GULF OF MAINE ENVIRONMENTAL QUALITY MONITORING WORKSHOP

April 30-May 1, 2001

SUMMARY REPORT

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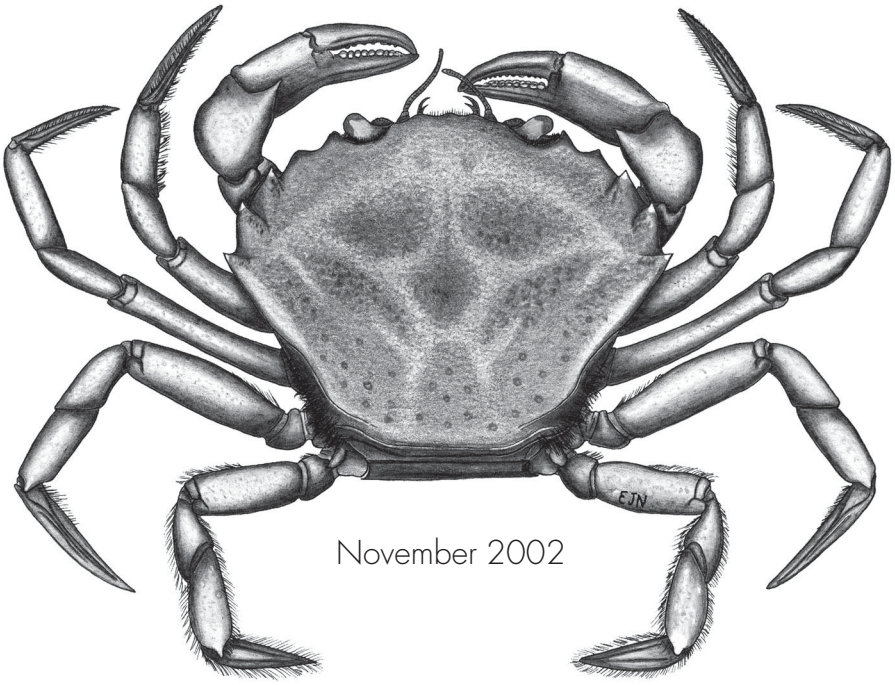

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"To maintain and enhance environmental quality in the Gulf of Maine and to allow for sustainable resource use by existing and future generations."

—**Gulf of Maine Council Mission**

Gulf of Maine Council on the Marine Environment

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

The Gulf of Maine Environmental Quality Monitoring Workshop was held April 29-May 1 2001, in Portsmouth, New Hampshire. It was sponsored by the Gulf of Maine Council on the Marine Environment (hereafter referred to as the "Council") and the Gulf of Maine Environmental Quality Monitoring Committee. Twenty-three environmental specialists representing government, academia, NGOs, and business attended the workshop. The goal of the workshop was to discuss development of an integrated monitoring program for the Gulf of Maine, with a focus on chemical contaminants. Participants discussed four main topics, including:

- The issues, current monitoring efforts, and previous recommendations on improving monitoring in the Gulf of Maine
- Components of a guiding framework for integrated monitoring
- Approaches for enhancing the current Gulfwatch program
- Actions to be taken toward achieving integrated environmental quality monitoring in the Gulf of Maine.

Highlights of the meeting and recommendations leading toward integrated monitoring for the protection of human health and ecosystem integrity in the Gulf of Maine are described below.

Highlights of the Workshop

- Participants agreed that the Council should play a more active role in integrated environmental quality monitoring, leading interactions between groups (e.g. the Council, RARGOM, government agencies, and NGOs) to achieve an integrated monitoring effort for the Gulf of Maine.

- The integrated monitoring effort, including Gulfwatch, should work toward a periodic report on the health of the Gulf of Maine, sponsored by the Council. Such a report would be a powerful tool to achieve integrated monitoring in the Gulf on key issues and to communicate to a wider audience the links between land-based activity, marine ecosystem health, and human health.

- There was considerable support for a guiding framework on integrated monitoring, as a way to initiate the process. The guiding framework on integrated monitoring should include:
    a. Inventories of information
    b. Networking
    c. Enhanced Gulfwatch monitoring program
    d. Data and information management
    e. Communication
    f. Logistics and financial support

- This report includes a draft compendium of monitoring programs for the Gulf of Maine, which is an important step toward networking and integrating monitoring programs.

- Data and database management was considered to be a core part of integrated monitoring. Data and information must be accessible to all participants and their clients.

- There is reasonable consensus on the priority contaminant issues facing the Gulf of Maine (e.g. sewage, nutrients and mercury). Other issues include pathogens, habitat degradation and loss, aquatic nuisance species, and sustainable harvest. There are specific management needs associated with chemical contamination (e.g. more monitoring is required near point sources, a nutrients protocol is required for QA/QC of monitoring, sewage impacts on humans need to be communicated, and biological effects measures should be added to all contaminant monitoring). A summary of contaminant source loading estimates for the Gulf of Maine is needed.

- Gulfwatch could be enhanced by increasing the number of sites, adding new indicator organisms, expanding monitoring to include new chemicals, exploring biological effects measures, monitoring sediments, improving the tissue bank, and linking with specific management questions. The current Gulfwatch monitoring sites could also be used for habitat monitoring, such as monitoring benthic organisms in subtidal areas.

- Several immediate needs were identified to move toward integrated monitoring in the Gulf of Maine:
    a. Develop a case study supporting integrated monitoring, such as mercury
    b. Drive the process by producing a "State of the Gulf" report during the next five years
    c. Focus on the requirement for status and trends analysis
    d. Increase the awareness and accessibility of different databases

INTRODUCTION

This report is a summary of presentations and discussions from the Environmental Quality Monitoring Workshop. It contains the major points made by workshop participants, and was made available for review by all participants and those who could not attend the meeting. This report should prove useful as a guidance document for establishing an integrated Gulf-wide monitoring program for contaminants. However, it is not meant to be a comprehensive summary of monitoring activities and needs in the Gulf of Maine. An inventory of monitoring programs has been compiled (Chandler 2001) and an enhanced inventory is underway.

The goal of the workshop was to initiate the development of an integrated Gulf of Maine monitoring program. Awareness of the Gulf of Maine as an integrated natural system, with many terrestrial and aquatic components, is growing in the management community. The Council is uniquely positioned to address Gulf-wide, trans-boundary issues, especially those that relate to environmental quality. However, answers to critical questions are limited by a lack of knowledge of current environmental conditions in the Gulf, which stems in part from incomplete or fragmented environmental monitoring.

The workshop attendees were invited to provide views on the core components of a monitoring program for the Gulf of Maine. The scope of the workshop was limited to contaminants, although attendees also discussed a more comprehensive monitoring program that included other elements such as resource and habitat monitoring. The workshop took advantage of the fact that an existing monitoring program, Gulfwatch, which was developed to address Gulf-wide contaminant issues (Chase et al. 2001, Jones et al. 1998), could be used as a basis from which to build an expanded Gulfwatch program.

Several key elements are critical for a successful monitoring program. The basic element is a broad conceptual framework upon which to base and guide the development of the program (Pesch 2000). The program design must allow for monitoring results to directly address both public health and ecosystem quality management needs. The Council develops five-year Action Plans to frame management needs of the Gulf of Maine. Recognition of ongoing monitoring programs is essential to take advantage of existing efforts and to link related programs. To accomplish this, a logistical framework is needed to network all programs and to provide integrated data and information management. With these elements established, the development of an integrated Gulf of Maine Monitoring Program can begin.

The focus of the monitoring program should be to address management issues. Prioritization of management issues could benefit from an iterative, comparative risk process involving scientists, managers and the public that could lead to a consensus. Supporting research will be needed for issues not well understood and to help guide and improve monitoring. A related process could recommend research needed to address management issues.

GOALS FOR AN INTEGRATED GULF-WIDE MONITORING PROGRAM

The goals of an integrated Gulf-wide monitoring program are to conduct monitoring that will provide information to managers and scientists to address critical management issues, track the effects of management actions, and provide early detection of unexpected or emerging problems. There is a growing number of monitoring programs in the Gulf of Maine (Chandler 2001), and a Gulf-wide program would be helpful to reduce duplication of effort, identify data and information gaps, and provide value-added information based on interpretation of an integrated database. Regional groups

such as the Council, RARGOM, BoFEP and GoMOOS all recognize the need for such an effort. Specific recommendations for an expanded Gulf-wide monitoring effort built from the Gulfwatch program are listed in the external review panel report (Jones et al. 1998).

Anticipating the benefits of an integrated monitoring program is essential for its initial marketing and long-term maintenance. A successful program could show that, after 20-30 years, management efforts and societal response have led to measurable and well-documented improvements in environmental quality, such as reduced concentrations of toxic contaminants in marine biota or restoration of shellfish harvesting and recreational uses of marine waters. Monitoring may also reveal persistent or new problems. Such messages are understandable to managers, legislators and the general public—all of who are needed for support and for assisting appropriate actions.

BACKGROUND INFORMATION AND PRESENT STATE OF MONITORING

The Gulf of Maine extends from Cape Sable, Nova Scotia, through to New Brunswick, Maine, and New Hampshire to Cape Cod, Massachusetts, and includes the Bay of Fundy and Georges Bank. As coastal populations around the Gulf have increased, forests and agricultural lands have been converted to industrial and residential developments. Such changes in land use and increases in population have contributed to the deteriorating quality of sections of the coastal environment (Dow and Braasch, 1996), especially visible in the southern Gulf. Inputs from non-point source and point source pollution are a significant threat to the near shore environment of the Gulf (Dow and Braasch, 1996).

Growth in industrial activity during the 20th century has resulted in a steady input of chemicals, either mobilized or synthesized by man, into estuarine and coastal environments of the Gulf. Some of these environmental contaminants are at toxic levels in water, sediments, or food, and thus induce adverse biological effects. Certain chemicals are bioconcentrated and bioaccumulated in animal tissue, resulting in concentrations significantly above ambient levels. In addition to toxic contaminants, other transboundary issues in the Gulf of Maine include problems with nutrients, sewage, pathogens, harmful algae, habitat degradation, aquatic nuisance species, marine resource uses, coastal development, economic development and marine protected areas.

To protect water quality and commercial uses in the Gulf of Maine, the *Agreement on the Conservation of the Marine Environment of the Gulf of Maine* was signed in 1989 by the premiers of Nova Scotia and New Brunswick, and the governors of Maine, New Hampshire and Massachusetts, establishing the Gulf of Maine Council on the Marine Environment. The overall mission of the Council is the maintenance of the Gulf's marine ecosystem, natural resources, and environmental quality. To help meet the Council's mission statement, the Gulf of Maine Monitoring Committee was formed and charged with the development of the Gulf of Maine Environmental Monitoring Plan (GOMC 1991). The Monitoring Plan is based on a mission statement provided by the Council and had three goals:

- Provide information on the status, trends, and sources of risk to the marine environment in the Gulf of Maine
- Provide information on the status, trends and sources of marine-based human health risks in the Gulf of Maine
- Provide appropriate and timely information to environmental and resource managers that will allow both efficient and effective management action and evaluation of such action

Planned activities included building on existing monitoring activities, networking between related programs, and regional coordination of monitoring with a comprehensive database management system. As can be seen in this workshop report, the same themes still are still relevant. There have been numerous workshops since the Council's Monitoring Plan was printed, and reports have been produced by both the Council and RARGOM that identify management issues and regional monitoring needs (Table 1).

TABLE 1. BRIEF SUMMARY OF MONITORING WORKSHOPS, 1994-2001

DATE	TITLE	MONITORING RESULTS & RECOMMENDATIONS
1994	RARGOM Workshop	Geographic database development Establish research priorities Communicate results
1995	Strategies for Implementing the Initial GOMC Monitoring Plan	Survey on environmental and biological resources issues Identify and rank information needs Suggested examples of GOM bioindicators
1995	RARGOM Workshop	Factors affecting health of GOM ecosystem - Fisheries harvesting - Anthropogenic inputs - Protected species
1996	RARGOM Gulf of Maine Ecosystem Dynamics Workshop (RARGOM 1997a)	Identification of management issues
1997	RARGOM Migis Lodge Workshop (RARGOM 1997b)	Mechanisms for improving the integration of science and management in decisions affecting environmental quality in the GOM
1998	The 1st Five Years of Gulfwatch: A Review of the Program and Results (Jones et al. 1998)	Reassess underlying rationale Network with related monitoring programs Communicate results and relate to management issues Detailed recommendations for the specific program
2000	RARGOM Gulf of Maine Monitoring Workshop (Pesch 2000)	Monitoring relative to GOMC management topics: Aquaculture, Sustainable resources, Persistent pollutants, Environmental indicators, Predictive models
2000	Ocean Observing Systems in the Gulf of Maine (GoMOOS)	Program concept Statement of need and next steps/GOM pilot
2000	GOMC Environmental Quality Monitoring Committee & GPAC Meeting	Modify current Gulfwatch program Identify and prioritize next steps for actions on GOM contaminant issues: sewage, pathogens, N, chemicals, biotoxins. Sewage/nitrogen example for developing framework of approach
2001	3rd GOMCME Action Plan 2001-2006	Contaminant goals Increase awareness and action Reduce contaminant discharges

In support of the mission and to meet the desired goals, the Gulfwatch project was established to measure Gulf-wide chemical contamination. Gulfwatch is a program in which the blue mussel, *Mytilus edulis*, is used as an indicator for habitat exposure to organic and inorganic contaminants. The program has remained essentially the same since 1991, but it is being modified to accommodate present-day management needs.

Beyond the Council and RARGOM activities, there have been studies on a variety of species, chemicals, habitats, environmental models, and other topics that have contributed to our present understanding about environmental quality and ecosystem health in the Gulf of Maine. Valuable summaries of related information exist (Backus and Bourne 1987, Wells and Rolston 1991, Percy et al. 1997, Pearce 2000). However, comprehensive summaries of any particular topic are generally lacking. Filling some of these information gaps is proposed in the Council's Action Plan 2001-2006.

A database for contaminated sediments was compiled in 1996 by the USGS Woods Hole Field Center and Gulf of Maine scientists (http://woodshole.er.usgs.gov/project-pages/gomaine/gomdb). The data were limited to sites in the US portion of the Gulf of Maine, studies of widely different approaches to measuring contaminants were included, and much of the data was more than 10 years old. However, it provided a useful baseline of information for comparison to present day measurements and identifies historical hotspots of contamination. It represents the kind of information that would be useful for all contaminant-related issues.

Management issues have been identified, but adequate monitoring to address these needs requires extensive improvement. For example, a tool for monitoring habitat integrity might be benthic index measurements (J. Gray, pers. comm.). The use of this tool is not as extensive as it could be in the Gulf of Maine, especially considering that the measurement could be added to an enhanced Gulfwatch program and add useful information for interpreting tissue contaminant data. There is also much published information on application of the benthic triad to marine ecosystems over the past 20 years (P. Chapman, pers. comm.). However, research and monitoring programs in the Gulf of Maine have commonly focused solely on contaminant concentrations and omitted the benthic community structure and sediment toxicity leg of the triad.

Eutrophication is a relatively new issue in the Gulf of Maine. It has been a significant problem in other marine ecosystems of the world (Sheppard 2000). There are extensive studies on the southern shore of Cape Cod and Long Island Sound where excessive nitrogen (N) loading via groundwater transport has likely caused significant eelgrass loss. However, environmental conditions present in southern New England and the mid-Atlantic coast are different than those in the Gulf of Maine, where eutrophication problems are less obvious. Studies in Maine on dissolved oxygen (DO) and N loading showed generally high DO levels in embayments that vary in many other characteristics (Kelly 1997). There are few DO problems in the Bay of Fundy (Percy et al. 1997) or the Great Bay Estuary. Other recent studies in the Gulf of Maine are exploring relationships between nutrients and harmful algal blooms. Several studies have examined atmospheric deposition of nitrogen in the Gulf of Maine and found its significance varies depending on local conditions (Sowles 2001). For example, it accounted for 10% of N loading to the Great Bay Estuary, in contrast to 40% loading from wastewater treatment facilities (NHEP 2000, Mosher 1995).

GUIDING FRAMEWORK FOR MONITORING IN THE GULF OF MAINE

The integrated monitoring framework presented at the workshop by Peter Wells was accepted as a good starting point. The basic framework is outlined in the textbox (facing page). The new program needs to have ecological risk assessment and management at its core, and the link to human health risk assessment is very important. Multiple indicators for ecological risk assessment will be required. The framework will provide a useful comprehensive vision of monitoring needs to help determine the best environmental indicators for the Gulf of Maine. Communication should be viewed as an integral part of the framework. The need for communication is implied with the emphasis on the need for networking monitoring programs, but the overall communication issue encompasses a variety of critical components of an integrated monitoring program.

A comprehensive monitoring program needs to address the major categories of contaminants (pathogens, nutrients, toxic chemicals, biotoxins and harmful algal blooms) as well as their impacts on habitats. It is clear that to gain an understanding of the significance of contaminants in the Gulf of Maine, there should be information on a wide range of animal and plant species in the Gulf. The framework should encompass many trophic levels within the entire marine food chain, such as mussels, fish, birds, and cetaceans. Information on contaminants in the atmosphere, water column, and sediments are also necessary. In addition, the framework should recognize the need to address both existing and emerging contaminant issues. It is also clear and instructive to point out that the current Gulfwatch program represents a small fraction of activities that would be part of a fully comprehensive and integrated monitoring program for the Gulf of Maine.

New programs such as Coastal 2000/2001 or the USEPA National Coastal Assessment Program might also be incorporated into a comprehensive monitoring program. These programs are limited to the US, but their comprehensive coverage provides both useful data and a useful model for the entire Gulf of Maine.

Another important aspect of Gulf-wide monitoring is geographical coverage. It could be assumed that each component would ideally be monitored Gulf-wide. At present, most of the management questions and monitoring programs that are related to contaminants are focused on estuarine and near-shore waters. The workshop discussion also was focused on near-shore environments with recognition that GoMOOS and other projects will be focusing on offshore waters. Linkages with shoreline and land-based monitoring programs will also be needed. More discussions will be needed to define how monitoring within the framework can be used to address critical management issues, enhance our understanding of important ecological processes, and determine relationships between different components of the monitoring program.

IMPORTANT QUESTIONS

- Have monitoring needs/issues been precisely identified?
- Is a guiding framework useful and are its components identified and linked?
- How do we proceed to network efficiently?
- How do we strengthen Gulfwatch?
- How do we structure the integrated monitoring program?
- Who is involved and what are their roles?
- Who pays?
- What else should we be asking?

TOWARD A GUIDING FRAMEWORK FOR CONTAMINANT MONITORING

GULF OF MAINE COUNCIL MONITORING PLAN GOALS, 1991:

1. Provide information on the status, trends and sources of risk in the marine environment in the Gulf of Maine, with four objectives addressing:
    - Changes in environmental quality
    - Ecological stability of harvested stocks
    - Identification of causes of degradation
    - Impacts of environmental catastrophes

2. Provide information on the status, trends and sources of marine-based human health risk in the Gulf of Maine, including risks from pathogens, toxic chemicals, and biotoxins.

3. Provide appropriate and timely information and data to environmental and resource managers that will allow both efficient and effective management action and assessment of such action.

COMPONENTS OF A "NEW" MONITORING FRAMEWORK:

1. Inventories critical to EQ monitoring in the Gulf of Maine and Bay of Fundy, including:
    - Regional and local issues
    - Monitoring programs and projects
    - Techniques – standard and new
    - Measures of marine environmental health, quality and integrity
    - Supporting research, e.g., ecological, oceanographic, climate change, etc.

2. Networking the Regional Programs
    - Linking Gulf of Maine environmental quality monitoring with RARGOM institutes, GoMOOS, ACAP, and other state, provincial, and federal programs.
    - This may include partnerships, joint projects, web site, and RARGOM meetings.

3. Gulfwatch
    - Redesign and enhance Gulfwatch to meet emerging needs and regional issues
    - Improve the spatial arrangement and number of monitoring sites
    - Include new measurements on mussels (new chemicals, bioeffects) and additional measures (sediment and habitat quality, bioeffects with other species).

4. Assessment of the environmental quality of the Gulf of Maine and Bay of Fundy
    - Periodic reports on the "State of the Gulf"
    - Infrastructure needed: dedicated working group, funding, agreement on environmental indicators, and a mechanism for review and distribution.

5. Funding for environmental quality monitoring
    - Dedicated funding is needed for a successful program.
    - Mechanisms to secure funding may include appointing a group through the Council & RARGOM, soliciting foundations, and linking to GPAC-CEC.

INVENTORIES OF INFORMATION

Some key types of information will be needed to guide development of the framework and the integrated monitoring program. A first step is to summarize the present conditions in the Gulf of Maine for priority issues. Related information on ecological, oceanographic, climate change and demographic geography from monitoring and research activities in the Gulf of Maine will also be needed. Ongoing monitoring will also require input from continuously updated information inventories. As new information is added, re-evaluations and new summaries of the information will also be required. The volume on Georges Bank by Backus and Bourne (1987) provides an excellent model for what might be useful for the Gulf of Maine. The following section is an abbreviated synopsis of existing information and gap identification for regionally important issues, monitoring programs and research. Again, the content reflects the input during the workshop and is not comprehensive.

REGIONAL AND LOCAL ISSUES

The Council has written five-year Action Plans for the Gulf of Maine in 1991, 1996, and 2001. The Action Plans have focused on the most important environmental and resource issues facing the Gulf of Maine at the beginning of each five-year time span. Among many general issues mentioned by workshop participants were cumulative change, microbial pathogens, sewage/nitrogen, toxic contaminants, habitat, mercury, indicators and endocrine disruptors. NAFTA's Commission of Environmental Cooperation/Global Program of Action Coalition (GPAC) for the Gulf of Maine went through a process that involved input from a broad based group of Gulf of Maine stakeholders that resulted in a priority list of contaminants. This list served as a valuable resource for the Council's 2001-2006 Action Plan. A recent survey conducted by NOAA/CICEET of estuarine environmental and resource managers around the US provided a similar list of priority issues (Frankic 1999).

As an integrated Gulf-wide monitoring program is developed, a guiding concept is required on the relationship between management needs and monitoring needs (NAS 1990). It was clear from workshop discussions that differences exist throughout the Gulf of Maine on levels of environmental knowledge and management responses to transboundary issues. A matrix should be constructed that matches management needs, geographic locations, and existing monitoring activities to determine the most critical monitoring and information gaps.

One consistent suggestion for all of these issues was to support the publication of a review of these issues that describes their current state and significance in the Gulf of Maine. Any regional or local issue should be related to management issues in a Gulf of Maine context. An updated, comprehensive list of management issues should be compiled, along with a clearly stated summary, as a guide for future monitoring efforts.

Existing information on contaminant concentrations in water, sediments or biota is essential for establishing a database that defines baseline conditions. Information on chemicals as both contaminants and pollutants is needed by managers. Managers also need to know whether cumulative effects of multiple contaminants are occurring and if there is any basis of concern for meeting the needs of permits and regulations. Use of contaminant concentration data, like the Gulfwatch database, should not be over interpreted. Thus, monitoring and research that provide evidence of biological effects as well as the fate of sediment-bound contaminants are needed.

Loading rates of contaminants to the marine environment is an important concept to address because reductions in contaminant loading are a measurable objective. Thus, trends in both loading

rates and contaminant concentrations will show if exposure conditions are improving or getting worse, as well as the impact of any management activities. Which contaminants are regulated and which are not is also an important consideration. Many of the POPs are regulated in the USA and Canada; the emphasis of emerging issues is shifting focus to other contaminants such as nutrients and sewage, unexpected industrial chemicals, and the ecosystem effects of the combination of all contaminants present in the environment.

Toxic Chemicals

Chemical contamination by priority toxic substances in the marine environment is a transboundary issue in the Gulf of Maine. Some existing monitoring programs address toxic contaminants (Chandler 2001). The Gulfwatch program is one of the few that spans the whole Gulf of Maine. However, Gulfwatch only provides a limited amount of information on the issue. More information is needed on significant contaminant sources and biological effects. New hypotheses will be needed to help guide the development of new monitoring activities and linkages with other programs within the more comprehensive Gulf of Maine monitoring program. Examples of research questions include:

- Is there an effect of increasing areas of impervious surfaces (e.g. concrete, asphalt) in coastal communities and additional loading of contaminants into the marine environment?
- Are sediments increasing in importance as the ultimate sink for many toxic contaminants and a source through resuspension of sediments?
- Are these problems widespread, localized, or both?

Some of these and other questions are being addressed by related monitoring programs that can serve to guide design of any new Gulf of Maine monitoring activities. The integration of other existing environmental information to provide a Gulf-wide perspective would also be useful. Ultimately, better consistency or harmonization in chemical and emission regulations, fish consumption warnings, etc., between jurisdictions would make sense for transboundary issues such as contaminants.

Mercury

Mercury contamination in the Gulf of Maine is widely recognized as an important regional issue. There are some existing monitoring and research activities directed at mercury in the Gulf of Maine, including Gulfwatch. For example, Gulfwatch results indicate that mercury concentrations in blue mussels are consistently higher than expected based on the NOAA Mussel Watch program (Chase et al. 2001). Coordination between mercury monitoring activities could be improved—better coordination would provide a more comprehensive overview of the problem. It is also important to identify mercury sources and how it moves in the Gulf of Maine as a result of biological and chemical processes (E. Sunderland, personal communication). The recent focus on mercury has resulted in some strong regulations to eliminate it from waste streams and other uses throughout the Gulf of Maine watershed. The impact of these regulations should be documented with monitoring data.

Pathogens

Fecal-borne microbial pathogens are being monitored around the Gulf of Maine by programs that classify waters for shellfish harvesting and recreational uses. However, these programs are not interconnected and there are inconsistencies between jurisdictions. It is well known that the commonly used indicators of fecal contamination—fecal and total coliforms—are inadequate indicators of human health risk for marine waters and shellfish. More effective indicators are needed and should be adopted throughout the Gulf of Maine. An emerging approach to enhance pathogen monitoring is Microbial Source Tracking, which identifies the actual source of contaminants detected in water (Jones 2002). This is valuable because it helps to differentiate between human and wildlife/livestock sources and to help direct mitigation efforts. There is little information on actual human health impacts from exposure

to pathogens in the Gulf of Maine, and scant information is available on the incidence of indigenous (not fecal-borne) pathogens. A more cohesive pathogen monitoring effort in the Gulf of Maine would help to direct resources for sewage treatment toward addressing the most significant (likely site-specific) problems and to prevent future problems.

Nitrogen

Eutrophication is a growing problem in many coastal areas of the world (GESAMP 2001). Not much information is available on the issue in the Gulf of Maine, and there are no Gulf-wide monitoring efforts to address any aspect of the issue at present (CICEET 2001). This may be a result of the fact that hot spots for nutrient effects are often surrounded by larger unaffected areas, diminishing the impetus to do region-wide monitoring. Data that relate to eutrophication in specific areas also need to be interpreted in a way that will relate to potential management responses. A synthesis of nutrient loading rates, concentrations and related data is needed as a first step in providing a sense of the current status and significance of this issue in the Gulf of Maine. Useful data related to eutrophication include nitrogen loading estimates and dissolved oxygen in near-shore waters. Other variables, such as the rate of water exchange or activity profiles, are also important because existing data suggest that DO problems are uncommon in some embayments known to have significant N loading. One goal would be to develop nutrient criteria for rivers and coastal embayments to allow for comparisons between different areas. Standardized sampling and analyses will be required prior to the initiation of Gulf-wide monitoring. Although this is needed for any new monitoring efforts, it is especially important for addressing nutrient issues.

Nuisance Algae

Harmful and nuisance algal blooms (HABs) are another important issue in the Gulf of Maine, including near shore and offshore harmful algal blooms as well as nuisance algal blooms along the shoreline—often these cases are related to nutrient levels. Various studies and monitoring programs around the Gulf of Maine are focused on this issue, but a summary of its status and significance would be useful for planning future monitoring.

Sewage

Treated and untreated sewage is another high priority concern. Sewage issues are related to pathogens and nitrogen, but also include inorganic and organic compounds, biological and chemical oxygen demand, suspended solids, and toxic contaminants. An emerging issue is the discharge of endocrine disrupting chemicals. The clear differences in how Canada and the US treat sewage as a contaminant were discussed in detail. Canada is in the process of producing new sewage regulations under the Canadian Environmental Protection Act.

Aquaculture

Several issues come from high intensity aquaculture and fishing activities. Overuse of fertilizers at intensive aquaculture sites can cause undesirable changes in benthic habitats. Use of antibiotics can affect non-target species and enhance microbial resistance, escape of farmed fish into the wild may have harmful effects on survival and genetic diversity of wild stocks, and diseases in farmed fish may spread to indigenous fauna. Fishing practices can have detrimental effects on fish habitats and ecological processes. There are also many cultural impacts of management decisions related to fishing.

Habitat

Habitat issues represent the other major focus of the Council (GOMCME 2001). It is important to note that the contaminant and habitat issues often overlap. The presence and effects of chemicals affect overall habitat quality, and they can have detrimental effects on the presence and numbers of organisms susceptible to chemical stress. Many monitoring activities in the Gulf of Maine relate to

habitat issues. As a practical matter, the main focus of the discussions from this workshop is contaminants. However, there have been several RARGOM meetings (1995 & 1996) and many Council meetings where discussions of both issues have occurred. As work on a more comprehensive Gulf-wide monitoring program progresses, linkages to ongoing habitat-related monitoring should be made. Auxiliary measurements that could be added to the contaminant-monitoring program could be useful information for habitat monitoring and vice versa. For example, physical and chemical measurements taken in marine waters and sediments would be useful to both types of programs. Sharing of such information will encourage more extensive networking. Other types of commonly useful data and information include measurements or descriptions of coastal development, habitat alteration practices, and community structure and ecosystem function.

An integrated monitoring program that addresses the contaminant end of the above issues would benefit from efforts made to relate results to impacts on habitat and marine resources. In particularly, it is important to relate results to impacts on sustainable fisheries. The benefits of the Gulfwatch monitoring program for addressing marine resource issues have been described (Jones et al. 1998, Jones et al. 2001). An expanded summary of how monitoring serves these issues and what kinds of monitoring would be useful is needed. Eventually, as critical areas for living resources (spawning, feeding, migration, etc.) are identified, different requirements for contamination levels could be adopted depending on the sensitivity of different areas.

MONITORING PROGRAMS AND PROJECTS

There are several ongoing monitoring programs and projects in the Gulf of Maine (Chandler 2001). For some of these programs, there may be mutual benefit in linking sampling, data collection, data analysis and interpretation of results with a comprehensive Gulf-wide program. A critical step in this process is to ensure compatibility of data and networking to allow for data comparisons and access to available databases.

A recent inventory of monitoring programs in the Gulf of Maine has been compiled (Chandler 2001). Other programs were mentioned at the workshop. One was the extensive pulp and paper industry EEM program in Canada. This and similar industry-based monitoring programs could conceivably serve as the basis for an expansion of biological effects monitoring in parts of the Gulf of Maine, both in terms of sampling areas and financial support. Some industries may be interested in partnership programs to expand their existing monitoring to cover more areas and serve ambient monitoring needs.

The Gulf of Maine Ocean Observing System (GoMOOS) is a Gulf-wide monitoring program that should be linked to any expanded GOM monitoring program. The goal of GoMOOS is to provide data and data products for management, event prediction and general information purposes. GoMOOS will benefit from many federally-funded projects (US: NOAA, NSF, ONR, Canada: DFO, EC) as sources of information from the Gulf of Maine and the results will serve many specific users. Its current emphasis is offshore, unlike the coastal focus of most of the the contaminants-based program discussed at the workshop. However, valuable information could be shared between the two programs.

CNet is a network of 250 volunteer monitoring groups in the GOM. These groups are involved in a variety of monitoring activities. Volunteer monitoring is an important component of Gulf-wide monitoring, and the Council has compiled a (soon to be searchable) database of these and other organizations (650 total) that provides their contact and project information.

Much discussion focused on the NPDES program in the US. There already is abundant archived data on toxic, nutrient and pathogenic contaminants from both major and minor permitted dischargers. An immediate benefit from these data is that monitoring occurs in both fresh and marine waters, a relatively unique aspect for Gulf of Maine monitoring programs. These data could be used to help determine sources of contaminants. A note of caution was raised about NPDES data: much of what is reported is not based on measurements. The program could also serve as a part of the basic framework of an integrated monitoring program in terms of nearby ambient monitoring, contaminant analysis and database structure, and possibly help to fund the wider Gulf of Maine program. The monitoring by each individual discharger could be integrated into one larger, Gulf-wide program to provide consistency in sample timing, sample types and measured parameters across all sites. Integration of NPDES monitoring could also benefit from industry partnering where an individual discharger could share unique facilities. For example, the Southern California Bight area inventoried potentially available funds as part of their efforts to enhance regional monitoring; of the $31 million per year they inventoried, $24 million came from the NPDES program.

Other key current monitoring programs include the Shellfish Sanitation Programs in each jurisdiction (CA & US), the various ongoing studies in the Parker River, MA area, the new push for Total Maximum Daily Load (TMDLs) programs in the US, NERR and NEP programs in the US, ACAP programs in CA and the US EPA Coastal 2000/EMAP/National Coastal Assessment programs. There are also ongoing programs for determining changes in land use/cover in some areas in the Gulf of Maine watershed. There are a number of programs where tissue(s) from marine biota are collected. Such samples could be useful for expanding contaminant monitoring. For example, there is a program that includes tissue sampling from seals in the Gulf of Maine. There are on-going programs for gathering weather information, stream gauging and describing changes in human population. The New England Aquarium is also evolving into a research institution and a source of useful information.

Existing aquaculture facilities have ongoing monitoring programs that are related to some of the high priority Gulf-wide issues, such as eutrophication. It was not known how consistent these programs are and how well the data could be related to issues of Gulf-wide concern. However, like other industries, they could possibly be used as bases for building expanded monitoring.

Establishing communication and linkages between related monitoring programs is an important first step; this is underway informally. Significant work will be required to develop methods for comparing and integrating the different databases. For example, linkages between the US NPDES program and the Gulfwatch program (i.e., nearby mussel monitoring sites) make sense for determining sources of contaminants found in mussels. However, NPDES permitted dischargers are usually only one source in a watershed. Work with models and more technically challenging monitoring or scientific studies usually would be needed to determine the significance of any one type of contaminant source.

Other types of monitoring programs can also provide useful information. Agriculture and forestry use significant amounts of the pesticides in the Gulf of Maine. Pesticide users are issued permits, and some assessment of use/loading in specific areas would be useful for interpreting contaminant monitoring. GIS approaches, remote sensing and other real-time capabilities could greatly enhance monitoring in the Gulf of Maine.

TECHNIQUES: STANDARD AND NEW

There was only limited discussion of techniques at the workshop. However, there was consensus to highlight this important topic as part of a comprehensive monitoring program. In the pilot stages of the Gulfwatch program, it was recognized that standardized methods of sample and data collection,

processing and analysis were absolutely necessary to ensure comparable results from sites throughout the region. Obviously, prior to initiation of any new Gulf-wide monitoring activities, the same standardization of protocols would be required.

As is the case for the existing Gulfwatch program, monitoring to address new issues should be designed to provide synoptic Gulf-wide data where possible. A more logistically difficult aspect of a comprehensive program is assessing impacts of events such as large storms. Not only are such events unpredictable except in short time frames, but they can have significant impacts on environmental quality and hamper our ability to make field assessments (e.g. large-scale movements of sediment or changes in the profiles of beaches).

MEASURES OF ENVIRONMENTAL QUALITY

At present, there is no adequate single measure of environmental integrity, marine environmental health or marine environmental quality to address the issues deemed important to managers and scientists. Multiple indicators are needed to address both ecological and human health issues. To date, steps taken to develop Gulf-wide monitoring are probably easier to accomplish than steps to link results to ecological and public health risk assessment.

Certain marine organisms may be suitable indicators of some aspects of the Gulf of Maine ecosystem. Blue mussels provide a basic assessment of biological exposure to toxic contaminants. Whales are at the other end of the spectrum—if the Gulf of Maine is not suitable for whales, it is probably also unfavorable or unsuitable for other organisms. For any organism, biological effects measurements should compliment data on contaminant levels. The more organisms in which both types of measurements are made, the more information is gained to model transfer of contaminants and impacts through the marine food web, which has relevance to humans.

Population and community assessments may give a better reflection of an ecosystem's health or integrity than individual organism-based response measurements. For example, benthic community structure can provide comprehensive insight into the effects of sediment contamination or habitat modification. This approach can compliment sediment concentration data for specific contaminants, and is typically included in the benthic triad (measurements of toxicity, community diversity and contaminant concentrations). Even though it can be labor intensive and expensive, it could be used in areas of critical concern. There are many other examples of population and community assessments at different trophic levels.

Knowledge of ecological integrity can help determine the effects of anthropogenic activities and the benefits of corrective management actions. Studies are needed to determine natural variability and 'background' conditions as a basis for determining effects of these activities. For example, as EPA develops guidelines for nutrients, it is critical to know what the normal dissolved oxygen levels are in specific areas, especially where sewage treatment or aquaculture facilities may influence water quality. Gulfwatch currently provides regionally based guidance for interpreting site-specific data on contaminant concentrations in mussels.

Some biological indicators may become useful in an expanded monitoring program once their applicability to the Gulf of Maine is established. Turgeon (1995) reported the results of a survey of scientists and managers for identifying Gulf-wide ecosystem problems. Some scientists provided details about biological indicators of habitat degradation, including eelgrass, cormorants, tomcod and green sea urchins—some of these species might also prove to be reliable indicators of contaminants. For

example, eelgrass is considered a good indicator of eutrophication, and has served as a key indicator in Cape Cod embayments affected by contaminated groundwater flow from septic systems. Yet the conditions that cause nutrient-related problems in Cape Cod are not common in the much of the Gulf of Maine, and eelgrass is not always present in some areas of the Gulf of Maine, especially in most of the Bay of Fundy.

Other types of integrated information are already used as measures of environmental integrity, marine environmental health and marine environmental quality. These include beach and shellfish harvest closures from fecal contamination, shellfish harvest closures based on biotoxin levels and HAB incidence, and consumption warnings for marine seafood based on toxic contaminant levels. These examples represent integration of contaminant level measurements with human health risk assessment, and are invaluable for informing the public on human health issues. Some other integrative indicators suggested at the workshop include:

- Percentage of coastline that is developed
- Number of septic systems within a mile of the shore
- Model estimates for loadings of fecal-borne bacteria, nitrogen and toxic contaminants
- Fisheries metrics and indices
- Status of marine mammals and avian populations
- Measures of erosion impacts resulting from sea-level changes
- Water temperature and the intensity and frequency of significant storm events
- The extent, type and effects of specific bio-invasions

More indicators of this type should be developed for both human and ecological conditions, and descriptive information on useful indicators should be communicated to the public.

MONITORING GAPS AND NEEDS

Very little Gulf-wide information is available on contaminants, making it relatively easy to identify information gaps. It is important to prioritize these gaps based on critical issues, the potential for coordinating related ongoing activities, and the potential for partnering between agencies. Gaps exist in any monitoring program, whether it be data-related or topic-related. Most monitoring programs do not provide continuous data, but rather collect and analyze samples made at irregular intervals, forcing investigators to interpolate or extrapolate to broader temporal scales. Most programs also have limited sampling coverage, which causes uncertainty at different spatial scales. Another way of considering gaps is by topic area. Gaps in a comprehensive monitoring program can be determined by identifying topics that are or are not currently being addressed. Consideration can be given to relationships between different types of ongoing monitoring that could be useful for prioritizing next steps and filling gaps.

There are significant modes of contaminant transport into the Gulf of Maine that are difficult to control. These include air, water, sediment and biota. Migratory mammals, birds, fish, and ocean-going vessels move in and out of the Gulf of Maine watershed, which makes it difficult to assess their effects on the Gulf of Maine ecosystem. This characteristic also makes them less useful as indicators of contamination, even though some of them may be key seafood species.

SUPPORTING RESEARCH FOR MONITORING

A comprehensive integrated monitoring program for the Gulf of Maine should respond to significant Gulf-wide management issues. It is imperative that scientists are informed of high priority issues and supported in their research to provide a scientifically sound understanding of issues. At present, it is

often difficult for scientists to communicate information to managers on these issues because of insufficient scientifically sound data. In some cases this is caused by a lack of funding because the issue is not a high priority to funding agencies, or it is a new issue. Better communication between managers and funding agencies is needed to ensure that important regional issues are considered important for research support. In other cases, it is simply a function of no studies being conducted on the issue, partially because of an absence of expertise or activity in the region. A comprehensive monitoring program would be well served by a network of adequately supported research studies that directly address key issues of interest to managers. There are many excellent academic and government institutions and other types of research programs around the Gulf of Maine that could be formal partners to support a comprehensive integrated monitoring program.

There are some questions that would benefit from immediate scientific research. One is the relationship between tissue, water or sediment concentrations and the bioavailability of specific contaminants. Use of discharge data for contaminant loading estimates and potential impacts may be misleading if the transport and environmental fate of contaminants are not understood. The effects of mixtures of contaminants are poorly understood. ER-L and ER-M guideline concentrations are useful for specific contaminants, but many areas in the Gulf of Maine have sediments that contain relatively high levels of multiple, potentially bioavailable, toxic compounds.

Another area where research is needed is on contaminants that may act as endocrine disruptors at levels below that which causes toxic effects. Food chain transfer is a process that is also not well understood, in part due to a lack of information on microbial ecology and on food sources for upper trophic level organisms. Mechanisms of uptake by key food chain organisms also needs more research, as well as studies of new contaminants. Thus, habitat and resource-related research can provide important information for toxic chemical monitoring programs. The examples are for "the official" toxic contaminants, but similar lists for other types of contaminants could be compiled. Model development is critical for understanding fate and effects processes, (e.g., source identification and fate) risk assessment and making linkages in databases with significant data gaps.

NETWORKING

Funding and administration of a comprehensive integrated monitoring program by a single agency is not feasible. It would be prohibitive, and also be repetitive for existing monitoring activities that are part of other programs. However, by definition, an integrated monitoring program will require some entity to run the program. A central entity that organizes and maintains an integrated monitoring program may help to facilitate wider participation and ensure that participants will not need to expend significant time and resources to reap the benefits of the program. In addition, an organization is needed to respond to inquiries about the program and to encourage wider participation by making it easier for people to access information and determine if they want to participate.

Significant resources will be required to link diverse monitoring programs to provide a comprehensive understanding the Gulf of Maine. Linkages, or infrastructure, that supports communication between many programs will provide the depth of understanding of the Gulf of Maine needed to address transboundary and global issues like climate change and global warming. Networking may be the most effective approach to address these and other emerging issues and to provide value-added information. A combination of networked ongoing programs and a review of existing databases will also probably result in the identification of new activities that are needed to link diverse information. For example, elucidating the relationship(s) between contaminant concentrations in marine biota and ecosystem-level effects would be facilitated by cooperative projects involving different groups.

One of the critical aspects of networking for an integrated monitoring program is to have linkages between related programs for databases. Through networking, different groups can work to better standardize procedures, reduce duplicity in effort, and benefit from shared activities like data and information management. Increasing the awareness of other monitoring activities between different groups will also help direct resources to fill gaps. During the initial stages of developing an integrated monitoring program for the Gulf of Maine, networking between programs will be extremely important. Incentives will be useful for encouraging networking. Eventually, networking will provide the glue for pulling all relevant data together so that information on the results and trends can be effectively interpreted and communicated.

Sharing of data and information is one way of networking, described by one workshop participant as "back to back" networking. This is in contrast to "front to front" networking, where different programs actually work together. As the integrated monitoring program is developed, programs that are most closely related should be encouraged to network 'front to front', while the effort required for this would probably be prohibitive for less closely related programs. Initial networking around the basic building block of the program, Gulfwatch, could include use of the Monitoring Inventory (Chandler, 2001) to determine the existing programs that are most closely related to Gulfwatch. "Front to front" networking between Gulfwatch and closely related programs could help to identify common gaps and how to best fill in information that each program needs. Sharing of more detailed information with other groups may help to identify ways to link into programs that address issues other than toxic contaminants, including pathogens, nutrients and habitat change. Finally, new monitoring can be built through agreements between programs on how best to proceed and which program is best suited to fill data gaps.

Networking between monitoring and research programs can help to save resources in numerous ways. Without networking, all the academic research institutions around the Gulf of Maine (and others involved in regional research) could be conducting separate research programs addressing common issues. Obviously, networking to either share data or even to collaborate would save resources and provide value-added information for all involved. One example of where linkages will save resources is between programs focused on offshore waters, such as GoMOOS, or near-shore waters, such as Gulfwatch.

Another important aspect of networking is between monitoring programs and the public. Long-term support for monitoring is difficult to justify, especially without awareness and participation by the general public. There are various mechanisms to assist networking, including use of websites continuously updated with results and new directions for monitoring in the Gulf of Maine. Another mechanism is use of the Gulf of Maine Times—a column for Gulfwatch/Gulf of Maine monitoring could be included in each issue to provide an update on monitoring activities in the Gulf. Volunteer/citizen monitoring groups in the Gulf of Maine have a solid and successful history of partnering with various monitoring programs. Their participation should be cultivated whenever possible.

The major emphasis on networking is to establish linkages between regional programs. There are closely related national and international programs that would enhance the Gulf of Maine efforts. The International Mussel Watch program, the NOAA Mussel Watch and Benthic Surveillance projects, the US EPA National Coastal Assessment program, the US NPDES program and the ACAP and NEP programs are a few. There is also research on the Pacific coast on trends of contaminants in harbor seals and in the Netherlands on sub-lethal effects of contaminants on seals.

Use of the Internet will be an essential tool for networking. The Council and RARGOM are already using it in this way. The Council has compiled a (soon to be searchable) database of organizations

(650) that provides their contact information. RARGOM is working toward having scientific expertise around the Gulf of Maine identified on a searchable database on their web site, and this will be cross-linked to the Council's website.

ENHANCED GULFWATCH MONITORING PROGRAM

There are many ways to begin to build onto the existing Gulfwatch program. A guide as to how to proceed would address certain basic questions, such as: what information is missing with the present chemical monitoring activities in the Gulf of Maine? Are we attaining enough information of the right quality? Ultimately, Gulfwatch should be used as a model from which a comprehensive monitoring program and network can be designed and built to address critical management issues in the Gulf of Maine.

Recognizing that Gulfwatch is presently quite limited in scope, the best approach for beginning an enhanced program is to initiate new activities that are closely related to the existing program, i.e., a toxic contaminant monitoring program. A guiding concept should be to build a hierarchical approach to risk-based monitoring. Mussel tissue data serves to help identify further work and as a basis to link to ecological risk assessment. There are three basic directions currently being considered for enhancing Gulfwatch. One is to make as many measurements as possible on mussels being collected. Continued interactions with academic research studies that expand the understanding of contaminant effects will help to guide how Gulfwatch is modified. Another is to begin networking with other related programs and to integrate related databases to help interpret Gulfwatch data. Networking could help to develop a more regional picture of present conditions using data from multiple, more localized databases. The final direction is to build out new monitoring activities that are not focused solely on mussels. In the same way that the Gulfwatch program began as a pilot project, other activities may be integrated into a more comprehensive program through the same mechanism.

In 2001, the Gulfwatch program will have completed the designed 9-year monitoring program it began in 1993 following its first two pilot years (1991-92). The program needs to be modified for future years to reflect changing management needs. The existing hypotheses need to be reexamined and modified, and new hypotheses to address emerging issues should be considered (see NAS 1990). One basic objective will remain: to determine spatial and temporal trends for contaminants of concern in mussel tissue at sites selected to provide a Gulf-wide assessment and to address any more highly contaminated locations. The results of an ongoing review of Gulfwatch will provide guidance for determining where sampling will occur and at what frequency, what contaminants will be measured and how often, and what other measurements are needed. Use of well-studied sites will be an important component of future monitoring activities and can serve as study sites for more in-depth research. An important consideration will be to decide what other types of media should be sampled, such as sediments and tissue from other species. Such expanded studies and monitoring could also occur at sites of heightened concern, i.e., those of elevated contaminant concentrations.

Another component of the present Gulfwatch program that needs reconsideration is the suite of contaminants that are measured. Some of the present contaminants are no longer of great concern while others do not provide much information about possible sources or even temporal trends. Other compounds not in the present suite of contaminants have increased in significance and should be considered for future tissue analysis. For example, toxophenes and brominated flame-retardants might be included in the program.

Because Gulfwatch focuses on a wide variety of contaminants, the program could serve as the basis for more detailed studies on any of these contaminants. For example, mercury contamination in the Gulf of Maine is currently considered a high priority issue. Gulfwatch has included mercury analysis of mussel tissue since 1993 at over 60 sites around the Gulf of Maine. A more detailed study of mercury contamination may include mercury analysis of other media such as sediments and tissue from other species, sampling of species that feed on mussels, sampling of tissue from species related to a known food chain, tissue analysis of species of other concern even with no food chain component of the study, etc. Any of these studies could be built from the existing mussel monitoring program. Ultimately, because of limited resources, any new study that is to be added to the existing program should be in response to high priority management needs.

One of the most glaring shortcomings of the present Gulfwatch program is the lack of site-specific information on the biological effects of the contaminants measured in mussel tissue. Information is generally sparse in the Gulf of Maine on biological responses to contaminants at all levels: molecular, cellular, organismal, population and especially reproductive. Available data are often not regional in scope. There are a variety of existing and emerging techniques for assessing effects of contaminants on mussels and other marine biota. Some of these assays are relatively complex and would be difficult to adopt into the program. Others are relatively simple and could be adopted and used by program participants in standardized protocols throughout the Gulf of Maine (Monette, 2000; Monette and Wells, in prep.). Alternatively, networking with such programs as the EPA National Coastal Assessment program could help to provide useful information to Gulfwatch. The main limitation is that site selection criteria for both programs are very different.

Efforts should be made to use predictive ecosystem modeling of contaminant effects when sufficient data are available. This will also be useful for helping to inform the public of contaminant issues by providing more direct linkage between environmental measurements and how people may be at risk. An expansion of field observations of habitat components at Gulfwatch sites could help to document the long-term impacts of contamination and management activities. Environmental indicators of habitat health would be required along with standardized protocols for their measurement. The development of biological indicators of environmental integrity for the Gulf of Maine will require careful consideration of management issues, agreement between scientists, buy-in by the public, and sufficient resources.

An important issue is the use of tissue residue concentrations as a means of gauging human and ecosystem health risks. Multiple criteria are required because tissue concentration criteria that are presently used are different for ecosystems and human health. It is highly unlikely that use of one organism, such as blue mussels, can give a comprehensive picture of potential problems for all other organisms in the marine environment. Thus, a critical next step is to gain a better understanding of contaminant concentrations in other trophic levels. This can be accomplished through direct measurements, either built into Gulfwatch or through networking with other programs. Addressing other trophic levels can also be accomplished by using theoretical modeling of how contaminants concentrate through the marine food chain. There are useful existing models, and new models are being developed. For example, the Council and the EQMC are supporting a mercury fate and transport modeling effort in Passamaquoddy Bay (E. Sunderland, pers. comm.).

Another piece of missing information is the relationship between detection of contaminants in mussels and the sources of the contaminants. There is information available, such as the in the NPDES program, that could be used to help interpret contaminant sources in areas where the monitoring program is conducted. Another source of information is the Mercury Deposition Network, which monitors atmospheric deposition of mercury at both US and Canadian sites in the Gulf of Maine.

A byproduct of the long-term success of Gulfwatch is that there exists a network of scientists and managers from each jurisdiction bordering the Gulf of Maine that are direct participants or have other input to the monitoring program. The coordinated program has successfully demonstrated that a Gulf-wide monitoring program can function even with a minimum of direct financial support. The reason for this is that the actual sampling involved has been almost entirely supported by in-kind participation (worth >100K's). The most expensive aspect of the existing program is the contaminant analyses, followed by data management, interpretation and reporting. Thus, the sampling part of the monitoring program is not expensive. This suggests that more extensive, multi-purpose sampling could easily be added on or integrated into the existing program. This could include measurements or observations of new bioindicators.

Other logistical needs for a long-term program include the need to archive environmental samples, e.g. tissues. Among the many benefits of archiving is that it allows for future re-examination of samples for contaminants not presently of concern. Archiving for the present Gulfwatch program is at a critical stage and in need of support to accommodate samples collected to date; an expanded program will make even more demand for archiving space. An agreement on archiving at the Atlantic Reference Centre, Huntsman Marine Science Centre (HMSC), New Brunswick, simply awaits adequate support, as it has been approved by DFO and the HMSC and is partially funded by the Council.

DATA AND INFORMATION MANAGEMENT

Monitoring programs must not only generate data, but they must also provide information. This requires a knowledge of what types of information are required, scientifically-sound statistical analysis of data, and clear translation of results into language that can be understood by the intended audience. The integrated monitoring program will need a distributed database (example: Distributed Ocean Data System) to ensure that these things happen, as well as to track trends and to measure progress in management efforts. A database for the Gulf of Maine that could be used constructively would be of great interest to many environmental agencies that could in turn support it. An integrated database would also serve as an attractive incentive to other monitoring groups to participate in networking.

An obvious shortcoming of the present Gulfwatch program, as well as many other monitoring programs, is the "lag time" between collection of samples and the reporting of results to managers and the public. This lag time is a function of the many steps required to communicate useful information and reflects the level of program resources.

One of the critical data and information management aspects of an integrated monitoring program is to have active, direct linkages between related programs for databases. In fact, the new NOAA database on salt marsh restoration around the Gulf of Maine could serve as a model or even be linked into a larger monitoring program database. However, the proposed Gulf of Maine monitoring program would have many different types of data to organize and integrate, which will pose a serious challenge to be effective.

A database for an integrated monitoring program will need to ensure comparison of data sets for the same variables. Some strategies to accomplish this have been worked out and existing databases such as those of the US EPA and Environment Canada (e.g. IGETG 2001) for air-borne toxic chemicals and water quality parameters could be useful guides. The use of standardized procedures for sample collection, sample analyses, data management and QA/QC for all components of any data collection and database would help to ensure data compatibility. This may not always be possible—some databases only fulfill local purposes or they may not be standardized. In the end, the data need to be analyzed

and interpreted and the results communicated to the public and to managers. This need should be central to the design of the database and monitoring program.

There is an immense amount of information on contaminants and other critical issues in the Gulf of Maine that already exists from historical and ongoing monitoring and research programs (Plant 1985, Backus and Bourne 1987, Percy et al. 1997, Pearce 2000). One largely untapped group of data sources is the various permitting and regulatory databases. The situation represents what might be termed "data deluge, analysis drought." As limited resources are made available for new monitoring and research to address critical issues, consideration should be given to using some funds to support examination of existing data and reporting/synthesis of findings. Such activities would help to prevent repetition of previous efforts and would help to guide the direction of new resource allocation to address unstudied topics and to fill information gaps. Once useful databases are identified, efforts will be needed to obtain and centralize the data in useful formats. Feedback to monitoring programs can include recommendations to add or even remove measurements.

How would a data and information management system be structured for an integrated gulf-wide monitoring program? Suggestions were made that partnerships between related programs are necessary, as is the need for one agency or person to provide leadership. Coordination between such organizations as RARGOM, GPAC and the Council will be essential. Maintenance and updating of such a system will require major, long-term support. An alternate model to consider is a network of existing systems, maintained by a monitoring coordinator.

Ultimately, monitoring data for the Gulf of Maine should be made available on line. This would make the data available to a wider audience and potentially spark different interpretations by researchers and NGOs who may not be directly involved in the monitoring programs. Data will need to be submitted to whichever agency manages the on line database in standardized formats so common accession methods can be used. The US EPA website, particularly that related to the NPDES program, is organized in a useful way and could serve as a guide for the Gulf of Maine monitoring program database. There are many difficulties involved with sharing databases, and every need cannot be addressed when structuring databases. Groups that request data can conduct analyses to fit their own needs.

COMMUNICATION

The need for effective communication throughout the process of developing an integrated monitoring program in the Gulf of Maine is critical. Support will be enhanced by communicating how well the monitoring program meets missions and justifies mandates already recognized as important by federal agencies and jurisdictional legislators. It must be recognized that expertise beyond that for scientific research and monitoring is needed to ensure effective communication. Thus, partnerships between monitoring programs and organizations or individuals with expertise in communication and science translation will be essential.

Newsletters that go to the general public have been a successful strategy in Chesapeake Bay. The more the general public is aware of and directly involved in monitoring, the more support will be given to monitoring. Direct communications with groups that coordinate citizen monitoring, school teachers/students and environmental groups can help to enable participation and training of volunteers. Easy to read pamphlets and fact sheets can help to communicate information to managers, legislators, school children, scientists, NGOs, industry, ecotourism groups and the general public and be adapted by media for more general exposure of issues. These mechanisms of communication can also be used for marketing the Gulf of Maine monitoring program(s).

As mentioned under NETWORKING, there are various communication mechanisms to assist networking, including use of websites continuously updated with results and new directions for monitoring in the Gulf of Maine. Mechanisms for communication are needed both to enhance networking but also to distribute information for educational and marketing purposes. Another mechanism is use of the Gulf of Maine Times and the RARGOM Gulf of Maine News—perhaps a column for Gulfwatch/ Gulf of Maine monitoring could be included in each issue to provide an update on monitoring activities. News releases for significant monitoring-related events would reach the public in a different way.

Ultimately, the goal of communicating information to the public is to change people's behavior through increasing their awareness and showing them how the information is relevant to their personal lives. The timing of when to release findings and results can have many effects. The example of MWRA's consideration of the use of the copepod *Acartia tonsa* as an indicator of nutrient enrichment is a good example of the difficulties and impacts of trying to simplify complex scientific information for communication to the public. The source of information is also a significant consideration. In Massachusetts Bay, the public, managers and environmental groups did not always believe information that was communicated from the MWRA.

The 'State of the Gulf" report, or some other summary of this subject area, would be a valuable resource for education purposes. Cooperation between the Council (PEPC and EQM committees) and RARGOM could produce useful education materials from the report and other data and information to help inform the public about the Gulf of Maine. Review of related educational materials produced elsewhere can help guide what is done in the Gulf of Maine. Summarizing complex data into visual indicators of impact are needed for educating the public. Distribution of any material produced could be aided by partnering with other networks, such as the NE Aquarium, Island Institute, HMSC, BoFEP, etc. The State of the Gulf report could eventually serve as a basis for developing an Action Plan for public participation.

To assure continued support for the program, monitoring activities will always need to be directed at management issues, and environmental managers should actively participate in the program. Reports of progress directed at upper level managers for environmental agencies would be useful to provide information for policy development around critical issues and to justify continued funding. Again, it will be critical to recruit partners with expertise in communication and data translation to participate in the monitoring program.

LOGISTICS AND FINANCIAL SUPPORT

The initiation of an integrated monitoring program would require action on a number of different fronts, the most basic being a consensus on the basic framework for integrated monitoring. Eventually there is a need for leadership from a coordinating body of experts and stakeholders (Advisory Board) and one or a few people to guide the process to completion. As is the case for the existing Gulfwatch program and many other Council activities, an integrated monitoring program will probably rely heavily on in-kind resources from federal, provincial and state agencies. For example, the existing Gulfwatch program costs ~$120,000 (US) each year, but also includes >$300,000 (US) of in-kind contributions from both countries.

It was recognized that hard work is required to achieve the important goal of establishing a more comprehensive Gulf of Maine monitoring program. Sustained funding will be needed for all aspects of an integrated monitoring program. Not only do sampling and analyses cost money, but support will

also be required for data management, communication and overall administration of the program. It will be important to also track the value of in-kind services. Federal, state and provincial agencies can probably provide some of the support, possibly to a designated funding pool for the Gulf of Maine through the Council. A group for soliciting support from foundations would also be useful to raise more short-term support.

Sources of funding include federal agencies on both sides of the border. NOAA/NOS was mentioned as a possible source of funding for synthesizing existing information on nutrients and eutrophication in the Gulf of Maine, similar to their previous geographical assessments. The Southern California NPDES-funded monitoring program was discussed at length as a potential model to pursue in the Gulf of Maine. In that program, discharge permitees pay into a fund to conduct monitoring. In one year, of the $31 million for monitoring, $24 million was contributed from NPDES permit monitoring resources. Overlap and inefficiencies of monitoring by individual dischargers are eliminated and savings go to a broader monitoring program to address regional management issues.

The group that eventually coordinates the Gulf of Maine monitoring program would have to serve in many capacities. One of these is to ensure data and information exchange between scientists / monitoring programs and both managers and the public. There will be a need for continuous consensus building to keep participating groups active and to ensure that results serve needs.

NEXT STEPS AND ACTION ITEMS

The Council has already initiated next steps by supporting a continued, modified Gulfwatch program and prioritizing other related projects to serve as pilots for an expanded program. The Council has also listed as high priority reviews of existing information on all types of contaminants of concern in the Gulf of Maine. Linkages have also been made with numerous potential funding agencies to raise their awareness of the management issues considered a priority by the Council.

The "State of the Gulf" report should be the primary driving force and should be an initial step toward an integrated monitoring program. It will require leadership by one or two people and input from many to ensure that it will be useful and make a difference to the Gulf of Maine. The workshop participants had many specific suggestions on aspects of the production of the report and how to start the process of report production. Many observations were made on the potential value-added benefits of producing a report, including getting buy-in from stakeholders. Other benefits include use of the report for public education, a structure for an integrated monitoring program, identification of information gaps, problem areas and research needs, and a compilation of information on standard approaches. Just having so much information in one place, either as the full report, executive summary or other interpreted piece, will be an invaluable resource. At a basic level, such a report will also further connect the different jurisdictions around the Gulf of Maine and provide a mechanism for everyone to see their own area as part of the larger ecosystem. It will likely stimulate both additional information and further editions!

The concept of the report is to provide an assessment of the overall 'health' of the Gulf of Maine. It should focus initially on contaminants, and include statements to address basic questions about trends, i.e., are conditions better or worse? Are concentrations increasing or decreasing? What effects have management activities had? Are there discernable improvements since the Council and RARGOM were formed? It would probably be too much work and would take too long to do a good job in coming out with a comprehensive "State of the Gulf" report in the next two years. Instead, a phased or sequential report strategy is recommended. The initial focus on contaminants would build on a relatively

solid and accessible information base, and other issues like habitat, marine resources, and land use, etc. could be incorporated into reports published in ensuing years. In addition, the first report will probably be a pilot project that will serve as a straw man to be critiqued and modified; the effort put into its organization will be a useful template for writing ensuing reports. As more knowledge on all topics accumulates, each consecutive report will be updated and serve to focus efforts to improve the state of the Gulf of Maine. The report should be guided by identifying which environmental conditions would be desirable in 20-50 years; the report should provide a vision of possible outcomes for the Gulf of Maine environment.

The organization of the information will need to be worked out, but there should be sections that address toxic, nutrient, pathogenic, and sewage contamination. It should also relate contaminant information to possible effects on biota and any resulting population, ecosystem and habitat changes. The report can have as a basic component the results from and the overall logistics of the Gulfwatch program. Other components of the report could be to report on what information is missing, what procedures are available to conduct monitoring, recommendations for supportive research, what new indicators could be used to address issues not currently addressed, etc. The report should be considered an initial template, should not exceed 50 pages and should be the first in a series of readily updated reports that are published every 2-3 years.

The steps involved should include initial organization, soliciting papers from experts to summarize present knowledge, and a workshop where the papers can be presented and discussed. Consensus will be needed on critical management issues, environmental and indicators, and other issues. Contacts from every agency that would benefit from the report should be identified and their ensuing participation would be useful to help spread the workload and to ensure wide participation. A review of similar reports can help guide the Gulf of Maine effort. Coordination of activities should eventually fall to a few people; a small group will be needed to complete the task in a more efficient manner. This group would rely on support from all interested parties, especially regional groups like RARGOM and the Council.

The whole process of producing a report will require significant money. The Mid Atlantic Integration Assessment (MAIA) project cost $300,000 (US). Such resources are probably only available from federal agencies. Resources will be needed to support data management, report writing and review, publication, marketing, outreach and administration.

A review of other similar documents would be a useful step. The UN publishes reports that are written for scientists and managers, but also have included a highly detailed technical report and a primary report directed at the public (GESAMP 2001). There have been comprehensive, expertly written, 'state of the environment' reports in Canada (Environment Canada 1991, 1996), with marine chapters. These are no longer being written, as there were staff cutbacks during program reviews in the early-mid 1990s and the message was that such reports were 'unwanted' by government and industry. The USEPA/NEP programs produce different reports for specific estuarine areas. In the Gulf of Maine there are three NEPs: Casco Bay, New Hampshire and Massachusetts Bay. There are Technical Characterization reports that summarize all existing technical information on the areas, monitoring plans and there are also 'State of the Bay" reports that are written with the general public in mind. The eventual Action Plans that are written provide a guide describing data trends, data and information gaps, monitoring needs and specific actions for the near future.

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APPENDIX A

WORKSHOP AGENDA

Gulf of Maine Environmental Quality Monitoring Workshop

MONDAY APRIL 30TH

8:00 Coffee and bagels available
8:30 Welcome, Introductions, & Purpose of the Workshop: Steve Jones and Peter Wells
9:15 What are the leading management issues and priority contaminants?: John Clarke
9:45 Clarifying Questions and Discussion: Cindy Krum
10:15 Break
10:30 What monitoring is occurring in the Gulf?: David Keeley
11:00 What monitoring recommendations have previously been offered for the Gulf of Maine?*: Steve Jones (followed by 30-minute discussion)
12:00 Lunch
1:00 Creating a "guiding framework" for monitoring in the Gulf of Maine: Peter Wells
1:30 Discussion Questions: Cindy Krum (facilitator) and Peter Wells
- What are our long and short-term monitoring needs?
- What are the gaps?
- What data management, synthesis and dissemination is needed?
- How do we integrate & network with what is being monitored?
- How is an expanded monitoring effort structured & implemented?
- Who is involved and what are their roles?
- How are the programs funded?

3:00 Break
3:15 Group discussion/working session on "guiding framework"
4:45 Small group progress report and wrap-up: Steve Jones and Peter Wells
5:15 Adjourn
6:30 Dinner as a group (optional)

TUESDAY MAY 1ST

8:00am Coffee and bagels available
8:30am Contaminants Monitoring Framework—Recap: Steve Jones
9:00am Identifying Testable hypotheses—Preliminary Concepts: Peter Wells
9:45am Small Groups: Measures to address hypotheses.
- How does the specific problem it manifests itself
- What indicators test?
- What tools/measures would be used?
- Who should be involved?
- What data is available?
- How is data interpreted?
- What types of research are needed?
- What standardized procedures can be used?
- What are the data management needs?
- How is the information communicated?

11:15am Communicating with the Public: Judy Pederson, MIT Sea Grant
12:00pm Lunch served onsite
1:00pm Recommendations for a regional monitoring program
- Monitoring needs
- Data/info management
- Networking
- Funding

3:30pm Co-chair summary and conclusions
4:00pm Adjourn

APPENDIX B

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APPENDIX C

ADDITIONAL REFERENCES

Background Information

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APPENDIX D

RECOMMENDATIONS TO GPAC
For Prioritizing Next Steps on Contaminants in the Marine Environment from Land-Based Sources

GOMC-Environmental Quality Monitoring Committee/GPAC Meeting
October 5-6, 2000
St. Andrews, New Brunswick

EXPERT PANEL

Marc Bernier (Environment Canada), Sean Brilliant (ACAP-St. John), Guy Brun (Environment Canada), Marilyn Buchholtz ten Brink (USGS), Gareth Harding (DFO), Peter Hennigar (Environment Canada), Steve Jones (UNH), Natalie Landry (NHDES), Tom O'Connor (NOAA), Jack Schwartz (MA DMF), Bruce Thorp (NBDFA), Bruce Tripp (WHOI Rinehart Coastal Research Center), Peter Wells (Environment Canada)

SUMMARY

A panel of experts was assembled at GPAC request to consider the GPAC-prepared list of chemical contaminants as to recommend ways to better focus future efforts on reducing contamination of the Gulf of Maine from land-based sources. A list of seven contaminants resulting from a wide range of stakeholder input was provided by GPAC as a basis for the discussions. The Monitoring Committee and panel recognized that public education on contaminant issues in the Gulf is essential, and that the GPAC effort to date is a valuable first step to bring additional stakeholders to the table. In addition, the panel recommended that actions be taken to reduce inputs of all the contaminants on the list, as well as some others, and existing regulations on contaminant inputs be enforced. The panel was unanimous in recommending that next steps addressing this issue involve getting the best scientific input with adequate time to craft scientifically sound recommendations for specific management actions. The panel developed an assessment process that should be applied to each of the contaminants on the GPAC list to provide a basis for consideration of issues prior to the recommendation of future actions. Application of the process was illustrated using sewage/nitrogen, which the panel agreed is an important Gulf-wide contaminant issue. However, the panel had inadequate time and expertise to continue the process, and it recommended that GPAC put all contaminants, including sewage/nitrogen, through a similar, more vigorous review process that involves experts and other stakeholders having direct interest in each contaminant category. When this is completed, it is likely that a re-sorted list will evolve from the assessment process and that recommendations for action will be appropriately directed to agencies with authority to act. The panel strongly recommends against the identification of a single "most important" Gulf contaminant at this point in time. RARGOM and the GOMC Environmental Monitoring Committee could be considered as regional resources to help GPAC and GOMC assemble experts, facilitate the evaluation process and to provide the linkage to managers and the public.

INTRODUCTION

GPAC has been active in the Gulf of Maine for the past few years in addressing issues of land-based sources of contaminants to the marine environment. Two multi-sectoral workshops were held to develop consensus on significant environmental issues in the GOM. Workshop attendees represented a broad base of the stakeholders in the Gulf of Maine watershed. The GPAC workshops yielded a list of seven

types of priority contaminants, and GPAC decided to seek expert advice to evaluate the list. The goal of the St. Andrews meeting was to gain expert recommendations to address these priority contaminants and to serve as a basis for future GPAC activities and more focused resource allocation.

PRIORITIZING NEXT STEPS FOR ACTIONS ON CONTAMINANT ISSUES IN THE GULF OF MAINE

The specific goal put forward by GPAC to the assembled panel was for the panel to choose one contaminant (type) as the highest priority for the GOM. The panel immediately came to a unanimous decision not to take such a "next step." The panel recognized that solicitation of input from a wide range of stakeholders to determine what is essentially a popular consensus on a list of priority contaminants is an extremely valuable exercise. However, use of such a list as a basis to develop public policy and to spend public resources following only a brief (one day) review by a limited expert panel was viewed as being flawed and was not considered thereafter. This decision was based on the following considerations, in no particular order:

- The list was based on limited scientific information, both as a result of inadequate information in scoping papers and limited expert influence
- The list was missing some important contaminants
- The issue for some of the contaminants was local in nature and not Gulf-wide
- All of the listed contaminants are important; the marine ecosystem is exposed to multiple contaminants, and contaminants cannot be ranked

Additional general conclusions by the panel included the following:

- The list shows that the most serious issue is a need for public education on contaminants in the GOM.
- A rationale is needed to determine if the list and actions related to the listed contaminants are scientifically valid.
- The list itself should be evaluated to determine if modification is necessary to include missing contaminants and to eliminate those that are of minimal gulf-wide importance or are redundant.

The assembled panel discussed alternative input that would be useful to GPAC as a basis for taking next steps. The panel proceeded to develop a process of evaluating the priority contaminant list. The process was developed using one example contaminant, but the panel recommended that the process be applied to every contaminant listed, and time should not be spent on prioritizing from lists until the process is complete. The process of careful review of each contaminant should be applied using experts and stakeholders with experience and interests in each specific contaminant. The evaluation process requires the following essential steps:

- Define the breadth of each contaminant or contaminant category; consider inputs, fate and transport of contaminants.
- What control measures are in place, or are not in place?
- What research is needed or is underway?
- What is the impact to public health and ecosystem health?
- Determine recommended actions.

The assembled panel chose one contaminant type, sewage/nitrogen, as an example of an important contaminant issue in the Gulf of Maine. Sewage/nitrogen is a regional Gulf of Maine issue that causes localized problems in areas along the coastline. It is probably the only contaminant category that is

expected to increase in scope and concentration with time, as loading is closely related to coastal development. It has a different focus on either side of the CA/US border in terms of sources, problems and regulatory jurisdiction barriers. The first step was to define the breadth of the contaminant category.

Sewage/nitrogen contaminant types:	**Sewage/nitrogen impacts:**
Nutrient enrichment	Eutrophication
Microbial contaminants	Species changes
Organic loading	Habitat alteration
Toxic contaminants	Negative economic effects

Some recommended actions on sewage/nitrogen were:

- Remove solids from discharged sewage
- Determine if nitrogen/carbon loading is having significant impacts on local receiving waters
- Enforce existing regulations, and consider new regulations
- Encourage local assessments of eutrophication and other problems
- Conduct a study of human health impacts
- Further development of modeling and predictive capabilities

The consensus of the panel was that there is no existing gulf-wide assessment of the status of sewage/nitrogen inputs or concentrations of the contaminants included in this category. More importantly, there has been no assessment of public health and ecosystem health impacts. Numerous localized studies and partial regional surveys were noted, as were some current, related research projects. However, it was obvious that more information is needed on the issue. The complexities of sewage/nitrogen should be discussed in more depth prior to initiation of any course of action.

The panel engaged in a comparatively brief discussion of mercury. Because of all of the attention that mercury has had over the past few years in the GOM watershed, the panel briefly discussed the process by skipping the first three steps. For mercury, the following actions were recommended:

- Continue advocacy activities for continued research on coastal impacts of mercury, i.e., sediment processes, ecosystem biomagnification, transport processes, impacts to saltwater species, how much freshwater information is transferable to the marine environment;
- Maintain mercury as a high priority contaminant;
- GPAC should support a complete assessment of mercury using the process suggested by the panel;
- Research is needed on sediment

All of the complexities of each contaminant category need to be discussed prior to any prioritization of contaminant lists. The list may need to be modified to include other important contaminants such as TBT, organic loading, toxic metals, as well as a need for indicators of multiple stressors. The suggested process will provide an improved technical basis for action planning and allow GPAC to proceed to the next steps in a rational and scientifically sound manner. Participants in the review processes for each contaminant should include experts in the field, as well as interested stakeholders. RARGOM and the GOMC Environmental Monitoring Committee should be considered as regional resources to help recruit and assemble experts, facilitate the evaluation process and to provide the linkage to managers and the public. In turn, direct participation of GPAC in GOMC Monitoring Committee activities is encouraged.

GPAC should ensure that the outcomes of these contaminant assessments are provided to regulators to make them aware of current needs for source reductions and to encourage harmonization of regulatory standards on a regional scale. GPAC is also strongly encouraged to act as advocates and put pressure on governments and funding agencies to provide support for synthesis of existing data and translate findings for public education.