JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 108, NO. C11, 8000, doi:10.1029/2003JC002165, 2003

Introduction to special section: U.S. GLOBEC: Physical processes on Georges Bank (GLOBEC)

Robert C. Beardsley
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA

Peter C. Smith
Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

Craig M. Lee
Applied Physics Laboratory, University of Washington, Seattle, Washington, USA

Published 18 November 2003.

INDEX TERMS: 4219 Oceanography: General: Continental shelf processes; 4223 Oceanography: General: Descriptive and regional oceanography; 4512 Oceanography: Physical: Currents; 4528 Oceanography: Physical: Fronts and jets; *KEYWORDS:* physical processes on Georges Bank, Gulf of Maine, Scotian Shelf

Citation: Beardsley, R. C., P. C. Smith, and C. M. Lee, Introduction to special section: U.S. GLOBEC: Physical processes on Georges Bank (GLOBEC), *J. Geophys. Res.*, *108*(C11), 8000, doi:10.1029/2003JC002165, 2003.

[1] The papers in this special section are one result of the U.S. GLOBEC (GLOBal ocean ECosystem) Northwest Atlantic/Georges Bank program, which conducted an extensive set of physical and biological measurements on Georges Bank (GB) and surrounding waters during 1995–1999 (Figure 1). The GB GLOBEC program was designed to investigate the development of zooplankton and larval fish communities on GB, with special emphasis on the physical and biological processes that influence the population dynamics of four target species: cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) and their zooplankton prey (*Calanus finmarchicus* and *Pseudocalanus*) [*GLOBEC*, 1992; *Wiebe et al.*, 2002]. These species were chosen for several reasons. They are important members of the Georges Bank and other North Atlantic ecosystems; much is known about their life histories; and their populations are thought to be sensitive to changing climatic conditions, a growing concern for resource management. Georges Bank, a wide shallow bank separating the Gulf of Maine from the North Atlantic, was chosen because it has historically supported significant cod and haddock fisheries, a basic knowledge of its physics and biology was known from past interdisciplinary studies starting with *Bigelow* [1926, 1927], and its clockwise around-bank circulation was thought to form a semi-enclosed or isolated environment for cod and haddock that would be strongly affected by climate variability over the northeast margin of North America.

[2] The GB GLOBEC field program featured broad-scale studies conducted during January through August of each year 1995 through 1999. These are the months when cod and haddock generally spawn (January–March) over the northern half of Georges Bank and then develop into active swimming juveniles by summer (June–August) as they drift around the bank along the southern flank. In this January through August period, physical processes are thought to most strongly influence larval fish behavior, survival, and eventual recruitment. The broad-scale studies included long-term mooring and drifter deployments, remote sensing, and shipboard surveys. In addition, intensive process studies were conducted in 1995 to investigate the physical processes that determine water structure and onset of seasonal stratification and their influence on larval cod and haddock, in 1997 to examine the sources, retention, and losses of water and organisms from over and around the Bank, and in 1999 to investigate cross-frontal exchange through the tidal mixing front and shelf/slope front around the eastern and southern flanks of the bank. The GB GLOBEC program also featured coupled physical/biological modeling to improve understanding of the physical environment, the causes of its variability, and how it influences the spatial and temporal distribution of the target species. Some early physical and biological results from GB GLOBEC were reported in two special issues of *Deep Sea Research, Part II* [*Wiebe and Beardsley*, 1996; *Wiebe et al.*, 2001].

[3] The papers presented here are grouped as follows. *Brink et al.* [2003] and *Flagg and Dunn* [2003] present descriptions of the Lagrangian and Eulerian circulation based on the 1995–1999 drifter and broad-scale survey ADCP measurements. *Loder et al.* [2003] use long-term hydrographic section data collected off Halifax to describe the properties and variability of the along-shelf transport of Scotian Shelf Water, the primary upstream freshwater source for the bank. *Werner et al.* [2003a, 2003b] use bottom tripod and moored data taken on the southern flank during the 1995 stratification process study to investigate bottom stress, its effect on bottom bedforms, and the structure of the tidal boundary layer outside the tidal mixing front. *Lentz et al.* [2003] also use the 1995 stratification study moored data to investigate the relative roles of surface forcing (determined by *Beardsley et al.* [2003])and horizontal advection in the temporal evolution of the water

0148-0227/03/2003JC002165$09.00

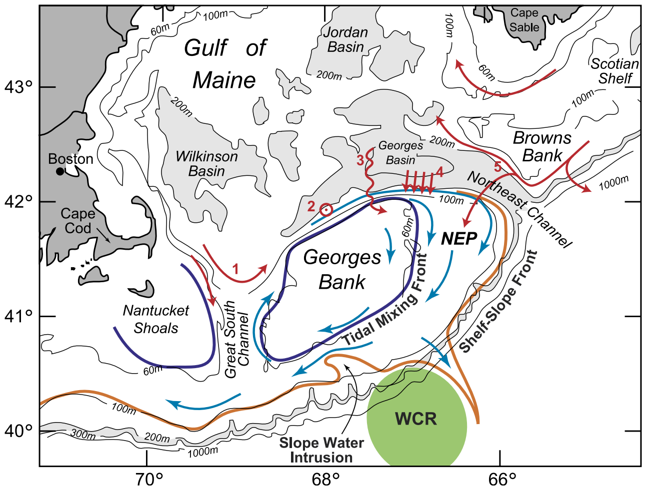

Figure 1. Georges Bank/Gulf of Maine region, with the upper water column (depths < 75 m) currents during the warm stratified season shown by the blue and red arrows. The tidal mixing fronts around GB and Nantucket Shoals indicated by black solid lines and the shelf-slope front along the southern flank of GB by the yellow solid line. NEP stands for northeast peak and WCR for the warm core ring shown off the southern flank. The numbers represent different pathways for water can get onto the northern flank of GB to start the clockwise circulation around the bank: (1) flow across the Great South Channel and then eastward along the northern flank (the historical view), (2) up onto the bank in a tidally driven near-bottom residual flow, (3) wind-driven near-surface flow onto the bank, (4) small-scale cross-frontal processes, and (5) surface-intensified advection of water from the eastern side of the Northeast Channel (Scotian Shelf “Cross-overs”).

column heat and salt content. With a 3-D numerical model, *Chen et al.* [2003a] investigate the influence of using realistic surface forcing on springtime stratification and tidally driven residual circulation. *Dale et al.* [2003] and *Ullman et al.* [2003] use a towed, undulating CTD (Sea-Soar) and other measurements made in the 1999 frontal exchange process study to describe the front on the bank’s northern flank, its dynamic structure, and cross-front exchange and mixing. *Chen et al.* [2003b] use a simple 2-D numerical model to study how near-surface biological particles can be transported across the tidal mixing front on GB by the actions of wind and seasonal heating. *Churchill et al.* [2003] examine the physical impacts of slope water intrusions onto GB during the 1995 stratification study, and *Smith et al.* [2003] explore the process of “Scotian Shelf crossover” (SSC), by which the surface waters of Browns Bank are transported onto the northeast peak of GB by various physical mechanisms, including wind and offshore rings and eddies. *Wishner et al.* [2003] further this study by investigating the horizontal and vertical zooplankton distributions in SSC waters as compared to that in other onbank locations. *Bisagni* [2003] examines the seasonal variability in nitrate supply and potential new production in the surface layers of the Gulf of Maine and GB area, delimiting five separate hydrographic provinces in the region. *Zakardjian et al.* [2003] use a 3-D biophysical model to study the effects of temperature and circulation on the population dynamics of *Calanus finmarchicus* in the region upstream from the Gulf of Maine and GB (Scotian Shelf and Gulf of St. Lawrence).

[4] **Acknowledgments.** We want to thank John Klinck, Aylin An, Alice O’Donnell, and the other members of the JGR-Oceans staff for their immense help in making this special section come to completion. We also want to thank the many reviewers who helped shape and sharpen the papers in this section. The U.S. GLOBEC Northwest Atlantic/Georges Bank program has been jointly funded by the National Science Foundation-Division of Ocean Sciences (NSF) and the NOAA National Marine Fisheries Service (NMFS). A research program of this scope and complexity has involved many people with diverse interests and talents. We want to especially acknowledge their efforts in making this program happen and successful. Support for the guest editors was provided by NSF grant OCE 02-27679 (RB), the Bedford Institute of Oceanography (PS), and NSF grant OCE 01-07946 (CL). This is U.S. GLOBEC contribution 415.

References

Beardsley, R. C., S. J. Lentz, R. A. Weller, R. Limeburner, J. D. Irish, and J. B. Edson, Surface forcing on the southern flank of Georges Bank, February–August 1995, *J. Geophys. Res.*, *108*(C11), 8007, doi:10.1029/2002JC001359, in press, 2003.

Bigelow, H. B., Plankton of the offshore waters of the Gulf of Maine, *Bull. U.S. Bur. Fish.*, *40*, 1–509, 1926.

Bigelow, H. B., Physical oceanography of the Gulf of Maine, *Bull. U.S. Bur. Fish.*, *40*, 511–1027, 1927.

Bisagni, J. J., Seasonal variability of nitrate supply and potential new production in the Gulf of Maine and Georges Bank regions, *J. Geophys. Res.*, *108*(C11), 8015, doi:10.1029/2001JC001136, in press, 2003.

Brink, K. H., R. Limeburner, and R. C. Beardsley, Properties of flow and pressure over Georges Bank as observed with near-surface drifters, *J. Geophys. Res.*, *108*(C11), 8001, doi:10.1029/2001JC001019, in press, 2003.

Chen, C., R. C. Beardsley, P. J. S. Franks, and J. Van Keuren, Influences of the diurnally varying heat flux on stratification and residual circulation on Georges Bank, *J. Geophys. Res.*, *108*(C11), 8008, doi:10.1029/2001JC001245, in press, 2003a.

Chen, C., R. J. Schlitz, R. G. Lough, K. W. Smith, R. Beardsley, and J. P. Manning, Wind-induced, cross-frontal exchange on Georges Bank: A mechanism for early summer on-bank biological particle transport, *J. Geophys. Res.*, *108*(C11), 8011, doi:10.1029/2002JC001358, in press, 2003b.

Churchill, J. H., J. P. Manning, and R. C Beardsley, Slope water intrusions onto Georges Bank, *J. Geophys. Res.*, *108*(C11), 8012, doi:10.1029/2002JC001400, in press, 2003.

Dale, A. C., D. S. Ullman, J. A. Barth, and D. Hebert, The front on the northern flank of Georges Bank in spring: I. Tidal and subtidal variability, *J. Geophys. Res.*, *108*(C11), 8009, doi:10.1029/2002JC001327, in press, 2003.

Flagg, C. N., and M. Dunn, Characterization of the mean and seasonal flow regime on Georges Bank from shipboard acoustic Doppler current profiler data, *J. Geophys. Res.*, *108*(C11), 8002, doi:10.1020/2001JC001257, in press, 2003.

GLOBEC, Northwest Atlantic Implementation Plan, *U.S. Global Ocean Ecosyst. Dyn. Rep.* 6, 69 pp., U.S. Global Change Res. Program, Washington, D.C., 1992.

Lentz, S. J., R. C. Beardsley, J. D. Irish, J. Manning, P. C. Smith, and R. A. Weller, Temperature and salt balances on Georges Bank February–August 1995, *J. Geophys. Res.*, *108*(C11), 8006, doi:10.1029/2001JC001220, in press, 2003.

Loder, J. W., C. G. Hannah, B. D. Petrie, and E. A. Gonzalez, Hydrographic and transport variability on the Halifax section, *J. Geophys. Res.*, *108*(C11), 8003, doi:10.1029/2001JC001267, in press, 2003.

Smith, P. C., C. N. Flagg, R. Limeburner, C. Fuentes-Yaco, C. Hannah, R. C. Beardsley, and J. D. Irish, Scotian shelf crossovers during winter/spring 1999, *J. Geophys. Res.*, *108*(C11), 8013, doi:10.1029/2001JC001288, in press, 2003.

Ullman, D. S., A. C. Dale, D. Hebert, and J. A. Barth, The front on the northern flank of Georges Bank in spring: II. Cross-frontal fluxes and mixing, *J. Geophys. Res.*, *108*(C11), 8010, doi:10.1029/2002JC001328, in press, 2003.

Werner, S. R., R. C. Beardsley, and A. J. Williams III, Bottom friction and bedforms on the southern flank of Georges Bank, *J. Geophys. Res.*, *108*(C11), 8004, doi:10.1029/2000JC000692, in press, 2003a.

Werner, S. R., R. C. Beardsley, S. J. Lentz, D. L. Hebert, and N. S. Oakey, Observations and modeling of the tidal bottom boundary layer on the

southern flank of Georges Bank, *J. Geophys. Res.*, *108*(C11), 8005, doi:10.1029/2001JC001271, in press, 2003b.
Wiebe, P., and R. Beardsley (Eds.), Physical-biological interactions on Georges Bank and its environs, *Deep Sea Res., Part II*, *43* (7–8), 1437–2006, 1996.
Wiebe, P., R. Beardsley, A. Bucklin, and D. Mountain (Eds.), Coupled biological and physical studies of plankton populations: Georges Bank and related North Atlantic regions, *Deep Sea Res*., *Part II*, *48* (1–3), 1–684, 2001.
Wiebe, P., R. Beardsley, D. Mountain, and A. Bucklin, U.S. GLOBEC Northwest Atlantic/Georges Bank Program, *Oceanography*, *15*(2), 13–29, 2002.
Wishner, K., D. J. Gifford, B. K. Sullivan, J. J. Bisagni, D. M. Outram, and D. E. Van Keuren, Biological signature of Scotian Shelf Water crossovers on Georges Bank during spring 1997, *J. Geophys. Res.*, *108*(C11), 8014, doi:10.1029/2001JC001266, in press, 2003.
Zakardjian, B. A., J. Sheng, J. A. Runge, I. McLaren, S. Plourde, K. R. Thompson, and Y. Gratton, Effects of temperature and circulation on the population dynamics of *Calanus finmarchicus* in the Gulf of St. Lawrence and Scotian Shelf: Study with a coupled, three-dimensional hydrodynamic, stage-based life history model, *J. Geophys. Res.*, *108*(C11), 8016, doi:10.1029/2002JC001410, in press, 2003.

R. C. Beardsley, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA. (rbeardsley@whoi.edu)
C. M. Lee, Applied Physics Laboratory, University of Washington, Seattle, WA 98105-6698, USA. (craig@apl.washington.edu)
P. C. Smith, Bedford Institute of Oceanography, P.O. 1006, Dartmouth, N.S. B2Y 4A2 Canada. (smithpc@mar.dfo-mpo.gc.ca)