

**Synthesis: Gulf of Maine Area Program, Census of Marine Life
Proposal to Alfred P. Sloan Foundation
1 April 2008 - 31 December 2010**

Contents	Page
1. Context	1
Long-term project goals and scope	
Notable accomplishments to date	
Scientific questions	
Methods; Limits to knowledge	
Achieving representative global coverage	
Contribution to CoML Legacies	
Applications	
2. Project Description	5
Biodiversity in the Gulf of Maine Area	
Bioinformatics and Visualizations	
Biodiversity Attributes in Relation to EAM	
GoMA Lessons Learned and Ecosystem Comparisons	
3. Project Milestones	10
4. Project Outputs	12
Scientific discoveries	
Papers	
Additions to the database	
Data visualizations	
5. Project Management	14
The management plan	
People and their responsibilities	
6. Data Management	15
Internal data management and integration	
OBIS interoperability	
7. Education and Outreach	16
8. Synthesis	18

Contents (continued)

Page

Appendices

A. Literature Cited	A-1
B. Acronyms	A-2
C. Funding and Ship Time	A-4
D. GoMA-funded projects	A-7
E. Research Investments and Proposals	A-8
F. Accomplishments to Date: Details and Additions	A-9
Scientific highlights	
E&O highlights	
G. Project Description: Details	A-13
Biodiversity working groups	
Bioinformatics	
Ecosystem Comparisons	
H. Regional E & O Activities	A-14

**Synthesis: Gulf of Maine Area Program, Census of Marine Life
Proposal to Alfred P. Sloan Foundation
1 April 2008 - 31 December 2010**

1. Context

Long-term project goals and scope: The over-arching goals of our project are to increase understanding of ecosystem biodiversity in the Gulf of Maine area; describe--within the context of the known, unknown, and unknowable--how this biodiversity supports regional ecosystem functioning; and suggest ways that the information can be used to support better decision-making regarding the marine environment. To ensure that we develop a realistic and useful model of how knowledge of biodiversity can be used by managers, we are working in partnership with U.S. and Canadian fisheries agencies. Our funded tasks are to describe the biodiversity underpinnings for ecosystem approaches to management (EAM), synthesize data, help develop databases and information systems to make the data available, and recommend next steps needed for research and monitoring. Our study area includes U.S. and Canadian waters: the western Scotian Shelf, the Gulf of Maine, Georges Bank; the continental slope, and the western New England Seamounts. Specific goals are to:

1. Increase biodiversity knowledge through new exploration;
2. Synthesize data to describe patterns of the known biodiversity and its changes over time;
3. Describe the multi-scale contribution of biodiversity to ecosystem function in the context of the known, unknown, and “unknowable”;
4. Describe anthropogenic and natural forcing of biodiversity change;
5. Work with U.S. and Canadian agencies that are developing frameworks for EAM to describe how biodiversity knowledge can be used;

6. Initiate and help develop an integrated information capacity (through the Gulf of Maine Ocean Data Partnership) to provide biodiversity-relevant information through the IOOS for research, education and application;
7. Compare our results and development process with selected marine biodiversity and ecosystem-based research elsewhere;
8. Increase public knowledge of the connections between biodiversity and ecosystem function;
9. Contribute to the global synthesis of the Census of Marine Life.

The present focus of GoMA was initiated in 2003 and has developed through scientific and advisory committees and working groups over the past five years. Canadian scientists collaborated informally on this US-led program until mid-2007, when GoMA's project management was revised to include formal Canadian representation. The program consists of contributed projects that began before this CoML program was funded (Appendix C); projects that were partially or fully funded by GoMA (Appendix D); and partnership activities established during this funded period (but also see Appendix E). Because ours is a "whole ecosystem" project, the synthesis phase will engage many results and experts that have not been involved in specific GoMA-CoML field programs to date. (Acronyms used in this proposal are given in Appendix B.)

Notable accomplishments to date: Details and additional accomplishments are listed in Appendix F. Summary points are: (1) Changes in biodiversity over the past 20 years were examined in the intertidal zone and in an offshore ledge system; (2) Major drivers of variability in biodiversity and feeding at an offshore "hotspot" were identified; (3) A Gulf of Maine Ocean Data Partnership (GoMODP) was formed and has completed three years of growth and successful operation; (4) GMBIS has been updated and provides online querying, display, and download of biological and

environmental data; (5) The Canadian Discovery Corridor initiative has received widespread recognition after completing two successful cruises in the northern Gulf of Maine; (6) Five US (NOAA) cruises explored Jordan Basin, the continental slope, and three of the New England seamounts; (7) Two NaGISA study locations were established in a macrotidal estuary shared by the U.S. and Canada; (8) Stellwagen Bank National Marine Sanctuary has been established as a site of collaborative study of biodiversity; (9) The GoMRMS is well on the way to providing a comprehensive species list of taxa reported in the Gulf of Maine; (11) Two DVDs of GoMA and Discovery Corridor work have been distributed to educators and students. (See Appendix F for more E&O accomplishments including recent media coverage.)

Scientific Questions: In 2003 our program established as a goal to increase and integrate biodiversity knowledge in ways that could be useful to management. This is a timely challenge given that the U.S. and Canada both have legislation to conserve biodiversity and to pursue “ecosystem approaches” to managing their marine systems, but it is not yet known how to do this^[1]. Our strategy is to make signal contributions to each of the following broad questions: (1) *What is the biodiversity of the region, including estimates of the unknown, and how is this diversity distributed?* (2) *What does biodiversity contribute, functionally, to the ecosystem?* (3) *What processes control these patterns of biodiversity?* (4) *How can we characterize biodiversity patterns and processes so that information can be used to understand, monitor and respond to changes in the marine environment?*

Methods: Limits to Knowledge: Even in a well-studied system, much of the biodiversity remains undescribed and our knowledge will remain incomplete for the foreseeable future. How, then, can

we describe how the many unknown species, along with the known, collectively contribute to ecosystem function? Specifically, can we say why it is important to conserve *all* species, describe how to achieve conservation goals for all this biodiversity, and assess how well we are doing with that objective?

Another primary limit to understanding biodiversity, and developing more sophisticated management approaches, is that we cannot adequately characterize patterns of biodiversity from small to large scales. Biological communities are enormously variable, and the ability to rapidly assess patterns over large areas is thus an important technological hurdle that must be overcome. Rapid assessment tools are being developed, such as automated benthic image analysis techniques (NEBO: Northeast Benthic-Pelagic Observatory: nebo.whoi.edu/node/14) and large-scale fish schooling patterns that include species distributions and behaviors (OAWRS: acoustics.mit.edu/faculty/makris/Laboratory_for_Undersea_Remote_Sensing.html). In the meantime, we will start developing models that include spatial attributes of biodiversity and related functions, making practical but wise allowances for the unknowns.

Achieving representative global coverage: We will provide a forum for comparing our approach and findings with up to four other regional ecosystem/EAM projects. See Project Description.

Contribution to CoML Legacies: We expect the enduring results of GoMA to include recognition and greater understanding of the broader suite of biodiversity that must be included in future research and management approaches, public appreciation and support for these approaches and for the underlying research, and greatly improved data resources. Specifically, we wish to provide a logical structure within which biodiversity knowledge and concepts are accessed, valued and

actively used by human societies, thereby stimulating new funding and enabling research. Some specific legacies will be improved access to biological and environmental data via GMBIS, new regional knowledge summarized in scientific papers, a dedicated journal issue and the GoMRMS, and increased public awareness through outreach products such as magazine articles, DVDs, and a documentary film.

Applications: Our developing information systems, models, publications and other results will be accessed by a broad range of stakeholders in the ocean, including scientists, managers, NGOs, ocean users, educators and the public. We expect the biggest users to be scientists and managers.

2. Project Description

For our final project phase we define four theme areas that provide rallying points for the program and our regional research community. We will also build on existing linkages with other CoML field programs and projects to achieve comprehensive outputs across the four themes. The CoML field programs we will interact with are HMAP, OAWRS, NaGISA, MarECO and TOPP (based on geographic overlap) plus CeDAMAR, CoMARGE, iCoMM, CenSEAM, and FMAP based on their expertise in areas that we need to tap.

Biodiversity (Diversity, Distribution and Abundance) in the Gulf of Maine Area: Between April 2008 and March 2009, our original working group chairs (Appendix G), PIs from GoMA-funded projects, and additional experts will work together to describe spatial patterns of biodiversity at GoM and medium scales (basins, slope, banks, coastal zone, sea mounts, etc.), estimate the total biodiversity, describe the functionality of that biodiversity, and the impacts of anthropogenic and

climate forcing. [Products: paper or set of papers in Can. J. Fish. Aquat. Sci. or ICES J Mar Sci; new web content].

We will engage HMAP (Rosenberg^[2] Alexander, Lotze^[3], et al.), FMAP (Worm^[4], Lotze et al.) and others (Steneck^[5], Melvin and others) to evaluate two questions. (1) For selected species (e.g., cod, herring, mackerel, lobster), describe historical biomass/population estimates and the types of ecosystem that may have existed with them. (2) Evaluate the impacts of possible future biodiversity changes on ecosystem attributes. [Products: paper in Proceedings of the Gulf of Maine Summit or other; new web content].

We are working on a proposal to NSF (due February 2008) with Makris, Ratilal, Jech (OAWRS) and others to analyze the ecological context and implications of the large herring shoals observed during their experiments north of Georges Bank.

Recognizing the rapid pace of development, ongoing accumulation of new material, and critical importance of barcoding approaches to marine biodiversity assessment, GoMA will work towards an inventory of current marine barcoding initiatives underway in the region. We will initiate contact with BCOL (Dirk Steinke) to request a summary of their current relationships with the GoM research community. We will review these existing links and develop recommendations for improvement and greater awareness among the regional community.

Biodiversity Informatics and Visualization: We will continue to improve our data discovery and delivery portals that serve GoM data (go to our data mapping portal on our project website at www.usm.maine.edu/gulfofmaine-census/). This includes streamlining the addition of new GoM data to GMBIS and augmenting its interoperability using OBIS-compliant and OGC-compliant (WMS and WFS) standards, with other standards-compliant data providers. By focusing on

interoperability in a joint effort with other major data providers in the region, we are equipping the GoMODP (currently 24 institutions/agencies) to serve biological and other environmental data to IOOS. We are also upgrading our system to allow not only for the visual *viewing* of data layers from the different data sources, but also the download of *integrated* data in new tables. We will continue working with the Atlantic Reference Center to update the GoMRMS and increase its functionality, including flexible searching, downloading and links to content pulled from the Encyclopedia of Life (EOL), ITIS, Tree of Life web project, and Interactive Tree of Life (iTOL). All GoMA-generated data will be available through the GMBIS data and mapping portals as well as OBIS. Additional details are given in Appendix G.

We will create new visualizations of GoM data for our website in two classes of products: (1) Google Earth plots of tracking data for large migratory taxa (whales and tunas: Halpin, Block and Kraus) and “power of ten” scale-ins to some of the better-studied sites (Platts Bank, Stellwagen Bank, Grand Manan Basin); and (2) other selected products, including fly-throughs, photos and/or other illustrative materials from each of the GoMA field projects. This will expand on GoMA’s current Google Earth projects. During August 2009-August 2010 we plan to hand off GMBIS and our projects content areas to appropriate inheritor sites (*e.g.*, for GMBIS this would be GoMODP/IOOS).

Biodiversity Attributes in Relation to EAM: The US NMFS and Canadian DFO will contribute a significant joint Ecosystem Overview Report (March 2009) describing the ecosystem and its gross functionality, with an emphasis on species and areas of special concern to management. This report will serve as a background document for EAM at the agencies. Our involvement will be a dialogue with the agencies to ensure that there are logical connections between the system

attributes identified in the report and the GoMA work described in theme 1, above. We anticipate a joint paper in 2010.

Spatial scaling of habitats and biological communities, and functionality of the communities and their spatial structure, will be addressed by two projects. (1) A Canadian Ecosystem Research Initiative (ERI) includes a significant emphasis on predictive modeling of benthic community structure and a synthesis of available information from the northern GoM. (2) For the Stellwagen Bank sanctuary, we are working with other researchers (especially GoMA collaborator P. Auster^[6]) on approaches to modeling ecosystem functions as a function of oceanography and benthic spatial structures. We expect at least one CoML publication on this topic during the synthesis phase.

During the time-line of GoMA, several community-wide communication and planning efforts have emerged that place considerable effort at including managers and other stakeholders along with scientists in their deliberations. These developments decrease the prior need for GoMA to facilitate this process, and we are now able to focus more directly on the scientific needs. We single out the COMPASS Gulf of Maine Project as one we are working with. GoMA is contributing biodiversity information and modeling ideas to COMPASS, with an emphasis on the Stellwagen Bank area.

GoMA Lessons and Ecosystem Comparisons: There have been many challenges to designing and prioritizing a plan for expanding and utilizing biodiversity information in a system as large and complex as the GoM. One of the major challenges is how to design and conduct a coherent project without it becoming a study of everything. Here, we will provide an overview of scientific findings and then consider “Lessons Learned” in the context of implementing and benefiting from a

program of biodiversity research, exploration, and bioinformatics. What did we learn, factually; what did we learn about approaches; what did we accomplish, and to what benefit; and what do we recommend for future work? Our synthesis will be presented at the GoM Summit, a scientific conference being organized by RARGOM to be held in St. Andrews, NB in October 2009.

We also want to compare ecosystem studies in several prominent systems where biodiversity is being studied at a system level with an eye to heuristic value, conservation and/or understanding of ecosystem functioning. We have identified the Gulf of Mexico, the Gulf of Alaska, the Baltic and Australia's Great Barrier Reef as the best candidate systems for a focused workshop. Following-up on our preliminary discussions with principals involved in these programs we will convene a steering committee by late June 2008, which will submit a joint proposal to organize a workshop that would be held in December 2009 (possibly at the Harte Institute in Corpus Christi, TX). Results would be presented as part of the 2010 CoML wrap-up. Possible focus themes are given in Appendix G.

3. Project Milestones

Our milestones are listed by 6-month periods in the following order: biodiversity, bioinformatics and visualization, ecosystem approaches to management, lessons learned/ecosystem comparisons, and education and outreach. These milestones include only the larger synthetic products that we have direct control over. We expect that all GoMA-funded projects will publish one or more research papers from their efforts and will acknowledge GoMA-CoML. They will be part of the program's eventual output, but the timing and number of these cannot be anticipated at this time.

Period Milestones [Lead investigator(s) in parentheses]

2008 1st half

- Convene working group chairs, GoM project PIs and other experts to organize and initiate GoM DDA synthesis (Incze)
- Makris, Ratilal, Incze et al. submit proposal to NSF on ecological context of herring shoals
- US and Canadian informatics experts begin collaboration on interoperability and functionality of GMBIS and ACON (Incze, Lawton)
- Steering committee for ecosystem comparison formed, develops terms of reference, selects venue for workshop and submits proposal for funding (Ellis)
- Create visualizations of whale migrations and “power of 10” on Platts & Stellwagen Banks and Grand Manan Basin (Incze, Halpin, Kraus, Wiley) and Canadian Discovery Corridor (Lawton, Halpin)
- Documentary film group develops GoMA film concept. Submits proposals for incremental funding if required. Links with GoMA data visualization work clarified (Lawton, Ryan)
- Co-host COSEE-NE “Telling your Story” workshop for scientists and teachers (Ryan)

2008 2nd half

- Assemble HMAP/FMAP team for synthesis geared to Oct 2009 GoM Summit (Ellis)
- Platts Bank cruise (ONR funded, Incze)
- Follow through with BCOL to track all sample agreements (Incze, Lawton)
- All data from GoMA projects submitted to OBIS (Wolff)
- Contract filmmaker for documentary film (Lawton, Ryan)
- Approach *National Geographic* or *Discover* on “Three Gulfs” article (Ellis)
- Participate in Visualization Workshop (Duke Univ.); work with Halpin’s team and Block on tuna visualizations (Wolff)
- Discovery Corridor and other GoMA “small-project” visualizations (Lawton, Ellis, Ryan)
- Presentation at Ocean Literacy Summit (Ryan)
- Launch GoMA lecture series (Ryan)

2009 1st half

- Participate in CoML All-Program Meeting, Long Beach CA
- Complete review of BCOL-GoMA research community interaction and provide dynamic links to online resources from GoMA’s website (Lawton)

Period Milestones continued [Lead investigator(s) in parentheses]

2009 1st half continued

- Finish updates on GoMRMS (Wolff)
- GoMRMS hyper-linked to EOL, ITIS, Tree of Life web project, and iTOL
- NMFS and DFO release Ecosystem Overview Report
- DFO holds EAM workshop (Lawton leads interaction with GoMA)
- Whale, tuna, and project visualizations (2008) released and publicized (Ellis, Ryan)

2009 2nd half

- Complete expert vetting of KUU for GoM (Incze, Lawton, Ellis)
- GoM biodiversity synthesis team submits paper (Can. J. Fish. Aquat. Sci. or ICES J. Mar. Sci.; Incze, Lawton, Ellis)
- Discovery Corridor cruise (NSERC-DFO funded; Lawton)
- Present “GoMA Lessons Learned” synthesis at GoM Summit, submit paper (Ellis)
- Present results on historical biomass/population estimates and impacts of possible future biodiversity changes at GOM Summit, submit paper (FMAP, lead TBD)
- Hold ecosystem comparison workshop; establish writing team (Ellis)
- GoMA reports/papers to CoML Synthesis Team (Ellis)
- Updated GoMRMS released and publicized (Wolff, Ryan)

2010 1st half

- Biodiversity-EAM paper that combines GoMA synthesis with EOR report (Lawton, Incze, Ellis)
- GoM documentary film released (Lawton, Ellis, Incze, Ryan)
- GMBIS transferred to new host organization (Incze, Wolff)
- Policy briefings begin (Ryan)
- Popular article on “Three Gulfs” published and promoted (Ellis, Ryan)

2010 2nd half

- Publication on ecosystem comparison (Ellis)
- Discovery Corridor cruise (NSERC and DFO funded; Lawton)
- GoMA website content transferred to appropriate inheritor site(s) (Incze, Ellis, Wolff)
- Public release of first Census of Marine Life, London (October)
- Intensive media campaign (Ryan)

4. Outputs from the Project

Scientific Discoveries: Discoveries to be detailed (where the work is sufficiently advanced) or summarized (in ways appropriate for preliminary release), include: 1) several species range extensions and new species from deep-water explorations; 2) additions to knowledge of reproductive biology and genetics of deep water corals; 3) greater biomass and species diversity than previously known from a deep basin within the Gulf ; 4) trophic implications of herring schools described by OAWRS results (Makris^[7]); 5) mechanisms that cause feeding hotspots to be turned “on” or “off”, thereby affecting feeding efficiency, local distributions and ecosystem-wide movements of predators^[8] (partially funded by ONR); 6) a genetically traced rate of new invasion of a shore crab throughout the system; 7) an oceanographic division of intertidal biodiversity along the western coast of the Gulf; and 8) several historical comparisons of ecosystem change—some of them at least partly human-induced.

Scientific Papers: GoMA plans to produce either a special report or a dedicated issue on “Gulf of Maine Biodiversity.” The material would include: (1) an introduction/executive summary; (2) a series of papers on CoML discoveries and integration with prior work; (3) interpretation of the relationship between biodiversity and ecosystem function; (4) bioinformatics efforts, including integration into IOOS; and (5) the use of biodiversity conservation as a management objective (EAM—rationale and approaches). Journals we are considering include the *Can. J. Fish. Aquat. Sci.* (a dedicated issue or partial issue); a special report of that journal (a refereed series that is indexed throughout major reference services); or the *ICES J. Mar. Sci.* In addition to the synthetic collection above, we expect one or more papers to be published by all GoMA-funded projects (Appendix D).

Additions to Databases: The Canadian trawl survey database is now accessible through OBIS. We have converted the corresponding US trawl survey database into OBIS format and serve it from our GoMA CoML server per agreement with NMFS. We have worked with NMFS to implement DiGIR, but the decision to provide their data through OBIS is in their hands. The states of Maine and New Hampshire nearshore surveys are accessible through OBIS and cover waters inside 100 m (thus complementing the federal US data). We are seeking Massachusetts' agreement to provide their coastal survey data. Intertidal surveys funded by GoMA will soon be available through OBIS; the new GoM NaGISA data are already served. We expect that all other GoMA projects will have their data OBIS accessible by the end of 2008.

Our program has emphasized not just technical access to biological data, but also easy web-based exploration of biological as well as other relevant ecological and environmental data needed for ecosystem studies. We have strived for modern interoperability based on geospatial standards and an open-source web mapping feature (see Project Description: Biodiversity Informatics). In doing this, we initiated and have helped to sustain the development of GoMODP, which now has 24 actively involved institutions and will be partnered into IOOS. We believe we are ahead of any other region in this respect.

Data visualizations: In November 2007 GoMA launched a more powerful version of GMBIS which allows users to create interactive maps of layered biological and geophysical data and download selected data. We are currently conducting public beta-testing and have had inquiries from other CoML field programs, NEBO and other data providers to make the software available. We propose continued development through mid-2009 and a hand-off in the fall of 2009 to a new host organization, yet to be determined, which will maintain it as part of IOOS. We are working

with Canada's DFO to evaluate technology sharing of code with their ACON program package which has desirable features that we have not yet implemented.

We will build migration visualizations with Pat Halpin's group at Duke University, beginning with right whales (species of concern) and humpback whales (abundant data). We intend to include bird foraging in our approach. Barbara Block (TOPP) has volunteered her Atlantic bluefin tagging data (we will decide how to deliver the data without further threatening the fish). We also plan to expand the migration visualizations to include current Canadian programs (World Wildlife Fund, Species At Risk Assessment Program, and tuna research based in St Andrews, NB).

We also have discussed with Halpin the idea of creating an interactive fly-through of the Discovery Corridor. This will be a showcase for GoMA's multiple realm approach: as users "travel" from the intertidal zone outward past slopes, banks, basins, channels and seamounts they will be able to click on text, photos and video clips about marine life, habitats and research techniques. This has great potential to educate and inspire and could additionally serve as a stimulus for public and governmental funding of biodiversity science.

5. Project Management

Principal investigators from USM began to manage GoMA in 2003, with guidance from scientific and advisory committees and working groups. As of mid-2007, GoMA is managed jointly by US and Canadian investigators, using input from a wide range of researchers from both countries (more than the original advisory committees). Because one of GoMA's goals is to describe how biodiversity information might be used in ecosystem approaches to management, GoMA also relies on guidance from three principal advisors from federal management agencies in both countries.

People and their responsibilities: GoMA is led by Chief Scientist and Principal Investigator Lewis Incze (USM), Co-Principal Investigator Peter Lawton (DFO and Centre for Marine Biodiversity) and Project Manager Sara Ellis (see Appendix J for CVs). Our chief EAM advisors are Mike Fogarty (NMFS), Robert Stephenson (DFO), and Mike Sinclair (DFO). Sinclair also serves as GoMA's liaison to the CoML SSC.

Incze's team at USM includes Nicholas Wolf (data manager and OBIS liaison) and Susan Ryan (E&O Coordinator). Other staff and graduate students work on GMBIS development and implementation, website design and content, and data analyses and visualizations.

Lawton will lead the incorporation of Canadian research results into the GoMA synthesis. Lawton will hire one full time doctoral level and one Masters level research associate to help with Canadian data analysis, synthesis outputs, and GIS visualisations. Short-term contracts will be provided to other Canadian researchers requiring assistance to provide customized outputs from existing research, tailored to GoMA synthesis requirements.

Ellis will serve as program management contact with the Sloan Foundation and CoML Program Office. She will assist program Co-PIs and the E&O Coordinator with planning and execution of critical tasks, and will plan and track budgets. She will also take the lead in several scientific projects and outreach efforts (project leaders are noted in the Milestones section). See Appendix I for more details on personnel responsibilities.

6. Data Management

Our data are stored in an open source PostgreSQL database, which is based on the OBIS format. The schema uses four tables, with a fifth used to preserve the original data columns, so no information is lost. In addition, we integrate all our taxonomic data with the Integrated Taxonomic Information System (ITIS), assigning an ITIS Taxonomic Serial Number (TSN) to each taxon. We

have created a semi-automated routine that downloads and reformats the ITIS database into a schema that allows for easy updating of our database (available upon request).

Data are available for download through our Data and Mapping Portal in a variety of formats, including, CSV, Excel, Google Earth KML, and ESRI Shapefile. In each of these formats, we adhere to the OBIS schema.

For providing data via our website, we have used two open source approaches. The Biogeographical Data Explorer combines our PostgreSQL database with Mapserver, and the Biogeographical and Physical Data Integrator combines our PostgreSQL database with PostGIS and Geoserver. The former is simpler and faster to operate if you just want biological data. The latter is our focus of development and emphasizes interoperability across numerous data types.

To serve our data to OBIS, we have mirrored our PostgreSQL database on an Oracle10g database. We have found our DiGIR server operates best with Oracle. Ideally, updates to DiGIR would allow us to abandon our Oracle database and work entirely within PostgreSQL. This would reduce the costs of maintaining Oracle, an expensive software. Our hope is that OBIS will provide alternatives to DiGIR, such as Web Feature Services (WFS), for serving data.

7. Education and Outreach

Our goal is to increase public awareness about the importance of marine biodiversity in the Gulf of Maine. We will showcase the wide range of marine life, habitats, and research with outreach products that reach across national borders (US and Canada) and marine realms (nearshore to sea mounts). We will collaborate with E&O teams from sister CoML projects in the development and promotion of primary synthetic outputs including a documentary film, a popular magazine article, data visualizations, and policy briefings (described below). Activities more specific to the GoM region will include features in regional print and television, lecture series, GMBIS-based

curriculum and a video contest (Appendix H). We will also continue to participate in the planning and development of regional educational initiatives in the US and forge new relationships with Canadian educational networks (Appendix H).

Synthetic E&O Outputs

Documentary film and videos: We envision a film on the Discovery Corridor, as a lens through which to communicate various aspects of the CoML research in the Gulf of Maine area. We will build on existing relationships with regional and national media, including CBC, PBS, National Geographic (Gregg Marshall), and independent film maker Peter McWhirter (Arrival Productions, Halifax, NS). Production (½ h to 1h length) will be based on sequences obtained by professional videographers, short clips from researchers, GIS data visualizations, etc. Material compiled during the film project will be made available for other outreach activity (media, GoMA and CoML website). We will include HMAP and NaGISA (and other CoML projects as appropriate) in this documentary.

Popular Magazines: Our major goal is to team up with the Gulf of Alaska (North Pacific Research Board, Clarence Pautzke) and the Gulf of Mexico (GoMex and Harte Institute, Wes Tunnell) for a “Three Gulfs” article to be published in an internationally renowned magazine such as *National Geographic* or *Discover*.

Data visualizations: Our planned migration visualizations of top predators are ideally suited to share with various audiences, and build on a theme we have established with GMRI’s education program (DVD: Exploring Platts Bank: A Biological Hotspot in the GoM). GMRI’s programming reaches more than 10,000 middle school students in Maine each year. We will continue to share these products with regional and national audiences.

The Discovery Corridor concept was specifically designed to offer E&O opportunities as its science program developed. There are now visual resources (still and video) as well as seabed mapping images ranging from intertidal to 2500 m depths. These will be used to develop innovative “fly-throughs” of the corridor, giving an opportunity to convey a representative cross-section of environments within the GoMA. We envision using such visualizations on our website and in film projects.

Policy Briefings: GoMA plans to give briefings to policy-making agencies within federal government and regional associations in the US and Canada. (We will seek non-Sloan funding for this). These briefings would be informed by collaborative work with HMAP, FMAP, and NaGISA. Target agencies include US NMFS, US EPA, US Fish and Wildlife Service, DFO Canada, and Environment Canada. One clear strategy for reaching regional agencies and governors/premiers is to give a major presentation to the Gulf of Maine Council on the Marine Environment. GoMA program findings should also be communicated to current and evolving national and international networks such as NERACOOS, IOOS, GoM Ocean Data Partnership, and the Atlantic Zone Monitoring Program to help inform their development.

8. Synthesis

Over the next 33 months we will assemble a description of the region’s biodiversity, including estimates of the unknown, and describe the ways in which patterns of biodiversity affect attributes and functioning of the ecosystem. Although the Gulf of Maine is a comparatively well-studied region, our focus on biodiversity and function at the regional system level will be unique. To accomplish this, we will engage many from the broader research community as well as CoML scientists from GoMA and other CoML programs. In considering patterns and functioning, we will incorporate historical views of the system, as well as the predicted impacts of biodiversity

alterations that have emerged from FMAP (trophic and age-structure alterations)^[4] and other studies (such as ecosystem disturbance^[9] and simplification^[10], and climate change^[11]). Other CoML field programs have tremendous expertise, insight and data in environments where we have comparatively little new information specific to our region; we plan to involve this valuable and exciting resource of information at every appropriate step to make ours a truly synthetic and integrative product. There are several ecosystem-oriented projects now underway in the Gulf of Maine region. Our “total biodiversity” approach occupies a unique niche that distinguishes our program and makes it complementary to other efforts; we will maintain our focus on this niche. Our collaboration with senior scientists at the two federal fisheries agencies will help ensure another goal: that our accomplishments and communications indeed prove useful in the broader conservation and ocean management realm.

GoMA will also contribute to planned CoML-wide products, activities and presentations as requested. We think likely contributions from our program will include an illustration of the large variety of community types that can exist within a complex coastal shelf ecosystem, the extent to which even “our own backyard” is unknown, and the importance of continued efforts to explore and understand biodiversity and ecosystem processes in order to conserve them. We believe a “Three Gulfs” popular article and our proposed film production will do much to capture public attention at a larger scale, and that these ideas and our contributions to data systems and ocean observing will stand as legacies of CoML’s contributions to global society.

Appendix A. References

1. Murawski, S.A. 2007. Ten myths concerning ecosystem approaches to marine resource management. *Mar. Policy* 31: 681-690. Palumbi, S.R. et al. (12 co-authors). In press. Managing for ocean biodiversity: Creating a national biodiversity conservation agenda to sustain marine ecosystem services. *Frontiers Ecol. Envir.*
2. Rosenberg, A. A., W. J. Bolster, K. E. Alexander, W. B. Leavenworth, A. B. Cooper, and M. G. McKenzie. 2005. The history of ocean resources: modeling cod biomass using historical records. *Frontiers Ecol. Envir.* 3:84-90.
3. Lotze, H.K. and I. Milewski. 2004. Two centuries of multiple human impacts and successive changes in a North Atlantic food web. *Ecol. Appl.* 14: 1428-1447.
4. Worm, B. et al. (13 co-authors). 2006. Impacts of biodiversity loss on ocean ecosystem services. *Science* 314: 787-790. Frank, K.T., B. Petrie, J. Choi and W.C. Leggett. 2005. Trophic cascades in a formerly cod-dominated ecosystem. *Science* 308: 1621-1623.
5. Steneck, R.S., J. Vavrinec, J. and A.V. Leland. 2004. Accelerating trophic level dysfunction in kelp forest ecosystems of the western North Atlantic. *Ecosystems* 7: 323-331.
6. Cook, R.R. and P.J. Auster. 2006. Developing alternatives for optimal representation of seafloor habitats and associated communities in Stellwagen Bank National Marine Sanctuary. NOAA Office of National Marine Sanctuaries, February 2006, 33 p.
7. Makris, N.C., P. Ratilal, D.T. Symonds, S. Jagannathan, S. Lee and R.W. Nero. 2006. Fish population and behavior revealed by instantaneous continental shelf-scale imaging. *Science* 311: 660-663.
8. Stevick P.T., L.S. Incze, S.D. Kraus, S. Rosen, N. Wolff and A. Baukus. Trophic relationships and oceanography on and around a small offshore bank. *Mar. Ecol. Progr. Ser.* In revision.
9. Hiddink, J.G., S. Jennings, M.J. Kaiser, A.M. Quierós, D.E. Duplisea, and G.J. Piet. 2006. Cumulative impacts of seabed trawl disturbance on benthic biomass, production and species richness in different habitats. *Can. J. Fish. Aquat. Sci.* 63: 721-736.
10. Cardinale, et al. (6 co-authors). 2006. Effects of biodiversity on the functioning of trophic groups and ecosystems. *Nature* 443: 989-992.
11. IPCC. 2002. *Climate Change and Biodiversity*, 86 p. Greene, C.H. and A.J. Pershing. 2007. Climate drives sea change. *Science* 315: 1084-1085.

Appendix B. Acronyms Used

ACON	A CONtouring data visualization application (www.mar.dfo-mpo.gc.ca/science/acon)
ARC	Atlantic Reference Centre
BCOL	BarCode of Life
CeDAMAR	Census of the Diversity of Abyssal Marine Life
CenSEAM	Census of Marine Life on Seamounts
CHONe	Canadian Healthy Oceans Network
CMB	Centre for Marine Biodiversity
CoMARGE	Continental Margin Ecosystems
CoML	Census of Marine Life
COMPASS	Communication Partnership for Science and the Sea
COSEE-NE	Center for Ocean Sciences Education Excellence - New England
DFO	Department of Fisheries and Oceans Canada
DiGIR	Distributed Generic Information Retrieval
EAM	Ecosystem Approaches to Management
E&O	Education and Outreach
EO	Ecosystem Overview
EOL	Encyclopedia of Life
ERI	Ecosystem Research Initiative
FMAP	Future of Marine Animal Populations
GMBIS	Gulf of Maine Biogeographic Information System
GMRI	Gulf of Maine Research Institute
GoM	Gulf of Maine
GoMA	Gulf of Maine Area Program
GOMC	Gulf of Maine Council on the Marine Environment
GOMMEA	Gulf of Maine Marine Educators Association
GoMODP	Gulf of Maine Ocean Data Partnership
GoMRMS	Gulf of Maine Register of Marine Species
HMAP	History of Marine Animal Populations
HMSC	Huntsman Marine Science Centre
HNS	History of the Nearshore
ICES	International Council for the Exploration of the Sea
ICoMM	International Census of Marine Microbes
IOOS	Integrated Ocean Observing System

Acronyms continued

ITIS	Integrated Taxonomic Information System
iTOL	Interactive Tree of Life
KML	Keyhole Markup Language
KMZ	Zipped Keyhole Markup Language
MarECO	Mid-Atlantic Ridge Ecosystem Project
NaGISA	Natural Geography in Shore Areas
NEBO	Northeast Benthic-Pelagic Observatory
NEOSEC	New England Ocean Sciences Education Collaborative
NERACOOS	Northeast Regional Association of Coastal Ocean Observing Systems
NGO	Non-governmental Organization
NMEA	National Marine Educators Association
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Ocean Partnership Program
NSERC	Natural Sciences and Engineering Research Council
NSF	National Science Foundation
OAWRS	Ocean Acoustic Waveguide Remote Sensing
OAWRS	Ocean Acoustic Waveguide Remote Sensing
OBIS	Ocean Biogeographic Information System
OE	Ocean Exploration Program, NOAA
OGC	Open Geospatial Consortium
ONR	Office of Naval Research
PRIMER	Plymouth Routines in Multivariate Ecological Research
RARGOM	Regional Association for Research on the Gulf of Maine
RMS	Register of Marine Species
SSC	Scientific Steering Committee
SABS	Saint Andrews Biological Station
TOPP	Tagging of Pacific Predators
TSN	Taxonomic Serial Number
UConn	University of Connecticut
UNH	University of New Hampshire
USM	University of Southern Maine
WFS	Web Features Service
WMS	Web Mapping Services

Appendix C. Funding and Ship time

Estimated values of matching funds for research and ship time for projects in the Gulf of Maine that are being contributed to GoMA syntheses are summarized in Table 2, and detailed in Tables 3-6. These are divided into two periods: 2003-2007 and 2008-2010.

Table 2. Summary of previous and anticipated non-Sloan funding in CoML-related GoM research

Period	Matching funds	Ship time	Totals
2003-2007	2,370,000	2,510,000	4,880,000
2008-2010	2,258,900	700,000	2,958,900
Totals	4,628,900	3,210,000	7,838,900

Table 3. Matching funds for CoML-related work in the Gulf of Maine, 2003-2007

Year	Country	Lead	Project/Organization	Note	Funder	Value
2003	US	Richert/Incze	USM	GMBIS	Davis Fndn	30,000
	US	H. Singh	AUV on Stellwagen	Field work at sea	ONR	19,000
		L. Watling	Mountains in the Sea	Field work at sea	NOAA OE	400,000
2004	US	J. Moore	Bear Sea Mount	Field work at sea	NOAA OE	150,000
		M. Vecchione	Bear Sea Mount	Field work at sea	NOAA OE	300,000
		M. Fogarty	Continental Slope	Field work at sea	NOAA OE	300,000
		Richert/Incze	USM	GMBIS	NFWF	75,000
2005	US	Trott	Intertidal Survey	Cobscook Bay	Sea Grant	40,000
	Cda	Lawton	Discovery Corridor	Inshore video surveys	DFO	10,000
		Lawton	Discovery Corridor	Scientist salary 1 mo	DFO	7,500
		Lawton	Discovery Corridor	Operating funds	DFO	40,000
2006	US	Trott	Intertidal Survey	Cobscook Bay	TNC	15,000
	Cda	Lawton	Discovery Corridor	Inshore video surveys	DFO	14,000
		Lawton	Discovery Corridor	Scientist salary 1 mo	DFO	7,500
		Lawton	Discovery Corridor	Operating funds	DFO	40,000
2007	US	Incze/Fields	USM/Bigelow	Platts Bank	ONR	250,000
	Cda	Lawton	GoMA	Salary @0.5 FTE, 4 mo	DFO	13,500
		Lawton	Discovery Corridor	Inshore video surveys	DFO	24,000
		Van	ARC	NaGISA HNS	NB Environ Trust Fund	25,000
		Guelpen/Pohle				
		Lawton	DFO	NaGISA funding	DFO	17,000
		Lawton	Discovery Corridor	Scientist salary 1 mo	DFO	7,500
		Lawton	Discovery Corridor	Group contribution (20 person days)	DFO	5,000
		Lawton	Discovery Corridor	Operating funds (incl. workshop in 2007)	DFO	30,000
2003-07	US	Incze	USM	USM waived indirect cost to meet Sloan indirect 15% cost cap	USM	450,000
		Incze	USM	IT and grad student support	USM	100,000
						2,370,000

Table 4. Anticipated matching funds for CoML-related work in the Gulf of Maine, 2008-2010

Year	Country	Lead	Organization	Note	Funder	Value	Status	
2008	US	Incze	USM	2nd yr, Platts Bank, 2006-2009	ONR	250,000	Awarded	
		Makris	OAWRS	Ecological impacts of herring schools	NSF	400,000	Proposal in progress	
		Ryan	GoMA E&O	GoMA E&O support	Oak Fndn	20,000	To be written	
		Cda	Lawton	GoMA	Scientist salary @0.5 FTE	DFO	45,000	Committed
			Clayton	CMB	Admin Assistant salary @0.10 FTE	DFO	5,000	Committed
		Cooper	DFO, SABS	Involvement on marine fish/other diversity informatics at ~0.15FTE	DFO	14,000	Committed	
		Lawton	CMB	O&M support of CMB office	DFO	15,000	Committed	
		Pohle multiple	ARC ERI	DFO, SABS	Cost share	HMSC	6,800	Committed
					O&M funds only	DFO	300,000	Committed
		Lawton	DFO, SABS	Seamount workshop	DFO	35,000	Committed	
		Lawton	NaGISA	Field work in Bay of Fundy	DFO	17,000	Committed	
		Stephenson et al.	EAM	DFO-sponsored workshops and contributions on EAM (O&M est.)	DFO	100,000	Estimated	
		Snelgrove et al.	CHONe	Bay of Fundy and SWNS (basic estimate of O&M)	NSERC	50,000	Awarded	
2009	US	Incze/Fields	USM/Bigelow	3rd yr, Plats 2006-2009	NSF	250,000	Awarded	
		Ryan	GoMA E&O	E&O brochures, policy briefings	Davis Fndn	20,000	To be written	
		Ellis	GoMA	Ecosystem comparisons workshop	TBD	40,000	To be written	
		Cda	Lawton	GoMA	Scientist salary @0.5 FTE	DFO	47,000	Committed
			Clayton	CMB	Admin Assistant salary @0.10 FTE	DFO	5,100	Committed
		Cooper	DFO, SABS	Involvement on marine fish/other diversity informatics at ~0.15FTE	DFO	14,000	Committed	
		Lawton	CMB	O&M support of CMB office	DFO	15,000	Committed	
		Pohle multiple	ARC ERI	NaGISA	Cost share	HMSC	9,000	Committed
					O&M funds only	DFO	300,000	Committed
		Lawton	NaGISA	Field work in Bay of Fundy	DFO	17,000	Committed	

Table 4. Anticipated matching funds, 2008-2010 (Continued)

Year	Country	Lead	Organization	Note	Funder	Value	Status
2010	Cda	Stephenson et al.	EAM	DFO-sponsored workshops & contributions on EAM (O&M est.)	DFO	100,000	Estimated
		Snelgrove et al.	CHONe	Activities in Bay of Fundy and SWNS (estimate of O&M)	NSERC	100,000	Awarded
		Lawton	CMB, GoMA	Senior Scientist salary @0.50 FTE	DFO	50,000	Committed
		Clayton	CMB	Admin Assistant salary @0.10 FTE	DFO	5,000	Committed
		Cooper	DFO, SABS	Involvement on marine fish/other diversity informatics at ~0.15FTE	DFO	14,000	Committed
		Lawton	CMB	O&M support of CMB office	DFO	15,000	Committed
		multiple Snelgrove et al.	ERI CHONe	O&M funds only Bay of Fundy and SWNS (basic estimate of O&M)	DFO NSERC	300,000 100,000	Committed Awarded
2008-2010	US	Incze	USM, GoMA	USM waived indirect cost to meet Sloan 15% indirect cost cap	USM	306,000	Anticipated
		Incze	USM, GoMA	Contributions as IT and grad student support	USM	75,000	Anticipated
TOTAL						2,258,900	

Table 5. Ship time for CoML-related work in the Gulf of Maine, 2003-2007

Country	Year	PI	Funder	Project	Vessel	No. Days	Est. Value
US	2003	H. Singh	ONR	AUV "Seabed", Stellwagen	<i>Oceanus</i>	7	175,000
	2003	L. Watling	NOAA OE	Mountains in the Sea	<i>Atlantis/Alvin</i>	9	295,000
	2003	J. Moore	NOAA OE	Bear Sea Mount	<i>Delaware II</i>	12	180,000
	2004	L. Watling	NOAA OE	Mountains in the Sea	<i>Ron Brown</i>	17	400,000
	2004	M. Vecchione	NOAA OE	Bear Sea Mount	<i>Delaware II</i>	10	150,000
	2004	M. Fogarty	NOAA OE	Continental Slope	<i>Delaware II</i>	12	180,000
	Canada	2004	P. Lawton	DFO	Discovery Corridor, Offshore	<i>Hudson</i>	7
2006		P. Lawton	DFO	Discovery Corridor, Offshore	<i>Hudson</i>	14	420,000
2006		A. Metaxas, P. Snelgrove	NSERC	Discovery Corridor, Offshore	ROPOS ROV	14	500,000
TOTAL						2,510,000	

Table 6. Committed ship time for CoML-related work in the Gulf of Maine, proposal period 2008-2010

Country	Year	PI	Funder	Project	Vessel	No. Days	Est. Value
Canada	2009	P. Lawton	DFO	Discovery Corridor, Offshore	<i>Hudson</i>	10	350,000
	2010	P. Lawton	DFO	Discovery Corridor, Offshore	<i>Hudson</i>	10	350,000
						TOTAL	700,000

Appendix D. GoMA-funded projects

Since 2003 GoMA has fully or partially funded several regional research projects (Table 7).

Table 7. Fully or partially funded GoMA-funded projects, 2003-2007

Year	PI	Institution	Topic
2003	P. Bogden	GoMOOS	Organizational set-up for GoMODP
2004	P. Larsen D. Phinney	Bigelow Laboratory for Ocean Sciences	Remote sensing for classification of intertidal habitats
2004	T. Trott	Suffolk University	A "20-year-later" survey of change in the intertidal zone
2004	L. van Guelpen G. Pohle	HMSC, ARC	GoMRMS database
2004	A Rosenberg K. Alexander	UNH UNH	Examination of historical fishing records from Frenchman's Bay for HMAP
2004-05	P. Auster	UConn	Diversity of fishes in the GoM
2005	T. Trott	Suffolk University	Quantifying patterns of diversity and community change in the intertidal zone
2005-06	L. Incze S. Kraus P. Stevick	USM New England Aquarium USM	Platt's Bank and Three Dory Ridge: Oceanography and pelagic community structure
2006	L. van Guelpen G. Pohle	HMSC, ARC	Metadata writing and training
2006-07	P. Auster	UConn	Ecosystem model for Stellwagen Bank; analysis of data from Jordan Basin and the western New England Seamounts
2006-07	A. Cooper A. Solow	UNH WHOI	Statistical analyses of diversity measures extracted from the NMFS trawl survey database
2006-07	J. Witman	Brown University	A "20-years-later" survey of diversity on Cashes Ledge
2007	T. Trott	Suffolk University	Collaborate with HMSC and NaGISA on an intertidal and shallow subtidal survey of Cobscook/Passamaquoddy Bay
2007	J. Byers J. Pringle	UNH UNH	Using genetics to evaluate the rate of southward spread of green crabs from a secondary invasion

Appendix E: Research Investments and Proposals

Between 2003 and 2005 there were numerous proposals written by GoM scientists to U.S. agencies specifically aimed at GoMA CoML goals, usually citing the Census program and in most cases accompanied by a letter of support from GoMA's Chief Scientist. These were all submitted by very successful PIs, and many of the proposals were rated extremely favorably. Most were declined due to a combination of factors, including the very competitive nature of funding, uneven support for the exploratory and descriptive approaches often needed to build biodiversity understanding, and insufficient funds to support even the best proposals. To make substantial progress in our basic understanding of biodiversity and its contributions to ecosystem functioning, including functions vital to human well being, there will have to be growth of funding sources to support it. This will likely be one of the big legacies of CoML, GoMA, the US National Committee for CoML, and other foundation grants, but it will require continued promotion as a national agenda.

The list below shows major proposal activity that was coordinated with GoMA – CoML during earlier years of the Gulf of Maine Census program, 2003-2005. Proposals that were sent in without specific GoMA involvement are not listed. Titles and PI names are withheld except for the single successful grant at the end of the list.

- NSF 2003: 1 proposal on the topic of benthic landscape ecology for the interior of the GoM using multi-scale sampling on a variety of substrates in intermediate depth waters (generally 100-175 m).
- NOAA Cooperative Research Partners Initiative 2003 -- 1 proposal: multi-scale habitat complexity and fish demography at Cashes Ledge
- NOPP 2004 – 3 proposals: two for development of benthic sampling technologies, one for

pelagic ecology.

- NOPP 2005 – 1 proposal for the ecology of inshore ledge systems.
- NOAA-OE 2005 – 3 proposals: one for microbial ecology and one for benthic landscape ecology, both to be conducted aboard Canada’s Discovery Corridor cruises; one for deepwater ecology in the GoM (Jordan Basin).
- ONR 2005 – 1 proposal (successful, L. Incze, S. Kraus, D. Fields) for understanding coupled bio-physical processes affecting diversity and trophic dynamics on a small offshore bank.

Appendix F. Notable Accomplishments to Date: Details and Additional Items

Scientific highlights

- Changes in biodiversity over the past 20 years have been examined in the intertidal and in an offshore ledge system in two projects. The intertidal study (Maine coast only) found no significant temporal changes in biodiversity based on a new PRIMER analysis, but added considerably to the previous species list and demonstrated an along-shore difference in diversity associated with a discontinuity in the coastal current system. The offshore study (preliminary results) showed a significant shift in the fish community that seems to be impacting the benthic community composition. Local restrictions on fishing did not prevent shifts in the benthic community because the predator shifts occurred at the larger Gulf of Maine scale.
- Major drivers of variability in biodiversity and feeding at an offshore “hotspot” were identified as the background abundance and the vertical distribution of euphausiids and copepods. Vertical distribution affected interactions with internal waves, which affected

surface concentrations, and thus access by birds and whales. To date, this small offshore bank has been “hot” only one year in three. New funding (\$750,000 over 3 years) has been obtained from ONR to continue this study.

- The GoMODP has completed three years of growing and successful operation and will provide a huge source of biological and other data to the regional component of IOOS. Since its inception, GoMA has pushed to incorporate these “non-traditional” data sources into ocean observing and initiated the formation of the GoMODP.
- The updated GMBIS software provides online querying, display, and download of biological and environmental data, including OBIS-formatted data. Data layers include information such as surficial substrate and depth, biological survey data, and circulation model output from the Gulf of Maine Ocean Observing System. The software is open source.
- A NaGISA study location was established in the Gulf of Maine in a macrotidal estuary shared by the U.S. and Canada, with sites in both countries. The location benefits from being at the head of the “Discovery Corridor”, thus in a good location for continued study in the future. It is also in an area that has been studied for many years and is part of an HNS-funded data synthesis. GoMA, HMAP and the Discovery Corridor programs have all contributed.
- Stellwagen Bank National Marine Sanctuary has been established as a site of collaborative study by several groups. COMPASS is coordinating the discussions and GoMA is providing an analysis of biodiversity patterns and a preliminary assessment of related ecosystem functions provided by specific features of the sanctuary and by the integrated effects of these features.
- The GoMRMS was developed as collaboration between GoMA and ARC. A register of

species inhabiting Gulf of Maine waters, including those over Georges Bank and the adjacent continental slope, the list spans from diatoms to marine mammals, with scientific and common names, synonyms, and TSNs under ITIS. Currently the register is in preliminary form as a first attempt to develop a comprehensive list of marine species in Gulf of Maine waters.

- Peter Auster's research on diversity patterns of fish (partially funded by GoMA) is among a number of recent regional efforts that have taken place to synthesize fish diversity information, using results from specific ecological research programs and long-term standardized trawl survey datasets, such as those obtained by NMFS and DFO (e.g. Ken Frank, Andrew Cooper). GoMA will bring these fish diversity specialists together to review these existing project outputs and develop a synthesis.
- Two DVDs of GoMA and Discovery Corridor work have been widely distributed to educators and students through the North American Marine Educators' Association conference (>3000 attendees, Portland, ME, July 2007) and through the GMRI's education program for 5th-6th graders (>10,000 students in 2007).
- Two Canadian Discovery Corridor cruises were conducted in 2005 and 2006 in deep waters of the Gulf of Maine and the continental slope. The Discovery Corridor (<http://www.marinebiodiversity.ca/cmb/research/discovery-corridor/>) stemmed from a Canadian workshop on marine biodiversity research needs held in 2002, and co-sponsored by the Sloan Foundation. The subsequent regional discussion on how to take this concept forward involved scientists from GoMA, leading to a corridor which bisects the Canada:US border. This corridor concept has since been adopted by a new Canadian research initiative (CHONe) that will see the establishment of similar corridors in the Arctic and Pacific coasts.

E&O Highlights 2007

- GoMA featured on Maine PBN show, *Maine Watch* (Dec. 28, 2007)
(www.mpbn.net/mainewatch/gulf+of+maine.html)
- GoMA co-sponsored NMEA conference (July 23-27, 2007), featuring four CoML presentations to an audience of 400 educators:
 - Keynote speaker: Ron O'Dor, Senior Scientist, CoML International
 - Speaker: Lewis Incze, GoMA Chief Scientist
 - Panel discussion: Platts Bank study, release of documentary "Diversity at Sea"
 - Teacher workshop: Google Earth-based lesson plans on ocean science(research.usm.maine.edu/nmeaconference2007/)
- Feature article on GoMA. "Race Against Time" published by Colin Woodard in *Down East* magazine (distribution ~10,000) (July 2007).
- History of Near Shore - Cobscook Bay research project (Aug 2007), photo journal and research summary posted online (research.usm.maine.edu/gulfofmaine-census/history-of-the-near-shore-project)
- Contribution to Science Insights section of *Gulf of Maine Times* Vol. 11(2), p. 7. by Peter Lawton, "What Lies Beneath: Exploring the Gulf of Maine Biodiversity Discovery Corridor" (www.gulfofmaine.org/times/summer2007/biodiversity.html)
- 2-page article on the Discovery Corridor produced for public display area at DFO's SABS and HMSC, Saint Andrews, NB.

Appendix G. Project Description Details and Additions

Biodiversity Working Groups: GoMA Working Groups and Chairs are: (1) Microbial Communities –Michael Sieracki, Bigelow Laboratory; (2) Benthic Communities and Demersal Nekton – Peter Auster, UConn; (3) Planktonic Communities and Pelagic Nekton – Jeffrey Runge, University of Maine/GMRI; (4) Upper Trophic Level Predators – Scott Kraus, New England Aquarium; (5) Land-Sea Margin and Nearshore – Michelle Dionne, Wells National Estuarine Research Reserve; and (6) Ecosystem-Based Management Applications – Michael Fogarty, NEFSC, NOAA.

Bioinformatics: We are now serving OBIS-formatted data using OGC technologies, such as Web Features Service (WFS) and Web Mapping Services (WMS; OBIS does not yet do this). We will continue to work towards serving data in a wide-variety of formats. We currently support the OGC's Geography Markup Language and ESRI's Shapefile format and are working towards serving GoM data in Google Earth's KML and KMZ formats. A primary goal is to make our efforts, both software systems and applicable data, readily available to OBIS, ACON, the GoMODP (thereby including IOOS) and other CoML programs. We have already been approached by others and have agreed to share the software currently being developed. This will require the development of strategies and platforms that allow for a controlled, yet open, communal development and deployment environment. One of our activities during the coming year will be to share technologies between GMBIS and ACON, and in-house DFO package.

Updates to the Register of Marine Species include: (1) add validated observations to the database (*e.g.*, numerous Nematoda from Abebe 2004¹ are not in the current RMS); (2)

¹ **Abebe, E.** 2004. Nematode diversity in the Gulf of Maine, USA, and a web-accessible, relational database. *J. Mar. Biol. Assoc. U.K.* 84: 1159-1167.

complete the assignment of ITIS TSNs to species in the database; (3) evaluate and, where possible, update (using ITIS or literature) the species names and taxonomic classifications provided in RMS (for example, the polychaete classifications need updating); (4) work with ARC and DFO to migrate the existing register to Oracle and open source (PostgreSQL) databases; (5) make the RMS database available online for download and queries; and (6) provide links to content in the Encyclopedia of Life, ITIS, Tree of Life web project, and Interactive Tree of Life.

Ecosystem Comparisons: Focus themes for the proposed ecosystems comparison workshop must still be identified, but possible topics include: (1) How did each region elect to structure and focus its program(s)? (2) How did each program envision knowledge being accessed and used by society? (3) What was learned (highlights)? (4) What are the outstanding similarities and differences between systems in terms of biodiversity and functional attributes? (5) What impact(s) has each program had?

Appendix H. Regional E&O Activities

Regional E&O initiatives: We will continue to integrate GoMA with existing efforts by participating in the planning and development of regional education initiatives. Support activities include assisting NEOSEC with solicitation of grant funding and planning of Ocean Literacy Summit (Fall 2008); co-hosting COSEE-NE “Telling Your Story” workshop for scientists and teachers (2008); working with GMRI’s Cohen Center programs; serving on GoMMEA board and attending annual NMEA conferences, serving on GoMC Ecosystem Indicators Partnership committee and other outreach as appropriate.

E&O experience and cumulative products will be shared with Canadian E&O networks through preliminary linkages to be established with the HMSC, in Saint Andrews, NB. HMSC serves primary through secondary school marine education, as well as public education through its marine aquarium facility.

Regional media. We will continue to promote Census work through regional/national print including *Down East*, *Boston Globe Science*, *Gulf of Maine Times*, *Canadian Geographic* and other Canadian regional magazines, as well as television stations including PBS and CBC.

GoMA lectures: We will develop a lecture series with a standardized introduction to CoML and GoMA program (video or PPT), followed by a lecture by one of GoMA's researchers or associates. Use of USM's video conference system could expand the audience to other campuses and universities.

Website: We will continue to refine and build educational content for GoMA and CMB websites. We recommend conducting a survey to explore GoMA web traffic and solicit feedback from users. We will explore options for an appropriate "hand-off" of the GoMA site by the end of 2010.

Printed brochures/Posters –We will develop new GoMA brochures that could be tailored for policy briefings, workshops, as needed. At least one of these brochures will be produced in a bilingual version for distribution in Atlantic Canada.

Building on CMB's experience of public interest in its series of attractive posters describing specific Atlantic marine fauna groups, GoMA will sponsor one (or more) additional posters. These will be available through both the GoMA and CMB websites, and distributed through educational networks.

Incorporate GMBIS into university and college curriculum. GMBIS is an excellent tool to introduce students to the field of marine GIS. USM Professor Matthew Bampton is the USM Representative to the Coastal Marine GIS Committee and is currently working on a regional effort to develop a virtual GIS department for institutes of higher learning (to be funded through NSF). Dr. Bampton has expressed interest in working with GoMA, with the goal of incorporating GMBIS into university and college curriculum. Some activities toward this end would include:

- **Hosting on-line regional workshops** to demonstrate data and mapping tools.
- **Forming an internal review team**, i.e., a working group of CoML researchers who can pilot the project, e.g. Jeff Runge (UMaine), Tom Trott, (Suffolk University).

Video contest. In 2008/09 school year, we plan to sponsor a Gulf of Maine video contest for regional high schools, in conjunction with an annual educational event such as the Boston University Science Bowl. The winner would receive a small cash award (\$500) and have their work posted on websites (e.g., GoMA, You Tube, CoML).