

Marine Monitoring Programs in the Gulf of Maine

An Inventory



**Prepared by:
Heather Chandler for
the Maine State Planning Office
and the Gulf of Maine Council**

**Augusta, Maine
June 2001**

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Introduction

This report presents the findings of an inventory of marine environmental quality monitoring programs in the Gulf of Maine. The inventory focuses on active and ongoing monitoring programs, including federal, state, local, volunteer, and private efforts.

This directory updates a 1989 publication titled: “Marine environmental quality monitoring programs in the Gulf of Maine: An Inventory,” prepared by the Maine State Planning Office on behalf of the Gulf of Maine Council. The purpose of this inventory is to obtain an overview of the scope of active marine monitoring in the Gulf of Maine.

This inventory utilizes a very broad definition of marine environmental monitoring: activities which provide information on the source, transport, fate and effect of contaminants in the marine environment, and supply information useful for identifying and controlling anthropogenic impacts on the environment. For the purpose of this report, any program which conducts ongoing monitoring activities in the marine environment is considered to be a monitoring program.

For purposes of this survey, the Gulf of Maine region includes Georges Bank as well as the Bay of Fundy. The seaward boundary is approximate, and extends from Cape Sable, Nova Scotia, south to the eastern limit of Georges Bank, then follows the edge of Georges Bank at about the 100 meter contour to the South Channel from which it extends northward to Monomoy Island off of Cape Cod.

Disposal Area Monitoring System (DAMOS)

Sponsor U.S. Army Corps of Engineers, New England Division

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Goals

This program is designed to assure that sediments dredged from New England's harbors and placed at offshore disposal sites do not result in unacceptable impacts. The program also investigates improved management techniques and produces various public education material.

Contaminants

Data collected by the program includes samples of water, sediment, and tissue. Contaminants may include various metals and organics, including mercury, zinc, lead, copper, PAHs, PCBs, dioxin/furans, and others.

Dates and Frequency of Sampling

Data are collected on an aperiodic, project- or site-specific basis.

Sampling Stations

Most data are collected in association with the regional dredged material disposal sites located in the Gulf of Maine, including the Cape Cod Bay, Massachusetts Bay, Cape Arundel, and Portland sites.

Sampling and Analytical Procedures

Procedures used include various EPA and NOAA methods

Reference

The program publishes a series of reports. These reports, dating back to 1978, are available from the New England District, USACE. A full listing of reports is available on the web site or via mail or e-mail.

Discussion

The DAMOS program collects a wide array of data types, depending on the specific management information needs. In addition to contaminant information, this includes bathymetric surveys, side scan data, physical oceanography, benthic biology, fishery surveys, and others. Public education materials available through the program include brochures and a video.

Bioeffects Studies

National Status and Trends (NS&T) Program for Marine Environmental Quality

Sponsor National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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Goals

The goal of NOAA's National Status and Trends (NS&T) program is to conduct monitoring and assessment, and associated research, to provide a sound basis for stewardship of the Nation's coastal environment and resources.

The purpose of the Bioeffects Studies is to describe the geographical extent and severity of contamination and associated biological effects in selected estuaries and coastal areas of the United States. Data from a series of individual studies are periodically integrated to describe the results on a nationwide basis.

Contaminants

Using criteria similar to those for the Mussel Watch project, the Bioeffects Studies measure pesticides, industrial chemicals, polycyclic aromatic hydrocarbons, and major and trace elements. In addition, and responding to specific regional needs, other contaminants are also measured, such as currently used pesticides, dioxins and furans.

Sampling Stations

To date, more than 25 different estuaries and coastal areas have been studied under this project. The Gulf of Maine has not been studied, although Boston Harbor was studied in 1993. Sampling sites are selected on the basis of a stratified-random sampling design. The size and dimensions of sampling strata are determined in close consultation with local and state agencies. Depending on the size of the study area, as many as 300 sites are sampled (for example in Chesapeake Bay). Sediment toxicity assessments have generally been based on results of sediment toxicity tests, levels of contamination and evaluation of biomarkers. Beginning in 1994, measures of in situ changes in benthic biological community structure and composite indicators of environmental quality have also been included

Sampling Procedures

The Bioeffects Studies are based on the concept of Sediment Quality Triad, i.e., synoptic measurements of chemical contaminants, sediment toxicity tests, and analyses of benthic macroinvertebrate community structure. The triad data are obtained at each randomly selected site within a sampling stratum.

Sediment samples are collected with a Kynar-coated, Young-modified Van Veen grab. Samples for benthic macrofauna are collected with a smaller version of the modified Van Veen grab. The entire content of an acceptable grab samples (at least 5 cm deep at the center of the grab) are retained and sieved in the field with a 0.5 mm sieve. Materials retained are preserved in buffered formalin with a Rose Bengal stain.

Depending on the special requirements of a study area, additional sampling may be performed. This may include water sampling for currently used pesticides, water and sediment sampling for sewage-derived materials, faunal or tissue sampling for biomarkers, etc.

Analysis

As in the case of the Mussel Watch project, chemical measurements are made for levels of metals, pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons, and, in some case, for butyltins, dioxins, and planar PCBs (ref. the Mussel Watch section of this document). Sediment toxicity tests generally include tests for amphipod survival in bulk sediment, sea urchin fertilization success in sediment porewater, Microtox response in sediment organic extract, and induction of P450 enzyme as indicated genetically engineered Reporter Gene System (RGS). Other frequently used tests include inhibition of acetylcholinesterase (responding to organophosphorus compounds), induction of metallothioneins (responding to certain metals), and DNA strand breakage (a measure of potential genotoxicity). A summary of the general approach and procedures can be found in the following publication:

Turgeon, D.D., et al. (1998) Sediment Toxicity in U.S. Coastal Waters. Special Report, Center for Coastal Monitoring and Assessment, National Ocean Service, NOAA, Silver Spring, MD, 20p.

Additional information and a publications listing can be found at <http://ccmaserver.nos.noaa.gov>

Quality Assurance/Quality Control

All aspects of Bioeffects Studies), such as chemical analyses, toxicity testing, biomarker testing, and benthic community analysis include QA/QC protocols. Some of the toxicity tests follow standard procedures as outlined by the American Society for Testing and Materials, U.S. Environmental Protection Agency, American Public Health Association, among others.

Reference

Data and results from the Bioeffects Studies have been reported in dozens of recent publications in scientific journals and NOAA Technical Memoranda. The following three publications provide information of a general nature.

Turgeon, D.D., et al. (1998) Sediment Toxicity in U.S. Coastal Waters. Special Report, Center for Coastal Monitoring and Assessment, National Ocean Service, NOAA, Silver Spring, MD, 20p.

Long, et al. (1996) Estimates of the spatial extent of sediment toxicity in major U.S. estuaries.
Environmental Science and Technology, 30: 3585-3592

Long, E.R. (2000) Spatial extent of sediment toxicity in U.S. estuaries and marine bays. Environmental Monitoring and Assessment 64: 391-407

Discussion

The Bioeffects Studies project is an integral component of NOAAs National Status and Trends Program. It is designed to document the prevalence and severity of adverse biological effects associated with coastal contamination and other sources of environmental degradation.

Based on results of sediment toxicity bioassays performed as part of Bioeffects Studies and data from the literature, NS&T program has developed effects-based numerical guidelines to infer toxicological relevance of contaminant concentrations. These guidelines, known as Effects Range-Low (ERL) and Effects Range-Median (ERM), define contaminant concentration ranges that are rarely, occasionally or frequently associated with toxic effects in biota. The guidelines have been used as a screening measure or, in some instances, as numerical targets for management of coastal resources, by many local and state agencies and a few foreign countries.

The project data are also being used to further develop or modify environmental indicators, both at the sub-cellular (as biomarkers) and biological community (ecological indices) levels.

Gulf of Maine Ocean Observing System (GoMOOS)

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Goals

To provide real time or near real time information on the Gulf of Maine on a free and open basis to those who rely on the Gulf for work, research or recreation.

Contaminants

GoMOOS collects information on currents (surface and depth), temperature (surface and depth), meteorology, dissolved oxygen, waves, chlorophyll, salinity, winds and other oceanographic parameters. Nutrients will be sampled twice a year during mooring servicing cruises.

Dates and Frequency of Sampling

The GoMOOS mooring array and CODAR systems will be deployed in May of 2001. Observations will be posted on an hourly basis.

Sampling Stations

The moorings will be located throughout the Gulf of Maine. The locations of the moorings and the parameters they will be collected can be found at the GoMOOS website, gomoos.org.

Sampling and Analytical Procedures

The information will be collected by optical and physical sensors mounted on mooring and telemetered to shore. See website for more details.

Reference

Richert, Evan D., et al. "A Proposal to Implement the Gulf of Maine Ocean Observing System" 2000.

Discussion

GoMOOS will be collecting information from a moored array, land-based radar that monitors surface currents, satellite information and modeling and providing that data to the general public through the website, gomoos.org. The information will be made freely available to all interested parties. The system will be deployed in May of 2001.

Gulfwatch Program

Sponsor Gulf of Maine Council on the Marine Environment

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Goals

The presence of potentially toxic contaminants in the Gulf of Maine is a transboundary issue with many poorly understood ramifications. Gulfwatch is a program in which mussels are used as a sentinel species for habitat exposure to organic and inorganic contaminants. It has been successful for nine years in assessing the water column and potential exposure concentrations of a wide range of contaminants, as well as growth and condition of mussels, at sites throughout the Gulf. To be an effective monitoring program, long-term measurements are needed to interpret temporal trends for contaminant concentrations. The present Gulfwatch program constitutes a basic, first step approach towards understanding the fate and impacts of toxic contaminants in the Gulf of Maine that is critical for expanding further, complementary studies in a coordinated fashion.

Contaminants

Samples of mussel tissue are analyzed for the following: 10 trace metals (Ag, Al, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Zn); 24 different PAHs; 24 different PCB congeners; 17 different chlorinated pesticides, including DDT and 5 of its homologues; percent dry weight; and condition index.

Sampling Stations

There have been over 71 sites sampled as part of the Gulfwatch program. There are sites in all five jurisdictions around the Gulf of Maine: Massachusetts, New Hampshire, Maine, New Brunswick, Nova Scotia.

The present program is designed to have sampling take place at a subgroup of the routine sites, and these sites are resampled after two ensuing years during which sampling occurs at two other subgroups of sites (3 year cycle).

There is one “benchmark” site in each jurisdiction that is sampled every year. Sites are located both to assess background levels of contaminants at relatively uncontaminated sites and to assess contamination at sites near potential pollution sources.

Sampling Procedures

Subtidal mussel beds are located and mussel samples of uniform (50-60 mm length) size are collected from four distinct areas with a given bed. For each of the four replicate samples, 50 mussels are collected, debris is removed from the shells and the mussels are refrigerated while transported to the processing laboratory. Mussels are shucked, tissue removed and placed in Mason jars. Mussels (20 individuals) processed for trace metals analysis are shucked with acid-washed plastic wedges. Mussels (20 individuals) processed for toxic organic contaminants are shucked with solvent rinsed steel knives. The Mason jars are acid washed or solvent rinsed for trace metal and organic analyses, respectively. The samples are frozen at -20°C until transport to analytical labs.

Analysis

Analytical procedures are reported in Jones et al. (1998). Inorganic contaminants are analyzed at the State of Maine Health and Environmental Testing Laboratory (Orono, Maine). Analyses for mercury is by cold vapor atomic. Analyses for all other metals is by flame atomic absorption.

Organic contaminants in mussel samples are analyzed at the Environment Canada, ECB Laboratory in Moncton, NB. Tissue samples are extracted by homogenization with an organic solvent and a drying agent. Solvent extracts are obtained by vacuum filtration, and biomatrix interference is separated from target analytes in extracts by size exclusion chromatography. Purified extracts are subjected to silica gel liquid chromatography, which provided a non-polar PCB/chlorinated pesticides fraction and a polar chlorinated pesticide fraction. PCBs and pesticides are analyzed by high resolution dual column gas chromatography/electron capture detection (HRGC/ECD). Following PCB and pesticide analysis, the two fractions are combined and the resulting extract was analyzed for aromatic hydrocarbons by high resolution gas chromatography/mass spectrometry (HRGC/MS).

Condition index is determined by using measurements of wet weight and shell length, width and height of ten individual mussels from each of three replicate samples for each site.

Quality Assurance/Quality Control

A description of the full analytical protocol and accompanying performance based QA/QC procedures is found in Jones et al. (1998). Standard laboratory procedures for metals incorporated method blanks, spike matrix samples, duplicate samples, surrogate addition and standard oyster tissue (SRM 1566A). The method blanks were inserted: throughout the run. Duplicate samples and matrix spike recoveries were conducted on 15% of the samples. The Moncton laboratory participated in the NIST Status and Trends Intercomparison Marine Sediment Exercise IV and Bivalve Homogenate Exercise. Internal quality control and method performance specifications are described in the Environment Canada Shellfish Surveillance Protocol (Jones et al. 1998). The protocol includes mandatory QC measures with every sample batch including method blanks, spike matrix samples, duplicate samples, surrogate addition, and certified reference materials (SRM 1974a). The protocol specifies the performance criteria relevant to method accuracy, precision, and detection limits and data reporting requirements for the analysis of organic contaminants in shellfish samples.

References

Jones, S.H., M. Chase, J. Sowles, P. Hennigar, W. Robinson, G. Harding, R. Crawford, D. Taylor, K. Freeman, J. Pederson, L. Mucklow & K. Coombs. 1998. Evaluation of Gulfwatch: the first five years. The Gulf of Maine Council on the Marine Environment, State Planning Office, Augusta Maine.

Reports and data, including Jones et al. (1998) are available at:
www.gulfofmaine.org/library/gulfwatch/index.html

Marine Resources Monitoring, Assessment and Prediction (MARMAP)

Ecosystem Monitoring

Sponsor US Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center

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Goals

To (1) assess the seasonal, interannual, and decadal variability in the planktonic and oceanographic components of the Northeast Shelf ecosystem; (2) characterize changes in these variables as an indication of broad-scale ecological and environmental changes; and (3) develop appropriate indices of the changing states of the marine ecosystem.

Dates and Frequency of Sampling

Three approaches are used for meeting program goals:

1. Monthly monitoring of the Gulf of Maine via ships of opportunity deploying the Continuous Plankton Recorder (CPR) began in 1961; deploying expendable bathythermographs (XBT's) began in 1977. Monitoring continues.
2. Monitoring of various planktonic and oceanographic components via research vessels began in 1977 at the rate of at least six surveys/year, and continues.
3. Monitoring of the surface oceanographic features of the Gulf of Maine via remote sensing began in 1979 at usually no more than a daily rate, and continues.

Sampling Stations

Ship of opportunity transect between Massachusetts, U.S.A. and Cape Sable, N.S. results in 24 CPR and 12 XBT samples/month.

Research vessels have sampled at up to 90 sites/survey in the Gulf of Maine. Since 1996 the standard has been 30 random sites across this area.

Remote sensing of surface features may have a resolution of several kilometers, weather permitting, or, may be from selected buoy sites.

Sampling and Analytical Procedures

Ships of opportunity produce data on phytoplankton abundance and composition; zooplankton abundance and composition; water column temperature; surface salinity; meteorological conditions.

Research vessels produce data on zooplankton abundance and composition; water column temperature and salinity; surface chlorophyll fluorescence; and meteorological conditions.

Remote sensing produces data on surface temperature, ocean color, and wind velocity and its effects.

Analyses generally involve establishing of baselines in time and space, identifying departures from these baselines, determining the statistical significance of departures, revealing ecological relationships between the measured variables, and deriving indices describing the changing states of the ecosystem.

References

Jossi, J.W., R.L. Benway, and J.R. Goulet. In Review. MARMAP ecosystem monitoring: program description. *NOAA Technical Memorandum NMFS-F/NEC: 1-30*. [Available from: NOAA Narragansett Laboratory, 28 Tarzwell Drive, Narragansett, RI 02882.]

Jossi, J.W., and Griswold, C.A. (Eds.). In Review. MARMAP ecosystem monitoring: Operations manual. *NOAA Technical Memorandum NMFS-F/NEC: 185*. [Available from: NOAA Narragansett Laboratory, 28 Tarzwell Drive, Narragansett, RI 02882.]

Sherman, K. 1980. MARMAP, a fisheries ecosystem study in the northwest Atlantic: Fluctuations in ichthyoplankton-zooplankton components and their impact on the system. In: Diemer, F.P., Vernberg, F.J., and Mirkes, D.Z. (Eds.). 1980. Advanced concepts in ocean measurements for marine biology. Belle W. Baruch Institute for Marine Biology and Coastal Research. *University of South Carolina Press, Columbia, South Carolina*, 1-572.

For information on NOAA Coastwatch Program go to:

<http://sgiot2.wwb.noaa.gov/COASTWATCH/index.htm>

For information on NOAA Coastwatch Northeast Regional Node: <http://narwhal.gso.uri.edu>

Website Master: CwatchNE@narwhal.gso.uri.edu

The Mussel Watch Project

National Status and Trends Program for Marine Environmental Quality

Sponsor: National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce

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Goals

The goal of NOAA's National Status and Trends (NS&T) program is to conduct monitoring and assessment, and associated research, to provide a sound basis for stewardship of the Nation's coastal environment and resources.

The Mussel Watch project is one component of the NS&T program. Bivalve mollusks, which are ubiquitous, sedentary, and filter feeding organisms in coastal waters, are used in the program to monitor regional and national environmental quality and trends.

Contaminants

Mollusk tissues are analyzed to determine levels of several pesticides (such as, DDT), industrial chemicals (such as PCBs), polycyclic aromatic hydrocarbons (PAHs), and 17 major and trace elements. Sediment samples are analyzed for the same parameters as well as for the presence of the bacterium *Clostridium perfringens*, a sewage indicator, and total organic carbon.

Dates and Frequency of Sampling

The Mussel Watch project was initiated in 1986 and is ongoing. Samples are collected biennially.

Sampling Sites

There are approximately 300 Mussel Watch sites throughout the U.S. of which about 224 are regularly sampled. Sampling occurs along the contiguous coasts of the U.S. as well as in the Great Lakes, Alaska, Hawaii and Puerto Rico. Sampling sites are selected away from point sources or in areas known to be heavily contaminated, i.e., hot spots. As such, the project provides nationwide data on background levels of chemical contaminants that can be used to evaluate short- and long-term impacts of oil and other chemical spills, dumping of wastes, and temporal changes in contamination on local and regional scales.

Sites in the Gulf of Maine (GOM) region are:

<u>Site code</u>	<u>Site name</u>	<u>Site location</u>
PBPI	Penobscot Bay	Pickering Island
PBSI	Penobscot Bay	Sears Island
MSSP	Merriconeag Sound	Stover Point
CAKP	Cape Arundel	Kennebunkport
GBDP	Great Bay	Dover Point
CAGH	Cape Ann	Gap Head
SHFP	Salem Harbor	Folger Point
MBNB	Massachusetts Bay	Nahant Bay
BHDI	Boston Harbor	Deer Island
BHDB	Boston Harbor	Dorchester Bay
BHNB	Boston Harbor	Hingham Bay
BHBI	Boston Harbor	Brewster Island
MBNR	Massachusetts Bay	North River
DBCI	Duxbury Bay	Clarks Island

Sampling Procedures

Mussels (*Mytilus edulis*) are collected at all sites in the Gulf of Maine while oysters *Crassostrea virginica* are collected from Delaware Bay south and in the Gulf of Mexico.

Samples of sediment are collected with a Kynar-coated, Young-modified Van Veen grab sampler, or with a stainless steel box corer. Separate surface skims are taken for the analysis of organic contaminants, major and trace elements, and sediment properties. Sediment sampling is conducted much less frequently than sampling for mussels and oysters. GOM sediment samples were first collected in 1986 and 1987, and again in 1996 and 1997.

Analyses

Procedures for analysis of organic contaminants and trace elements in tissues and sediments have evolved during the course of the project. Methods are found in the following documents, documents that can be downloaded from <http://ccma.nos.noaa.gov> as PDF files:

Lauenstein, G. G. and A. Y. Cantillo (1998) Analytical Methods of the National Status and Trends Program Mussel Watch Project - 1993 -1997 Update. NOAA Technical Memorandum NOS ORCA 130.

Lauenstein, G. G. and A. Y. Cantillo (eds.) (1993) Sampling and analytical methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Overview and Summary of Methods, Volume I NOAA Technical Memorandum NOS ORCA 71, Silver Spring, MD.

Lauenstein, G. G. and A. Y. Cantillo (eds.) (1993) Sampling and analytical methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-

1992: Comprehensive descriptions of complementary measurements, Volume II NOAA Technical Memorandum NOS ORCA 71, Silver Spring, MD.

Lauenstein, G. G. and A. Y. Cantillo (eds.) (1993) Sampling and analytical methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Comprehensive descriptions of elemental analytical methods, Volume III NOAA Technical Memorandum NOS ORCA 71, Silver Spring, MD.

Lauenstein, G. G. and A. Y. Cantillo (eds.) (1993) Sampling and analytical methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Comprehensive descriptions of trace organic analytical methods, Volume IV NOAA Technical Memorandum NOS ORCA 71, Silver Spring, MD.

Quality Assurance/ Quality Control

One objective of the NS&T program is to develop standard protocols for the handling and analysis of data. Specific programs include, inter-laboratory comparisons, and development of Standard Reference Materials for tissues and sediments sampled by the program.

Reference

<http://ccma.nos.noaa.gov>

Discussion

The Mussel Watch project is an integral component of NOAA's National Status and Trends Program. Other parts of the program include sediment toxicity studies, application and development of biomarkers and ecological indices, sediment quality guidelines, and regional assessment of coastal contamination and other sources of environmental contamination. The wide range of contaminants and long-term data records are strengths of the Mussel Watch project. Regional coverage in the Gulf of Maine encompasses 14 sites. Data are posted on the internet after checking for quality assurance.

National Benthic Surveillance Project

National Status and Trends (NS&T) Program for Marine Environmental Quality

Sponsor National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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Goals

The goal of NOAA's National Status and Trends (NS&T) program is to conduct monitoring and assessment, and associated research, to provide a sound basis for stewardship of the Nation's coastal environment and resources.

The National Benthic Surveillance Project (NABS) was initiated to monitor levels of chemical contaminants in Demersal fish and selected species benthic invertebrates fauna in US coastal waters. The project also included measuring the biological effects of contaminant exposure, primarily as prevalence of toxicopathic liver diseases, such as neoplasms (tumors), preneoplasms, and other diseases. Pathological conditions in other organs, such as kidneys, as well as biomarkers of contaminant exposure, such as DNA adducts, were also described.

Contaminants

Using criteria similar to those for the Mussel Watch project, the NBSP measured pesticides, industrial chemicals, polycyclic aromatic hydrocarbons, and major and trace elements.

Sampling Stations

Benthic sediments and biota were sampled at over 120 coastal sites. Sampling sites in the Gulf of Maine were located at Machias Bay, Frenchman Bay, Penobscot Bay, Casco Bay, Merrimack River Mouth, Salem Harbor, and Boston Harbor.

Each site consisted of three sediment-sampling stations separated by up to 5 km. The sites were located close to shore, in or near major bays and estuaries. Trawls for winter flounder are taken as close as possible to sediment stations.

Sampling Procedures

Sediments samples were obtained with a specially constructed box core device or a standard Smith-MacIntyre bottom grab. Surface skims were taken from these samples for organic contaminant analyses, while cores were taken from the samples for metal analysis.

Trawls for benthic vertebrates are made at stations as near as practical to the sediment stations. Winter Flounder (*Pseudopleuronectes americanus*) was the primary target species in the Gulf of Maine.

Liver tissue was sampled from fish at each station for analysis of chlorinated organic compounds and trace elements. Liver, kidney, and gill samples from these fish were also examined for histopathological examination. Stomach contents and bile were sampled from a smaller number of individuals at each station, and analyzed for chlorinated organic compounds, aromatic hydrocarbons, and their metabolic products. The stomach contents were further analyzed to identify prey species. Finally, the age of the fish sampled was determined to relate growth-related parameters to observed pathological conditions or physiological abnormalities in test species.

Analysis

Procedures for analysis of organic contaminants and trace elements in tissues and sediments have evolved during the course of the project. In general methods described in the Mussel Watch section of this documents have been followed for chemical analyses. Additional procedures, for example, those for histopathological examination and biomarkers, are referenced in the summary document noted below and in several research publications. In many instances, portions of the collected samples were held in a specimen bank for archival and retrospective analyses.

Quality Assurance/Quality Control

QA/QC features incorporated into the NS&T Program involve interlaboratory comparisons, blind sampling, and the development of standard reference materials.

Reference

A summary of data resulting from NBSP studies was published in 1998.

Harmon, M.R., B.W. Gottholm, and A. Robertson (1998) A summary of chemical contaminant levels at Benthic Surveillance Sites (1984-92). NOAA Technical Memorandum NOS ORCA 124, Silver Spring, MD, 633 p.

Additional information is available on the CCMA website: <http://ccma.nos.noaa.gov>

Discussion

The National Benthic Surveillance Project was an integral component of NOAAs National Status and Trends Program. The project was a cooperative effort between the Center for Coastal Monitoring and Assessment and laboratories of NOAAs National Marine Fisheries Services Northwest, Southeast, and Northeast Fisheries Science Centers. The project was concluded in 1992. Documentation of adverse biological effects of coastal contamination and other sources of environmental degradation is now part of the NS&T programs Biological Effects Studies. The Biological Effects Studies also include testing for sediment toxicity, application and development of biomarkers and ecological indices, sediment quality guidelines, and regional assessment of coastal contamination and other sources of environmental contamination.

In a few instances, the NBSP activities in the northeastern United States were based on groundwork laid by the initial phase of the NEMP. The NEMP also undertook benchmark studies in Penobscot and Casco Bays. Boston Harbor has been the site of numerous studies. Casco Bay, Penobscot Bay, Machias Bay and some of the other sites surveyed have been the sites of local studies. (See Metals in Northern NE Estuaries Machias Bay and Penobscot Bay; Dredge Spoils in Penobscot Bay; the Northern Gulf Spill Casco Bay; and the Merrimack River Project.).

National Estuarine Research Reserve System Monitoring

Sponsor National Ocean Service, National Oceanic and Atmospheric Administration,
U.S. Department of Commerce

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Goals

The System-wide Monitoring Program (SWMP) is designed to track changes in estuarine water quality, habitat and land use to ensure that the nation's coastal areas are healthy. It provides information on national environmental trends, while allowing flexibility for coastal managers to gain a better understanding of regional or local issues.

Contaminants

Sampling Stations

The System-wide Monitoring Program is operating at twenty-two National Estuarine Research Reserve System (NERRS) sites. The NERRS sites represent a variety of estuarine ecosystems throughout the US. Each site collects water quality data from two locations and the program is expanding to include nutrients and chlorophyll.

Sampling Procedures

To measure changes in water quality, reserve staff use a Yellow Springs Instrument Co. (YSI™) model 6000/6600 datalogger to collect samples on water depth, temperature, salinity, dissolved oxygen, turbidity and pH. These variables can serve as indicators of environmental stress and are linked to a range of anthropogenic activities (e.g., landuse). The measurements are taken at a minimum of two sites in each reserve and are recorded 30 minute intervals. One datalogger is placed at a reference site, while the other is placed at a site impacted by human activity and exemplifies a concern of the reserve (e.g. nonpoint source pollution).

Analysis

In depth analysis of the data are conducted and results captured every few years in a synthesis report

Quality Assurance/Quality Control

Each NERRS site conducts QA/QC on the data. A Centralized Data Management Office provides additional quality control for data and metadata. This office compiles and disseminates the data over the web (<http://inlet.geol.sc.edu/nerrscdm.html>).

Reference

Wenner, Elizabeth and Maggie Geist. 2001. The National Estuarine Research Reserves Program to Monitor and Preserve Estuarine Waters. *Coastal Management* 29:1-17.

For further information see www.ocrm.nos.noaa.gov/nerr/monsys.html

Discussion

Scientists at the National Estuarine Research Reserve sites began sampling for this program in 1995. The first phase of this program consists of monitoring a suite of water quality variables over a range of spatial and temporal scales. The program is in the process of adding weather data and nutrient/chlorophyll monitoring. In the future the program may include invasive species monitoring, benthic intertidal habitat mapping and watershed landuse mapping to monitor habitat change.

Environmental Quality Data Bank (ENVIRODAT)

Sponsor Environment Canada -- Atlantic Region

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Goals

To observe trends in environmental quality generally. It contains data on local and regional conditions in streams, rivers, lakes, wetlands, estuaries, observation wells, tissue and bottom sediments.

Contaminants

Water, tissue and sediment samples are analyzed for "a wide range of chemical, physical, and biological parameters." (Bird and Rapport, 1986) Included are nutrients, including nitrates, nitrites, and phosphorus. Occasional analysis for pesticides, PAHs, PCBs and metals, including As, Cd, Hg, and Pb, are also conducted.

Dates and Frequency of Sampling

Sampling frequency varies. Data are available back to at least 1971. The program is ongoing.

Sampling Stations/Area Covered

The majority of sampling stations are in freshwater lakes and along rivers and streams of major drainage basins. The farthest downstream sites may give an indication of contaminant loading to the marine environment. There are also ongoing stations situated in estuaries and coastal zone bays.

Sampling and Analytical Procedures

Environment Canada procedures as annotated in the data base.

Reference

This discussion was originally derived from Bird and Rapport (1986) and updated by EC in '01.

Discussion

This program now attempts to monitor limited marine and estuarine systems. The data are of use in determining inputs to the marine system, and for comparison with other sites located farther downstream.

This program is very similar to the USGS Water Resources system in the United States. Coordinate data collection techniques have been developed for rivers that span the border.

Toxic Chemicals in Canadian Seabirds, The Canadian Registry of Toxic Chemicals

Sponsor Canadian Wildlife Service, Environment Canada

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Goals

To monitor the long-term spatial and temporal trends in organochlorine (OC) contaminants and mercury in seabird eggs in Atlantic Canada. This project uses seabirds as indicators of marine environmental quality. The program focuses on three primary species: double-crested cormorant, the Leach's storm-petrel, and the Atlantic puffin.

Contaminants

The focus of the study is organochlorine residues and mercury in seabird eggs. The 12 OCs for which analyses are conducted are listed below. Most eggs are also analyzed for Hg. Organochlorine residues analyzed

DDT	DDD	DDE
Dieldrin	Chlordane	HCH
Heptachlor epoxide	HCB	Mirex
Oxychlordane	Nonachlor	PCB

Sampling Dates and Frequency

GOM sites were included in this program in 1972. Eggs from three primary sites are collected every four years.

Sampling Stations

There are three active sampling stations. Atlantic puffin eggs are collected at Machias Seal Island, on the Maine/ NB border. Leach's storm-petrel eggs are collected at Kent Island, NB, and double-crested cormorant eggs are collected at Manawagonish Island, NB.

Sampling Procedures

Sampling and chemical analysis protocols have varied slightly between years and sites. Egg collection procedure is the most standardized. In most cases fresh eggs are collected early in the nesting season. Nests are randomly selected from near the center of the colony, and where possible eggs are taken

from the first clutch. Eggs are refrigerated until the contents can be removed to acetone and hexane-cleaned glass jars and frozen till analysis.

Chemical Analysis

Samples are homogenized prior to analysis. OC procedures follow Reynolds and Cooper (1975) and Norstrom et al (1980). PCB levels are determined using capillary gas chromatography (as Aroclor 1260 or as a 1:1 mixture of Aroclors 1254 and 1260) (Reynolds, 1971; Norstrom et al, 1978; Won and Norstrom, 1980). Samples for Hg analysis are prepared by wet digestion and analyzed by cold vapor atomic absorption spectrophotometry (AAS) (Fimreite and Reynolds, 1973). Since 1988, PCB congeners have been analysed individually as well. Current analytical methods for OCs follow Won et al. (2001) and for mercury follow Neugebauer et al. (2000).

Portions of the samples which have not been analyzed are stored to provide an archive of specimens for retrospective analysis.

Quality Assurance/Quality Control

NBS or NRC Standard Reference Material for Bovine or Dogfish Liver is utilized to standardize procedures. A review of the methodologies used was conducted in 1978. It showed that the vacuum oven drying procedure led to reproducible losses of DDT, DDD, HCB, and Oxychlorane. The procedures have been changed, and corrections have been added to the data base for pre-1978 data.

Reference

Data is included in the Canadian Registry of Toxic Chemicals (CRTC) data base. A summary of the results through 1985 has been published by Noble and Elliott (1986).

Discussion

This monitoring program provides a data base for observing large-scale trends in contaminants to the marine system. Its value for observing localized phenomena is less clear, as the species studied range widely during the non-breeding season, and so may collect contaminants far from the Gulf of Maine. Direct extension of this program to other regions of the Gulf of Maine would be difficult, as neither Leach's storm-petrels nor puffins nest through the southern reaches of the gulf. Selection of other more locally representative species would minimize continuity with the existing data sets.

Seabirds of various species have been sampled from sites across the Gulf of Maine, but few of these are of the species monitored in this program.

In general, most organochlorines have decreased in concentration in all species since the program began in 1972. In contrast, mercury levels have increased steadily in Leach's storm-petrels and Atlantic puffins since 1972.

References

Fimreite, N., and L.M. Reynolds. 1973. Mercury contamination of fish in northwestern Ontario. *J. Wildl. Manage.* 37:62-68.

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- Norstrom, R.J., D.J. Hallett, F.I. Onuska, and M.E. Comba. 1980. Mirex and its degradation products in Great Lakes herring gulls. Environ. Sci. Technol. 14:860-866.
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- Won, H.T., M.J. Mulvihill, and B.J. Wakeford. 2001. Multiresidue methods for the determination of chlorinated pesticides and polychlorinated biphenyls (PCBs) in wildlife tissues by gas chromatograph/mass spectrometry. Can. Wildl. Serv. Tech. Rep. 335.

Maritime Shellfish Sanitation Program

Sponsor Environment Canada (Environmental Protection Branch)

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web site: www.ns.ec.gc.ca/epb/sfish/sfish.html

Goals

To protect human health from bacterial contamination associated with shellfish.

Contaminants

Water is analyzed for the presence of fecal coliform bacteria.

Dates and Frequency of Sampling

This program started in Canada in 1948. Procedures and timing are carried out in according to the Manual of Operation of the Canadian Shellfish Sanitation Program. Currently each approved shellfish harvesting area is evaluated every three years. Conditionally approved areas are sampled annually. A comprehensive sanitary and water quality survey is conducted for each new shellfish growing area. A minimum of 15 samples are collected from each representative station for the initial classification of an area. The program is ongoing.

Sampling Stations

Survey sites are concentrated where the shellfish resource are located and where problem areas are known or suspected. Samples are collected at approximately 5000 sites along the Maritime coast. Each sites are sampled at a minimum of five times for each survey.

Sampling and Analytical Procedures

Water samples are collected from within the tidal range as prescribed by the Canadian Shellfish Sanitation Program - Manual of Operation. To the extent that it is practical to do so, samples are collected under conditions likely to maximize bacterial concentration. Analysis for coliforms (fecal) is performed. Analytical and quality assurance procedures followed are those approved by the Interstate Shellfish Sanitation Conference.

Reference

Recommended Procedures for the Examination of Sea Water and Shellfish, American Public Health Association (1970),

Standard Methods for the Examination of Water and Wastewater, APHA, (1999)

National Shellfish Sanitation Program (1995),

Canadian Shellfish Sanitation Program, Manual of Operations (1992)

Discussion

All of the Gulf of Maine States, and the government of Canada follow the procedures developed by the Interstate Shellfish Sanitation Conference.

Biotoxin Monitoring Program

Sponsor Canadian Food Inspection Agency (CFIA)

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Canadian Food Inspection Agency (CFIA)
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web site: www.cfia-acia.agr.ca/

Goals

To protect the public health from paralytic shellfish poisoning (PSP), amnesic shellfish poison (ASP) and diarrhetic shellfish poisoning (DSP)

Contaminants

Mollusc tissues are analyzed for levels of Paralytic Shellfish Poison (PSP), domoic acid (ASP) and, where indicated, diarrhetic shellfish poisoning (DSP)

Dates and Frequency of Sampling

The PSP monitoring program has been ongoing since 1943. ASP was identified in the Bay of Fundy in 1988 and has been included in the monitoring program since that time. Intensity of monitoring effort increases during the peak of shellfish toxicity in the summer months.

Sampling Stations

Sampling sites have been chosen on the Nova Scotia and New Brunswick shores of the Bay of Fundy based on historic data and commercial shellfish resource. Many of the sites currently monitored have been monitored since 1943.

Sampling and Analytical Procedures

Softshell clams (*Mya arenaria*) and blue mussels (*Mytilus edulis*) are sampled by CFIA employees from key sites on the beach and analysed in CFIA laboratories in Dartmouth, NS and Moncton, NB. The mouse bioassay method has been used in nearly unaltered form since the inception of the program (AOAC, 1965) for the analysis of PSP. ASP and DSP are measured by HPLC.

References

Prakash, et al. 1971, Bull. Fish. Res. Bd. Can. 177, 87pp.

Martin, J.L. & D. Richard, 1996, Shellfish Toxicity from the Bay of Fundy, Eastern Canada: 50 years in retrospect, in Harmful and Toxic Algal Blooms, Yasumato et al.

AOAC. 1965. Official methods of analysis, 16th edition.

Fisheries and Oceans Canada, Chemical Method Manual, 1999.

Discussion

A program was initiated in 1943 to monitor PSP toxins in shellfish in the Bay of Fundy, and has been continued since that time. Many shellfish areas are closed every summer for a period of several weeks. ASP was identified in the Bay in 1988, and was found again in 1995 and 1996. Closures for ASP occurred in 1988 and 1995.

Dredged Material Ocean Disposal Site Monitoring Program

Sponsor Disposal at Sea Program, Environment Canada

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Goals

- ♦ To meet legislative mandate under the Canadian Environmental Protection Act, Part VII and Canada's treaty obligations under the London Convention 1972 and its 1996 Protocol.
- ♦ To ensure compliance with Disposal at Sea Permit requirements.
- ♦ To assess the impact hypothesis upon which Disposal at Sea Permit was approved.

Contaminants

Grain size, TOC, Cd, Hg, Cu, Pb, Zn, total PAHs (16 EPA priority compounds) and total PCBs. Other parameters (e.g. TBT, Dioxins and Furans) may be required.

Dates and Frequency of Sampling

Monitoring programs are designed to start in April each year and complete by end of March the following year. Sampling dates and frequency are project specific.

Sampling Stations

There are more than 100 dredged material disposal sites in Atlantic Canada. Each year, one or two disposal sites are selected for monitoring.

Sampling and Analytical Procedures

Sampling for chemical and biological measurements follows Environment Canada's standard sampling protocol. Chemical analytical procedures follow those recommended by USEPA.

Reference

National guidelines for monitoring dredged and excavated material at ocean disposal sites. A. Chevrier and P. Topping, Disposal at Sea Program, Environment Canada, Ottawa, 1998.

Monitoring of the Black Point Ocean Disposal Site - Saint John Harbour, New Brunswick (1992-1994), Ocean Disposal Report #9. K.-L. Tay, K.G. Doe, A.J. MacDonald and K. Lee, Environment Canada, Atlantic Region, 1997.

Discussion

Recent (1999 - 2001) monitoring program conducted at the Saint John Black Point disposal site in the Bay of Fundy is most relevant to the Gulf of Maine Program. The site has been used for dredged material disposal for more than 50 years. Physical, chemical and biological surveys were conducted at the site to assess the impacts of disposal on the surrounding habitat.

Cooperative Bacterial Monitoring Program

Sponsor Eastern Charlotte Waterways Inc.

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web site: www.ecwinc.org

Goals

This program is designed to maintain shellfish harvest classification and indicate areas of bacterial contamination requiring remedial actions.

Contaminants

Water samples are analyzed for fecal coliform bacteria.

Dates and Frequency of Sampling

Samples are established based on an area rotation method. X amount of samples in specific areas are outlined by the management committee for each fiscal.

Sampling Stations

Samples are collected at sites which have been established by Environment Canada under the CSSP. Subsequent investigative samples are incorporated where shellfish harvesting is determined to occur and where sources of pollution are likely to impact shellfish growing waters.

Sampling and Analytical Procedures

Water samples are collected from within the tidal range primarily in high tide conditions. To the extent that it is practical to do so, samples are collected under conditions likely to maximize bacterial concentration. Analytical techniques for fecal coliforms and quality assurance procedures followed are those of the Canadian Shellfish Sanitation Program.

Reference

Canadian Shellfish Sanitation Program. Reference Site:
<http://www.ns.ec.gc.ca/epb/sfish/maps/nb/nb.html>

Discussion

All of the Gulf of Maine States, and the government of Canada follow the procedures developed by the Interstate Shellfish Sanitation Conference.

ACAP Saint John Community Environmental Monitoring

Sponsor Numerous government and private sponsors.

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web site: <http://user.fundy.net/acapsj>

Goals

ACAP Saint John has four main goals for its environmental monitoring programs:

1. To gather information on the environmental quality of the Saint John area;
2. To educate the community on the state of the environment and its connection to human activities;
3. To support other ACAP Saint John initiatives (*e.g.* habitat restoration); and
4. To influence future decisions having an impact on the environment of the Saint John area.

ACAP Saint John developed the first comprehensive water quality monitoring program in New Brunswick in 1993 in order to provide precise and accurate data on the state of our coastline. The past 8 years of water sampling has allowed ACAP to establish background conditions of the water quality in several parts of the harbor and its estuaries. The program had detected trends of improving and degrading water quality.

In addition to water quality monitoring, ACAPSJ is involved in a variety of other monitoring initiatives. Some of which are regular events (*e.g.* Beach Sweeps) and others are occasional (*e.g.* intertidal surveys).

Contaminants

Water samples are analyzed for total nitrogen content, dissolved oxygen, fecal coliform levels, pH, salinity, turbidity, and total phosphate content. Other relevant observations for each sample such as weather (sky/clouds, precipitation, winds, wind direction), water color, debris in water and along shore, miscellaneous pollutants, biological activity, and temperature of water and air.

Additional parameters of interest have included intertidal surveys (community assemblages), benthic macroinvertebrates, tissue contaminants, fish abundance, stream habitat, weather conditions, bird counts and coastal debris.

Dates and Frequency of Sampling

The water quality monitoring program was initiated in the 1993. Significant changes occurred in the program throughout the years with the institution of new testing parameters and new sampling locations. Water samples are collected from each site once a week for approximately 10 weeks between June and August. A sampling schedule is developed at the start of each season.

Additional monitoring programs are generally conducted during the spring to fall season with specified sampling schedules for each project.

Sampling Stations

Water sampling locations were selected based on their proximity to sources of contamination, sensitive uses such as swimming and water fowl habitat, and on the basis of safety, ease of access and the ability to obtain a representative measure of water quality. Sampling stations are, where appropriate, located up and down stream from major industrial areas.

Approximately 25 water sampling locations throughout the Saint John Harbour and estuaries are monitored. Most are paired samples (*i.e.* upstream and downstream of an area of interest), however, some are individual samples and others are composed of three.

Sampling and Analytical Procedures

Volunteers are used extensively in the collection of water samples and are trained in the proper procedure for the sampling. Samples are collected two hours before low tide. Low tide has been chosen to reduce the dilution effect of salt water from the Bay of Fundy. At sites unaffected by tides, samples are obtained at the same time of the day.

Samples are collected in clean Nalgene bottles, dissolved oxygen bottles, and pre-sterilized Whirlpak bags, and transported on ice to the laboratory for analysis. All samples are collected following a detailed quality assurance and control procedure that includes frequent triplicate sampling and, where possible, split sampling. Analytical techniques and quality assurance procedures are in accordance with Standard Methods for the Examination of Water and Wastewater.

At the completion of every monitoring initiative, including the water quality monitoring program, a final report is compiled and presented to the community. This report documents the sampling procedures, quality controls, raw data and data interpretation.

Reference

Standard Methods for the Examination of Water and Wastewater, 16th ed., American Public Health Association, New York, 1985.

New Brunswick FinFish Aquaculture Monitoring Program

Sponsors New Brunswick Department of the Environment and Local Government *and* New Brunswick Department of Agriculture, Fisheries and Aquaculture

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Goals

This program is intended to guide the long term environmental sustainability of the marine finfish cage aquaculture industry in New Brunswick in the context of a healthy marine environment.

Contaminants

Sediment samples are analyzed for their redox and sulfide levels. Also, visual observations are noted on a chart.

Dates and Frequency of Sampling

Samples are taken annually between mid-August and mid-October at each finfish aquaculture site. Should a site indicate conditions described in the Environmental Management Guidelines, confirmation sampling will also occur immediately after the first sampling. Also, sampling will be undertaken in March for those sites triggering response.

Sampling Stations

Three sampling stations are identified in each cage cluster containing 100,000 fish. or more. A transect is placed 50 meters from the cage cluster and proceeds against the direction of the prevailing current to the center of the cage with the highest biomass of fish.. Visual observations are recorded on a chart at 50 meters from the cage cluster, at the cage cluster edge and under the cage. Eh/sulfide measurements are taken within the 10 meter section of the transect, one at the cage center, one going toward the cage edge, and one at the 10 meter mark.

Sampling and Analytical Procedures

The Eh/sulfide samples are taken according to standard protocol with instrumentation that is calibrated regularly.

Reference

Protocol and reference levels for readings are identified in Wildish, D.J., Akagi, H.M., Hamilton, N.,and Hargrave, B.T. 1999, *A Recommended Method for Monitoring Sediments to Detect*

Enrichment from Mariculture in the Bay of Fundy. Canadian Technical Report of Fisheries and Aquatic Sciences, 2286.31pp.

Shellfish Fishery Management Plan for Oak Bay

Sponsor: St. Croix Estuary Project, Fisheries and Oceans Canada, Environment Canada, Canadian Food Inspection Agency, New Brunswick Department of Agriculture, Fisheries and Aquaculture, East Charlotte Waterway Inc., Lepreau Clam Diggers Association, West Charlotte Clam Diggers Association, New Brunswick Research and Productivity Council.

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St. Stephen, New Brunswick E3L 1G8
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web site: www.scep.org

Goals

The goals of this management plan are to allow the safe and productive opening of the shellfish fishery in Oak Bay, New Brunswick.

Contaminants

Water samples and soft-shelled clam meat samples are both analyzed for presence and concentrations of fecal coliform bacteria.

Dates and Frequency

Water samples are taken a minimum of once per month. Meat samples are taken a minimum of once per week. Rainfall amounts may require further sampling above minimum requirements.

Sampling Stations

All sampling stations are systematically placed to allow the most accurate sampling and assessment of the Oak Bay system.

Sampling and Analytical Procedure

Water and Meat sampling locations have been designated within the tidal range of Oak Bay. The Canadian Food Inspection Agency and Environment Canada laboratories will conduct inspection of water and meat samples.

Reference

Saint Croix Estuary Project Management Plan and Fisheries and Oceans Canada Shellfish Management Plan for Oak Bay, 2001.

Enteromorpha Monitoring

Sponsor: St. Croix Estuary Project

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Goals

By monitoring Enteromorpha algae development, the conditions of the system the algae are contained within may be assessed.

Contaminants

Samples of Enteromorpha algae were analyzed for concentrations of nutrients sources of phosphorous and nitrogen.

Dates and Frequency

Seventy-five marine samples and 62 fresh water samples were collected from study sites in Oak Bay, Waweig River and Pottery Creek.

Sampling Stations

Locations were chosen which would allow for the most accurate comparison possible between the growth of Enteromorpha algae in salt and freshwater systems.

Sampling and Analytical Procedure

Freshwater samples were taken to the New Brunswick Department of Environment in Fredericton. Saltwater samples were taken to the Environment Canada laboratory in Moncton.

Reference

Saint Croix Estuary Project Management Plan

Discussion

Phytoplankton Monitoring

Sponsor Fisheries and Oceans Canada

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Goals

A phytoplankton monitoring program was initiated in the Western Isles region of the Bay of Fundy in 1987. The purposes of the study were: to establish baseline data on phytoplankton populations since little detailed work had been published since the earlier studies by Gran and Braarud (1935); to identify harmful algal species that could potentially cause harm to the aquaculture industry; to provide an early warning to the industry by sorting and identifying samples soon after collection; and to determine patterns and trends in phytoplankton populations. In addition, it could provide an early warning to regulatory agencies such as the Canadian Food Inspection Agency (CFIA) for the occurrence of species that produce toxins resulting in shellfish toxicities and closures of shellfish beds to harvesting, generally during the summer.

Contaminants

Dates and Frequency of Sampling

Weekly samples are collected from May to the end of September and biweekly sampling is conducted in the months of April and October and monthly during all other months.

Sampling Stations

The number of sampling sites in the southwest New Brunswick area of the Bay of Fundy has changed since the program started in 1987. Four stations that continue to be monitored today include: Brandy Cove (a brackish site influenced by the Saint Croix River estuary), Lime Kiln Bay (Letang estuary where a number of aquaculture sites are located), Deadmans Harbour (an open bay with offshore influence), and the Wolves Islands (an offshore indicator site).

Sampling and Analytical Procedures

Either a Seabird Model 19 or Model 25 is used to collect vertical profiles of oxygen, temperature, salinity and fluorescence at each site. Phytoplankton and nutrient samples are collected at the surface by bucket and at depth with a Niskin bottle. During the summer months a vertical plankton haul is made with a 20- μ m mesh net, 0.3 m in diameter. A subsample was preserved with formalin:acetic acid (1:1

by volume) for further identification and SEM. Samples are also collected for ammonia, nitrate (nitrite and nitrate), phosphate and silicate measured using a Technicon Autoanalyzer II.

Water samples (250 mL) were immediately preserved with 5 mL formalin:acetic acid. Later, 50-mL subsamples were settled in Zeiss counting chambers for 16 h. All phytoplankton greater than 5 μm were identified and enumerated (as cells L^{-1}) using a Nikon inverted microscope. Further identification was done using either a JEOL JSM-5600 scanning electron microscope (SEM) or a Hitachi S-2400 SEM.

Reference

Discussion

Results are published at regular intervals in the Fisheries and Oceans Technical Report Series.

Rockweed Study

Sponsor: St. Croix Estuary Project

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web site: www.scep.org

Goals

Ensure that rockweed (*Ascophyllum nodosum*) harvesting does not adversely impact on local flora and fauna associated with rockweed.

Contaminants

No contaminants will be surveyed for. Instead, damage to the local environment due to harvesting will be studied.

Dates and Frequency

Monitoring will take place relative to when rockweed harvesting occurs. Dates preceding and directly following harvesting will provide measurements of immediate damage. Consistent monitoring following harvesting will determine short and long term effects of harvesting.

Sampling Stations

Stations will be adjacent to harvesting areas.

Sampling and Analytical Procedure

Sampling will consist of inspecting harvesting areas to determine overall disturbance. Inspection of raw data will be the responsibility of SCEP staff and volunteers. Changes in species presence, habitat destruction and available food sources are parameters involved in data analysis.

Reference

St. Croix Estuary Project Community Management Plan.

Estuary Classification Program

Sponsor: St. Croix Estuary Project, Maine Department of Marine Resources Shellfish Harvest Area Bacterial Monitoring Program.

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St. Croix Estuary Project
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web site: www.scep.org

Goals

Establish the health trend of the St. Croix River estuary over the last 20 years using historical data and modern survey protocols. Introduce a unified means of estuarine classification through water chemistry acceptable to both U.S. and Canadian partners. Determine practical and affordable biological sampling and analytical protocols that will provide a useful assessment of estuarine health through the monitoring of biodiversity, biological integrity, and shifts in species assemblages; maintain the conditional opening of Oak Bay to commercial clam harvests; and maintain presence on the US side of the estuary through participation in the Maine Department of Marine Resources Shellfish Harvest Area Bacterial Monitoring Program.

Contaminants

Effluent from sewage treatment plants, manufacturing facilities and local agriculture practices.

Dates and Frequency

Sampling will depend upon type of sampling and duration required for accurate sampling.

Sampling Stations

Stations will be located within the St. Croix River Estuary.

Sampling and Analytical Procedure

Reference

St. Croix Estuary Project Management

Discussion

Atmospheric Deposition Monitoring Program

Sponsors: Maine Department of Environmental Protection, State Agricultural Experiment Stations- University of Maine, University of Southern Maine, Environmental Protection Agency, National Oceanic and Atmospheric Administration-Air Resources Lab, U.S. Geological Survey, National Park Service-Air Resources Division

Contact: Andrew Johnson
Maine Department of Environmental Protection
Bureau of Air Quality
17 State House Station
Augusta, Maine 04333-0017
tel: 207.287.2437 / fax: 207.287.7641
email: *andy.johnson@state.me.us*
website: www.state.me.us/dep/home.htm

Goals:

To provide quality assured data and information on the exposure of managed and natural ecosystems and cultural resources to acidic compounds, nutrients, and base cations; to characterize spatial and temporal trends in atmospheric wet deposition; to provide data to support investigations of the effects of atmospheric deposition

Contaminants:

Hydrogen (acidity as pH), sulfate, nitrate, phosphate, ammonium, chloride and base cations (such as calcium, magnesium, potassium and sodium).

Dates and Frequency of Sampling:

Weekly composite (7 days) samples year round.

Sampling Stations:

Bar Harbor	Freeport
Bridgton	Gilead
Caribou	Greenville

Sampling and Analytical Procedures:

Wet deposition is collected in clean buckets over a 7-day sampling period. The weekly composite samples are collected each Tuesday morning at 9:00, field chemistry measurements are made, and then the sample is shipped to the Central Analytical Laboratory in Illinois for precipitation chemistry analyses. Sampling and analytical procedures follow strict quality-assured protocols as developed by the National Atmospheric Deposition Program (NADP).

References:

The NADP web site contains a lot of excellent background and supporting information about the atmospheric deposition monitoring program, as well as access to individual data points, seasonal and annual averages, trend plots, concentration and deposition maps, reports and publications (<http://nadp.sws.uiuc.edu>)

Discussion:

The sponsoring agencies listed above who financially support the atmospheric deposition monitoring sites in Maine, all participate in the NADP, which is a cooperative research program of federal, state and private organizations. Four of the existing Maine sites have been in operation since the late 1970's and early 1980s. The newest sites, Freeport and Gilead began operation in 1998 and 1999 respectively.

Air Toxics Monitoring Program

Sponsors: Maine Department of Environmental Protection,
Environmental Protection Agency

Contact: Jeff Emery
Maine Department of Environmental Protection
Bureau of Air Quality
106 Hogan Road
Bangor, Maine 04401
tel: 207.941.4583 / fax: 207.941.4584
email: jeff.emery@state.me.us
web site: www.state.me.us/dep/home.htm

Goals:

To provide quality assured data and information to characterize spatial and temporal trends for selected air toxic compounds; to provide quantified data for use in assessing public health exposures.

Contaminants:

COMPOUND NAME	COMPOUND NAME
FREON 12	1,1,2,2-TETRACHLOROETHANE
1,3- DICHLOROPROPENE	METHYL BROMIDE
BENZENE	1,1,2-TRICHLOROETHANE
TOLUENE	TRICHLOROETHYLENE
ETHYL BENZENE	PROPYLENE DICHLORIDE
TOTAL XYLENES	ETHYLENE DIBROMIDE
1,3,5-TRIMETHYLBENZENE	HEXACHLOROBUTADIENE
STYRENE	VINYL CHLORIDE
FREON 113	1,2,4-TRIMETHYLBENZENE
FREON 114	CHLOROBENZENE
1,3-BUTADIENE	1,2-DICHLOROBENZENE

METHYL CHLORIDE		1,3-DICHLOROBENZENE
METHYLENE CHLORIDE		1,4-DICHLOROBENZENE
CHLOROFORM		1,2,4-TRICHLOROBENZENE
CARBON TETRACHLORIDE		TETRACHLOROETHYLENE
FREON 11		cis-1,2-DICHLOROETHYLENE
ETHYL CHLORIDE		1,2-DICHLOROETHANE
1,1-DICHLOROETHANE		1,1,1-TRICHLOROETHANE

Dates and Frequency of Sampling:

A sample is collected every 6 days following a prescribed schedule year round.

Sampling Stations:

Rumford: 1 site - Rumford Avenue Parking Lot

Portland: 4 sites - Canco Road
Cape Elizabeth
Cumberland County Jail Grounds
Marginal Way

Sampling and Analytical Procedures:

A sample is taken over a 24-hour period in an evacuated canister (typically midnight to midnight) and then analyzed at either the DEP or EPA laboratory using EPA method TO 14.

References:

The EPA Ambient Monitoring Technology Information Center (AMTIC) web site contains some useful information on ambient air toxics: <http://www.epa.gov/ttn/amtic/airtoxpg.html>

Discussion

Ozone Monitoring Program

Sponsors: Maine Department of Environmental Protection, Environmental Protection Agency,
National Park Service-Air Resources Division

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Bureau of Air Quality
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Bangor, Maine 04401
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email: jeff.emery@state.me.us
web site: www.state.me.us/dep/home.htm

Goals:

To provide quality assured data for determining and/or demonstrating attainment of the National Ambient Air Quality Standard (NAAQS) for ground-level ozone; to characterize spatial patterns and temporal long-term trends of ozone, as well as episodes of high ozone concentrations; to provide data to support the real-time reporting of ozone concentrations through the Ozone Mapping Program.

Contaminants:

Ozone (O₃)

Dates and Frequency of Sampling:

Monitoring is done seasonally from April 1 through September 30 using continuous electronic analyzers that provide hourly concentration data around the clock (24/7).

Sampling Stations: (as of 2001)

Ashland	Holden	North Lovell
Bar Harbor-McFarland Hill	Howland	Phippsburg
Cape Elizabeth	Kennebunkport	Port Clyde
Dover-Foxcroft	Kittery	Roosevelt Campobello Internat.
Park	Gardiner	M/S Scotia Prince
Seawall Bar Harbor-Cadillac Mtn.	West Buxton	

Sampling and Analytical Procedures:

All ozone monitoring in Maine is conducted using the EPA equivalent method of Ultra-Violet (UV) photometry.

References:

The Maine DEP web site contains information about the ozone and the ozone ambient air monitoring network in Maine, air quality forecasts, current and archived data, as well as links to other ozone related sites (<http://www.state.me.us/dep/air/ozone/ozone/.htm>).

Discussion:

Ozone has been monitored at various locations throughout Maine since the mid-1970s. The majority of sites in the current ozone monitoring network are ones that have been in operation long-term (greater than 5 years). A majority of the sites are located along the coast because past monitoring results have shown there are consistently higher concentrations of ozone there than at inland locations. The monitor aboard the M/S Scotia Prince is strictly for research purposes, and not regulatory purposes. The international ferry traverses the Gulf of Maine twice daily, leaving from Portland, Maine at 9:00PM (local time), and from Yarmouth, Nova Scotia, at 9:00AM (local time).

Mercury Deposition Monitoring Program

Sponsors: Maine Department of Environmental Protection, University of Southern Maine, Environmental Protection Agency, and National Park Service- Air Resources Division

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Bureau of Air Quality
17 State House Station
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web site: www.state.me.us/dep/home.htm

Goals:

To develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition. The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Contaminants:

Total mercury, methylmercury.

Dates and Frequency of Sampling:

Weekly composite (7 days) samples year round.

Sampling Stations:

Bar Harbor

Bridgton

Freeport

Greenville

Sampling and Analytical Procedures:

The network uses standardized methods for collection and analyses. Weekly precipitation samples are collected in a modified Aerochem Metrics model 301 collector. The "wet-side" sampling glassware is removed from the collector every Tuesday and mailed to the Hg Analytical Laboratory (HAL) at Frontier Geosciences in Seattle, WA for analysis by cold vapor atomic fluorescence. The MDN provides data for total mercury, but also includes methylmercury if desired by a site sponsor.

References:

The NADP web site is also the source for excellent background and supporting information about the Mercury Deposition Network (MDN) monitoring program, as well as access to individual data points, seasonal and annual averages, trend plots, concentration and deposition maps, reports and publications (<http://nadp.sws.uiuc.edu>)

Discussion:

The sponsoring agencies listed above who financially support the mercury deposition monitoring sites in Maine, all participate in the Mercury Deposition Network (MDN) of the NADP, which is a cooperative research program of federal, state and private organizations. The four existing Maine sites began operation in the 1996-1998 timeframe.

Casco Bay - Changes in Eelgrass

Sponsor Casco Bay Estuary Project/Maine Dept. of Marine Resources

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email: kgroves@usm.maine.edu
web site: www.cascobay.usm.maine.edu

Goals

Assess indices of habitat quality in Casco Bay and assess the effectiveness of actions designed to eliminate net habitat loss.

Dates and Frequency of Sampling

Every five years.

Sampling Stations/Area Covered

All eelgrass beds in Casco Bay.

Sampling and Analytical Procedures

Protocols developed by the NOAA Coastwatch Change Analysis Program are used to interpret the photographs and to assess trends in eelgrass distribution. The analysis of trends in the distribution of eelgrass include assessment of loss of important habitats as identified by the U.S. Fish and Wildlife Service.

Reference

Casco Bay Plan (1996), www.cascobay.usm.maine.edu

Casco Bay Lobster Tissue Analysis

Sponsor Casco Bay Estuary Project

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Goals

Assess the variation in toxic contaminants in tissue over time and throughout the bay.

Contaminants

The meat and tomalley are analyzed for metals, pesticides, PAHs, PCBs, butyltins, dioxin and furans.

Dates and Frequency of Sampling

Biennial.

Sampling Stations/Area Covered

Initial year samples were collected from outer Casco Bay and the New Meadows River. Subsequent year samples were from Quahog Bay to get an indication bay-wide contaminant levels.

Sampling and Analytical Procedures

Using the methodology employed by the Maine DEP's Surface Waters Ambient Toxics Monitoring Program.

Reference

Casco Bay Plan (1996), www.cascobay.usm.maine.edu

Surface Water Ambient Toxic Monitoring Report for methodology,
www.state.me.us/dep/blwq/docmonitoring/99marine.pdf

Discussion

Results have been generally favorable, with the exception of an advisory on eating the tomalley from the lobsters.

Casco Bay Wildlife Areas and Protected Lands Mapping

Sponsor Casco Bay Estuary Project/U.S. Fish and Wildlife Service

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Goals

To create a set of maps that depict where species overlap to form the Bay's most valuable habitats and overlay that map with protected areas. These maps are then used by decisionmakers to help them make wise decisions about land use and its connection with wildlife.

Dates and Frequency of Sampling

Annually.

Sampling Stations/Area Covered

Fourteen communities surrounding Casco Bay.

Sampling and Analytical Procedures

Significant Wildlife categories determined by the U.S. Fish and Wildlife Service.

Reference

Casco Bay Plan (1996), www.cascobay.usm.maine.edu

U.S. Fish and Wildlife Service, Gulf of Maine Project, www.gulfofmaine.fws.gov.

Discussion

The program also examined regional patterns of ownership and land use to produce build-out scenarios. The final analysis revealed that one-third of the Bay's wildlife habitat could be endangered by human development, but few of the highest value habitats face imminent threats.

Casco Bay Mussel Tissue Analysis

Sponsor Casco Bay Estuary Project

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Goals

Assess the variation in toxic contaminants in tissue over time and throughout the bay.

Contaminants

Mussel tissue is sampled for metals, pesticides, PAHs, PCBs, butyltins, dioxin and furans.

Dates and Frequency of Sampling

Biennial.

Sampling Stations/Area Covered

Various locations throughout Casco Bay.

Sampling and Analytical Procedures

Using the methodology of the Maine DEP's Marine Environmental Monitoring Program, Gulfwatch and the NOAA National Status and Trends Program. In addition, the data will be analyzed to determine if a relationship exists between contaminant levels in cooked and uncooked animals.

Reference

Casco Bay Plan (1996), www.cascobay.usm.maine.edu

Casco Bay Sediment Sampling

Sponsor Casco Bay Estuary Project

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Goals

Assess the level of sediment contamination over time and throughout the bay.

Contaminants

The sediments are tested for dioxins, furans, coplanar PCBs and butyltins, PAHs, PCBs, pesticides and heavy metals.

Dates and Frequency of Sampling

Every ten years. Last sampling conducted during the summers of 2000 and 2001.

Sampling Stations/Area Covered

Approximately 70 stations throughout Casco Bay.

Sampling and Analytical Procedures

Sediments are collected with a grab sampler and the top 2 cm. removed, placed in clean glass jars, frozen and shipped to a laboratory for analysis. Analytical procedures used are those of the NOAA National Status and Trends Program, EPA's Environmental Monitoring and Assessment Program - Estuarine (EMAP-E), and the U.S. Fish and Wildlife Service trace organic analytical program.

Reference

Casco Bay Plan (1996), www.cascobay.usm.maine.edu

Casco Bay Waterbird Survey

Sponsor Casco Bay Estuary Project
U.S. Fish and Wildlife Service
Maine Dept. of Inland Fisheries and Wildlife.

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Goals

Characterize changes in sea bird populations in the Bay and assess the impact of habitat on the structure and function of the biological community.

Dates and Frequency of Sampling

Periodic. Last survey conducted in 2000.

Sampling Stations/Area Covered

Casco Bay.

Sampling and Analytical Procedures

Aerial flights with the U.S. Fish and Wildlife Service procedures in coordination with the Maine Dept. of Inland Fisheries and Wildlife.

Marine Environmental Monitoring Program

Sponsor Maine Departments of Marine Resources and Environmental Protection

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McKown Point Road
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Goals

Goals are to examine the extent and effect of industrial contaminants and pollutants on marine and estuarine ecosystems and to determine compliance with and attainment of water quality standards. The program investigates sources, fates and biological availability of contaminants, the impact of these contaminants on marine and estuarine biota, and assesses the condition of marine and estuarine habitats.

Dates and Frequency of Sampling

Irregular according to specific workplans. Generally, late summer and early fall when conditions are most stressful.

Sampling Stations

Coastwide according to specific objectives of investigation.

Sampling and Analytical Procedures

Variable according to goals of project. Available on request.

Reference

Maine Revised Statutes Annotated Title 38: § 410-F. Marine Environmental Monitoring Program

Discussion

The program has followed a deliberate path of collecting information to understand natural variability in order to assess impacts from human activity. The course set in 1986 when the program began was to begin with toxic contaminants, move on to nutrients, and then to biological communities and habitat. Until recently, program has focused on defining natural variability of toxic contaminants in various marine and estuarine media including sediments and biota such as the blue mussel, soft shelled clam, lobster, and cormorant. The program interfaces with Gulf of Maine Gulfwatch Project. In the mid 1990s, as knowledge of toxic contaminants became more complete, emphasis shifted to assessing near shore nutrient and oxygen regimes. Then in the late 1990s, habitat assessments began with intertidal activity. All three areas of study; toxic contaminants, nutrients, and habitats, will lead to the State's ability to assess and manage the health of marine and estuarine biological communities.

Maine Coastal 2000 - Gulf of Maine Assessment

Sponsor U.S. Environmental Protection Agency/Maine Dept. of Environmental Protection

Contact Jerry Pesch/Walter Galloway
National Health and Environmental Effects Laboratory
Atlantic Ecology Division EPA/NHEERL/ORD
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Narragansett, Rhode Island 02882
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web site: www.epa.gov/emap/

Maine Contact

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Goals

To assess the condition of coastal resources nationally, regionally and by state using a probabilistic design and a common set of environmental indicators.

Contaminants

Dissolved oxygen, salinity, temperature, depth, pH, nutrients, chlorophyll, grain size, total organic carbon, sediment chemistry, benthic community structure, sediment toxicity, benthic community structure, and if possible, fish community structure, external pathology and tissue analysis.

Sampling Stations

Seventy stations along the whole coast of Maine over a two-year period, 2000 and 2001.
Approximately 35 station each year.

Sampling Procedures

Procedures are specified in EPA's National Coastal Assessment Quality Assurance Project Plan - 2000 and in EPA's Coastal 2000 Field Operations Manual, Northeast Component prepared by Charles J. Strobel of the Atlantic Ecology Division, U.S. EPA, Narragansett, RI.

Analysis

By contract laboratories selected by EPA in accordance with EPA's National Coastal Assessment Quality Assurance Project Plan - 2000

Quality Assurance/ Quality Control

EPA's National Coastal Assessment Quality Assurance Project Plan - 2000

Reference

<http://www.epa.gov/emap/>

Ocean Studies Penobscot Estuary Program

Sponsor Maine Maritime Academy, Corning School of Ocean Studies

Contact Barry Kilch
Head, Corning School of Ocean Studies
103 Andrews Hall
Castine, Maine 04420-3200
tel: 207.326.2395 / fax: 207.326.2391
email: bkilch@mma.edu
web site: <http://supersloop.mma.edu/os/>

Goals

We designed and implemented this program to develop a historical record of hydrographically significant parameters for a variety of curricular and undergraduate research applications.

Contaminants

We analyze all water samples for salinity, temperature, dissolved oxygen, and pH. Many samples are also analyzed for dissolved nutrients (N, P, Si), and turbidity.

Dates and Frequency of Sampling

Sampling occurs three to six times each year across all seasons.

Sampling Stations

We sample a series of (up to 37) stations in the Penobscot River and the Penobscot Bay.

Sampling and Analytical Procedures

We sense hydrographic parameters in situ with a SBE 19 or a SBE 911+ CTD with an onboard transmissometer and DO and pH probes. We analyze water samples for nutrients using a continuous-flow ion analyzer.

Discussion

This program is part of a long-term investigation of seasonal hydrographic conditions in the Penobscot Estuary in the context of curricular activity and undergraduate research at MMA's Corning School of Ocean Studies. We initiated the program in 1991 to develop a database of hydrographic parameters for use by our students, our faculty, and the public. Many of the data are available at the Maine Office of GIS website

(<http://apollo.gis.state.me.us/projects/penobay/penobay.htm>).

Finfish Aquaculture Monitoring Program

Sponsor Maine Department of Marine Resources

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web site: www.state.me.us/dmr

Goals

To monitor and evaluate environmental impacts of finfish mariculture contaminants waste byproducts associated with net pen aquaculture.

Dates and Frequency of Sampling

Spring and fall diver surveys and video transects are conducted on each site every year. Benthic and water column monitoring is done at every other year on all sites and may be more frequent depending on conditions encountered during diver survey.

Sampling Stations

Transects begin 100 meters from pens and continue under and 100 meters beyond. Benthic cores and water column samples are collected 5M, 30M and 60M from pen edge.

Sampling and Analytical Procedures

Available on request.

Reference

Finfish Aquaculture Monitoring Program, Annual Reports. Maine Dept. of Marine Resources, P.O. Box 8, West Boothbay Harbor, Maine 04575

Discussion

This is a joint program conducted by the Departments of Marine Resources and Environmental Protection. The program is funded by industry and implemented using a third party contractor accountable solely to the State of Maine. This ensures QA/QC and standardization for comparability over time and across sites.

Maine Shellfish Sanitation Program

Sponsor Maine Department of Marine Resources

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Goals

This program is designed to protect consumers of shellfish from health hazards associated with bacterial contamination.

Contaminants

Water samples are analyzed for fecal coliform bacteria.

Dates and Frequency of Sampling

This survey was initiated in the 1940s. Significant changes occurred in the program in 1986, with the institution of new procedures.

Sampling frequency has changed throughout the life of the program. Samples are currently taken six times each year for open approved areas and each month for conditionally approved areas when they are in the open status.

Sampling Stations/Area Covered

Samples are collected at about 1000 sites along the Maine coast. These samples are collected on a random basis in an attempt to encounter as wide a variety of tidal, meteorological, and other conditions as possible in areas where shellfish harvesting is likely to occur. In times of limited resources, emphasis is placed on those sites likely to be classified as open approved or conditionally approved for shellfishing.

Sampling and Analytical Procedures

Water samples are collected from within the tidal range as prescribed in the NSSP Guide for the Control of Molluscan Shellfish (1999). These samples are collected on a random basis in an attempt to encounter as wide a variety of tidal, meteorological, and other conditions as possible in areas where shellfish harvesting is likely to occur. Analytical techniques for coliforms (total and fecal) and quality

assurance procedures followed are those of the American Public Health Association (1984).

Reference

American Public Health Association (1984), and National Shellfish Sanitation Program (1999).

Data from a number of recent years has been computerized, and is accessible through the Department of Marine Resources.

Discussion

All of the Gulf of Maine states, State of Maine, and the government of Canada follow the procedures developed by the Interstate Shellfish Sanitation Conference administered by the USFDA under the codified regulations of the National Shellfish Sanitation Program.

Paralytic Shellfish Poisoning (PSP) Monitoring Program

Sponsor Maine Department of Marine Resources

Contact John Hurst
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email: john.hurst@state.me.us
web site: www.state.me.us/dmr

Goals

To protect the public health from Paralytic shellfish poisoning caused by shellfish intoxicated by toxic dinoflagellate blooms.

Contaminants

Mollusc, clams and other shellfish tissues are analyzed for the presence of saxatoxin and other toxins.

Dates and Frequency of Sampling

The program was initiated in 1958. Sampling is carried out weekly from April until October. Sampling intensifies in areas where toxicity has been observed.

Sampling Stations

Twenty nine primary sampling stations are located along the Maine coast. These stations are determined based on historical experience as being reliable early indicators of intoxication. On toxicity is observed, other sites are occupied in order to isolate the extent of the contamination.

Sampling and Analytical Procedures

Standard mouse bioassay procedures are followed (AOAC, 1065).

Reference

Hurst and Yentsch, 1981, Monitoring a Monster, Shumway, Hurst, et al.

Discussion

While PSP is a naturally occurring phenomenon, the work of White suggests that the pattern of occurrence is changing. If this change is related to anthropogenic influence, then PSP may be considered a biological effects indicator.

Shellfish hotline - 1-800-232-4733.

Toxic Chemicals in Gulf of Maine Seals

Sponsor Marine Environmental Research Institute (MERI)

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MERI Center for Marine Studies
Main Street on Mill Stream
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Blue Hill, Maine 04614
tel: 207.359.2135 / fax: 207.359.2931
email: sshaw@downeast.net
web site: www.meriresearch.org

Goals

To monitor temporal and spatial trends in persistent organic pollutants (POPs) and metals in tissues of Gulf of Maine harbor and gray seals and identify some of the factors (age, gender, genetic, geographic) influencing their contaminant burdens. The study also includes measures of immune and endocrine function. The program uses seals as sentinel species for the health of the Gulf of Maine ecosystem.

Contaminants

Seal blubber samples are analyzed for PCB congeners, coplanar PCBs, PCDD/Fs (tetra - octa), organochlorine pesticides (including toxaphene), and brominated flame retardants (PBDEs). Seal hair is analyzed for Hg (total and methyl), Cd, Pb, and trace elements. Seal plasma is analyzed for dioxin-like (TEQ) activity using an Ah receptor binding assay.

Sampling Dates and Frequency

Sampling of tissues from free-ranging seals began in 2001 as part of a NMFS population survey. Sampling of tissues from stranded seals began in 2000 and is conducted annually from late spring through early winter. Sampling of by-caught seals (in gillnet fisheries) is conducted throughout the year on an opportunistic basis.

Sampling Stations

Live seals are sampled at haulout sites in Cape Cod and Penobscot Bay, Maine. Stranded seals are sampled throughout the GOM both in the field and at NMFS Stranding Network facilities. By-caught seals are sampled by NMFS Observers on fishing vessels throughout the GOM.

Sampling Procedures

Sampling protocols have been standardized, but can vary between programs and sites depending on field conditions. Blubber samples are collected from the dorsal surface, foil-wrapped and frozen until analysis. Hair samples are taken from the back using veterinary clippers. Blood is drawn from the extradural intravertebral vein into heparin tubes, kept cool, and shipped overnight to the laboratory for processing and analysis.

Analysis

POPs and metals in seal tissues are analyzed at the Environmental Research Institute (ERI), University of Connecticut. PCB congeners and pesticides in blubber are analyzed by high-resolution gas chromatography with electron capture detection (HRGC/ μ ECD). Dioxins and furans are analyzed by HRGC/HRMS. Mercury (total and methyl) in hair is analyzed by a GC/atomic fluorescence spectroscopy (AFS). Other metals and elements are analyzed in hair by inductively coupled plasma atomic emission spectroscopy with mass spectral detection (ICP/MSD). Arsenic is analyzed by graphite furnace atomic absorption spectroscopy (GFAAS). Additional procedures, such as those for the Ah receptor (AhR) binding assay in plasma, and immune and endocrine assays are referenced in the research publications noted below.

QA/QC

QA/QC procedures involve double-blinded interlaboratory analyses, method blanks, recovery of spiked matrices, duplicate samples, and certified reference materials (see NOAA ORCA 130, EPA Method 245.6, and EPA Method 8290). The ERI participates in the NIST/NOAA National Status and Trends QA Organics program and NIST/NOAA Organochlorines and Inorganics in Marine Mammal Blubber Inter Comparison program.

References

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Discussion

This program is part of a long-term, multidisciplinary investigation of the impacts of persistent pollutants on the health of Gulf of Maine seal populations. It was initiated in 2000 given the current need to understand the effects of environmental chemicals on the health status of marine mammal populations. Its first goal is to generate baseline information about contaminant levels in seals throughout the GOM. The project data are also being used to develop accurate power calculations for future studies of toxic impacts on marine mammals at the cellular and sub-cellular (biomarkers) and population levels. These studies will help identify and quantify trends related to the distribution and trophic transfer of contaminants to marine mammals, and characterize potential risks associated with maternal transfer of contaminants to offspring.

Surface Water Ambient Toxics (SWAT) Monitoring Program

Sponsor Maine Department of Environmental Protection

Contact David Courtemanch
Maine Department of Environmental Protection
17 State House Station
Augusta, Maine 04333
tel: 207.287.3901
email: *dave.l.courtemanch@state.me.us*

Goals

Goals of the SWAT program is to develop a statewide assessment of the nature and extent of toxic contamination in the state's surface waters. This assessment may be used to direct management and remediation programs in the state.

Contaminants

Toxic substances only. Heavy metals and persistent bioaccumulative toxics (PBTs).

Sampling Stations

Determined annually in workplan.

Sampling Procedures

Determined annually in workplan. Tissue and sediment have been the primary media for analysis.

Quality Assurance/ Quality Control

QA/QC procedures generally follow those used in the DEP'S REMAP program (1991) or method revisions as presented in data reports.

Reference

Surface Water Ambient Toxic Monitoring Report (1996, 1998, 1999, 2000, 2001) Maine Department of Environmental Protection and at www.state.me.us/dep/blwq/docmonitoring/99marine.pdf

Discussion

Each annual monitoring program is determined by the department in cooperation with a technical advisory committee. The primary purpose of the program is to assess toxic contamination, source and impacts within the State's marine and aquatic ecosystems. The DEP annually produces reports from the SWAT program presenting data from previous year's work. See website.

Maine Phytoplankton Monitoring Program

Sponsor: UMaine Cooperative Extension, Maine Sea Grant Program,
U.S. Food and Drug Administration, Maine Department of Marine Resources,
National Oceanographic and Atmospheric Administration

Contact: Sarah Gladu
Phytoplankton/Water Quality Coordinator
UMaine Cooperative Extension
235 Jefferson Street
P.O. Box 309
Waldoboro, Maine 04572
tel: 207.832.0343 or 1-800-244-2104 (Maine only) / fax: 207.832.0377
email: sgladu@umext.maine.edu
web site: www.seagrants.umaine.edu

Goals

Our goal is to qualitatively evaluate correlations that might exist between toxic algae in the ocean and toxins present in shellfish. DMR currently monitors for toxins that are present in shellfish. This project augments DMR's biotoxin monitoring program with a citizen-based phytoplankton monitoring project. We also work to gather new information about phytoplankton populations in the Gulf of Maine and to work with the scientific community to learn more about these populations.

Contaminants

We monitor for four species of potentially toxic phytoplankton: *Alexandrium tamerense*, *Pseudo-nitzschia*, *Prorocentrum Lima* and *Dinophysis norvegica*.

Sampling Stations/Area Effected

We sample along the entire coast of Maine, from Kittery to Eastport.

Sampling Procedures (Abbreviated)

Volunteers sample at least once a week at their identified station(s) April through October. Generally, samples are examined in the field but occasionally a sample is stained with Lugol's iodine solution and transported if field conditions are difficult, for classroom education situations or to confirm difficult identification.

Analysis

- Collect a water sample using a 20 micron plankton net with a bottle attached.
- "Swim" the net throughout the water column for three minutes.
- Submerge capillary tubes in the collection bottle and use a field microscope at 10x.
- Count cells in three views in two different capillary tubes (total of six views).
- Record target species and dominant species identified on data sheet.

- Also record: sampler name, station number, date, time, water temperature, wind speed and direction (optional: dissolved oxygen, salinity and transparency).
- Fax data sheet to DMR (Laurie Bean, Biotoxin Monitoring Program).
- If any of the target species are identified call DMR directly to provide information about situation.

Quality Assurance/Quality Control

Volunteers are checked at least once during the year by UMCE or DMR staff for identification and sampling skills. Equipment is checked on a regular basis by the volunteers and annually by staff.

Thermometers are calibrated annually.

Reference

Annual data summaries and articles reviewing the data are published in the Maine Shore Stewards' (a partnership of the Maine Coastal Program, State Planning Office, the Dept. of Marine Resources, University of Maine Cooperative Extension, and Maine Dept. of Environmental Protection) newsletter "The Maine Shore Steward."

<http://www.ume.maine.edu/ssteward/phyto.htm>

Discussion

The Phytoplankton Monitoring Volunteers are responsible for visiting the field on a regular basis in order to determine if there are any potentially toxic species of phytoplankton in the area. The volunteers are not responsible for determining if those phytoplankton are causing a toxic event (commonly called a red tide or a harmful algal bloom). This determination is the sole responsibility of the Department of Marine Resources' Biotoxin Monitoring Program. The DMR takes samples of shellfish tissue and through bioassays determines if the shellfish are toxic or not. Just because there are toxic phytoplankton cells in a region does not necessarily mean that there is a toxic event. The shellfish may or may not be toxic, depending on many variables including: the level of biotoxins that the phytoplankton are producing at the time, how quickly the tide carries the phytoplankton in and out of the area, the quantity of phytoplankton the shellfish have consumed and how quickly they depurate themselves.

Local Water Quality Monitoring Initiatives, Maine*

** Note: This section diverges from the pattern established in the rest of this document. Rather than discussing a single program, it summarizes the efforts of numerous volunteer monitoring groups along the Maine coast.*

Sponsor Various, including Land Trusts, "Friends" Groups, and Municipalities

Contact Sarah Gladu
Phytoplankton/Watershed Coordinator
UMaine Cooperative Extension
235 Jefferson Street
P.O. Box 309
Waldoboro, Maine 04572-0309
tel: 207.832.0343 or 1-800-244-2104 (Maine only) / fax: 207.832.0377
email: sgladu@umext.maine.edu
web: www.ume.maine.edu/ssteward

Goals

Since 1988, more than 22 citizens groups and high schools in Maine have been involved in monitoring the health of their coastal estuaries and feeder streams. The goals of the monitoring groups vary according to local interests from collection of baseline data, establishment of trends information, development of recommendations for municipalities, identification of potential sources of pollution and assistance with reopening of shellfish growing areas.

Contaminants

Most groups sample for temperature, salinity, dissolved oxygen, and fecal coliform bacteria. Transparency information is collected at certain locations for the Maine DEP. Some groups do dissolved oxygen profiles, special studies, and watershed surveys. Some groups analyze their own samples in the field and in community labs, while others collect samples for analysis by the Maine Department of Marine Resources.

Dates and Frequency of Sampling

Most Maine coastal volunteer monitoring groups sample on a monthly basis. A database to house coastal volunteer data is currently under development. Currently individual groups house and maintain their own data.

Sampling Stations

These vary from community to community. A CD-ROM of sampling sites of groups participating in a GPS mapping project in 2000 is available. The Friends of Casco Bay sample more than 100 sites, while smaller groups have fewer stations.

Sampling and Analytical Procedures

See Clean Water: A Manual for Coastal Water Quality Monitoring, Stancioff, Esperanza, University of Maine Cooperative Extension, 1992; Volunteer Estuary Monitoring : A Methods Manual, Fisher, Nina A., U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Oceans and Coastal Protection Division, 1993; and Volunteer Manual, Shellfish Sanitation Program, Maine Department of Marine Resources. Some groups such as the Friends of Casco Bay have their own methods manual. References: See above -- also Data to Information: A Guide Book for Coastal Volunteer Monitoring Groups in New Hampshire and Maine, Dates, G and Schloss, J. 1998, University of Maine Cooperative Extension; A Citizen's Guide to Coastal Watershed Surveys, Maine Department of Environmental Protection; and The Maine Clam Handbook; A Community Guide for Improving Shellfish Management, 1998, University of Maine Cooperative Extension.

Discussion

Coastal monitoring groups in Maine have been very successful at bringing information about water quality problems to decisionmakers at the local and state level. Many groups receive technical assistance and ongoing support from UMCE and many were started with financial support from the Maine Coastal Program. By and large, these programs are all-volunteer efforts (Friends of Casco Bay, WNERR WET Team, the Cobscook Bay Resource Center and the Friends of MerryMeeting Bay are the exceptions and have staff assistance.) Volunteer monitors form an effective, informed constituency for water quality protection and enhancement in the Gulf of Maine. Gulf of Maine Council grants have funded C-NET, a collaborative effort between volunteer groups in the Gulf jurisdictions, have supported regional conferences and trainings and have assisted individual Maine groups with financial support.

Current Groups:

- Kennebunk Coastal Commission - Contact: Chris Fuert, 149 Brown Street, Kennebunk, Maine 04043, 207-985-4686, *osprey47@hotmail.com*, *osprey@cybertours.com*
- Saco Conservation Commission - Contact: David Shaw, 207-284-8400
- Freeport Shellfish Committee - Contact: Mick McGivaren, P.O. Box 176, Freeport, Maine 04032, 207.865.1141
- Scarborough Coastal Commission - Contact: John Lyon, 269 Pine Point Road, Scarborough, Maine 04074-9238, 207-885-9032 or Ann Delahanty, 207-883-9614, *justincw@ime.net*
- Sheepscot Valley Conservation Association - Contact: Peter Abello, P.O. Box 125, Alna, Maine 04535, 207-586-5616, *jumpenjethro@yahoo.com*
- Coastal Mountains Land Trust - Contact: Scott Dickerson, P.O. Box 101, Rockport, Maine 04856, 207-236-0612, *tarnd@coastalmountains.org*
- Dennys River Watershed Association - Contact: Maurry Mills, 207-729-4494, *mills@hemaine.com*
- Damariscotta River Tidewater Watch - Contact: Susanne Meidel, 207.563.3146, *meidel@maine.edu*
- ♦ East Machias Watershed Council - Contact: Sherry Springars, 207-255-1205, *springars@nemaine.com*
- ♦ Machias River Watershed Council - Contact: Charles Berry, 207-255-3086

- ♦ Friends of MerryMeeting Bay - Ed Benedikt, 45 Harding Road, Brunswick, Maine 04011
- ♦ Friends of the Royal River - Contact: Robert Houston, 71 Summit Terrace, North Yarmouth, Maine 04097, 207-781-8364, nyconcom@aol.com
- ♦ Friends of Taunton Bay - Contact: Mary Lou Barker, 207.422.3756
- ♦ Friends of the Passagassawamkeag - Contact: Dale Mitchell, Pleasant Point Passamaquoddy Tribe, 207.853.2600
- ♦ Frenchman's Bay Conservancy - Contact: Barbara Welch, 207.422.2328, fbc@acadia.net
- ♦ Camden Partners in Monitoring - Contact: Rob Lovell, 207-236-2161, Rob_lovell@fivetowns.net
- ♦ Georges Tidewater Association - Contact: Denise Messier (DEP), 1610 Eastern Rd., Warren, Maine 04864, 207-287-4851 or Margo Murphy , 207-354-2502
- ♦ Friends of Casco Bay - Contact: Peter Millholland, 207-799-8574, pmilholland@cascobay.org, www.cascobay.org
- ♦ MDI Water Quality Coalition - Contact: Lelania Avila 207.288.2598, lelania@mdiwqc.org, www.mdiwqc.org
- ♦ Wells National Estuarine Reserve - Contact: Scott Orringer, 207.646.1555, www.wellsreserve.org
- ♦ Medomak Valley High School - Contact: Neil Lash, 207.832.5389, 207.832.4211
- ♦ Islesboro Water Quality Club - Contact: John Kerr, 207.734.6723
- ♦ Deer Isle/Stonington Partners in Monitoring - Deer Isle Conservation Commission, Contact: Dud Hendrick, 207.348.2511, dudhe@stel.net
- ♦ Camden-Rockport Environmental Club - Contact: Sue Klemmer, 207.233.7800, sue_klemmer@fivetowns.net
- ♦ Eastport Partners in Monitoring- Contact: Stephanie Allard, 207.853.4800, sallard@shead.org
- ♦ Marshwood High School, Eliot - Contact: Joyce Tugal, 207.439.2173, jtugel@nh.ultranet.com
- ♦ Jonesport-Beals High School/Phytoplankton Monitoring - Contact: Lynn Alley, 207.497.5454
- ♦ Great Water Works Watershed - Contact: Forrest Bell, 207.324.4462, chinacat@cybertours.com
- ♦ Bagaduce Water Watch - Contact: Dot McMahan, 207.326.4927, dot.mcmahan@ecunet.org
- ♦ Pleasant River Watershed Council - Greg Dawes, P.O. Box 244, Columbia Falls, Maine 04623, godawes@panax.com
- ♦ Narraguagus River watershed - Charles Corliss, P.O. Box 406, Cherryfield, Maine 04622.

Great Bay Coast Watch

Sponsor University of New Hampshire Cooperative Extension / Sea Grant Program

Contact Ann Reid
UNH Cooperative Extension/Sea Grant Office
University of New Hampshire
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web site: www.gbcw.unh.edu/

Goals

- ♦ To monitor the chemical, physical and biological systems of the New Hampshire coast and Great Bay Estuary.
- ♦ To educate residents of New Hampshire's coastal and estuarine communities about the health status and protection of these natural resources.
- ♦ To develop a management structure that engages volunteers in all aspects of the Great Bay Coast Watch and continuously improve the quality of the monitoring and education projects

Sampling Stations

GBCW volunteers monitor water quality at 21 sites around Great Bay and its tributaries. Harmful algae blooms are monitored at five coastal sites and one offshore site

Dates and Frequency of Sampling

GBCW conducts baseline water quality monitoring from April to November once a month at both high and low tide on the week day closest to the new moon. Volunteers measure temperature, pH, salinity, dissolved oxygen, and turbidity and also collect water samples which are cultured for fecal coliform.

Beginning in March and continuing through November, GBCW volunteers also monitor for harmful algae blooms (HAB's) weekly, twice weekly during heavy bloom periods, at five shore sites and one offshore site.

Sampling and Analytical Procedures

The GBCW has an EPA approved QAQC plan for its monitoring procedures which is available for purchase along with manuals for water quality and phytoplankton monitoring.

Great Bay National Estuarine Research Reserve Systemwide Monitoring Program (SWMP)¹

with augmentation by the Remote Estuarine Contaminant Monitoring System
(RECOMS)²

Sponsor NOAA/NOS/ERD¹ and NOAA/NOS/CICEET²

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CICEET Co-Director
University of New Hampshire
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email: rlangan@cisunix.unh.edu

Goals

The goal of the Great Bay SWMP program is to develop and maintain temporally intensive long-term datasets of physio-chemical parameters of water quality at locations that are representative of the Great Bay Estuarine System using automated instrumentation. The program also includes operation of a meteorological station at the Jackson Estuarine Laboratory and discrete monthly sampling and analysis of nutrient and microbial conditions in order to document their status and trends.

The goal of RECOMS, (1997-2001) was to enhance the existing Great Bay SWMP program by expanding the spatial array of monitoring stations, adding real-time data transmission capabilities, and evaluating new probe technologies for use with the established instrument platforms.

Contaminants

Monthly Measurements

Dissolved inorganic nitrogen(nitrite, nitrate, ammonium), orthophosphate, total suspended sediments, particulate organic matter, photosynthetic pigments, *E. coli*, enterococci and fecal coliforms.

Continuous half-hour measurements

Temperature, salinity, dissolved oxygen, percent oxygen saturation, pH, tidal stage (via water depth), turbidity (NTU), chlorophyll a (by fluorescence).

Sampling Stations

Stations are located in mid channel in the center of Great Bay, and in four tidal rivers: the Lamprey, Squamscott, Oyster and Bellamy. The meteorological station is located at the Jackson Estuarine Laboratory on Adams Point in Durham, NH.

Sampling Procedures

YSI 660 datasondes are programmed to obtain measurements of specific conductivity, salinity, dissolved oxygen, percent oxygen saturation, pH, temperature, water level, fluorescence and turbidity every half hour. The instruments are deployed continuously during ice-free seasons, except for brief periods when they are removed for cleaning, maintenance and recalibration. Pre and post-deployment calibrations are performed using the diagnostics menu of the YSI Ecowatch program and QA/QC procedures developed by NERR Research Coordinators and YSI engineers. VWR conductivity and pH standards are used for calibration. Hach formazin is used to calibrate turbidity probes, and zero point calibration with de-ionized water is used for fluorescence. The sonde in Great Bay is deployed in a YSI EM 550 telemetered buoy while the Lamprey, Squamscott and Oyster river stations are telemetered piling-mounted deployments. The Bellamy River sonde is anchored and records data in unattended mode.

Monthly discrete sampling is conducted at low tide at the five sonde stations. Triplicate subsurface grab water samples are collected following UNH JEL SOP 1.05 (Langan 1992). Once monthly, hourly samples are collected at the location of the mid-Great Buoy for a full tidal cycle. Separate sterilized containers are used to collect water samples for microbial analyses.

Analysis

Water samples are processed and analyzed for total suspended solids, particulate organic matter, chlorophyll a and phaeopigments following UNH JEL SOP 1.06 (Langan 1992). Water sample filtrate is analyzed for NO₂ +NO₃ concentration (Lachat method #30-107-04-1-A), and NH₄⁺ concentration (Lachat method 11-107-06-1-C, Lachat Instruments 1991) on a LACHAT Quick-Chem nutrient autoanalyzer. PO₄⁻ concentration is measured using the orthophosphate method for wet chemistry as described in Strickland and Parsons (1968). Microbial samples are analyzed for enterococci, fecal coliforms, and *Escherichia coli*. Enterococci is measured using standard membrane filtration method and mE agar with standard confirmation steps (U.S. EPA, 1986). Fecal coliforms and *E. coli* is measured using standard multiple tube fermentation, MPN analyses that incorporate a fluorogenic molecule, 4-methylumbelliferyl-B-D-glucuronide (MUG) into the FC confirmed medium (EC) for E.coli determinations (Motes and Peeler, 1991).

Quality Assurance/Quality Control

Established QA/QC procedures are followed for automated instrumentation (YSI, NERR) and sample collection and analyses (UNH JEL SOP 1.05, 1.06, 1.07; Lachat method #30-107-04-1-A; Lachat method 11-107-06-1-C, Lachat Instruments 1991; Motes and Peeler, 1991)

Reference

Data collection and data management follows all NERR and Central Data Management Office protocols for data review, analysis, QA/QC and electronic reporting. Data is processed and managed at the Jackson Estuarine Laboratory and archived at the Jackson Estuarine Laboratory and the Central Data Management Office at the Belle Baruch Laboratory at the University of South Carolina. The project director submits semi-annual progress reports and annual reports to the Great Bay National Estuarine Research Reserve in Durham, NH.

- Lachat Instruments. 1991. Operating manual for the Quick Chem Autoanalyzer Lachat Instruments. Milwaukee, Wisconsin.
- Langan, R. 1992a. UNH JEL Standard operating procedure for water sampling for suspended solids, chlorophyll, and nutrients. JEL SOP 1.05. In: Standard operating procedures and field methods used for conducting ecological risk assessment case studies. Mueller et al. eds. 1992. USEPA, US Navy (NRaD) Technical Document 2296.
- Langan, R. 1992b. UNH JEL Standard operating procedure for water sample filtration and analysis of total suspended solids, chlorophyll and phaeopigments. JEL SOP 1.06. In: Standard operating procedures and field methods used for conducting ecological risk assessment case studies. Mueller et al. eds. 1992. USEPA, US Navy (NRaD) Technical Document 2296.
- Motes, M.L. and J.T. Peeler. 1991. Field evaluation of the MUG assay for enumerating *Escherichia coli* in seawater and oysters from southeastern United States. *J. Food Prot.* 54: 246-248.
- Strickland, J.D.H. and T.R. Parsons. 1968. *A Practical Handbook of Seawater Analysis*. Fisheries Research Board Of Canada, Ottawa, 1968.
- U.S. Environmental Protection Agency (U.S. E.P.A.). 1986. Test methods for *Escherichia coli* and enterococci in water by the membrane filtration procedure, EPA 600/4-85/076. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH.
- Wolf, J.S. and R. Langan. 1992. Standard operating procedure for analysis of seawater samples for phosphate (PO₄³⁻) using wet chemistry procedure. JEL SOP 1.07. In: Mueller et al. (eds.), *Standard Operating Procedures and Field Methods Used for Conducting Ecological Risk Assessment Case Studies*. USEPA, US Navy (NRaD) Technical Document 2296. pp. 381-383.

New Hampshire Coastal 2000/2001 - Gulf of Maine Assessment

Sponsor U.S. Environmental Protection Agency / NH Dept. of Environmental Services

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New Hampshire Contacts

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Dr. Steve Jones
University of New Hampshire
Jackson Estuarine Laboratory
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email: *shj@cisunix.unh.edu*

Goals

To assess the condition of coastal resources nationally, regionally and by state using a probabilistic design and a common set of environmental indicators.

Contaminants

Dissolved oxygen, salinity, temperature, depth, pH, nutrients, chlorophyll, grain size, total organic carbon, sediment chemistry, benthic community structure, sediment toxicity, benthic community structure, and if possible, fish community structure, external pathology and tissue analysis.

Sampling Stations

Eighty stations throughout the whole Seacoast of New Hampshire over a two-year period, 2000 and 2001. Approximately 40 stations each year.

Sampling Procedures

Procedures are specified in EPA's National Coastal Assessment Quality Assurance Project Plan - 2000 and in EPA's Coastal 2000 Field Operations Manual, Northeast Component prepared by Charles J. Strobel of the Atlantic Ecology Division, U.S. EPA, Narragansett, RI.

Analysis

By contract laboratories selected by EPA in accordance with EPA's National Coastal Assessment Quality Assurance Project Plan - 2000

Quality Assurance/ Quality Control

EPA's National Coastal Assessment Quality Assurance Project Plan - 2000

Reference

<http://www.epa.gov/emap/>

New Hampshire Gulfwatch Program

Sponsor New Hampshire Department of Environmental Services
UNH Jackson Estuarine Laboratory

Contact Natalie Landry, Coastal Watershed Coordinator
NH Department of Environmental Services
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Concord, New Hampshire 03301
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email: nlandry@des.state.nh.us
web site: www.des.state.nh.us/wmb/was/Gulfwatch.htm

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email: shj@christa.unh.edu

Goals

The goal of the New Hampshire Gulfwatch Program is to provide a more comprehensive assessment of toxic contaminant exposure, particularly oil, to biota in NH tidal waters. The specific objectives are:

- ♦ to develop a baseline database for contaminant exposure concentrations for New Hampshire mussels in coordination with the broader Gulf of Maine Gulfwatch program, which is designed to provide information on status, trends, and sources of risks to the marine environment and human health;
- ♦ to determine the impact and fate of spilled oil on the biota of the Great Bay Estuary;
- ♦ to develop a petroleum contamination baseline to assist in damage assessment in the event of an oil spill; and
- ♦ to expand the geographical coverage of sampling sites to include mussels located in critical habitat areas of coastal New Hampshire.

Contaminants

Blue mussels are utilized as an indicator organism of exposure to toxic contamination. Samples of blue mussel tissue are analyzed for a wide range of organic and inorganic toxic compounds, including chlorinated pesticides, heavy metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs).

Dates and Frequency of Sampling

Sampling typically occurs in the fall of each year, with sampling sites visited on a rotating basis such that each site is sampled once every three years.

Sampling Stations

Fourteen sampling locations are located throughout coastal New Hampshire, including the Great Bay, Little Bay, Piscataqua River, Hampton/Seabrook Harbor, Rye Harbor, and Little Harbor.

Sampling and Analytical Procedures

Sample collection procedures are consistent with those set forth in the Gulf of Maine Gulfwatch program (Sowles et al., 1997). From each sampling site, indigenous mussels (45-50 mussels of 50-60mm shell length) are collected from four discrete areas in the subtidal zone, cleaned of external mud and debris, and transported to the UNH/Jackson Estuarine Laboratory dry and on ice. At the laboratory, shell height, length, and width are measured, and all mussels are immediately shucked with stainless steel or plastic wedges and preserved for transport to an outside laboratory for chemical analyses. All procedures are in accordance with those developed by the Gulf of Maine Council on the Marine Environment Gulfwatch Program.

Reference

Jones, S.H. and N. Landry (2000). The New Hampshire Gulfwatch Program, 1998.

Sowles, J., R. Crawford, P. Hennigar, G. Harding, S. Jones, M.E. Chase, W. Robinson, J. Pederson, K. Coombs, D. Taylor, and K. Freeman (1997). Gulfwatch project standard procedures: field and laboratory. Gulfwatch implementation period 1993-2001. Gulf of Maine Council on the Marine Environment, State Planning Office, Augusta, Maine.

Discussion

The Gulf of Maine Council on the Marine Environment, through its Gulfwatch Program, has been collecting and analyzing mussels since 1991 from sampling sites in the Gulf of Maine, which includes the waters of Nova Scotia, New Brunswick, Maine, Massachusetts, as well as New Hampshire. Out of the 60 sampling locations, six are situated in New Hampshire and only one or two of those sites were sampled each year, providing limited environmental data. The NH Gulfwatch expands mussel monitoring in NH tidal waters by increasing the total number of sites to 14, and augmenting the sampling frequency depending on the site.

New Hampshire Public Beach Program

Sponsor New Hampshire Department of Environmental Services

Contact Jody Connor, Director
DES Limnology Center
6 Hazen Drive
Concord, New Hampshire 03301
email: *jconnor@des.state.nh.us*

Goal

NHDES monitors coastal and freshwater waters to determine the suitability of beaches for swimming. Maintaining public health through the monitoring of public beaches is important to the recreational significance of New Hampshire.

Dates and Frequency of Sampling

For 3 month swim season all coastal beaches are sampled weekly.

Contaminants

Enterococcus/per 100 mL. An instantaneous level of 104 enterococcus/per 100mL, or a geometric mean of 35 enterococcus/per 100mL over 60 days

Sampling and analytical procedures

Membrane Filtration

Sample stations

3 samples/beach

SAMPLE SITES-

1. Hampton Beach State Park, North
2. Hampton Beach State Park, South
3. North Hampton State Park
4. Rye Town Beach, Sawyer Beach
5. Rye Town Beach, Cable Beach
6. Rye Town Beach, Pirates Cove Beach
7. Jenness Beach, Rye
8. Wallis Sands State Park, Rye
9. New Castle Town Beach
10. Seabrook Town Beach

Discussion

If testing reveals high bacteria levels, advisories are posted at the beach until further samples show bacteria levels within the state standards for public swim beaches.

New Hampshire Shellfish - Bacteria

Sponsor New Hampshire Department of Environmental Services

Contact Chris Nash, Manager
DES Shellfish Program
360 Corporate Drive, Suite 2
Pease Tradeport
Portsmouth, New Hampshire 03801
tel: 603.430.7900 / fax: 603.427.2947
email: cnash@des.state.nh.us / web site: www.des.state.nh.us/wmb/shellfish

Goals

This program is designed to protect consumers of shellfish from health hazards associated with bacterial contamination through the maintenance of an updated database of water quality in shellfish growing waters.

Contaminants

Water samples are analyzed for fecal coliform bacteria (Most Probable Number [MPN] per 100ml, using the 5-tube MPN method). Other parameters such as water temperature, salinity, pH, and others are also measured. Other relevant observations for each sample (weather, antecedent precipitation, tidal conditions, etc.) are also maintained in the database.

Dates and Frequency of Sampling

This program was initiated in the 1940's. Significant changes occurred in the program in 1986, with the institution of new procedures and again in 1999 when the program moved from NH Department of Health and Human Services to the Department of Environmental Services.

Sampling frequency has changed throughout the life of the program. Samples are currently collected at least six times per year from each site, though most sites are sampled nine to ten times per year. Sampling is conducted in accordance with the Systematic Random Sampling Strategy, modified to be targeted on the low tide condition, in accordance with NSSP guidelines. A sampling schedule is developed at the start of each calendar year and is modified only when weather conditions or other factors pose a safety hazard to sampling personnel.

Sampling Stations

Approximately 75 locations in the Great Bay Estuary (including Little Bay and Piscataqua River), Hampton/Seabrook Harbor, Little Harbor/Back Channel, Rye Harbor, the Atlantic Coast.

Sampling and Analytical Procedures

Water samples are generally collected near the time of low tide. Samples are collected in presterilized Nalgene bottles or Whirlpak bags, and transported on ice to the laboratory for analysis. Analytical

techniques for fecal coliform and quality assurance procedures are in accordance with National Shellfish Sanitation Program guidelines.

Reference

National Shellfish Sanitation Program: Guide for the Control of Molluscan Shellfish (1999)

New Hampshire Shellfish - Paralytic Shellfish Poisoning/ Red Tide

Sponsor New Hampshire Department of Environmental Services

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DES Shellfish Program
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email: cnash@des.state.nh.us
web site: www.des.state.nh.us/wmb/shellfish

Goals

This program is designed to protect consumers of shellfish from health hazards associated with Paralytic Shellfish Poisoning.

Contaminants

Blue mussel samples are analyzed for PSP toxin levels in shellfish meats.

Dates and Frequency of Sampling

Sampling is conducted on a weekly basis from April through October. Sampling frequency is increased during periods of elevated PSP toxin levels in shellfish meats.

Sampling Stations

Samples are collected from Hampton/Seabrook Harbor and from the Isles of Shoals (Star Island). Secondary stations are sampled during periods of elevated PSP toxin levels in shellfish meats.

Sampling and Analytical Procedures

Hampton/Seabrook mussels are collected from a major mussel bed within the harbor. Isles of Shoals mussels are transplanted from Hampton/Seabrook and are hung in plastic mesh cages for at least one week before collection and analysis. All samples are cleaned of external mud and debris, transported dry and on ice, and analyzed by the NH Department of Health and Human Services Public Health Laboratory in accordance with National Shellfish Sanitation Program procedures.

Reference

National Shellfish Sanitation Program: Guide for the Control of Molluscan Shellfish (1999)

Discussion

UNH Open Ocean Aquaculture Demonstration Project Monitoring Program

Sponsor: NOAA/OAR/Cooperative Institute for New England Mariculture and Fisheries
(CINEMar)

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Goals

The goal of the UNH Open Ocean Aquaculture Demonstration Project Monitoring Program are to: 1) measure environmental impacts of finfish culture component of the project on the seabed and water column and 2) measure ambient physical and environmental conditions to be used in conjunction with biology of the culture organisms to determine optimal engineering and husbandry. The program includes continuous measurement of a number of physio-chemical parameters using an moored oceanographic buoy, continuous measurements of wave height using a WHOI designed wave rider buoy, and monthly discrete samples and measurements in the watercolumn and bottom substrate.

Contaminants

Water column measurements include dissolved inorganic nitrogen(nitrite + nitrate, ammonium), orthophosphate, total suspended sediments, particulate organic matter, photosynthetic pigments. Bottom sediment grain size and organic content are also measured.

Additional Measurements: temperature, salinity, dissolved oxygen, percent oxygen saturation, pH, tidal stage (via water depth), transmissivity, photosynthetically available radiation (PAR), chlorophyll a (by fluorescence), currents, wave heights.

Sampling Stations

Continental shelf in the Gulf of Maine, approximately five miles off the NH coast and one mile south of White Island at the Isles of Shoals.

Sampling Procedures

Oceanographic Buoy

Three Seabird Microcat CTD's record temperature, salinity, tidal stage (via water depth) every ten minutes at 0.5, 28, and 48 m. In addition, transmissivity and chlorophyll a (by fluorescence) are measured.

Monthly discrete water samples are collected at multiple depths at several stations in the vicinity of the aquaculture site using a Niskin Bottle. Samples are preserved using UNH JEL SOP 1.05.

Bottom grab samples are collected using a Wildco Box corer and subsampled for benthic infaunal analysis using a 0.0085 m² acrylic core tube. Water column conditions are measured at one meter intervals at several sites using a SeaBird SBE-25 Sealogger CTD. Measurements include temperature, salinity, transmissivity, photosynthetically available radiation (PAR), and chlorophyll a (by fluorescence).

Analysis

Instrument data are downloaded and analyzed using standard procedures for Seabird and RDI instruments. Grab samples are analyzed for sediment grain size and organic content using standard procedures for these parameters. Subsamples for infauna are analyzed by sieving through a 0.5 mm sieve, separating, fixing and preserving organisms. Organisms are identified to family level

Discrete water samples are processed and analyzed for total suspended solids, particulate organic matter, chlorophyll a and phaeopigments following UNH JEL SOP 1.06 (Langan 1992). Water sample filtrate is analyzed for NO₂ +NO₃ concentration (Lachat method #30-107-04-1-A), and NH₄⁺ concentration (Lachat method 11-107-06-1-C, Lachat Instruments 1991) on a LACHAT Quick-Chem nutrient autoanalyzer. PO₄⁻ concentration is measured using the orthophosphate method for wet chemistry as described in Strickland and Parsons (1968).

Quality Assurance/Quality Control

Established QA/QC procedures are followed for automated instrumentation (Seabird and RDI) and water sample collection and analyses (UNH JEL SOP 1.05, 1.06, 1.07; Lachat method #30-107-04-1-A; Lachat method 11-107-06-1-C, Lachat Instruments 1991). Benthic infaunal samples are QA/QC'd by checking 10% of samples for error.

Reference

Contact Dr. Ward for specifics.

Lachat Instruments. 1991. Operating manual for the Quick Chem Autoanalyzer Lachat Instruments. Milwaukee, Wisconsin.

Langan, R. 1992a. UNH JEL Standard operating procedure for water sampling for suspended solids, chlorophyll, and nutrients. JEL SOP 1.05. In: Standard operating procedures and field methods used for conducting ecological risk assessment case studies. Mueller et al. eds. 1992. USEPA, US Navy (NRaD) Technical Document 2296.

Langan, R. 1992b. UNH JEL Standard operating procedure for water sample filtration and analysis of total suspended solids, chlorophyll and phaeopigments. JEL SOP 1.06. In: Standard operating procedures and field methods used for conducting ecological risk assessment case studies. Mueller et al. eds. 1992. USEPA, US Navy (NRaD) Technical Document 2296.

Strickland, J.D.H. and T.R. Parsons. 1968. A Practical Handbook of Seawater Analysis. Fisheries Research Board Of Canada, Ottawa, 1968.

Wolf, J.S. and R. Langan. 1992. Standard operating procedure for analysis of seawater samples for phosphate (PO_4^{3-}) using wet chemistry procedure. JEL SOP 1.07. In: Mueller et al. (eds.), Standard Operating Procedures and Field Methods Used for Conducting Ecological Risk Assessment Case Studies. USEPA, US Navy (NRaD) Technical Document 2296. pp. 381-383.

Local and Regional Beach Monitoring

Sponsor Local Boards of Health, Metropolitan District Commission

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Mass CZM Marine Monitoring and Research Program
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Goals

To protect the public health through monitoring and reporting of microbial contamination of beach water.

Contaminants

Traditionally, fecal coliform. Some towns additionally monitor *E.coli* (for freshwater beaches) and Enterococci for coastal marine beach waters.

Dates and Frequency of Sampling

Some groups began sample from once a month, every two weeks, or once every week during the bathing season

Sampling Stations

A summary of stations for Massachusetts was compiled by the Natural Resources Defense Council in a report titled: "Testing the Waters 2000: A guide to Water Quality at Vacation Beaches" and can be found at: <http://www.nrdc.org/water/oceans/ttw/mapmas.asp>

Sampling and Analytical Procedures

These vary from community to community. Techniques for determination of coliform bacteria counts will generally follow the ISSC guidelines, or utilizing the new methodologies adapted by EPA for Enterococci and *E. coli* as these are used by government agencies in their decision making. Massachusetts recently passed into law the Beaches Act which is meant to standardize both sampling protocols and analytical methodologies; including the adoption of the newer indicators: Enterococci and *E. coli* for marine and freshwater bathing beaches. An important part of the Beaches Act is to ensure adequate and timely public notification of beach water quality.

References:

Natural Resources Defense Council Report: Clean Water & Oceans: Oceans: In Depth: Report:
Testing the Waters 2000 A Guide to Water Quality at Vacation Beaches.
<http://www.nrdc.org/water/oceans/ttw/titinx.asp>

Massachusetts Coastal Zone Management, 2nd Annual Marine Monitoring Symposium Report:
Focus on Beach Monitoring, 5 May, 2001. <http://www.state.ma.us/czm/mmp.htm>

Massachusetts Shellfish Sanitation Program

Sponsor Massachusetts Department of Fisheries, Wildlife, and Environmental Law Enforcement,
Division of Marine Fisheries

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web site: www.state.ma.us/dfwele/dmf

Goals

This program is designed to protect consumers of shellfish from health hazards associated with bacterial contamination and marine biotoxins.

Contaminants

Water samples are analyzed for fecal coliform bacteria, marine biotoxins (seasonally), and heavy metals as needed.

Dates and Frequency of Sampling

Samples are currently taken a minimum of five times each year.

Sampling Stations

Samples are collected at sites where shellfish harvesting is likely to occur and where sources of pollution are likely to impact shellfish growing waters.

Sampling and Analytical Procedures

Water samples are collected from within the tidal range as prescribed in the Shellfish Sanitation Model Ordinance (1999 revision). To the extent that it is practical to do so, samples are collected under conditions likely to maximize bacterial concentration. Analytical techniques for fecal coliforms and quality assurance procedures followed are those of the American Public Health Association (1984) as prescribed in the National Shellfish Sanitation Program and approved by the Interstate Shellfish Sanitation Conference.

Reference

American Public Health Association (1984), and Shellfish Sanitation Model Ordinance (1999 revision). Data is available through shellfish database and can be accessed through the following web address (up to the end of the previous calendar year). www.state.ma.us/dfwele/dmf

Discussion

All of the Gulf of Maine States, and the government of Canada follow the procedures developed by the Interstate Shellfish Sanitation Conference.

Massachusetts Ecosystem Assessment Program, Estuaries (MEAP-E)

Sponsor EPA Coastal 2000 / Massachusetts Coastal Zone Management Program

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Goals

Determine the ecological health of Massachusetts Estuaries

Measured Parameters:

Variables determined for each site will include:

Station Variables

- Location (GPS)
- Depth
- Weather: Current conditions as well as those 3 days prior to sampling
- Tidal stage
- Submerged aquatic vegetation/macroalgae (presence or absence)
- Secchi depth

Water Column Variables

Continuous Depth Profiles (CTD with PAR, DO, pH and Fluorescence detectors) of:

- Conductivity
- Temperature
- Oxygen
- Fluorescence
- pH
- Light attenuation

Discrete sample (bottom, mid-depth, and surface) concentration of:

- Total suspended matter
- Particulate organic nitrogen and carbon
- Chlorophyll a and phaeopigment
- Dissolved inorganic nutrients (NH₃, NO₃ + NO₂, Si and P)
- Dissolved O₂ (calibration only)

Dissolved metals (Cu, Zn, Pb, Cd, Ni, Fe)

Sediment Variables

- Grain size
- Organic carbon
- Inorganic and organic contaminants
- Toxicity (amphipod bioassay)
- Community structure (macrobenthos)

Fish Trawls (collected by Division Marine Fisheries and shipped by CZM)

- Community composition
- Pathology
- Parasites
- Inorganic and organic contaminants

Dates and Frequency of Sampling

Sampling is conducted during the summer months for two years

Sampling Stations/Area Covered

40 stations / year for two years for a total of 80 stations, beginning in year 2000. Further sampling is expected a selected estuaries for years 2002-2004.

Sampling and Analytical Procedures

EPA methods, following EPA's coastal 2000 Quality Assurance Program Plan (QAPP) with modifications documented in the MMRP's MEAP-E QAPP. Obtainable from Christian Krahforst, MMRP, at CZM.

Discussion

Beginning in 2000, the Commonwealth of Massachusetts has begun one of the most comprehensive assessments of Commonwealth's coastal sediments and waters as part of the nationwide Environmental Protection Agency's Coastal 2000 Monitoring effort. Through a grant from EPA, the Commonwealth's Office of Coastal Zone Management (CZM) in the Executive Office of Environmental Affairs will coordinate the monitoring. The Division of Marine Fisheries will conduct fish sampling. The University of Massachusetts at Boston (UMB) and Dartmouth (UMD) in cooperation with CZM will conduct sampling and some of the analyses (Chlorophyll, some sediment metals, hydrocasts, particulate organic carbon, and water column nutrients). Surface sediments from 90 randomly selected stations will be sampled through the summer of 2001 for a variety of contaminants of environmental concern, both inorganic (metals) and organic (PAHs, PCBs, and pesticides). Water column samples will be taken at each site to provide a "snapshot" of hydrographic variables (such as temperature and salinity), nutrients, pigments and suspended matter at the time of sampling. A schematic of sampling stations are shown in the watermark of this page. Details of measured parameters and station locations can be obtained by contacting Christian Krahforst at 617.626.1216 or *via* email: *christian.krahforst@state.ma.us*.

Gloucester 301(h) Monitoring Program

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Goals

To comply with the 301(h) legislation and establish that primary treatment is adequate to protect the environment.

Contaminants

Water quality tests are performed for total suspended solids, oil and grease, dissolved oxygen and chlorophyll. Tests for benthic sampling include oil and grease, priority pollutants, pesticides and total volatile solids. Benthic infaunal sample identification and grain size analysis are also performed for the monitoring program.

Dates and Frequency of Sampling

Sampling began in 1985, though prior to 1990 the results are of questionable reliability. Water quality sampling is conducted from April to November. There are single sampling events in April, May, June, October and November. Two sampling events are conducted in July, August and September. Benthic sampling is conducted once in March and again in September.

Sampling Stations

Samples for water quality are taken from four sites located 30 meters away from the outfall and four sites 150 meters away from the outfall. Samples are also taken at two control sites, one upstream and one downstream in terms of net flow for this region. Benthic samples are taken at six stations located 30 to 1500 meters away from the outfall.

Sampling and Analytical Procedures

Standard EPA procedures are followed for the detection of priority pollutants.

Reference

United States Environmental Protection Agency, 1982. Design of 301(h) Monitoring Program for Municipal Wastewater Discharges to Marine Waters.

Discussion

The Gloucester 301(h) monitoring program began in 1985, underwent some changes in 1990, and has been continued to date. The three components to the program include sampling the treatment plant effluent for priority pollutants, water quality monitoring near the outfall, and sampling the sediments on

the sea floor for benthic infauna and contaminants. In the near future the project will be modified slightly due to the issuance of a new permit for the treatment plant.

Shellfish Clean Waters Initiative

Sponsor Massachusetts Office of Coastal Zone Management

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Goals

This program is a multi-agency initiative to protect and restore coastal water quality in shellfish areas impacted by stormwater discharges and other sources of fecal coliform bacterial contamination.

Contaminants

The primary constituent of concern is fecal coliform bacteria (FCB). FCB is the main parameter used by the Massachusetts Division of Marine Fisheries (DMF) in their shellfish area classification program, as mandated by federal regulations.

Dates and Frequency of Sampling

Water samples are taken as needed during pollution source investigation projects. Sampling locations and schedules are determined for each individual site. DMF base data found in the Sanitary Shoreline Surveys is used initially. DMF also analyzes the shellfish area after BMP implementation, and makes changes to the areas classification status when appropriate.

Sampling Procedures

Sampling procedures are determined for each specific situation. Both wet weather and/or dry weather samples might be taken, depending on the site. Sometimes storm drain pipes or head wall pipe discharges are sampled; sometimes stream flows are sampled. Optical brightener sampling has been conducted alongside bacteria sampling in an effort to establish the presence of illegal greywater or blackwater connections to stormdrain systems.

Discussion

This program is unique in that it has an inter-agency agreement to conduct a cooperative effort towards the overall goal of improving water quality in shellfish areas. Each signatory agency agrees to provide access to some sort of technical resources. One agency might provide water sampling analysis, while another agency might assist in the preparation of funding applications. Another agency might provide soils analysis, while another agency might review engineering plans or options. Government agencies

might be local, state or federal entities. Or non-governmental agencies (NGO's) might contribute some of their resources to a project. This program seeks to minimize duplicative efforts and maximize the Commonwealth's efficiency in addressing marine water quality problems in impacted shellfish areas.

Clean Beaches and Streams Program

Sponsor Salem Sound 2000

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web site: www.salemsound.org

Goals

The primary objective of the Clean Beaches and Streams Program water quality monitoring is to identify sources of pathogen pollution to Salem Sound, particularly illicit sewage discharges to storm drains, and promote their remediation. Some of the highest priority sites relate to potential public health risk. To this end, three areas of interest for this investigation are:

1. Assessment and public notification of pollution sources to public swimming areas;
2. Investigation and tracking of pollution sources to shellfish beds; and
3. Confirmation of repairs in municipal infrastructure and investigation of areas needing repair.

Contaminants

Water samples are analyzed for fecal coliform and enterococci bacteria.

Dates and Frequency of Sampling

The SS2000 water quality monitoring program began in 1993 with the Shoreline Survey and Source Identification (SSASI) program. The SSASI program kicked off with a citizen survey of the 47-mile shoreline of Salem Sound to identify sources of pathogen contamination conducted in the summer of 1993. The shoreline survey employed over 100 trained volunteers and recorded detailed information on all observed potential pollution sources to the Sound. Based on the shoreline survey, approximately 300 potential sources of water pollution were documented.

Twenty-five trained volunteer monitors took as many as 30 samples weekly from roughly 100 sites for analysis of fecal coliform bacteria. Between September 1993 and July 1996, Salem Sound 2000 volunteers collected over 2,500 water samples that were analyzed for fecal coliform bacteria.

Beginning in 1997 and building on the original SSASI work, the program began collecting flow data in addition to continuing to document dry weather fecal coliform contamination. Flow data were collected on several major Salem Sound tributaries including Sawmill Brook in Manchester and the North River in Salem/Peabody. Fecal coliform testing continued with an emphasis on remediation and documentation of sources to shellfish resource areas. Due to the more limited availability of laboratory analysis after the first few years of the program, fewer samples were collected on a biweekly basis and monitoring sites

were prioritized based on the sensitivity of the receiving waterbody and/or the flow and concentration of the pathogen source.

In 1999, SS2000 launched the Clean Beaches and Streams Program to better focus its monitoring effort on pollution sources of the greatest concern to the community and to better utilize its results to trigger local action. The Clean Beaches and Streams Program focuses primarily on public health risks posed by pollution sources at swimming beaches and, secondarily, on sources of pollution to shellfish resource areas. In 1999 and 2000, twenty-five sampling locations in these categories were targeted for sampling and analysis on a biweekly basis.

Sampling Stations

Samples are collected from approximately 25 source locations around Salem Sound.

Sampling and Analytical Procedures

Water samples are generally collected near the time of low tide. Samples are collected in pre sterilized Nalgene bottles or disposable, sterile Nalgene bottles, and transported on ice to the laboratory for analysis. Analytical and collection techniques are in accordance with a MA DEP-approved quality assurance project plan (QAPP).

Circulation and Contaminant Transport in Massachusetts Coastal Waters

Sponsor: U.S. Geological Survey
Coastal and Marine Geology Program

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Goals:

- ♦ To develop a predictive capability for the transport of sediments and associated contaminants in Massachusetts Bay
- ♦ To monitor levels of selected contaminant in sediments and to assess changes in contaminants associated with new Boston sewage outfall.
- ♦ To monitor processes causing transport of sediments

Contaminants (and other parameters)

- ♦ Metals (Ag, Al, Ba, Cr, Cu, Fe, Hg, Ni, Pb, V, Zn)
- ♦ *Clostridium perfringens*
- ♦ Sediment texture
- ♦ Organic carbon

Dates and Frequency of Sampling

- ♦ Sampling at 2 locations near the new Massachusetts Bay outfall for Boston's treated sewage 3 times/year since 1989
- ♦ Sampling in Boston Harbor at 4 locations about every 5 years since 1978
- ♦ Sampling in Massachusetts Bay, Cape Cod Bay and Gulf of Maine in 1992, 1997, and 1999

Sampling Stations

- ♦ Boston Harbor (4 stations)
- ♦ Massachusetts Bay (2 stations near new ocean outfall)
- ♦ Massachusetts Bay (3- 8 stations located in Massachusetts Bay, Cape Cod Bay and Gulf of Maine)

Sampling and Analytical Procedures

- ♦ Undisturbed sediment samples obtained with hydrostatically damped gravity corer
- ♦ Chemical and grain size analysis of surface sediments and selected samples down core
- ♦ Suspended sediment samples collected with time-series sediment trap
- ♦ Trace metals analyzed by Inductively Coupled Plasma – Mass Spectrometry on totally dissolved samples

References

- Bothner, M.H., 1997, Metal concentrations in sediments of Boston Harbor and Massachusetts Bay document environmental change: U.S. Geological Survey Fact Sheet FS 150-97. (see <http://marine.usgs.gov/fact-sheets/fs150-97/>)
- Butman, B., and Bothner, M.H., 1997, Predicting the long-term fate of sediments and contaminants in Massachusetts Bay: U.S. Geological Survey Fact Sheet FS 172-97, 6 pp. (see <http://marine.usgs.gov/fact-sheets/fs172-97/>)
- Bothner, M.H., Buchholtz ten Brink, M., and Manheim, F.T., 1998, Metal concentrations in surface sediments of Boston Harbor changes with time: Marine Environmental Research, v. 45, No. 2, p. 127-155.
- Bothner, M.H., Buchholtz ten Brink, M., Parmenter, C.M., d'Angelo, W.M., and Doughten, M.W., 1993, The distribution of silver and other metals in sediments from Massachusetts and Cape Cod Bays: U.S. Geological Survey Open-File report 93-725. 31 pp.
- See complete list of references at <http://woodshole.er.usgs.gov/project-pages/bostonharbor>

Discussion

This long-term sampling is part of a program carried out by the U.S. Geological Survey in cooperation with the Massachusetts Water Resources Authority. It complements the Outfall Monitoring Program being conducted by the MWRA.

Outfall and Harbor Monitoring Program

Sponsor Massachusetts Water Resources Authority

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Goals

To monitor for impacts as a result of wastewater discharge relocation into western Massachusetts Bay and to monitor Boston Harbor for remediation as a result of wastewater diversion.

Contaminants

Several hundred effluent contaminants; metals, pesticides, PCBs, PAHs, AND physical properties in sediments, biota in sediments; nutrients, DO, salinity, temperature, chlorophyll in water column; phytoplankton and zooplankton in water column; tissue concentrations of metals, and organic contaminants in lobster, flounder, and mussels; benthic flux measurements of oxygen and numerous nutrients; bacteria and viruses in water column.

Dates and Frequency of Sampling

1992 to present. Harbor Sampling every other week in winter every week in summer. Offshore 17 water column surveys in western Massachusetts Bay, 6 surveys in "farfield" regions (Stellwagen Basin, Cape Ann, Cape Cod Bay). 1-2 benthic surveys per year.

Sampling Stations

Approximately 60 separate sites in harbor, Massachusetts Bay and Cape Cod Bay. Most concentrated effort in Boston Harbor and western Massachusetts Bay.

Sampling and Analytical Procedures

We have several volumes of SOPs.

Wetland Assessment Program

Sponsor Massachusetts Coastal Zone Management Program

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email: bruce.carlisle@state.ma.us
web site: www.state.ma.us/czm/wastart.htm

Goals

- ♦ To develop and evaluate techniques for assessing the ecological integrity of coastal wetlands;
- ♦ To utilize information for management action by identifying degraded wetland sites, monitoring restoration efforts, and inventory of wetland sites in localized area; and
- ♦ To transfer techniques to interested parties.

Contaminants

Key Components of Assessment Technique

Utilize direct measurements of biology, supported by hydrology and chemistry:

- > Vegetation > Macro Invertebrates
- > Avifauna > Fish/Nekton

Relies on a comparative design approach: study sites and reference (or control) sites

Consistent QAPP protocol with standardized evaluation areas

Biological data analyzed in a multi-metric framework, generating a quantitative index score

Dates and Frequency of Sampling

Biological Sampling:

Wetland vegetation: Once at peak of growing season

Aquatic macroinvertebrates: Samples in early May and late August, Sorted and identified in lab

Avifauna: 3 - 5 point-count observations during breeding and fall migration

Nekton (fish, shrimp, and crabs): 3 - 4 surveys from May to October

Sampling Stations

Samples are collected or surveys completed from approximately 3 stations at each study site at locations in the project area. Projects to date:

- ♦ 1995-1997 Waquoit Bay watershed,
- ♦ funded by NOAA Coastal Services Center, salt marsh and freshwater wetlands, 13 study sites.
- ♦ 1997-1999: North Coastal and Ipswich watersheds, funded by MA DEP, with federal 104(b)(3) grant, salt marsh and freshwater wetlands, 14 study sites.

- ♦ 1999-2001: Cape Cod Salt Marsh Project, funded by US EPA, Region I bioassessment initiative, only salt marsh wetlands, 12 study sites.

Sampling and Analytical Procedures

All studies are completed under an EPA-approved Quality Assurance Project Plan which contain the details of sample and survey protocol. Biological data are analyzed through a multi-metric framework.

Reference

- Carlisle, B.K., J.P. Smith, A.L. Hicks, B.G. Largay, S.R. Garcia. 1998. Wetland Ecological Integrity: An Assessment Approach: The Coastal Wetlands Ecosystem Protection Project. MA CZM: Boston, MA.
- Carlisle, B.K., A.L. Hicks, J.P. Smith, B.G. Largay, S.R. Garcia. 1999. Plants and aquatic invertebrates as indicators of wetland biological integrity in Waquoit Bay watershed, Cape Cod. *Journal Environment Cape Cod*. 2(2): 30-60.

Discussion

Salt Marsh Monitoring

Sponsor Massachusetts Audubon Society

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Goals

To detect and analyze changes in salt marsh vegetation and other aspects of fauna and flora over time, partly in relation to restoration activities. Many of the sites being studied have been impacted by tidal restrictions and are subject to invasion by *Phragmites australis*.

Contaminants

NA

Dates and Frequency of Sampling

Vegetation sampling has been ongoing since 1995. The program is ongoing. We sample vegetation once a year. Schools (high school and middle schools) are involved in sampling some of the sites through our Salt Marsh Science Education Program. Some sampling of fish and groundwater salinity is also ongoing.

Sampling Stations

We sample at approximately 12 different locations in the Great Marsh region of northeastern Massachusetts. Multiple transects per location.

Sampling and Analytical Procedures

Line intercept method for vegetation. Transects are 25-60 m long. Quadrats are placed down every 5 m along the transect to estimate % cover. Changes in *Phragmites* and *Spartina alterniflora* heights over the years are estimated by measuring the three tallest plants at 5 m intervals along transects. Groundwater salinities are measured by sampling well arrays that cover three depths (5-20, 35-50, 65-80 cm) in different types of marsh vegetation.

Reference

Brower, Zar and vonEnde. 1990. Field and Laboratory Methods for General Ecology. Wm Brown. See also protocols developed through the GPAC program (Neckles and Dionne. 1999. Regional standards to identify and evaluate tidal wetlands restoration in the Gulf of Maine. A GPAC workshop (June 2-3, 1999). Wells National Estuarine Research Reserve.)

Discussion

Our monitoring is intended to provide guidance for managers about the success of salt marsh restoration efforts or the need to restore degraded marshes. It will also be a barometer of long term changes related to potential climate change and other human impacts on marshes.

Monitoring Alewife Runs in Northeastern Massachusetts

Sponsor Massachusetts Audubon Society, Parker River Clean Water Association, Ipswich River Watershed Association, Eight Towns and the Bay Committee

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Wenham, Massachusetts 01984
tel: 978.927.1122 / fax: 978.922.8487
email: tpurinton@massaudubon.org
web site: www.massaudubon.org

Goals

To assess the populations of alewives migrating upstream in the spring to their spawning areas

Contaminants

NA

Dates and Frequency of Sampling

Sampling is ongoing. Sampling starts in early April and runs through about the third week in May.

Sampling Stations

Massachusetts Audubon Society and the Eight Towns and the Bay Committee monitor two alewife runs, the Little River in Gloucester and the Essex River/Alewife Brook in Essex. The Parker River Clean Water Association monitors the Parker River in Newbury and the Ipswich River Watershed Association monitors alewives moving past the Sylvania Dam in the center of Ipswich.

Sampling and Analytical Procedures

Volunteers count fish migrating up fishways for ten minutes of every hour. We attempt to get complete coverage.

Reference

Discussion

Our monitoring and those of other organizations in our region is intended to provide guidance for managers about the health of alewife runs in northeastern Massachusetts. It is also an excellent public outreach activity.

Cape Cod Bay Marine Monitoring

Sponsor Center for Coastal Studies

Contact: Dr. Charles Mayo
Center for Coastal Studies
P.O. Box 1036
Provincetown, Massachusetts 02657
tel: 508.487.3622 x108 / fax: 508.487.4495
email: *stormym33@pobox.com*
web site: www.coastalstudies.org

Goals

To develop a baseline database to be used to track changes in Cape Cod Bay, with particular emphasis on the potential impact of sewage products on the midwater system of the bay.

Variables and Contaminants Sampled

A wide variety of important midwater characteristics are being analyzed including: phytoplankton, zooplankton, marine mammal, and aves distribution and abundance; oceanographic conditions including vertical profiles of salinity, temperature, light penetration, and chlorophyll-a. Focal work on the distribution and transport of nitrogenous compounds using stable isotope techniques is structured to look at the impacts of the Boston Sewage Outfall that went on line in September of 2001.

Dates and Frequency of Sampling

Sampling for some variables (zooplankton and phytoplankton) began in 1984 and, combined with new analyses is on going. Sampling of stations in the bay, supplemented with directed investigations triggered by the presence of right whales, occurs monthly.

Sampling Stations

Twelve stations throughout the bay are sampled monthly at 3 to 4 depths.

Sampling and Analytical Procedures

For each of the variables under study standard methods of assay and enumeration are used. Basic enumeration of organisms is made by trained senior staff using traditional collection and counting techniques while the more esoteric studies involving ^{15}N ratios are sent to laboratories at Georgia Institute of Technology and Boston University.

Local Water Quality Monitoring Initiatives, Cape Cod*

** Note: This section diverges from the pattern established in the rest of this document. Rather than discussing a single program, it summarizes the efforts of 18 communities to monitor water quality within their borders.*

Sponsor Town Governments on Cape Cod

Contact Kimberly Damon-Randall
Citizen Water Quality Monitoring Coordinator
Waquoit Bay National Estuarine Research Reserve
P.O. Box 3092
Waquoit, Massachusetts 02536
tel: 508.457.0495 x125 / fax: 617.727.5537
email: kdrandall@onemain.com
web site: www.capecod.net/waquoit

Goals

In order to supplement the information available to them from through state, provincial, and federal support, many communities take on water quality monitoring programs of their own. These vary considerably across the Gulf, and the communities of Cape Cod, Massachusetts are used here as an example of the types of programs which are underway, and the types of information which are available on this one area of the Gulf.

The Cape Cod area is chosen because a detailed survey has already been conducted of the water quality programs in that area, not because the region is typical of the Gulf as a whole. As water quality problems are highly visible in the Cape Cod area, the region is likely to have a rate of community involvement higher than might be anticipated in many other regions of the Gulf.

Shellfish closures are of primary concern on Cape Cod, and programs are oriented toward isolating areas where closures may be necessary, from areas which can remain open, and identifying contaminant sources which might be responsible for these closures. Also, the number of developments on the Cape is expanding exponentially. There is an increased interest in wastewater management in several communities due to this expansion. Eutrophication of many coastal embayments and ponds is also an area of concern.

Contaminants

The parameters analyzed in monitoring programs, and the water quality studies available from 18 communities with frontage on the Gulf of Maine are outlined in Table? Most of the factors analyzed are traditional pollutants, or indications of physical changes. The recording of biotic factors by some communities may represent a measure of biological effects.

Dates and Frequency of Sampling

Some groups began sampling in the late 1980s but the majority of the groups were established in the mid-1990s. Most sample monthly although there are a few groups who sample less frequently (quarterly) and some who augment their sampling efforts during the summer to better identify seasonal changes.

Sampling Stations

These vary from community to community.

Sampling and Analytical Procedures

These vary from community to community. Techniques for determination of coliform bacteria counts will generally follow the ISSC guidelines, as these are used by government agencies in their decision making. The Waquoit Bay National Estuarine Research Reserve is attempting to move the groups toward collecting comparable data. In this regard, a Standard Operating Procedures Manual was developed and sent to all the groups. Currently, laboratory analysis for samples is an issue as there is one particular laboratory that analyzes most groups' samples. This lab is overextended with other work and there is a delay for the groups in receiving their analyses. Efforts are underway to provide groups with supplemental laboratory services.

Reference

Cape Cod Marine Water Quality Task Force (1988)

Discussion

Reports to communities contain a great wealth of information, especially on the location and potential sources of traditional pollutants. This information is oriented exclusively to the local perspective, and to local needs. This information could be of use in developing a Gulf-wide understanding if it can be integrated into the regional perspective, and made readily available to decision makers on the regional level.

Current groups

- ♦ Buzzards Bay Citizen Monitoring Program – Contact: Tony Williams at (508) 999-6363 or by email: *williams@savebuzzardsbay.org*
- ♦ Cataumet Civic Association – Contact: George Seaver at (508) 564-4404 or by email: *72066.2046@compuserve.com*
- ♦ Chatham Water Watchers – Contact: Dr. Bob Duncanson at (508) 945-5188 or by email: *chathamlab@capecod.net*
- ♦ Cotuit Waders – Contact: Ken Molloy at (508) 428-3815 or by email: *kma2@mediaone.net*
- ♦ Falmouth Pond Watchers – Contact: Dr. Brian Howes by email: *bhowes@umassd.edu*
- ♦ Harwich Shellfish and Marine Water Quality Monitoring Committee – Contact: Heinz Proft at (508) 430-7532 or by email: *harbor@capecod.net*

- ♦ Orleans Water Quality Task Force – Contact Don Powers at (508) 255-1318
- ♦ Pleasant Bay Alliance – Contact: Dr. Bob Duncanson at (508) 945-5188 or by email: *chathamlab@capecod.net*
- ♦ Provincetown Harbor Water Quality Monitoring Program – Contact: Tony Jacket at (508) 487-7000
- ♦ Shawme Ponds Watershed Association – Contact: Chuck Kleekamp at (508) 833-1271 or by email: *kleekamp@tiac.net*
- ♦ Three Bays Water Quality Monitoring Program – Contact: Lindsey Counsell at (508) 420-0780 or by email: *3bays@cape.com*
- ♦ RSVP Martha’s Vineyard – Contact: Bill Walker at (508) 696-9010 or by email: *mistavista@aol.com*
- ♦ Wampanoag Tribe of Aquinnah – Contact: Bret Stearns at (508) 645-9265
- ♦ Waquoit Bay Watchers – Contact: Dr. Chris Weidman at (508) 457-0495 or by email: *wbnerr@capecod.net*
- ♦ Wequaquet Lake Protective Association – Dr. Dale Saad, (508) 862-4644
- ♦ Wheeler Road Association and Friends - Dr. Dale Saad, (508) 862-4644
- ♦ Chatham High School – Contact: Jean Avery, (508) 945-5140
- ♦ Lawrence School of Shiverick’s Pond Study – Contact: Pat Harcourt, (508) 457-0495 or by email: *wbnerr@capecod.net*

Appendix A - Inventories

In compiling this directory we discovered several state and regional specific monitoring program inventories. These inventories vary in terms of type of programs included (active, historic, remedial, etc.) and currency of information.

State/Regional Inventories

State of Maine Inventory

- ❖ <http://pearl.spatial.maine.edu/CEMA/intro.htm>

An online index of current environmental monitoring and assessment programs in Maine. The index is a joint effort of the University of Maine, the Governor-appointed *Committee for Environmental Monitoring and Assessment (CEMA)* and a *National Science Foundation* Post-doctoral Fellowship in Science, Math, Engineering, and Technology Education (PFSMETE) awarded to Molly Schaufler, through the Department of Geological Sciences at the University of Maine. Contact: Molly Schaufler, University of Maine, 103 Environmental Science Lab, Orono, Maine 04469, tel: 207.581.2707, fax: 207.581.3007, email: mschauff@maine.edu

State of Massachusetts Inventory

- ❖ <http://www.state.ma.us/czm/inventory.html>

The Coastal Monitoring Station Inventory is a spatial database, stored in ArcView GIS format, which contains the location of monitoring stations established by organizations and agencies involved in coastal monitoring projects. These stations are linked to data tables which detail the type of data collected at each station as well as other information relevant to each monitoring project. Contact: Jason Baker, Massachusetts Coastal Zone Management, tel: 617.626.1204, email: jason.baker@state.ma.us

- ❖ *Directory of Marine Monitoring Programs in Massachusetts*, J. Pederson, Ph.D., et al.

This publication was created in 1993 and is based on the 1989 version of “Marine Environmental Monitoring in the Gulf of Maine.” It expands the listings for Massachusetts and classifies monitoring activities into five categories: Water Quality, Ecosystem Health, Living Resources, Human Health, and Citizen and Local Government Groups. Contact: Judy Pederson, tel: 617-252-1741, email: jpederso@mit.edu

State of New Hampshire Inventory

A partial inventory was compiled by the New Hampshire Estuaries Project as part of the NHEP Monitoring Plan. Contact: Cynthia Lay, Director of NHEP at 603.433.7187.

Atlantic Canada Inventories

- ❖ www.dal.ca/aczisc/acdd_toc

This inventory was compiled by the Atlantic Coastal Zone Information Steering Committee (ACZISC) and lists several monitoring efforts in Atlantic Canada. Contact: ACZISC at 902.667.3087

- ❖ http://www.ccme.ca/5e_othertopics/5ef_database/5ef.html

Databases for Environmental Analysis: Federal, Provincial and Territorial Governments is a unique reference guide to environmental data available throughout Canada. It is a collection of descriptions documenting the contents of over 1 200 databases held by the Government of Canada and by the 12 provincial and territorial governments. It covers subjects from digital base maps through acid rain to biodiversity. The database is available on the web or by CD-ROM. Contact: H el ene Tr epanier, Statistics Canada, Ottawa, Ontario, K1A 0T6, tel: 613.951.3750, fax: 613.951.0634, email: trephe@statcan.ca

National Inventories

- ❖ U.S. Geological Survey Contaminant Data

Contact: Marilyn Tenbrink at US Geological Survey 508.457.2392

- ❖ <http://www2.nos.noaa.gov/cemc/htmls/inventory.html>

An Inventory of NOS Monitoring Programs and Related Activities. The purpose of this inventory is to compile a comprehensive listing of NOS monitoring programs and related activities, consistently characterize these programs, and gather geospatial information about their location and extent. The Committee will initially focus on what has been termed "operational" monitoring activities. However, many activities are involved in support of operational monitoring and will eventually be included. For instance, some programs that were originally identified as NOS Monitoring Programs have been determined not to be operational monitoring programs, but rather have been classified as *research that supports improved monitoring methods, monitoring not sponsored by NOS or simply not monitoring*. Contact: NOAA / NOS Coastal Environmental Monitoring Committee

- ❖ <http://www2.nos.noaa.gov/cemc/htmls/materials.html>

Current and planned NOS environmental monitoring activities report. Contact: NOAA / NOS Coastal Environmental Monitoring Committee

Appendix B - Massachusetts Office of Coastal Zone Management - Survey Summaries

Fish community survey

Otter trawl and beach seine sampling was conducted in Gloucester and New Bedford Harbors from June 1998 to May 1999. The primary objective of the survey was to describe seasonal and spatial characteristics of the juvenile fish community in the harbors. Fixed stations were located throughout the harbors. Sampling occurred twice a month from June to October 1998 and May 1999 and monthly from November 1998 to April 1999.

There are technical reports available that describe the survey methods and results.

Early benthic phase lobster study

The distribution and abundance of early benthic phase (EBP) lobster were investigated in Salem Sound and Gloucester Harbor in October 1998 and November 1999, respectively. This study was a collaborative demonstration project to examine appropriate techniques to collect EBP lobster in soft substrate. Transects were identified in the harbors and visually described via SCUBA. The survey provided qualitative description of benthic habitat conditions and EBP lobster presence in the study area.

There are technical reports available that describe survey methods and results.

Benthic habitat characterization

Sediment profile and planview imagery was used to characterize benthic conditions in Gloucester Harbor, Salem Sound, Massachusetts Bay, New Bedford Harbor and Fairhaven Harbor. The objective of the survey was to provide baseline data on the type and condition of seafloor habitat in the study area. Stations were located throughout the identified harbors and bays. Data collected at each station include substrate type and condition, biogenic structure, optical prism penetration depth, and apparent redox potential discontinuity depth.

There are technical reports available that describe survey methods and results.

Buzzards Bay resource characterization

The fish community and seafloor habitat are currently being investigated in a study area associated with the Buzzards Bay dredged material disposal site. The Buzzards Bay disposal site was previously used to dispose dredged materials from Buzzards Bay embayments. To examine temporal and geographic features of the Buzzards Bay fish community, an otter trawl survey is employed to collect creatures, and an observational survey is describing seafloor conditions and associated organisms. The otter trawl survey is occurring monthly from January to March 2001 and November to December 2001 and bi-monthly from April to October 2001. Observational surveys will occur during the spring, summer and fall 2001.

Sediment profile and planview imagery described seafloor habitat type and condition in the study area. Data collected at each station include substrate type and condition, biogenic structure, optical prism penetration depth, and apparent redox potential discontinuity depth.

The resource characterization is ongoing with an estimated completion date of May 2002.

For further information contact:

Tony Wilbur
Massachusetts Office of Coastal Zone Management
tel: 617-626-1217 / email: *tony.wilbur@state.ma.us*

Vin Malkoski
Massachusetts Division of Marine Fisheries
tel: 508-563-1779 x119 / email: *vincent.malkoski@state.ma.us*

Appendix C - Other Resources

Plum Island Ecosystem Long Term Ecological Research

❖ <http://ecosystems.mbl.edu/PIE/>

The Plum Island Ecosystem (PIE) research site, located on the Northern Massachusetts coast, is part of the National Science Foundation's (NSF) Long Term Ecological Research (LTER) Network. PIE-LTER research is conducted by scientists from the Ecosystems Center at the Marine Biological Laboratory, the University of South Carolina, the Massachusetts Audubon Society, the Wells National Estuarine Research Reserve, and the University of New Hampshire. From 1992-1996, researchers from the Ecosystems Center were funded by the NSF Land Margin Ecosystems Research (LMER) program in Plum Island. The website lists program objectives as well as a synthesis of research to date.

❖ <http://pielter.org>

This field station server also lists real time climate and water quality information.