf regions of the northern North Atlantic that, until recently, had supported cod and haddock fisheries for centuries.

The US GLOBEC (GLOBal ocean ECosystems dynamics) research program on Georges Bank was initiated in 1994 to investigate how global climate change might affect the abundance and production of animals in this important fishery. The program specifically addresses the population dynamics of zooplankton species focusing on the “target species” Calanus finmarchicus and Pseudocalanus spp. A guiding premise of the program is that climate change will impact marine animal communities through the effects of air/sea interaction on the physical structure of the ocean. These effects in turn are hypothesized to alter the distribution, abundance, and dynamics of the zooplankton and fish inhabiting the ecosystem.

This logo illustrates the mean clockwise circulation around Georges Bank and features the two key target species of the U.S. GLOBEC Georges Bank program, the copepod Calanus finmarchicus *and larval cod.*

The Georges Bank program consists of four major programmatic elements: modeling, retrospective/synthesis analyses, broad-scale studies, and process-oriented studies. The field programs are structured for alternate years of intensive process - oriented studies in 1995, 1997, and 1999. Broad-scale studies (via ship, drifter, mooring, and satellite observations) are conducted in each of the intensive process-study years as well as in the intervening years (1996 and 1998).

Modeling. Modeling is an essential part of the effort to interpret and synthesize the field and

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Coastal Ocean Processes Symposium Honors Memory of Bill Grant

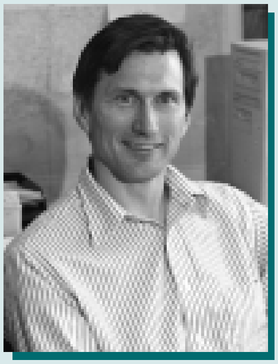
William D. (Bill) Grant was a dynamic and gifted researcher who made an indelible mark on coastal research before his untimely death in 1986. His interest in and excitement about interdisciplinary, coastal research spurred a major growth in fluid dynamics investigations in the AOP&E Department, and his insights into continental shelf boundary layers have guided the scientific community for more than a decade.

Bill Grant – page 2


Gretchen McManamin

Runners and symposium participants at the kick-off luncheon for the Coastal Ocean Processes Symposium.

A Message from the Director:



There are few topics of more universal interest than weather and fish. While not long ago these were both safe topics for discourse with one's father-in-law or barber, they are quickly approaching "hot-button" status. The human contribution to climate change on the one hand and the worldwide decline of fish stocks on the other have intensified the political stakes in both of these issues, with major potential consequences for industry, resource management, and diplomacy.

But what is the connection between weather and fish? Are there factors beyond fishing activity itself that may explain the decline of fish stocks? And what are the consequences of climate change on the last, wild food resource? These questions motivated the US GLOBEC (GLOBal ocean ECosystem dynamics) Program, perhaps the most ambitious, interdisciplinary investigation of marine ecology ever undertaken. The life histories of fish and their prey, the zooplankton, are complex, with some stages that are particularly sensitive to physical variations in the marine environment. These variations are often forced by atmospheric conditions, hence the weather connection.

The GLOBEC Program generates a powerful synergy between physical and biological oceanographic research in a massive observational and modeling study of Georges Bank. As chair of the US GLOBEC Georges Bank executive committee, WHOI biologist Peter Wiebe leads a large and talented team of investigators from WHOI and a number of other institutions in the US and Canada. GLOBEC provides one of the best examples to date of tightly integrating observations and modeling to address a complex, interdisciplinary problem. The program also holds promise for effectively bringing together two unlikely bedfellows: scientific research and environmental resource management. Because the GLOBEC Program so well exemplifies the goals of the RCRC, it is featured prominently in this issue of the newsletter.

Rocky Geyer
Director

RCRC Calendar for January – June 1999

JANUARY ------------------ Coastal Traineeship Seminars

MARCH 15 ------ Pre-proposal Deadline for WHOI Sea Grant's 2000 – 2002 Omnibus Competition

APRIL 16 ---------------- Annual RCRC Proposal Deadline

JUNE -------------------------------- RCRC Open House

Bill Grant – from page 1

Friends and colleagues gathered in Woods Hole to celebrate Bill's life and science at The Coastal Ocean Processes Symposium held September 27–30, 1998 (photo page 1).

The symposium opened with the third Annual Bill Grant Memorial Run, a hotly contested one-tenth marathon from the Captain Kidd Restaurant to the Rinehart Coastal Research Center. Joint Program graduate Michael Bruno won the men's division. Bethany Grant, who married Bill Grant's brother Jonathan the day before the Run, won the women's division.

More than 80 scientists in a variety of disciplines gathered to discuss coastal fluid dynamics, sediment transport, and animal/sediment-flow interactions, three fields on which Bill Grant focused during his brief career. Highlights of the presentations included a sophisticated analysis of wind-forced relaxation events on the California shelf by John Allen (Oregon State University); an innovative and surprising laboratory investigation of shoreline response to changes in sea level at geological time scales by Chris Paola (University of Minnesota); and an insightful review of research on organism/sediment-flow interactions by Cheryl Ann Butman.

The Symposium was funded by the Office of Naval Research, the Rinehart Coastal Research Center, the United States Geological Survey, and the Woods Hole Oceanographic Institution. Organizers were John Trowbridge, Dave Cachione (USGS), and Gretchen McManamin.

Studies Examine Benthic Transport Processes That Influence Protozoa in Buzzards Bay

Protozoa are widely recognized as key links in planktonic food webs, where they are the principal grazers of microalgae and bacteria. Similarly, near-bottom and sedimentary protozoa are likely to be as important to food webs, but their ecology has been much less studied, partly due to difficulties in addressing the complex physical-biological interactions occurring at the sediment-water interface. Our ongoing research in Buzzards Bay has revealed tight couplings between such benthic transport processes as sediment resuspension and protozoan ecology.

With funding from the Rinehart Coastal Research Center and the National Science Foundation, we built an instrument to sample protozoa in near-bottom water as close as 0.5 centimeters above the unstable sediments in Buzzards Bay. Deployed by scuba divers from R/V Asterias, and in conjunction with simultaneous sediment sampling, this sampler allows us to track changing distributions of protozoa as tidal currents repeatedly transfer cells between the sedimentary and water-column habitats. Surprisingly, only certain species engage in cycles of resuspension and deposition corresponding to the tides, while others maintain relatively constant distributions. These results are altering views of habitat specificity among protozoa, and they point to potentially complex food-web connections between the sediments and the water column that are controlled by bottom currents.

This summer we plan to use a new annular flume in the RCRC Coastal Research Laboratory to determine whether bottom flow has a direct influence on protozoan feeding rates. We theorize that prey contact rate is determined partly by turbulence and laminar shear near the sediment-water interface, to a degree that depends on flow strength and the vertical position of cells. These processes may constitute links between coastal currents, protozoan population dynamics, and cycling of organic matter in coastal habitats.

Jeff Shimeta with a McLane pump, coupled to his instrument for sampling protozoa above the sediment-water interface.

This article was contributed by Jeff Shimeta, Assistant Professor in the Biology Department at Franklin & Marshall College and Guest Investigator in the Applied Ocean Physics and Engineering Department at Woods Hole Oceanographic Institution.

Coastal Traineeship Seminar Series

WHOI's Education Office and the RCRC are jointly sponsoring the Coastal Traineeship Seminar Series, to be held in January 1999. Addressing this year's theme "The challenges of complexity and variability in coastal oceanographic research," the program will endeavor to expose Joint Program students and the rest of the scientific community to important issues in coastal research. Many scientific problems in coastal oceanography are difficult to solve because of the high degree of complexity of coastal regimes. Much of this complexity is associated with spatial and temporal variability in the properties or processes being studied, which may be difficult to resolve with conventional instruments. Seminar speakers have established successful research programs in various aspects of coastal oceanography. In each case, these investigators have used a variety of approaches to overcome the challenges presented by these complex systems and make important advances in our understanding of coastal processes.

Jim Moffett is organizing a preliminary list of speakers including John Farrington, Rocky Geyer, Jim Moffett, Don Anderson, Candace Oviatt (University of Rhode Island), John Paul (EPA, Narragansett), and Chris Martens (University of North Carolina, Chapel Hill).

Questions regarding the series can be sent to Jim Moffett (508) 289-3218; jmoffett@whoi.edu

GLOBEC Studies Examine Tidal-front Entrainment and Retention of Fish Larvae

Atlantic cod and haddock spawn in the spring on northeastern Georges Bank, and their pelagic eggs and larvae are advected along the Bank's flank by the clockwise circulation (Figure 1). A key to the survival of the larval fish is their retention on the Bank. Georges Bank is encircled by tidal fronts, which are transition zones between well-mixed and thermally stratified waters that may play an important role in the retention of larvae.

In mid-May 1997, Greg Lough (NMFS), Jim Manning (NMFS), and other GLOBEC investigators examined the potential cross-frontal exchange in the vicinity of the tidal front and how it related to retention of fish larvae on Georges Bank. An initial grid of Bongo-net/CTD stations was occupied along the southern flank of the Bank, and, after the tidal front was identified along the 60-meter isobath, drifters were set out on either side of the front and followed for four days while vertical profile sampling was conducted for larval fish and zooplankton. Larval haddock and cod were observed to concentrate in the tidal front in a band 10–20 kilometers wide. Several cross-bank CTD and ADCP (Acoustic Doppler Current Profiler) sections indicated a narrow (less than 10 kilometers) but significant tidal-front jet with residual (that is, tidally averaged) along-isobath velocities of 10–20 centimeters per second in the upper water column (less than 35 meters), consistent with data from a satellite-tracked drifter that logged a residual velocity of 13 centimeters per second for over a week. Model simulations, initialized with observed density structure from the CTD measurements, suggest that only those larvae located shoalward of the ~70-meter isobath, and deeper than 40 meters could be advected onto the shoals, under the jet in the near-bottom, cross-isobath residual flow (0.61-1.2 centimeters per second).

Early larvae, which are relatively buoyant and remain in the surface above a thermocline, would be rapidly advected along the Bank when entrained in the tidal front. Older larvae (greater than eight millimeters), which have developed migratory ability and reside deeper in the water column, would have a greater potential for being transported onto the Bank. Larvae also will experience different physical and biological environments as a result of being advected along the front and/or exchanged from one side to the other.

Larval growth apparently is maximized at the tidal front due to near optimal temperature (7° C) and abundant food. The rapid decline in growth on either side of the optimum temperature suggests that larval survival and recruitment may be sensitive to climate change. The results of the 1997 study provide evidence for the strong influence of physical processes on the early life histories of fish on Georges Bank.

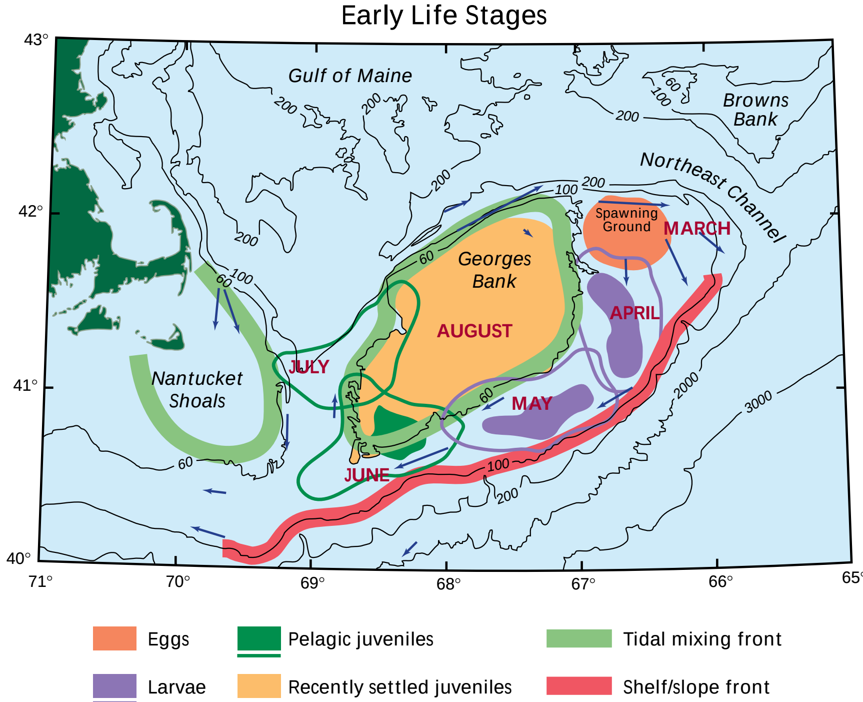


Figure 1. General distribution of cod and haddock eggs, larvae, and pelagic juveniles during their first 3-4 months of life in the clockwise circulation over Georges Bank. The arrows represent the direction and relative speed of mean subsurface flow.

This article was contributed by R. Gregory Lough and James P. Manning who are both Oceanographers with the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration, Woods Hole, MA.

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experimental measurements. The initial physical and subsequent combined physical and biological models are designed to capture the collective understanding of the processes that control the distribution and abundances of the target species. For much of the modeling work, a finite element grid provides the backbone for both diagnostic and prognostic modeling of the of Northwestern shelf system circulation including that on Georges Bank. A team led by Dan Lynch (Dartmouth College) and Cisco Werner (University of North Carolina) developed this hydrodynamic model. Biological models are coupled to physical models to integrate the population dynamics and to hind-cast distributional property fields in an effort to find links between spatial changes and physical and biological forces responsible for the changes. For example, Dennis McGillicuddy and Cabell Davis use the coupled models to study the distributions of Calanus finmarchicus and Pseudocalanus spp. on the Bank. McGillicuddy has teamed up with Lynch to apply advanced techniques of data assimilation to constrain the unknown model parameters using GLOBEC data on Calanus distributions (see article on page 7). Data-assimilative models are also being applied at finer spatial scales in order to determine the influence of fronts, turbulence, and small-scale circulations on organism distributions and survival. During the Phase III process studies, both interactive models capable of producing now-casts at sea for use in guiding shipboard studies and idealized process-oriented model studies will be used in tandem with the field work and laboratory experiments.

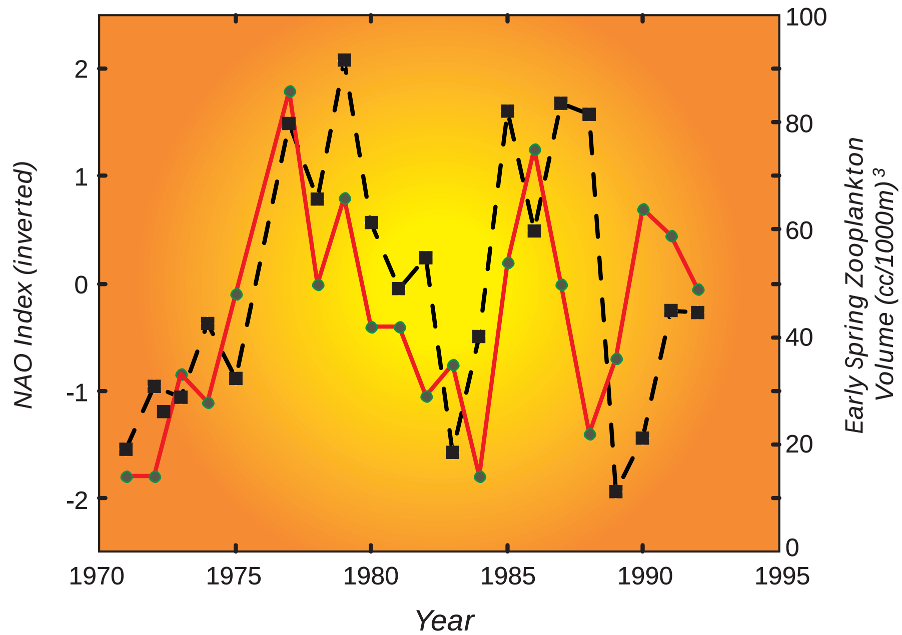

Figure 1: Comparison of the inverted, detrended NAO index and the average zooplankton displacements volume for Georges Bank during the MARMAP (Marine Resource Monitoring Assessment and Prediction Program) years.

Zooplankton data from Sherman et al., (1995); Comparison created by David Mountain.

Retrospective/Synthesis Analyses. Retrospective studies focus on both the hydrography and the biology of the Bank, using long-term historical records dating to the early 1900s. In an effort to determine the connection between physical and biological variability, David Mountain (National Marine Fisheries Service) found a significant relationship between large-scale variability of the climate over the North Atlantic (based on the detrended North Atlantic Oscillation [NAO] Index, a climate change indicator) and Georges Bank zooplankton displacement volumes (a measure of plankton abundance) (Figure 1). This kind of correlative study provides the direction and motivation for detailed analysis of the processes linking the physics and biology.

Broad-Scale Studies. The broad-scale studies include multi-disciplinary moorings (Jim Irish, Ken Brink, and Bob Beardsley), long-term drifter deployments (Dick Limeburner and Bob Beardsley), analysis of satellite data (Jim Bisagni, University of Massachusetts, Dartmouth), and shipboard surveys. Broad-scale cruises carry out CTD (conductivity, temperature and depth), zooplankton, fish larval, and acoustic surveys of Georges Bank and adjacent waters (Figure 2). The “standard” stations consist of a Bongo tow, a CTD cast and a one-meter-square MOCNESS (Multiple Opening/Closing Net Environmental Sensing System) tow (Figure 3). The Bongo net tow provides intensive coverage of the larval cod and haddock during the first five months of the year.

Process Studies. The first process-oriented study, conducted in 1995, was called the Stratification Study. A large team of scientists investigated how the spring development of vertical stratification and reduced wind-driven mixing over the southern flank of

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Georges Bank influences the distribution of the zooplankton food supply, thus affecting the vital rates and survival of cod and haddock during their planktonic early life stages. Studies of the small-scale spatial distribution of these species employed the Video Plankton Recorder (VPR) newly developed by Cabell Davis, Scott Gallager, and Carin Ashjian. In Phase II, the primary focus of the 1997 process studies was on the sources, retention, and losses of water and organisms from the Bank (see article on page 4).

The primary focus for Phase III (1999 field year) will be on cross-frontal exchange processes. The Georges Bank region has major frontal features around the periphery of the Bank and a tidal mixing front located near the 60-meter isobath that surrounds the well-mixed water over the shallow crest of the Bank. The exchange of physical and biological properties across these fronts can influence the supply of nutrients for primary production, the retention (loss) of the target species and their prey on (from) the Bank, and interactions between the target species, their prey, and their predators.

Cross-frontal exchange is influenced by physical processes that determine the location, deformation, and movement of the front, including tides, winds, seasonal heating/cooling, and offshore forcing, and by biological characteristics and behavior that may enhance or minimize exchange.

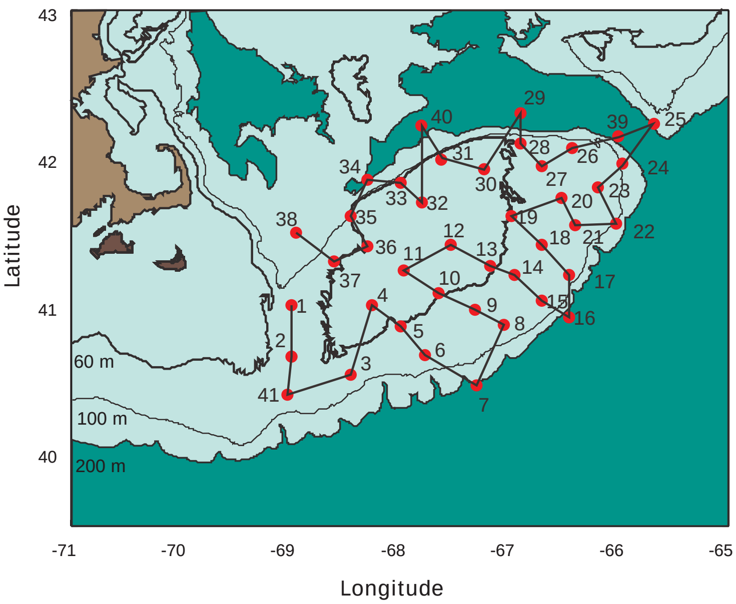


Figure 2: Broad-Scale Stations on Georges Bank.

Marine plankton tend to aggregate in frontal regions because of such physical processes as divergence or convergence and such biological factors as enhanced production or behavior (for example, depth-keeping swimming). These aggregations of plankton naturally provide an enhanced food source for predators, including larval cod and haddock. Fine-scale description of the physical and biological fields comprising fronts may reveal aggregations of phytoplankton and zooplankton associated with specific physical (for example, density, temperature) structures.

Phase III work will focus on:

- The three-dimensional circulation associated with the fronts around and on Georges Bank,
- determination of the patchiness structure of plankton and larval fish observed at the frontal structures on the Bank,
- determination of exchange rates, due to frontal processes, of water properties and the target species across the fronts on the Bank,
- the biological and physical processes that interact to control cross-frontal exchange of target organisms,
- how frontal movements influence the exchange of water and organisms across the different fronts, and
- how the cross-frontal exchange rates of water and target species vary on seasonal time scales.

Within the context of the cross-frontal exchange emphasis, there is a continuing need for cohort studies to determine the vital rates of the target species and the influence of frontal processes upon these rates.

A complete listing of all participants in the program and additional information about the program can be found at the U.S. GLOBEC Georges Bank Web Site (http://globec.whoi.edu).

This article was contributed by Peter H. Wiebe, a Senior Scientist in the Biology Department.

Figure 3: MOCNESS being deployed.

GLOBEC Scientists Model Physical/Biological Interactions on Georges Bank

Coupled physical/biological phenomena in the ocean are dauntingly complex. They involve numerous organisms, unknown or even unobservable processes, and space-time scales ranging from tiny (planktonic) to huge (ocean physics). Within the US GLOBEC program we are trying to construct computer simulation models for some key interactions among larval fish (cod, haddock), two zooplankton species, and their physical environment on Georges Bank (Figure 1). The combination of the complexity of the processes involved, and the requirement that results be spatially explicit (that is, relate to actual conditions observable on Georges Bank) represents a tall order. Thanks to a supportive and enthusiastic communitywide involvement, both among modelers and observationalists, we have been making headway.

Mathematically speaking, we are generally dealing with ill-posed problems, that is, problems with no unique solution. Why? To begin with, we often do not have clear and unambiguous sets of equations to work with, since the general ecosystem problem is far too complex to attempt. Then there is the problem of data support—we need enough to parameterize all processes, initialize all model states, and provide all forcing needed. However, for a spatially explicit model, the density of data needed for mathematical satisfaction is unattainable in practice. As a result, we are faced with a basic problem of how to fill in the gaps in scientifically meaningful ways. Fundamentally, we have a grand problem in system identification and inference:

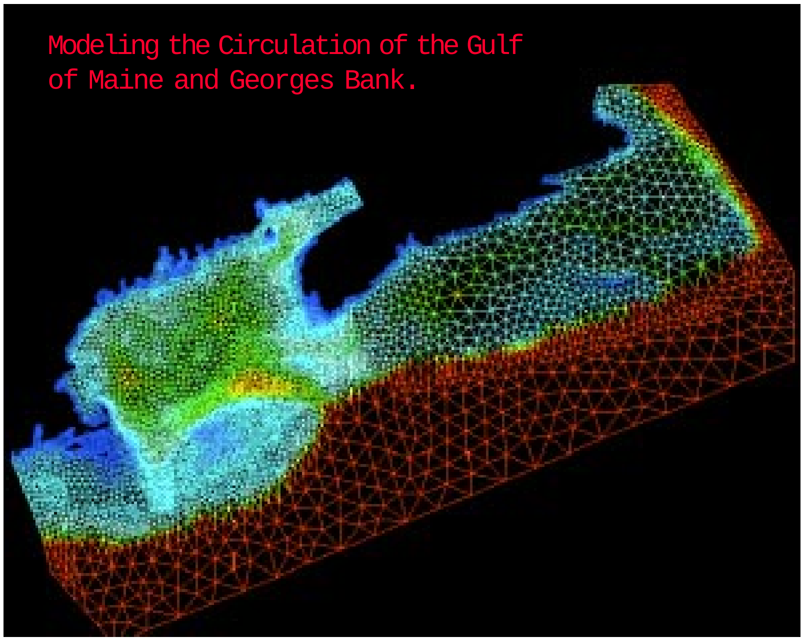


Figure 1. Finite element model grid for the GLOBEC region developed by Lynch and the Dartmouth modeling team.

We are using computer simulations to answer such questions as "what is going on here?" given that we are imperfectly sampling a system that is only partly understood.

Here are two examples concerning the copepod species Calanus finmarchicus and Pseudocalanus. The first involves simulating the large-scale abundance and distribution of the copepod Calanus finmarchicus in the Gulf of Maine and its transport to and from Georges Bank. In this work we are using carefully structured simulations to isolate a conceptual model wherein late-stage, diapausing copepodites (that is, pre-adult copepods which are in a resting state in deep waters near the bottom) are activated in winter, rise to near-surface waters, are transported to the Bank under the prevailing wind, and begin reproducing once in the food-rich Bank environment. In these simulations, we have been able to deduce that there must be significant, though to date unobserved, near-bottom populations of copepodites. Without these populations, observed concentrations of zooplankton wash out of the model much too quickly. We have also concluded that zooplankton reproduction may well be limited by insufficient food over the Gulf of Maine—otherwise we cannot explain the observed timing of the initial zooplankton bloom. Both of these inferences lead directly to recommendations for future field sampling. (See Reference 1 for details.)

We have adopted a more formal, mathematical approach to the problem of inference in a study of the copepod Pseudocalanus. As in the case of Calanus, we have decade-long observations of the annual cycle for this animal. We use simulations to transport observed patterns of

GLOBEC Scientists – page 11

Mud Snails Enhance Hydrodynamic Transport of Juvenile Clams

Many coastal clam species disperse in a larval stage and spend weeks drifting in currents. The location and timing of larval settlement back into the benthic habitat plays an important role in the distribution and dynamics of the populations. Small juveniles, however, do not necessarily remain in the spot where they settle, and post-settlement movement may result in substantial redistribution of individuals within a bay, or export out of it.

Because the newly settled juvenile clams are small (less than 1 millimeter) and have limited ability to migrate with their feet, most of their movement occurs through resuspension and transport in near-bottom flows. This transport is not solely determined by physical processes: Some species produce a byssal thread that enhances their drift (much like thread-drifting in wind by newborn spiders), and others burrow up or down to increase or decrease their susceptibility to suspension. Furthermore, activities of other, larger benthic organisms may disrupt the clams or alter sediments in ways that affect their suspension.

The objective of our study is to understand how the behaviors of juvenile clams and their benthic neighbors interact with coastal flows to cause resuspension and transport. We are looking specifically at disturbance by the mud snail Ilyanassa obsoleta, which occurs in very high densities in bays and estuaries along the eastern seaboard. Our question is whether burrowing and migration activities by the snail affect the susceptibility of soft shell clam Mya arenaria juveniles to resuspension in boundary-layer flows. We expect the effect to vary with clam size, because larger clams are able to burrow deeper, and with hydrodynamic regime (suspension may be more likely in episodic wind events than in typical tidal flows). Our ultimate goal is to define the clam's suspended life stages in a range of flow conditions in order to evaluate the importance of this process to their survival and distribution. We use a combined approach of laboratory flume studies and manipulative field experimentation.

We used the 17-meter flume in the Rinehart Coastal Research Center to investigate the effects of snails on resuspension of juvenile clams over a range of flow speeds (measured as shear velocity) and for clam sizes representing newly settled and late-season individuals. Juvenile clams were allowed to burrow into the sediment in the flume, and a series of 40-minute runs were conducted with and without snails (Figure 1). We found that snails reduced the critical erosion velocity (the lowest shear velocity causing suspension) for clams of both sizes. Furthermore, in flows faster than the critical erosion velocity, snails significantly increased the number of clams suspended. Visual observations of the clams showed that snails enhanced their suspension by disrupting their burrowing and causing them to be exposed at the sediment surface.

In the field, the effects of snails were investigated by creating on intertidal sand flats caged plots (one-square-meter each) that excluded snails and then comparing them to control plots that allowed snails access. We monitored a total of ten plots through the summer season starting on July 15, 1997. Juvenile clam abundances were counted in sediment cores collected at in-

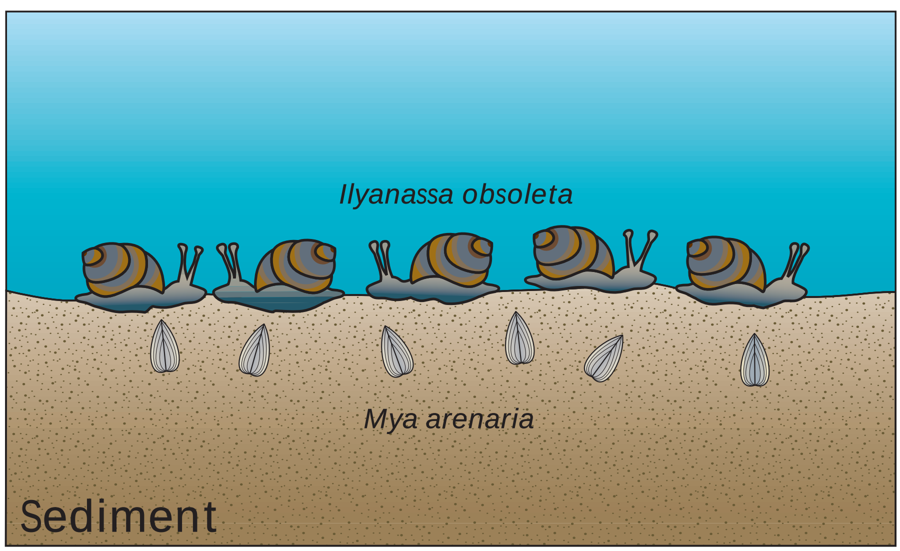


Figure 1. Side-view of experimental setup in 17-meter flume. After 200 clams (Mya arenaria) had burrowed into sediment in the flume, flow was established for a 40-minute run. Each run was conducted with one clam size (newly-settled or late-season), at one flow speed (shear velocity ranged from less than 1 centimeter per second to 2 centimeters per second), and with or without snails (Ilyanassa obsoleta). Three replicate runs were conducted for each combination of treatments.

tervals of 12, 34, and 45 days after the experiment was started. On day 12, clam abundances were substantially reduced in the plots with snails (Figure 2). This result indicated the snails were causing juvenile clams to be suspended and transported (the snails are not predators of live clams). On day 34, this pattern was still apparent but not as pronounced, possibly because erosion under the cages had allowed snails access to two of the snail-exclusion plots. On day 45, a major wind event had eroded access holes under most of the plots, and no difference was found between the snail-exclusion and control treatments.

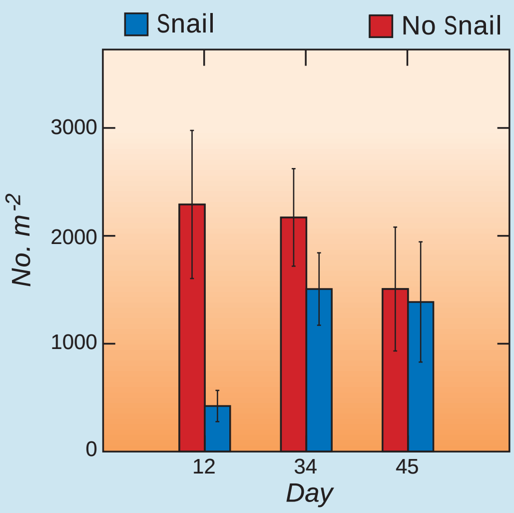


Figure 2. Abundance of juvenile clams (Mya arenaria) in sediment core samples collected under cages that excluded (No Snail) or allowed access to (Snail) the mud snail Ilyanassa obsoleta. Values are means and standard errors of five samples. All cages were intact on day 12, but by day 34 erosion had allowed access under two No Snail cages. The erosion holes were filled, but by day 45 a large wind event had again eroded holes under most of the cages, giving snails free access to the plots.

The laboratory flume results show that mud snails reduce the critical erosion velocity of juvenile soft-shell clams, and significantly increase clam suspension in faster flows. The field results indicate that this process has a substantial effect in the natural environment. Thus, disturbance by benthic organisms is likely to play an important role in the distribution and abundance of juvenile clams in coastal habitats

Acknowledgements. Most of the work for this study was done by Susan Mills (Senior Research Assistant in Biology) and Rob Dunn (undergraduate in the WHOI Summer Student Fellowship program). We are grateful to Tom Marcotti and Kris Clark for their tireless help in the field and to Doug Kalweit and the Barnstable Department of Natural Resources staff for generous use of facilities. Dale Leavitt helped inspire the project, and Beals Island Shellfish Hatchery and Mook Sea Farm provided clams and advice. Support was provided by WHOI Sea Grant, the RCRC, and WHOI Education. A manuscript based on this study is in revision for Marine Ecology Progress Series (in press, Dec. 98).

This article was contributed by Lauren S. Mullineaux, an Associate Scientist in the Biology Department.

Access to Scientific Information about the Gulf of Maine

The results of coastal research are in great demand by many groups, and this demand forces research organizations to make some effort in the area of “research translation” and “outreach.” In early November, the New England Aquarium and the Gulf of Maine Council on the Marine Environment sponsored a three-day workshop entitled “Out of the Fog: a workshop towards establishment of an effective electronic environmental information exchange system.” The purpose of this meeting was to expand the access to environmental data beyond marine scientists and resource managers to additional interested groups including marine educators, fishermen, business and community groups, and other non-government organizations.

There was overwhelming consensus that access to and sharing of Gulf of Maine region information and data should be maximized, probably through linkages among local initiatives. Most participants supported the notion of centralized access (a portal or a front door) to information, with a clear “road map” incorporated to assist users. However, ultimate responsibility for compiling, making available and maintaining information and data should lie with respective interest groups. Several possible action steps were identified as a follow up to this workshop, including: a) facilitate links between groups with related interests, b) identify an institutional leader to get things rolling, c) conduct a gap analysis of existing electronic data/information, and d) prepare a strategic plan to prioritize action steps and to identify sustainable sources of support for these steps.

This article was contributed by Bruce W. Tripp, Assistant Director of the Rinehart Coastal Research Center.

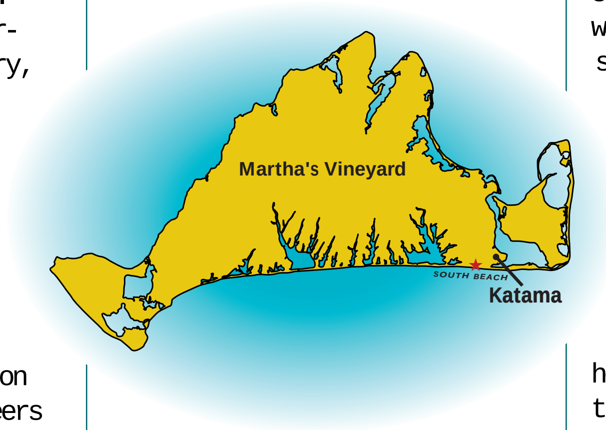
Work Begins on Katama Observatory

WHOI scientists will soon establish a new observatory on Martha's Vineyard to collect data on shoreline processes such as air-sea exchange, coastal storms, beach erosion, sediment transport, and coastal ecology.

Initial construction is underway on the Katama Observatory, to be located off the island's southern coast. The $1.2 million observatory will be built over the next two years with funding from the National Science Foundation and a 30 percent cost share by WHOI.

WHOI scientists James Edson and Wade McGillis and engineers Thomas Austin and Christopher von Alt will be heading the long-term project with co-Principal Investigators John Trowbridge and Cheryl Ann Butman. They plan to use the data collected at the Katama Observatory to better understand the diverse natural processes occurring along shorelines and coastal environments. Long-term operation of the observatory will allow researchers to learn more about how the ocean interacts with coastal regions over annual and, ultimately, decadal time periods.

The observatory will be barely visible to the public, since much of the hardware will be offshore and all cables will be underground. It will consist of a small shore station, a 20-foot meteorological tower to measure wind speed



and direction, and two nodes for the underwater ocean sensors (Figure 1). The shore station will be located at the Katama Air Park, near the Edgartown hanger facilities. The shore station will be connected to existing local power lines and will also have a backup generator that will automatically engage during power failures, such as during hurricanes or severe storms.

Long-term meteorological instruments will be deployed atop a mast located near the ocean's edge to monitor marine atmospheric conditions. Other instruments ashore will be mounted at a monitoring station located well behind the beach. Oceanic sensors deployed in 35 to 50 feet of water approximately 1 mile offshore will be connected to monitoring devices at the observatory by underground cable. Cameras will be deployed to transmit photographs and video of this unique environment at both locations. These combined sensors will collect data 24 hours a day, measuring everything from wind speed and direction to water temperature, salinity, and wave heights. The observations will then be posted to the World Wide Web so that scientists, local officials, students, and anyone else interested in ocean processes will be able to access the information as it is collected.

Using this equipment, scientists will be able to study underwater phenomena as they happen without getting their feet wet. The instrumentation will also allow investigations of how the passage of severe storms

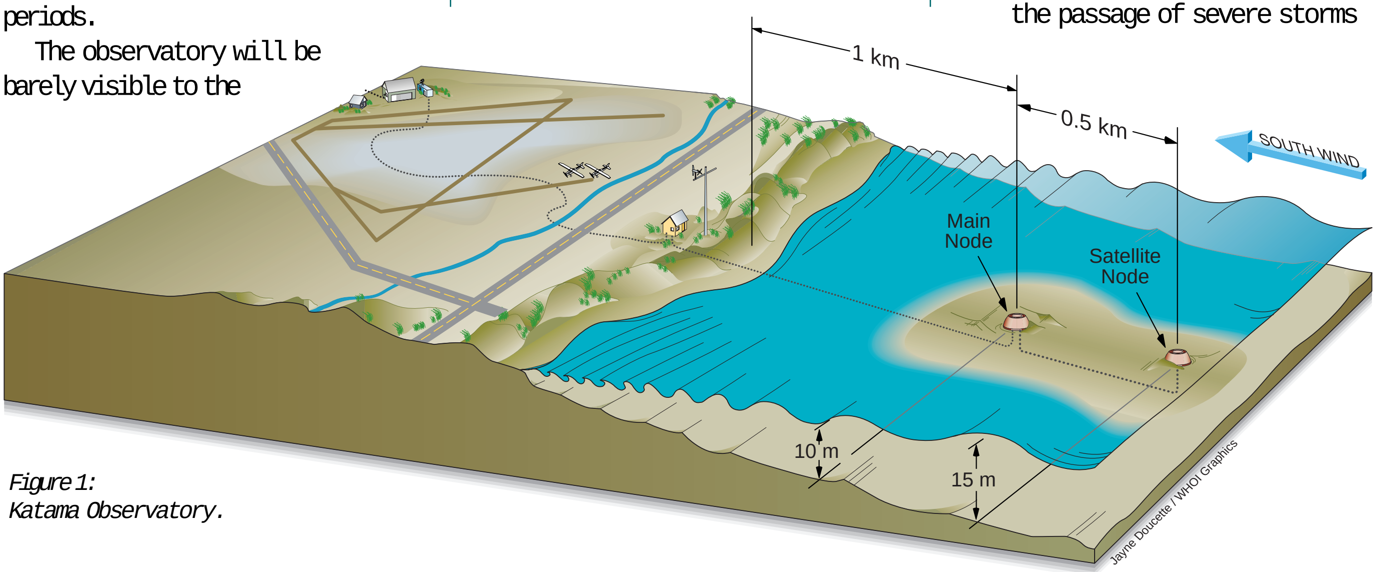


Figure 1: Katama Observatory.

and possibly even hurricanes affect coastline evolution.

The Katama Observatory joins two similar installations, "LEO-15" (Long-term Ecosystem Observatory in 15 meters of water) located off Tuckerton, New Jersey, and the US Army Corps of Engineers Field Research Facility in Duck, North Carolina. These three facilities will provide a unique network along the East Coast to monitor the variations of coastal processes along the Atlantic seaboard and provide valuable information to help manage coastal resources. Expertise gained during design and installation of LEO-15, a joint WHOI-Rutgers University project, will be applied to the Katama Observatory. One difference between the Katama Observatory and the other two is that it will face south rather than east, allowing the measurement of different onshore winds as weather systems propagate up the east coast and out to sea.

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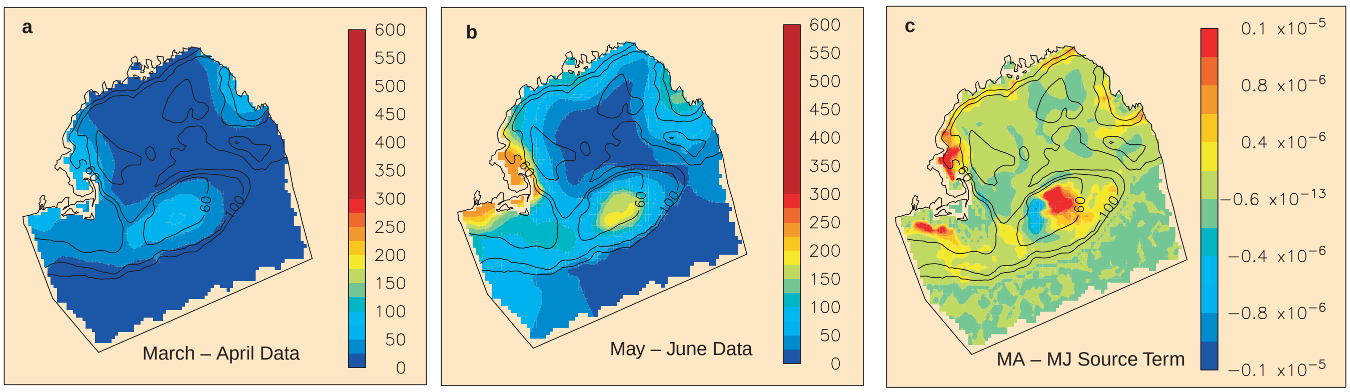

Figure 2: Data on zooplankton abundance (panels a and b) are used as inputs into an inverse calculation to determine the spatial variation of the "source term" for zooplankton on Georges Bank (panel c).

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abundance in, say, May, and ask, "what net population dynamics (net of birth minus death) needs to be added to obtain the observations two months later?" (Figure 2). The procedure is a formal inverse calculation, meaning that we calculate the unknown parameters related to copepod population dynamics based on the observations and model representation of the transport processes. These inverse calculations do not necessarily produce an incontrovertible representation of "reality," but they provide a mathematical formalism for "backing out" the ecological variables controlling population distributions. This work is at the very beginning of a scientifically iterative process by which forward and inverse approaches are used in tandem to systematically refine each other. (See Reference 2 for details.)

Using these and other inference techniques, we are beginning to see progress in understanding these complex issues. Many colleagues, both modelers and experimentalists, are contributing to this progress, and we are looking forward to the emergence of a community modeling capability in the coming phases of GLOBEC.

The GLOBEC Modeling Team Institutions include: Dartmouth College; University of North Carolina; Northeast Fisheries Science Center; Canadian Dept. of Fisheries and Oceans; Woods Hole Oceanographic Institution; and Rutgers University.

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