Gulf of Maine NEWS

Regional Association for Research on the Gulf of Maine Summer 1994

Metal Distributions in the Gulf of Maine

Gordon T. Wallace and George B. Gardner,
University of Massachusetts at Boston

The horizontal and vertical distribution of trace elements and organic compounds in coastal systems are governed by a complex array of physical, chemical and biological processes that are both temporally and spatially variable. Unraveling the exact nature and quantitative significance of these processes has been and will continue to be a significant challenge to the chemical oceanographer and his or her colleagues in physical and biological oceanography for some time. The physical circulation patterns in the Gulf of Maine suggest that the near shore region is strongly influenced by a "coastal current" moving around the Gulf in a counterclockwise direction. The influx of freshwater from the Merrimack, northern Maine and Canadian rivers discharging to the Gulf drives this seasonally variable flow.

It is upon this template that the input and distribution of metals and other trace constituents mobilized by both natural

(continues on page 2)

In This Issue:

Sediment Disturbance in the Gulf of Maine

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Sediment disturbance occurs at many temporal and spatial scales in the Gulf of Maine, and may result from physical and biological processes, including human activities (Figure 1). Most oceanographers are aware, to one degree or another, of the disturbances described below, but it is useful to list them in amanner that allows comparison. Although sophisticatedgeophysical tools, including sidescan sonar and seismicreflection profiling, routinely allow geologists to remotelyevaluate sediment disturbance, many other scientists who directlywork with the bottom through grab samplers and other means, maynot be aware how commonly the seabed is moved around. Suffice tosay: disturbance is everywhere! Why is this important? Disturbance is an important aspect of fisheries,causing both detrimental, neutral, and advantageous changes toecosystems. Unfortunately, when human disturbance is added tothe equation, the changes are often detrimental. Recent visits to the sea floor in small submersibles, coupled with sidescansonar images, brings home to us how much the bottom is disturbedby dragging. Some muddy bottoms have the appearance of a newlyplowed field, while on coarse bottom, boulders up to the size ofsmall chairs are over turned, and entire communities of sponges,anemones, and other organisms are killed. The ultimate effectsof this ecosystem disturbance are unknown.

(continues on page 4)

Figure 1

and anthropogenic forces are superimposed. As a significant fraction of these inputs is introduced through discharge to rivers and coastal estuaries, their transport and fate are expected to be strongly influenced by the presence of this "coastal current". Along shore rather than offshore transport may largely control the distribution of these coastally introduced constituents. Removal of particle-reactive constituents by *in situ* vertical scavenging processes and inhibition of their lateral transport offshore by coastal fronts may serve to "trap" them in the local inshore regions of the Gulf during much of the year. Recent measurements by our laboratory of the distribution of selected trace metals and the particle-reactive radioisotope Th-234 in Massachusetts Bay and in the western part of the Gulf of Maine are consistent with this hypothesis. Concentrations of most metals are highest in the near shore region and correlate well with the distribution of freshwater. In addition we estimate that transport from the western Gulf of Maine into Massachusetts Bay represents one of the major sources of metal (about one third for some metals) to the Bay, the others being the discharge of sewage effluent to the Bay and atmospheric deposition.

Of particular interest was the vertical distribution of trace metals and the Th-234 in an offshore station in the western Gulf of Maine. This station, near Wilkinson Basin, and outside the immediate influence of the near shore coastal current, was chosen to establish baseline concentrations of metals for comparison with those observed in Massachusetts Bay and near shore Gulf of Maine stations. It also allowed us to examine the potential influence of the atmospheric input of metals and that of the biological processes associated with the strong chlorophyll maximum present during periods of strong stratification in the Gulf. The details of the profile and its interpretation will be presented elsewhere and only a brief synopsis of the results is presented here.

The profile of Th-234 indicated accelerated scavenging of this element in the vicinity of the chlorophyll maximum as has been observed by others, implying a close linkage of this process with biological processes. The concentrations of the 0.4 µm filter-passing forms (dissolved and colloidal) of several of the metals analyzed in the surface samples were generally similar to those of pelagic offshore surface waters. However there was a distinct subsurface maximum in their concentrations, coincident with the pigment maximum, rather than the minimum expected if processes affecting their distribution were similar to those for Th-234 (Figure 1). (Because of its well-documented affinity for particles, Th-234 distribution and resultant estimates of particle-scavenging residence time have been frequently used to deduce the processes and rates of water column scavenging of other particle-reactive constituents in the water column, including metals and trace organic). Apparently changes occurred in the speciation of these metals in the region of the chlorophyll maximum to forms (organically complexed? (Moffett et al.,

Figure 2

1990)) with much lower sorption affinities for particles. This raises questions regarding the utility of Th-234 scavenging rates to predict the behavior of other particle-reactive species with distinctly different chemistries.

Perhaps of even greater interest is the profile of suspended aluminum observed at this station (Figure 1). We believe atmospheric deposition of largely insoluble fine-particle detrital suspended aluminum phases and their subsequent incorporation into rapidly sinking larger particles in the vicinity of the chlorophyll maximum as described earlier for the Gulf Stream (Wallace et al., 1981) produce this distribution. The dramatic exponential decay of suspended aluminum from the surface to a minimum coincident with the subsurface chlorophyll maximum is consistent with a first order removal process. We suspect that this process is mediated by biological processes, rather than by abiotic processes such as aggregation by the "brownian pumping" of colloidal particles, largely because of the low suspended matter concentrations present and the coincidence of the minimum with a maximum pigment concentrations. The increase in suspended aluminum concentration with depth is consistent with the rapid remineralization of these larger aggregates as they settle from their point of origin as described in the model described by Clegg and Whitfield (1990). We have fit this profile to this model with excellent results (Figure 2). Recent estimates of the atmospheric inputs of aluminum into the Gulf of Maine have allowed us to estimate both fine-particle and large particle vertical fluxes of metals and nutrients under these highly stratified conditions. It is apparent that the transport of metals and nutrients in the offshore regions of the Gulf of Maine during stratified conditions is dominated by vertical processes and largely mediated by biological and physical processes occurring in the vicinity of the pycnocline. Precise indentification of the biological processes that affect the distribution of metals and other trace constituents in the offshore regions on an annual time scale in the Gulf of Maine remain the objectives of future research. Achievement of these objectives will be important to those wishing to define the transport and fate of contaminants entering the Gulf of Maine ecosystem.

Clegg, S.L. and M. Whitfield, (1990): A generalized model for the scavenging of trace metals in the open ocean - I. Particle cycling. *Deep Sea Research* **37:**809-832.

Moffett, J.W., R.G. Zika and L.E. Brand, (1990): Distribution and potential sources and sinks of copper chelators in the Sargasso Sea. *Deep Sea Research* **37**: 27-36.

Wallace, Jr., G.T., O.M. Mahoney, R. Dulmage, F. Storti and N. Dudek, (1981): Vertical transport of particulate aluminum in oceanic surface layers. *Nature* **293**: 729-731.

(Sediment Disturbance continued)

At the smallest scale, organisms alter the bottom with theirtracks, trails and burrows (Figure 1). The size of anindividual's marks ranges from as large as a few tens ofcentimeters for fish, lobster and crab burrows, to millimetersand smaller for small invertebrates. The time period involved inthe disturbance probably extends from moments to several days fora larger excavation. Although both relatively small in size andbrief in occurrence, there are so many organisms busy all of thetime, that animals must be the most important source of naturaldisturbance to sediments of the Gulf of Maine, at least since theend of glacial times. Evidence for the ubiquitous disturbance ofmuddy sediment by animals is found in lack of physicalsedimentary structures in cores of fine-grained sedimentrecovered from the Gulf of Maine.

Waves and currents overlap with the time/space zone ofdisturbance by organisms (Figure 1). Tidal currents are packagedin daily intervals and their area of greatest concentration is innarrow constrictions, like tidal inlets. Here, bedforms likeripples and sand waves, with amplitudes of a few centimeters to afew meters, may migrate tens of meters per tidal cycle. Wavesalso rework the seafloor, especially during storms. Hundreds ofsquare kilometers of the seafloor off the Kennebec River, Merrimack River and some other large rivers are marked byoscillation ripples averaging 20 centimeters in height and 1.5 min wavelength (Belknap et al., 1988). These fields extend manykilometers offshore, although they are probably only active for afew days per year. The area of disturbance of a single largewave train is estimated as several hundred square meters andrequiring seconds to minutes to form. Unlike the sedimentdisturbances caused by organisms, which tend to homogenizesediment, those caused by waves and currents tend to causelayering in marine sediments. An interaction exists betweenbiological and physical disturbance when cyclic loading on thebottom by waves may pump pore fluids (water and gases) out ofburrows.

Human actions are relatively new to the Gulf of Maine, sothe time/space extent of our disturbance may be surprising. There are a great range of human actions which alter the seabed. Digging by one clammer may occur over a few hours and affect afew tens of square meters. A powerful dragging boat, on theother hand impacts hundreds of times that area in the same periodof time. In most muddy areas of the Gulf of Maine we haveobserved the characteristic parallel drag marks of fishingactivity. On the upper end of human actions are dredging andspoils disposal activities. Dredging a large anchorage takesmonths, and completely alters a square kilometer of seabed byboth dredging and disposal of spoils. Human actions are probablyless widespread than those of other organisms, but our impact hasincreased in scale regularly since we arrived in the Gulf ofMaine.

On the upper end of features representing disturbance of theseabed are submarine landslides and gas-escape pockmarks (Kelleyet al., 1989, 1994). Each of these disturbances involves porefluids and each has only been relatively recently recognized.Landslides occur near deep channels in estuaries where modernmuddy sediment accumulates until its slope is steep. Natural gasand excess pore water decrease sediment stability and lead toslumping. Animal burrows may also be involved as a de-stabilizing factor. Whether the process is slow, and analogousto "creep" on terrestrial hillsides, or rapid is not known. Gas-escape pockmarks involve the escape of pressured pore fluids andthe excavation of muddy sediment; again it is not known whetherthis occurs catastrophically or slowly over a long time.Measured slumps may involve several cubic kilometers of sediment,and pockmarks, which range in size up to 350 m in area and 35 mdeep, represent 99 million cubic meters of transported sedimentin the Belfast Bay, ME field alone (Kelley et al., 1994).

Figure 1: Schematic illustration of the time/space distribution of sediment disturbance to the Gulf of Maine bottom sediment. This is not a quantitative figure, only a quick sketch to provide an overview.

The largest scale of disturbance occurred in a process nolonger found in the Gulf of Maine: furrowing by keels of largeicebergs. In a cruise this past summer, we discovered hundredsof furrows kilometers in length, tens of meters width, and metersdeep, plowed into the rises of the southeastern Gulf of Maine inwater depths up to 250 meters. These are the drag marks oficeberg keels, formed approximately 14,000 years ago. They areso prominent that they have not been buried, erased by current,or even obscured by fisheries dragging. Although they are nolonger active, they still control the distribution of organismson scales visible from submersibles and sidescan sonar.

Clearly an understanding of sediment disturbance in the Gulfof Maine requires contributions from many disciplines. Such anappreciation is needed, however, because many researchers may bemaking observations on the bottom without realizing how active itis. Furthermore, since humans are an increasing influence on thebenthos, we need to see how our actions are altering the overallecosystem.

Sediment Budget for Maine's Sandy Embayments: A Proposal to Calculate Sand Volumes and Transport Pathways at the Mouth of the Kennebec River and in the Saco Embayment

Duncan M. FitzGerald, Boston University

The age, evolutionary history, and sand sources of Maine's barriers differ from those along most of the East Coast due to the region's complicated sea level history, the rocky nature of coastal Maine, and other effects of glaciation. In order to determine the age and mode of formation of the coastal barriers of Maine, we are in the process of calculating the volume of sand contained in the various coastal compartments. My students and I are part of a research team that includes Joe Kelley and Stephen Dickson from the Maine Geological Survey, Dan Belknap from the Department of Geological Sciences, University of Maine, and Ken Fink from the Oceanography Department, University of Maine.

This summer, surface and subsurface data at Popham Beach and Saco Embayment shorelines were gathered. Our fieldwork included the collection of 22 km of ground penetrating radar (GPR) transects, 21 vibracores, 11 auger cores, 10 view of the barrier's subsurface, which allows us to determine the underlying bedrock surface, sedimentation trends, and major crosional-depositional boundaries. The hypotheses that are generated by the radar information are ground-truthed using vibracores and auger cores. The vibracores provide a fairly undisturbed sample of the barrier stratigraphy and normally vary in length from 1 to 8 m. Augercores allow deeper sampling and penetration into tight clays, till, or semi-indurated sediments. The sediment cores also yield shells, wood, and peats for dating purposes. The offshore profiles and sediment samples will provide information concerning the sediment source of the barriers.

Preliminary analyses suggest a highly complex evolutionary history of the Saco Embayment barriers and Popham Beach in which bedrock and glacial promontories provided pinning points for barrier initiation. Transgressive, spit building, and regressive barrier phases are evident at both locations. The Popham barrier is further complicated by the closure of a more paleo-Kennebec distributary as well as lateral excursions of the present river mouth. In addition, the exposed southward-facing beach of Popham has experienced more than 150 m of landward and seaward migrations of the shoreline during the past 120 years. The figures below are examples of the GPR profiles and vibracore data.

Figure 2

Figure 1. Location map of Popham Beach study with Ground Penetrating Radar and vibracore locations depicted in figures 2 and 3.

Figure 2. Ground penetrating radar profile exhibiting former buried dune scarps. Accumulations of garnet sands (lag deposits formed during erosion) found in vibracores taken through these ridges confirm this interpretation.

Figure 3. Ground penetrating radar transect taken along the riverside portion of Popham Beach. The profile shows evidence of the easterly dipping beds formed as the paleo-Kennebec River migrated eastward.

Figure 3

Iceberg Furrows and Sand Waves in the Gulf of Maine

Daniel F. Belknap and Detmar Schnitker
University of Maine

This past July we conducted a research cruise on the R/VEdwin Link and the submersible Clelia to examine features that wehypothesized to be iceberg furrows, on rises in the southeasternGulf of Maine, and to examine large bedforms on the northern edgeof Georges Bank. In previous NSF-supported cruises, wediscovered hummocky disturbed sediments ubiquitously on top ofrises, such as Truxton Swell, Sewell Ridge, and Wright Swell.These were similar to iceberg furrows described by King and Fader(1986) from the Scotian Shelf. We also rediscovered regularbedforms, first mapped by Fader et al. (1977), near the HagueLine in 150 m water depth on the steep northern slope of GeorgesBank.

Our long-term project has involved seismic reflectionprofiling and coring to determine the deglacial and post-glacialgeologic evolution of the Gulf of Maine, roughly the past 18,000years. This summer, we had the additional resources, funded bythe NOAA National Undersea Research Program, University ofConnecticut, Avery Point, of a deep-tow sidescan sonar and thesubmersible Clelia, capable of diving to 300 m. We conducted tendives in the southeastern Gulf of Maine, on furrows, outcrops ofglaciomarine sediments, and on the sandwaves. At each site wealso had seismic data, and mapped a transect by sidescan sonar.We were joined by Canadian researcher Gordan B.J. Fader of theAtlantic Geoscience Centre, and six other professionals andstudents.

The iceberg furrows turn out to be kilometers in length,tens of meters width, and meters deep, plowed into the rises ofthe southeastern Gulf of Maine in water depths up to 250 meters.They are straight, or J-hooked in appearance, and cross-cut oneanother. They generally align from north to south in the easternGulf, but are aligned towards the east-northeast in the south-central Gulf (Wright Swell). These strongly suggest response toa surface flow out of the North-east Channel approximately 18-14thousand years ago. The plow marks are sharp and clear, controlsmall scale patches of sediment type and ecosystems on thebottom, and are not being erased by bioturbation or dragging.They will help us understand deglacial processes and timing ofevents in the change from ice age to modern conditions in theGulf of Maine.

Our second major discovery was the sand waves, generally 2-3m amplitude (up to 5 m), 30-50 m wavelength, and straight tosinuous crested. They are composed of clean, very coarse sand,and are characterized by a trough with coarse shell lag andlinear ripples, an avalanche face covered with linear ripplesnormal to slope (a flow along the slope), a sharp

Benthic Habitat Studies and GLOBEC Site Surveys on Georges Bank

Page Valentine, U.S. Geological Survey

The U.S. Geological Survey and the National Marine FisheriesService conducted a cruise to Georges Bank with the NOAA ShipAlbatross IV (AL 9401) from April 6 to 15, 1994. Participantsfrom the USGS and the University of Rhode Island mapped andsampled benthic habitats on the gravel pavement of the NorthernEdge and mapped sites selected for the deployment of long-termmoorings by the GLOBEC program. The objectives of the cruisewere to: (1) Document the character and distribution offisheries habitats along the Northern Edge of Georges Bank inU.S. and Canadian waters; (2) Determine the impact of scallopdredging and groundfish trawling on the sea bed and the benthicbiological community, including a quantitative comparison ofepibenthic faunal composition in fished and unfished areas of thegravel habitat on the Northern Edge of the bank; (3) Survey theseabed at several sites on the southern part of Georges Bankwhere long-term, instrumented moorings will be deployed laterthis year as part of the GLOBEC Program.

Equipment deployed included 100 kHz sidescan sonar withdigital data acquisition, a bottom video camera, and Naturalistand Digby dredges; navigation was by differential GPS. On theNorthern Edge, 21 bottom dredge stations and 21 video stationswere occupied, and 5 areas were mapped with sidescan sonar (31km2). In addition, approximately 200 color photographs weretaken of live specimens of benthic species. On the southern partof the bank, 3 GLOBEC mooring sites and 3 connecting lines weremapped (26 km2) and 2 video stations occupied.

Sidescan sonar records will be processed and archived atUSGS laboratories in Woods Hole, MA. Video tapes and biologicalphotographs (prints and CD-ROMs) will be duplicated and archivedat: USGS in Woods Hole, MA; Graduate School of Oceanography atthe University of Rhode Island, Narragansett, RI; and at theNational Undersea Research Center at the University ofConnecticut, Groton, CT. Biological samples will be processedand archived at the Graduate School of Oceanography, URI.

Preliminary Results

<u>Georges Bank Gravel Habitat</u>

Sidescan sonar surveys, videoobservations, and replicate dredging for benthic faunas wereconducted in disturbed and undisturbed areas of the gravelhabitat on the Northern Edge of the bank in U.S. and Canadianwaters. Scallop dredges and groundfish trawls account for thebottom disturbance, and fishing vessels were active in thedisturbed areas during the cruise. Replicate dredge samples werecollected in 4 areas (2 disturbed, 2 undisturbed) and livespecimens of most species were photographed at sea. Preliminaryinterpretation of data

U. S. GLOBEC Georges Bank Program Update

The U.S. GLOBEC Georges Bank science investigators will be meetingOctober 3-5 in Woods Hole, Massachusetts to review the results fromthis year's field and modeling work on the Bank, do additionalplanning for the 1995 field work and discuss data management issues.Several investigators will also participate in the National GLOBECSteering Committee meeting October 6-7 in Washington, D.C. Therewill be a cruise November 7-18 on the Albatross to study thebroad-scale distribution and abundance of zooplankton and fishlarvae on Georges Bank. This cruise will be a prelude to theintensive cruise schedule slated this coming winter/ spring.Manuscripts describing recent work on Georges Bank, which will bepublished as a special volume of Deep Sea Research, are due forsubmission shortly.

Bob Groman recently joined the U.S. GLOBEC Georges Bank Program asthe program services and data management administrator. He willprovide services, logistical support and data management. Animportant part of his job is to implement a distributed datamanagement system (currently being used by the U.S. JGOFS project)for the Georges Bank data and provide help in integrating thediverse biological and physical data sets for analysis by theinvestigators.

Bob worked in programming anddata management of the underway measurements for the Geology andGeophysics Department at Woods Hole Oceanographic Institution during the 1970's. Since1980 he held increasingly responsible positions at the Institution'scentral computing center. Bob has extensive experience in datamanagement, personal computers (both MS/DOS and Macintosh), VAX/VMS and most recently Unix based workstations.

Bob is in the process of setting up the new office and can be reached now via email at rgroman@whoi.edu and (508)457-2000 x2409.

(Iceberg Furrows continued)

crest, and astoss slope with three-dimensional flow ripples (lunate-linguoid)of 10 cm wavelength and 2 cm amplitude. These sandwaves werecreated by a flow downslope, and slightly to the right (thus,NNE), rather than the tidal E-W flow that we had originallypostulated. The small ripples in their troughs and lee face areprobably tidally controlled. The sand waves occur at thesteepest part of the slope. We hypothesize that they are createdby downwelling dense water masses, possibly created by winterrefrigeration of Georges Bank top, and accelerated at the steepflank of the bank. We will be modeling the flow required tocreate these features in the coming year. These features mayrepresent a previously unrecognized oceanographic processes inthe southern Gulf of Maine.

UMass Dartmouth Builds Marine Laboratory Seeks Director of Marine Science, Environment and Technology

LeBaron Colt, UMass Dartmouth

A new marine research facility with fifteen laboratories is in the final planning stages, with construction due to start next spring. This new center will be located on land deeded from the National Parks Service in Clarks Cove, New Bedford, Massachusetts. To launch the research programs and oversee the operations of this new facility, a new position has been created: Director of the Center of Marine Science, Environment and Technology at UMAss Dartmouth. Applications and nominations are currently invited for this position.

Responsibilities: The Director will coordinate present marine activities and provide leadership for development of UMass Dartmouth's marine science/technology, environmental and aquaculture programs. These duties will include representing UMass Dartmouth during the final stages of architectural work and construction of its new marine laboratory located on Buzzards Bay in New Bedford. The Director will be responsible for the operation of this laboratory and a planned aquaculture laboratory located on an adjacent site.

Qualifications: Candidates must hold an earned doctorate in a marine science or engineering related discipline and meet the standards for a tenure appointment at the full professor level in a science or engineering department. Application materials include curriculum vitae, a statement of interest and the names and addresses of four references. Send materials to Chairperson, Search & Screen Committee, Director of Marine Sciences, c/o Personnel Office, University of Massachusetts, Dartmouth, North Dartmouth, MA 02747. Application screening will begin on October 1, 1994.

(Benthic Habitat continued)

indicate that numerous benthic species(especially attached forms) that are present in undisturbed areasare sparse or absent from disturbed areas. Biodiversity is muchlower on disturbed bottom; and gravel particles are clean,presumably as a result of abrasion caused by bottom dredge andtrawl gear. Principal investigators are: Page Valentine (USGS),Jeremy Collie and Galo Escanero (URI), and Peter Auster(NURP/UCONN). A second cruise with a NOAA ship to the NorthernEdge study areas is scheduled for October.

<u>GLOBEC long-term mooring sites</u>

Sidescan sonar surveys ofproposed mooring sites revealed several bottom types on thesouthern flank of Georges Bank, including intensively dredged andtrawled, smooth sand bottom along the 40 fm (73 m) isobath,widespread storm sand dunes and shell deposits that extend from30 to 40 fm (55 to 73 m), and high amplitude (5 to 10 m) sanddunes at 23 fm (42 m) near the bank crest. These observationswill guide the placement and configuration of moorings to bedeployed in this region in the near future.

Calendar

September

7 — American Geophysical Union Fall meeting abstract deadline
contact: AGU editorial office (202) 462-6900

12 — U.S. GLOBEC Georges Bank Executive Committee meeting in Woods Hole , Massachusetts, contact: Bob Groman, WHOI, (508) 457-2000 ext. 2409

12-13 — Regional Marine Research Program Principal Investigators and Board meeting
University of Maine, Orono
contact: David Townsend, (207) 581-1435

20-23 — “Coastal Zone Canada ’94"
Halifax, Nova Scotia
contact: Mr. Brain Nicholls, Dept. Fisheries and Oceans Canada, (902) 429-9497

23 — registration deadline “Water Vapor & the Climate System”, AGU meeting
October 25-28th, Jeckyll Island, Georgia
contact: AGU meetings dept. (202) 461-6900

October

1 — Target Date NSF Division of Ocean Sciences Centers and Facilities Section (703) 306-1577

3-5 — U.S. GLOBEC Georges Bank Scientific Investigators meeting
Woods Hole, Massacuhsetts
contact: Bob Groman, WHOI, (508) 457-2000 ext. 2409

13-14 — **RARGOM meeting**
St. Andrews Biological Station
St. Andrews, New Brunswick
contact: Genie Braasch, Dartmouth College, (603) 646-3480

26-27 — Sixth Biennial Benthic workshop “Bivalve Culture”
St. Andrews Biological Station
St. Andrews, New Brunswick
contact: Dr. David Wildish (506) 529-8854

November

1 — Target Date NSF Division of Ocean Sciences Research Section (703) 306-1580
note: 1995 NSF Target Dates will change to February 15 and August 15.

2-4 — “Improving the Interaction between Sciences and Policy in the Gulf of Maine Region”
National Research Council’s Ocean Studies Board, Kennebunkport, Maine
contact: David Keeley, Maine State Planning Office (207) 287-3261

December

5-9 — American Geophysical Union Fall meeting
San Francisco, CA
contact: AGU meeting office (202) 462-6900

Reports Received

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

Gifford, D. et al. “RV Columbus Iselin Cruise 9407 to Georges Bank”: *U.S. GLOBEC NW Atlantic Georges Bank Study*, 25 May - 16 June, 1994

Weibe, P.H. et al. “RV Albatross IV Cruise 9404 to Georges Bank”. *U.S. GLOBEC NW Atlantic Georges Bank Study*, 31 May - 10 June, 1994

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