# Gulf of Maine NEWS

Regional Association for Research on the Gulf of Maine Spring 1996

## Abundance patterns of *Calanus finmarchicus* in the Gulf of Maine: 1977-1987

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During 1977-1987 the National Marine Fisheries Service maintained a broad-scale sampling program (MARMAP; Sherman 1980) off the northeast continental shelf. This time series of data allows a unique opportunity to characterize the distribution and seasonal cycle of various life history stages of *Calanus finmarchicus* throughout the Georges Bank-Gulf of Maine region. In this newsletter we will present the basis of our findings in the form of distributional maps for total Ca*lanus* and give some general discussion to the patterns that are evident. This work is in press in Deep Sea Research and the interested reader can refer to it for more detail (Meise and O'Reilly *in press*).

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**In This Issue:**



## Satellite-Derived Sea Surface Temperature Variability in the Gulf of Maine

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Oceanography has traditionally depended upon relatively sparse spatial and temporal sampling from research vessels. However, over the last two decades, satellite remote sensing has proven itself to be a method by which large ocean areas could be sampled synoptically at least every few days. This was achieved through 1) deployment of space-based sensors, e.g., the Advanced Very High Resolution Radiometer (AVHRR) for determination of sea surface temperature, 2) study of the interaction of electromagnetic radiation with the ocean and the intervening atmosphere, 3) development of computer algorithms for retrieval of oceanographic parameters from raw satellite data and 4) collection of "ground truth" information for algorithm validation.

Oceanographers from NOAA's National Marine Fisheries Service and the University of Rhode Island's Graduate School of Oceanography, co-located on the Bay Campus in Narragansett, Rhode Island, are using satellite-derived AVHRR data to study sea surface temperature (SST) variability over the Gulf of Maine, Georges Bank and the western Scotian Shelf (Fig. 1). In this overview, we provide information concerning the motivation for our work, a short summary of the methods used and some preliminary results. Support for this work is being provided primarily by the Gulf of Maine Regional Marine Research Program with additional support from NASA and the joint NSF/NOAA US-GLOBEC Northwest Atlantic Georges Bank Program.

*(continues on page 6)*

*Figure 1*

## Sampling

Cruises went out approximately 6-12 times a year and occupied standard stations (Figure 1) that were placed 25-35 km apart. Zooplankton samples were taken with a 333 mesh net towed from surface to bottom (max. depth 200m) at speeds ranging from 1.5-3.5 knots. Samples were sorted to species level at the Plankton Sorting Center, Szczecin, Poland.

## Statistical Analyses

The compiled data set consists of 5966 samples. To unify data from several field programs, each with different spatial sampling patterns, data were grouped into standard stations based on their proximity to the MARMAP stations (Figure 1).

Data over the entire ten-year period, irrespective of year, were grouped into six two-month intervals or 'seasons' (January-

*Figure 2*

February, March-April, May-June, July-August, September-October, and November-December). Abundance estimates (No. /10m$^2$) of *C. finmarchicus* were log-transformed [$Log_{10}$(abundance+1)] prior to statistical compositing and analyses. Contoured distributional maps for each two-month period were generated using means of log-transformed abundances grouped by standard station. Standard station coordinates were transformed to map coordinates using Lambert's conic conformal map projection (Snyder 1987), and Surface III contouring software (Sampson 1988).

## Georges Bank

There are several distinct water masses on Georges Bank due to the bathymetric gradients, tidal currents and hydrographic fronts found in this region (Butman and Beardsley 1987, Flagg 1987). These features all appear relevent to the distribution of *Calanus finmarchicus*. *C. finmarchicus* abundance patterns on Georges Bank (Figure 2) reflect the seasonally integrated influence that these frontal systems have on population abundance. From July-December, *C. finmarchicus* is relatively scarce in the shallow water on the Bank. The work of Perry et. al. (1993) reported sharp gradients in the composition and abundance of the zooplankton community along the northern flank of Georges Bank in July 1988. Their study revealed that adults and late stage copepodites of *C. finmarchicus* were much less abundant on the Georges Bank (unstratified) side of the tidal mixing front than on the Gulf of Maine (stratified) side. Abundance patterns shown in Figure 2 demonstrate a sharp deliniation between the Gulf of Maine and the northern edge of Georges Bank that is most apparent during the stratified season (May-October), when thermohaline density gradients and the near-surface current jet along the northern flank are generally strongest (Flagg 1987).

Low levels of *C. finmarchicus* in mixed Georges Bank begin in May-June and persist through December (Figure 2). The decline in the population from March-April to May-June is concurrent with the arrival of high numbers of *Sagitta* spp. (Davis 1987a; Sullivan and Meise *in press),* spring migrating Atlantic mackerel, *Scomber scombrus* and sand lance, *Ammodytes*

*Figure 3*

*ammericanus* (Grosslein and Azarovitz, 1982). These are potentially significant grazers of *C. finmarchicus*, but the quantitative extent of their influence on the Bank is uncertain.

Several physical features help to maintain the pattern of low abundance through December in mixed Georges Bank and relatively higher abundance in the stratified southern flank of Georges Bank. During summer and fall, the mixed area of Georges Bank is semi-closed, having limited horizontal exchange with surrounding water (Flagg 1987). Water column temperatures in the center of the bank increase to levels unfavourable to *Calanus* (Marshall and Orr 1955). These features, combined with the relatively long generation times of *C. finmarchicus* and its seasonal migration into deeper waters, make replenishment of this mixed area unlikely until winter, when the Georges Bank-Gulf of Maine frontal zone is less distinct and there is more movement of Gulf of Maine water onto Georges Bank (Hopkins and Garfield 1979). Seasonal distribution maps support this idea (Figure 2). Repopulation of the mixed area on Georges Bank begins in January-February along the northern flank, northeast peak, and the eastern side of Georges Bank and continues through March-April, when annual peak abundance is achieved in the mixed area.

As the seasons progress, the same limited horizontal exchange that isolates mixed Georges Bank starting in May-June would result in an increase of abundance in the stratified area of Georges Bank. The spring time cohort matures and is advected in from the Gulf of Maine or the Scotian Self, remaining in the stratified area. Advection of Gulf of Maine *Calanus* through the northeast peak onto the southern flank of Georges Bank has been suggested by Davis (1987a) and by our results in the lack of a sharp gradient. Influence from the Scotian Shelf is also suggested by stage and abundance patterns on the NE peak of Georges Bank (Meise and O'Reilly *in press*).

## Gulf of Maine

Southern Gulf of Maine is the area of highest overall *C. finmarchicus* abundance (Figure 2) and lowest seasonal, spatial and interannual variance (Figure 3)(Meise and O'Reilly *in press*). Wilkinson Basin resides here and has long been thought to be a haven for *C. finmarchicus* (see Davis 1987a). Our analyses support this hypothesis and suggests that this area of the Gulf of Maine may be an important source of *C. finmarchicus* for the rest of the region (Figure 2, see above discussion), particularly for the adjacent shallow waters on Georges Bank during winter and early spring.

Adult and younger copepodites of *C. finmarchicus* are present throughout the year in the Northern Gulf of Maine (Figure 2) (Meise and O'Reilly *in press*). Sameoto and Herman (1992) have found younger stages of C*alanus* in the Gulf of St. Lawrence late in the fall, suggesting late season reproduction. *C. finmarchicus* copepodites 1-3 were present in about 5% of the small mesh (165 and 53 um) samples taken in the Gulf of Maine-Georges Bank region during MARMAP surveys in October-December, 1978-1980 (Meise et. al. 1995). Durbin et. al. (1995) have found C. *finmarchicus* nauplii on Georges Bank as early as January. Together these results suggests that a portion of the *C. finmarchicus* population continues to reproduce throughout the year. Perhaps this helps to explain the continuously elevated populations of C. *finmarchicus* and relatively low seasonal variability in Northern Gulf of Maine and Southern Gulf of Maine (Figure 2, Figure 3) (Meise and O'Reilly *in press*).

## Conclusions

One of the more interesting results from our work is the low variance associated with the high 10-year mean abundance of Ca*lanus finmarchicus* in the Gulf of Maine, and to a lesser extent, over the stratified areas of Georges Bank, during all two-month periods (see Figure 2, Figure 3)(Meise and O'Reilly *in press*). This suggests there are stable population centers and pathways onto Georges Bank. This is particularly evident during the March-April period when *Calanus* appears to "wash-over" the bank from its high population centers in the Gulf of Maine. The work of Perry et. al. (1993) and our analyses indicate a sharp gradient, after this period, in the abundance of *Calanus finmarchicus* along the northern flank of Georges Bank. This ecotone is associated with strong gradients in density stratification, and the along-bank current jet, which limit exchange between Gulf of Maine and Georges Bank. During the stratified season, *C. finmarchicus* abundance gradients are less sharp between the Northeast Peak and adjacent water in the Gulf of Maine, suggesting that the Northeast Peak may be a major pathway for movement of *Calanus* from Gulf of Maine onto the southern flank of Georges Bank. However, resolution of the relative influence of Gulf of Maine (via the NE Peak) and Scotian-Shelf water (via NE Channel) on the dynamics of the C. *finmarchicus* population on the southern flank of Georges Bank during the stratified season remains to be clarified.

> The data that were used to generate the maps in this newsletter and those in the Meise and O'Reilly in press article are available as an appendix in Meise and O'Reilly.

## References


Butman, B. and R. Beardsley. (1987) Physical Oceanography. In Georges Bank (R.H. Backus and D.W. Bourne, eds), MIT Press, Cambridge, p.88-98.

Davis, C.S. (1987a) Zooplankton Life cycles. In Georges Bank (R.H. Backus and D.W. Bourne, eds), MIT Press, Cambridge, p.256-267.

Durbin, E., J. Runge, A. Durbin, R. Campbell, P.Garrahan, M. Bemis, S. Plourde. (1995) Late Fall-Early Winter Recruitment of *Calanus finmarchicus* on Georges Bank. The Oceanography Society Meetings. April 1995. Newport RI.

Flagg C. (1987) Hydrographic Structure and Variability. In Georges Bank (R.H. Backus and D.W. Bourne, eds), MIT Press, Cambridge, p.108-124.

Grosslein, M. and T. Azarovitz (1982) Fish Distribution.MESA New York Bight atlas monograph. New York Sea Grant. Albany, New York. 182 pp.

Hopkins T.S. and N.Garfield, III (1979) Gulf of Maine Intermediate Water. Journal of Marine Research 37:103-139.

Marshall S.M. and A.P. Orr (1955) The Biology of a Marine Copepod: *Calanus finmarchicus* (*Gunnerus)*. Oliver and Boyd, Edinburgh, 188 pp.

Meise, C. and J. O'Reilly (*in press*) Spatial and Seasonal patterns of *Calanus finmarchicus* in the Gulf of Maine and on Georges Bank: 1977-1987. Deep Sea Research Special Georges Bank Volume.

Meise, C.; J. O'Reilly; J. Kane (1995) Spatial and Seasonal patterns of *Calanus finmarchicus* and *Pseudocalanus* spp. in the Gulf of Maine and on Georges Bank: 1977-1987. The Oceanography Society Meetings. April 1995 Newport RI

Perry R.I., G.C. Harding, J.W. Loder, M.J. Tremblay, M.M. Sinclair, K.F. Drinkwater (1993) Zooplankton distributions at the Georges Bank frontal system: retention or dispersion? Continental Shelf Research, 13:357-383.

Sameoto D.D., A.W. Herman (1992) Effect of outflow from the Gulf of St. Lawrence on Nova Scotia Shelf Zooplankton. Canadian Journal of Aquatic Sciences, 4**9:**857-869.

Sampson, R.J. (1988) SURFACE III Users Manual. Kansas Geological Survey, Lawrence, Kansas. 277pp. Interactive Concepts Incorporated, Lawrence, KS

Sherman K. ( 1980) MARMAP, A Fisheries Ecosystem Study of the Northwest Atlantic Fluctuations in Icthyoplankton-zooplankton Components and their Potential for Impact on the System. In: Advanced Concepts in Ocean Measurements for Marine Biology. (Diemer, F.P., Verberg, F.J., Mirkes, D.Z. eds) Belle W. Baruch Inst. Marine Biology Coastal Research, University of South Carolina Press, Columbia, p.3-37.

Snyder J.P.(1987) Map Projections-A Working Manual. U.S. Geological Survey Professional Paper 1395. Unites States Government Printing Office, Washington, DC. 383 pp.

Sullivan, B. and C. Meise (*in press*) Invertebrate Predators of Zooplankton on Georges Bank, 1977-1987. Deep Sea Research. Special Georges Bank Volume.

*Figure 1. Study domain along with the locations of NOAA data buoys 44005, 44007, 44008, 44011 and 44013. Also shown are the locations of Georges Basin (GB), Jordan Basin (JB), Wilkinson Basin (WB) and Northeast Channel (NEC) within the Gulf of Maine along with the 200-m isobath (dashed).*

## Motivation & Background

The relevance of our work is rooted in an attempt to better describe and understand the complex, time-varying mesoscale circulation patterns within the eastern and northern Gulf of Maine and the advection of naturally-occurring, toxic phytoplankton blooms and anthropogenic pollutants in these regions. Satellite-derived SST has been used to trace the path of cold, low-salinity waters which enter the eastern Gulf of Maine south of Cape Sable, Nova Scotia, and extend southwestward along the Maine coast as a buoyant coastal plume termed the Maine Coastal Current (MCC). Satellite-derived SST maps from 1982 show that the MCC bifurcates south of Penobscot Bay in the northern Gulf of Maine into alongshore- and offshore-directed branches in response to a cyclonic eddy located over Jordan Basin (Bisagni et al., 1996). Furthermore, these satellite data together with near-surface measurements from a ship of opportunity show that the observed non-seasonal, low frequency physical, chemical and biological variability within both branches of the MCC are correlated with bottom temperature variability within Jordan Basin, and, by inference, the strength of the cyclonic eddy located over Jordan Basin. In addition, earlier work describes the “plume advection hypothesis”, in which toxic phytoplankton blooms are transported southwest along the Maine coast within the MCC in response to forcing by wind and local river runoff (Franks and Anderson, 1992a; 1992b). Additional work, currently underway by D. Anderson, Woods Hole Oceanographic Institution, Woods Hole, MA, is providing additional insights and refinements regarding this hypothesis using a time series of survey cruises from 1993 and 1994 (Anderson et al., 1995).

## Approach & Methods

Our approach is to build a multi-year time series of satellite-derived SST for the Gulf of Maine, extending from fall 1993 through end of summer 1996 in order to investigate SST variability related to wind forcing, river runoff and the strength of the Jordan Basin cyclone. Processing begins by conversion of the raw AVHRR satellite data to SST (Cornillon et al. 1987) using the standard split window algorithm (McClain et al. 1985) to correct for atmospheric absorption, followed by earth location to the study domain shown in Figure 1. Despite the potential for twice-daily SST sampling over the Gulf of Maine from the morning and evening overpasses of NOAA's polar orbiting satellite, a severe space-time constraint is imposed on the sampling as a result of cloud cover which may linger for periods of up to several days over the region. An example of a partly-cloudy image is shown in Figure 2. However, this constraint can be partly overcome using optimal interpolation (OI) after elimination (flagging) of cloud contaminated pixels using automated (Cayula and Cornillon, 1992) and manual (Bisagni and Sano, 1993) cloud-flagging techniques. Mean SST values are then extracted from each cloud-flagged image over a series of grid points (Figure 3) by averaging all non-cloud pixels from the 5x5 pixel array centered on each grid point, constructing a time series at each grid point. A simple criterion is used to decide if there is insufficient data at each grid point: if the number of cloud-flagged pixels in an array is 13 or greater, a mean SST is not computed, resulting in a temporal "gap". The "seasonal" SST signal is then removed from the "gappy" time series at each grid point using a harmonic regression technique, resulting in SST residuals.

Five-day averaged SST residuals are then output at fixed, five-day intervals from the temporally "gappy" input SST residuals at each grid point using OI (Chelton and Schlax, 1991). OI also allows computation of the error associated with each SST estimate, as a fraction of the non-seasonal SST root-mean-square (RMS) variability. Weights used for the OI are computed using an analytical function fitted to autocorrelations computed from daily-averaged near-surface (~1-m depth) temperatures from NOAA data buoy 44005. Restoration of the seasonal signal to the OI SST residuals results in cloud-free five-day averaged OI SST and error maps for the study domain.

## Results

At present time there are 135 five-day averaged SST and error maps: 4 October 1993 - 5 August 1995, which are available over the Internet through the World Wide Web (http://kraken.gso.uri.edu/bisagni.html) along with more detailed documentation. Validation of the 1993-1994 SST maps has been completed using five-day averaged "bulk" near-surface temperatures measured at a depth of ~1-m at the five NOAA data buoys located within the gridding domain (Fig. 1). Results show good agreement with data buoy temperatures (Table 1), with RMS differences which are generally less-than 1.0 ˚C, and regression slopes that are close to 1.0.

Table 1.
Statistics of the comparison between five-day averaged, bulk near-surface (1-m depth) temperatures measured at five NOAA data buoys and five-day averaged OI SST estimated at the nearest OI grid

| NOAA Buoy | NOAA Buoy Position | OI Grid Point Position | Slope | Intercept ( ˚C) | RMS Diff ( ˚C) |
|---|---|---|---|---|---|
| 44005 | 42.7 N, 68.6 W | 42.70 N, 68.59 W | 1.010 | -0.201 | 0.98 |
| 44007 | 43.5 N, 70.1 W | 43.50 N, 70.09 W | 0.993 | 0.268 | 0.79 |
| 44008 | 40.5 N, 69.5 W | 40.50 N, 69.49 W | 0.966 | 0.516 | 0.64 |
| 44011 | 41.1 N, 66.6 W | 41.10 N, 66.61 W | 0.848 | 0.902 | 1.42 |
| 44013 | 42.2 N, 70.8 W | 42.40 N, 70.75 W | 0.965 | 0.156 | 0.83 |

*(continues on page 8)*

*Figure 2. Raw, navigated satellite SST image, 8 October 1993 derived from NOAA-11 AVHRR data. Cloud contaminated regions are shown as white and shades of dark gray. Land areas are masked (black).*

*Figure 3. Gridded sub-domain used for computation of five-day averaged, optimally-interpolated (OI) SST and error maps. Also shown is the location of the 200-m isobath (dashed).*

The SST map from 8 October 1993, near the start of our time series (Fig. 4a) shows two regions of lower SST values: the first located west of Georges Bank over Nantucket Shoals where strong tidal mixing prevents development of a seasonal thermocline and the second located north of Browns Bank and extending into the Gulf of Maine and then westward along the Maine coast where tidal mixing and river runoff combine to form the colder MCC. The alongshore- and offshore-directed branches of the MCC are clearly evident in Figure 4a as two tongues of colder water: one flowing closer to the coast and eventually

*Figure 4a. Cloud-free gray scale OI SST map computed for the grid shown in Figure 3 and inferred current patterns within the two branches of the Maine Coastal Current (arrows) for noontime 8 October 1993 (elapsed year day 280.5). Also shown is a gray-scale sea surface temperature bar, the locations of Georges Basin (GB), Jordan Basin (JB), Wilkinson Basin (WB) and Northeast Channel (NEC) within the Gulf of Maine and the location of the 200-m isobath.*

turning offshore into Wilkinson Basin and the second flowing southward around the western side of Jordan Basin, through Georges Basin and onto northeastern Georges Bank. The second southward-flowing tongue may be a more permanent feature in that a nearly identical trajectory was followed by a drifting buoy drogued at 10-m depth and released in late April 1994 by N. Pettigrew, University of Maine, Orono, Maine. Additional drifter deployments and hydrographic measurements show that the principal circulation pattern in the region during spring 1994 was a large, linked cyclonic gyre located over Jordan and Georges

*Figure 4b. As in Figure 4a, for noontime 3 June 1994 (elapsed year day 153.5).*

Basins (Pettigrew and Hetland, 1995). We speculate that a similar cyclonic gyre system may have been responsible for steering the southward-flowing branch of the MCC onto Georges Bank during early October 1993.

The SST map from 3 June 1994 (Fig. 4b) shows some similarity to the October map, despite a reduced SST contrast within the Gulf of Maine: lowest SST values are once again located over Nantucket Shoals, north of Browns Bank and along the Maine coast. However, an additional isolated patch of cold water is visible on northeastern Georges Bank. Given the isolated nature of this feature and the reduced SST contrast across the region, we cannot in this case conclude that the southward-flowing branch of the MCC (clearly visible west of Jordan Basin) has reached Georges Bank. In addition, the alongshore branch of the MCC appears closer to the coast and does not extend into Wilkinson Basin.

Waters flowing onto Georges Bank from the MCC in the northern Gulf of Maine have traveled a much greater distance from their Scotian Shelf source waters than waters flowing directly onto eastern Georges Bank from the western Scotian Shelf (Bisagni et al., in press). An assessment of the frequency of occurrence of MCC flows from the northern Gulf of Maine onto Georges Bank may allow us to determine the importance of these flows and their potential effects on the water properties and biota of Georges Bank.

Additional maps will be produced for the fall 1995-summer 1996 period along with qualitative and quantitative data analyses including an empirical orthogonal function (EOF) analysis of the spatial and temporal SST variability. We would like to encourage researchers, managers and other interested persons to make use of our "cloud-free" SST maps in order to better understand the varied and complex circulation within the Gulf of Maine. Interested persons should contact the authors by electronic mail (`bisagni@fish1.gso.uri.edu`) prior to using these data. Additional information concerning the maps, including data descriptions and file formats, is available over the Internet through the World Wide Web site given above.


## Acknowledgements

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## References


Anderson, D. M., B. Butman, D. Fong, P. J. S. Franks, W. R. Geyer, B. A. Keafer, T. C. Loder III and R. P. Signell (1995) Sources, transport, & nutrient environment of toxic "red tide" populations in the western Gulf of Maine. G*ulf of Maine News*, Summer Issue: 6-8.

Bisagni, J.J. and M.H. Sano (1993) Satellite observations of short time scale sea surface temperature variability on southern Georges Bank. *Continental Shelf Research*, 13:1045-1064.

Bisagni, J. J., D. J. Gifford and C. M. Ruhsam (1996) The spatial and temporal distribution of the Maine Coastal Current during 1982. *Continental Shelf Research,* 16:1-24.

Bisagni, J. J., R. C. Beardsley, C. M. Ruhsam, J. P. Manning and W. Williams (in press) Historical and recent evidence concerning the presence of Scotian Shelf water on southern Georges Bank. *Deep-Sea Research*

Cayula J.-F. and P. Cornillon (1992) Edge detection algorithm for SST images. *Journal of Atmospheric and Oceanic Technology,* 9:67-80.

Chelton D. B and M. G. Schlax (1991) Estimation of time averages from irregularly spaced observations: With application to Coastal Zone Color Scanner estimates of chlorophyll concentration. *Journal of Geophysical Research,* 96:14669-14692.

Cornillon, P., C. Gilman, L. Stramma, O. Brown, R. Evans and J. Brown (1987) Processing and analysis of large volumes of satellite-derived thermal infrared data. *Journal of Geophysical Research*, 92:12993-13002.

Franks, P. J. S. and D. M. Anderson, (1992a) Alongshore transport of a toxic phytoplankton bloom in a buoyancy current: *Alexandrium tamarense* in the Gulf of Maine. *Marine Biology*, 112:153-164.

Franks, P. J. S. and D. M. Anderson, (1992b) Toxic phytoplankton blooms in the southwestern Gulf of Maine: testing hypotheses of physical control using historical data. *Marine Biology*, 112:165-174.

McClain, E. P., W. G. Pichel and C. C. Walton (1985) Comparative performance of AVHRR-based multichannel sea surface temperatures. J*ournal of Geophysical Research*, 90:11587-11601.

Pettigrew, N. R. and R. D. Hetland (1995) The cyclonic circulation of the eastern Gulf of Maine. The Oceanography Society Fourth Scientific Meeting, April 18-21, 1995, Newport, Rhode Island, (Abstract), p. 73.

# Resources

## New Seafloor Map of Massachusetts Coastal Region

The U.S. Geological Survey, in cooperation with the National Oceanic and Atmospheric Administration, has published a new map showing the topography of the seafloor off Massachusetts between Cape Cod and the Merrimack River and seaward to 69° 52'W longitude. The map shows Massachusetts and Cape Cod Bays, Stellwagen Bank National Marine Sanctuary, and parts of Jeffreys Ledge and Scantum Basin.

Seafloor contours were computer-generated using digital data from the National Ocean Service Hydrographic Data Base. The map measures 41" wide by 54" high and is published at a scale of 1:100 000. Contour interval is 5 meters.

Reference:
Valentine, P.C., Schmuck, E.A., Signell, R.P., and Ryland, C.A., 1995, Seafloor Topography of Massachusetts and Cape Cod Bays and Stellwagen Bank National Marine Sanctuary: U.S. Geological Survey Open-File Report 95-73, scale 1:100 000, 1 sheet.

The map is available from:

Brad Barr, Manager
Stellwagen Bank NMS
14 Union Street
Plymouth, MA 02360
Tel. 508-747-1691

Page Valentine
Center for Marine and Coastal Geoscience
U.S. Geological Survey'
Woods Hole, MA 02543
Tel. 508-457-2239

## U.S. GLOBEC Georges Bank Field Program Update

Robert Groman

The U.S. GLOBEC Georges Bank Program has completed four of its six broad-scale cruises and one of its four mooring cruises to Georges Bank this field season. Drifters were deployed on many of these cruises. Alongtrack navigation and meteorlogical data, hydrography data and drifter images are on-line and available through our home page, hhttp://globec.whoi.edu.

## Reports Received

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

Banner, A. and Libby, J., "Identification of Important Habitats in the Lower Casco Bay Watershed", U.S. Fish and Wildlife Service Gulf of Maine Project, December 11, 1995

Bright, S., "The Wild Gulf Almanac 1995/96": The Chewonki Foundation, The U.S. Fish and Wildlife Service Gulf of Maine Project, The Wells National Estuarine Research Reserve, 1995

Report of the "U.S. GLOBEC Georges Bank Program Scientific Investigators' Workshop": U.S. GLOBEC NW Atlantic Georges Bank Study, October 16-18 October 1995
This report is also available on-line, GLOBEC Georges Bank home page: `http://globec.whoi.edu/`

"R/V Endeavor Cruise EN276 to Georges Bank", *U.S. GLOBEC NW Atlantic Georges Bank Study*

"R/V Oceanus Cruise 275 to Georges Bank", *U.S. GLOBEC NW Atlantic Georges Bank Study*

All the reports from the 1995 *U.S. GLOBEC NW Atlantic Georges Bank Study* cruises are now complete. Contact Bob Groman (508) 289-2409 if you need a report.

"Scotia-Fundy Spring 1995 Stock Status Report for Pelagics, Invertebrates, and Marine Mammals": DFO Atlantic Fisheries Scotia-Fundy Regional Stock Status Report 95/1

"Status of the Fishery Resource off the Northeastern United States for 1994": NOAA Technical Memorandum NMFS-NE-108, Research Communications Unit, Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543-1026, January 1995.

"The Health of the Gulf of Maine Ecosystem: Cumulative Impacts of Multiple Stressors" Workshop Report, RARGOM Report 96-1, Dow, D. and Braasch, E. editors.

## Grants / Sponsored Research

OFFICE OF NAVAL RESEARCH
Biological and Biomedical Science and Technology Div.
Dr. Anna Palmisano, Acting Director
Ms. Angela Carter, Secretary
800 North Quincy Street, Code 1141
Arlington, VA 22217-5660
(703) 696-4760, FAX: (703) 696-1212
Deadlines: July 1 to Sept. 1*
S20-1722
ONR Program in the Biological Sciences
The ONR has an active program supporting basic and applied biological and biomedical research. Awards are made for up to three years and range between $70,000 and $150,000 per year. The naval needs addressed by this program include: deterioration of ships and platforms in marine environments due to biocorrosion and biofouling; the need for novel materials and catalysts; requirements for sensitive and selective detector systems (chemical, biological, bioacoustic, etc); and compliance with regulations maintaining the quality of shipboard and near-shore marine environments. These naval needs are addressed by program emphases on molecular and cellular marine biology, including basic principles governing molecular structure, function, and interactions; and on marine biology at various levels of integration, from the molecular to the environmental. Currently funded research areas include but are not limited to the following: Biodeterioration - biofouling and biocorrosion; Biomaterials - biocatalysis, biomimetics, and biofabrication; Biosensors - biomolecular recognition and combinatorial synthesis; Environmental Biotechnology - marine sediments and shipboard waste effluents; Marine Biology - algal biotechnology, biological sonars, biolum inescence, low frequencing sound, marine mammal physiology and locomotion, and molecular biology of marine organisms. For additional information contact Ms. Carter.
*These are the target dates for full proposals. A brief preproposal is requested in advance of the full proposal.

ENVIRONMENTAL PROTECTION AGENCY, Contracts Management Division, Cincinnati, OH 45268-7001; Attn: Raoul D. Scott, (513) 366-2071: Technical Support, Oceans and Coastal Protection Division/OWOW (Sol. C600312T1)
The Oceans and Coastal Protection Division of the Office of Water has a requirement for technical support to aid its responsibilities in the protection of the nation's oceans, estuaries, coastal waters, other designated water bodies and coastal watersheds. Technical support is required in the following task areas: 1) field work and lab analysis; 2) environmental, ecological and health risk assessments; 3) sources and control of floatable and aquatic debris; 4) ocean dumping and disposal and dredged material management activities; 5) data base development and modeling; 6) preparation of status reports, guidance documents, and workshops; 7) public outreach and technology transfer; 8) pollution control and mitigation; and 9) technical support for regulation development. It is anticipated that a CPFF reimbursement type contract will be awarded, with a base period of twelve months and three twelve-month option periods. Due: To be Announced. (CBD: March 7, 1996, page 3.)

THE CHARLES A. AND ANNE MORROW LINDBERGH FOUNDATION, INC.
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(612) 338-1703, FAX: (612) 338-6826, e-mail: lindfdtn@mtn.org, www: http://www.mtn.org/lindfdtn
Attn: Marlene K. White, Grants Coordinator
Deadline: June 11
S20-1813
Lindbergh Grants Program
Grants of up to $10,580 (a symbolic amount representing the total cost of Charles Lindbergh's "Spirit of St. Louis" in 1927) will be awarded to individuals for research projects that contribute toward the achievement of a better balance between technology and the natural environment. Areas of interest include the following: aviation/aerospace, agriculture, arts and humanities, biomedical research, conservation of natural resources, exploration, health and population sciences, intercultural communication, oceanography, water resource management, waste disposal management, and wildlife preservation. A Jonathan Lindbergh Brown Grant may be given to a project in the above categories to support adaptive technology or biomedical research which seeks to redress imbalance between an individual and his or her environment. Eligible applicants include individuals who may or may not be affiliated with an academic or nonprofit institution. Citizens of all countries are eligible but applications must be written in English. Contact the Foundation for application form. Each year approximately ten grants are awarded.

## Incze and Tripp are New Officers Elected to Chair the RARGOM Policy Board

At the end of June, Gordon Wallace and Daniel Lynch will complete four years of service as the Officers of the Association. We appreciate their leadership, vision, and the considerable time that they have provided during the Association's early years, working to establish the Association as a significant regional organization. After their tenure as officers, they are not retiring from the Association's work. Both are still actively involved in the upcoming Scientific Symposium, for which Gordon serves as program chair. Many thanks are extended to Gordon and Dan!

The Policy Board voted unanimously at its winter board meeting to elect Lewis Incze, of Bigelow Lab, and Bruce Tripp, of WHOI, as the next Chair and Vice Chair of the Policy Board. Both have served as representatives to the Board, and bring experience and perspectives that are needed for the Association's continued development. Genie Braasch will become the next Executive Director in July, providing essential continuity for the Association. The Association office will remain at Dartmouth College.

Lew Incze's research interests are in larval ecology and physiology and the interactions between zooplankton (primarily meroplankton) and ocean dynamics as they affect growth, survival, distribution and recruitment. His work has looked at a number of different size scales: current systems, eddies, fronts and, recently, at the effects of small-scale turbulence in stratified and partially stratified water columns. Interdisciplinary interests are in physical oceanography and meteorology. He has worked with larval fish and larval crustaceans and currently has projects focussed on two areas: GLOBEC work on Georges Bank (transport and turbulent effects on larval cod and their early copepod prey) and lobster postlarvae (the final planktonic stage) in the Gulf of Maine (broad-scale transport, wind forcing and quantitative aspects of settlement in nearshore cobble habitats). Lew has been a Research Scientist at Bigelow Laboratory since September 1987 and served as Bigelow's Director and CEO from 1991-1995, when he stepped down to return to full-time science.

In addition to basic research, Lew has interests in science policy and in strengthening the relationship between research and resource management, and serves on several committees and boards that try to promote communication between the two. Lew was the founding Chairman of RARGOM for one year (1991), and thinks that RARGOM and the Regional Marine Research Program have had positive influences on Gulf of Maine research. Incze believes that efforts of this sort, focusing on regional seas and processes, can make important contributions to ocean science (U.S. and international) and the wise future use of our coastal and marine environments.

Bruce Tripp's research interests have focused on the input, fate and effects of anthropogenic organic contaminants (e.g., PAH, PCB, petroleum hydrocarbons) in the open ocean and in coastal waters. His principle areas of research, in collaboration with several WHOI scientists, have been contaminant biogeochemistry in the water column and at the sediment-water interface with a special emphasis on the role benthic organisms play in the degredation, remobilization and transport of sediment-bound organics. This research has required field sampling and sample analysis, lab management and lab assistant supervision, development of coastal monitoring programs and the translation of research results into information to support resource management decision-making. From 1991-1995, Bruce was the "executive officer" for the initial phase of International Mussel Watch, a program for chemical contaminant monitoring in Latin America. He presently serves as the Assistant Director of the Coastal Research Center at Woods Hole, responsible for the day-to-day operation of the Center, including budget management and staff supervision. Coastal Research Center activities include support of new coastal research, education and "outreach" to translate the results of coastal research to non-scientists. One outreach effort has culminated in "Coastal Briefs", a prototype electronic mini-journal for non-scientists which can be accessed via the internet.

We welcome our new leaders and hope that all Gulf of Maine researchers will extend their support for, commitment to, and involvement in the continued development and success of future Association activities.

# Calendar

**April**

13 — Shellfish Aquaculture Conference
Massachusetts Maritime Academy,
Buzzards Bay, MA
(508) 830-5019

29-30 — Council on the Marine Environment meeting
Orono, Maine
contact: Beth Della Valle, (207) 287-1482

**May**

3 — Abstracts due for working group & poster sessions
Gulf of Maine Scientific Symposium & Workshop
contact: Genie Braasch, (603) 646-3480

6-7 — The Biodiversity Project Workshop
New England Center, Durham, New Hampshire
contact: Cindy Coffin, (608) 250-9876

**16 — RARGOM meeting**
**Wheatley Hall, UMassachusetts Boston**
**contact: Genie Braasch (603) 646-3480**

30-June 1 — Bridging the Gulf: A Citizen's Conference
on Environmental Monitoring
Portland, Maine
contact: Lissa Widoff, (617) 723-7415

**June**

3-5 — Quoddy Users Group Meeting
Dartmouth College, Hanover, NH
contact: Dan Lynch (603) 646-2308

7 — FINAL Deadline for Abstracts
Gulf of Maine Scientific Symposium & Workshop
contact: Genie Braasch, (603) 646-3480

12-13 — Council on the Marine Environment meeting
Bar Harbor, Maine
contact: Beth Della Valle, (207) 287-1482

## Gulf of Maine Ecosystem Dynamics

**A Scientific Symposium and Workshop**
**September 16-19, 1996**
**St. Andrews, New Brunswick**

**Abstract deadline extended to June 7th for poster and working group sessions.**

Contributed abstracts in the following areas and related topics on the Gulf of Maine are encouraged:

- physical and biological coupling
- large-scale transport and circulation
- small scale physical-biological interactions
- land-sea interactions
- biogeochemical processes & cycles, natural & perturbed
- sources, transport & fate of contaminants of environmental concern
- nearshore sediment transport & sedimentation processes
- fishery and aquaculture issues
- planktonic and benthic food webs
- human-induced biological changes
- ecosystem risk and risk assessment
- particulate organic matter fluxes and cycling
- modeling
- long-term research and database management

**Working Group Sessions:**

**Physical & Biological Coupling:** Bob Beardsley, chair
**Biogeochemical Processes & Cycles:** Gordon Wallace, chair
**Fishery & Aquaculture issues:** David Stevenson, chair
**Human-induced Biological Changes:** Larry Mayer, chair
Smaller sub-working group sessions will be formed to facilitate participation and in depth discussion. Details on this part of the program will come in the next newsletter.

**Planning documents & Abstract Submission Policies are located on the RARGOM web home page:**
`http://fundy.dartmouth.edu/rargom/`

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**Now Available:** *The Health of the Gulf of Maine Ecosystem: Cumulative Impacts of Multiple Stressors*.
Contact the Association office for a copy.
Workshop participants will be receiving them soon.