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Proceedings of a Maritimes Science Advisory Process to Develop a Framework for Monitoring of Contaminants in the Gully Marine Protected Area: Part 1 - Data Inputs

11 December 2007

Bedford Institute of Oceanography
Dartmouth, Nova Scotia

T. Worcester
Meeting Chair

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July 2009

Compte rendu d'une réunion du Processus consultatif scientifique des Maritimes en vue d'élaborer un cadre de surveillance des contaminants dans la zone de protection marine du Gully : Partie 1 - présentation des données

Le 11 decembre 2007

Institut océanographique de Bedford
Dartmouth (Nouvelle-Écosse)

T. Worcester
Présidente de la réunion

Institut océanographique de Bedford
1 Challenger Drive, C. P. 1006
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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings include research recommendations, uncertainties, and the rationale for decisions made by the meeting. Proceedings also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Avant-propos

Le présent compte rendu a pour but de documenter les principales activités et discussions qui ont eu lieu au cours de la réunion. Il contient des recommandations sur les recherches à effectuer, traite des incertitudes et expose les motifs ayant mené à la prise de décisions pendant la réunion. En outre, il fait état de données, d'analyses ou d'interprétations passées en revue et rejetées pour des raisons scientifiques, en donnant la raison du rejet. Bien que les interprétations et les opinions contenus dans le présent rapport puissent être inexacts ou propres à induire en erreur, ils sont quand même reproduits aussi fidèlement que possible afin de refléter les échanges tenus au cours de la réunion. Ainsi, aucune partie de ce rapport ne doit être considéré en tant que reflet des conclusions de la réunion, à moins d'indication précise en ce sens. De plus, un examen ultérieur de la question pourrait entraîner des changements aux conclusions, notamment si l'information supplémentaire pertinente, non disponible au moment de la réunion, est fournie par la suite. Finalement, dans les rares cas où des opinions divergentes sont exprimées officiellement, celles-ci sont également consignées dans les annexes du compte rendu.

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SUMMARY

Representatives from the Maritimes Region's Science Branch and Oceans and Coastal Management Division of Fisheries and Oceans Canada (DFO), Environment Canada, the Canada-Nova Scotia Offshore Petroleum Board, the Fishermen and Scientists Research Society, ExxonMobil, Dalhousie University, and Gadus Associates met at the Bedford Institute of Oceanography (BIO) in December 2007 to discuss past, present, and future contaminant monitoring in the Gully Marine Protected Area (MPA). This review of "data inputs" was the first in a series of 2 meetings that were intended to develop the scientific basis for a contaminant monitoring strategy for the Gully MPA. Presentations were made on the oceans management context for this work, followed by the history of contaminant studies in and around the Gully conducted by DFO Science, Dalhousie University, the Sable Offshore Energy Project, and others. A literature review of other relevant studies that might be informative in the development of a contaminant monitoring strategy was presented, as was an update of the oceanographic studies that had been conducted in the area to date. Finally, the components required for an effective contaminant monitoring strategy were discussed, including its scope, objectives, stressors, pathways of effects, indicators of impact, targets and reference points, monitoring approaches, evaluation and reporting, data management, and necessary resources. Additional sources of information of relevance for this discussion were identified, and planning for a second meeting (to be held in July 2008), which was intended to review the results of contaminant studies to date in more detail and to develop recommendations for next steps, was initiated.

SOMMAIRE

Des représentants de la Direction des sciences et de la Division de la gestion côtière et des océans de la Région des Maritimes de Pêches et Océans Canada (le MPO), d'Environnement Canada, de l'Office Canada/Nouvelle-Écosse des hydrocarbures extracôtiers, de la Fishermen and Scientists Research Society, d'ExxonMobil, de l'Université Dalhousie et de Gadus Associates se sont réunis à l'Institut océanographique de Bedford (IOB) en décembre 2007 pour discuter des activités passées, présentes et futures de surveillance des contaminants dans la zone de protection marine (ZPM) du Gully. Cette séance de présentation des données était la première de deux réunions destinées à établir le fondement scientifique d'une stratégie de surveillance des contaminants dans la ZPM du Gully. Elle a donné lieu à des exposés sur le contexte de gestion des océans dans lequel s'inscrit le travail attendu et à un historique des études des contaminants au sein et alentour du Gully réalisées par les Sciences du MPO, l'Université Dalhousie, les participants au Projet énergétique extracôtier de l'île de Sable et d'autres encore. On a présenté également une analyse documentaire d'autres études pertinentes pouvant être utiles à l'élaboration d'une stratégie de surveillance et fait le point sur les études océanographiques réalisées dans la zone jusqu'ici. Enfin, les participants ont discuté des éléments constitutifs d'une bonne stratégie (portée, objectifs, agresseurs, cheminement des effets, indicateurs d'impact, objectifs visés et points de référence, approches en matière de surveillance, évaluation et rapports, gestion des données et ressources nécessaires). D'autres sources d'information pertinentes ont été cernées et on a commencé à planifier une seconde réunion (pour juillet 2008) dans le but d'examiner plus en détail les résultats des études de contaminants effectuées jusqu'ici et de formuler des recommandations sur les étapes suivantes.

INTRODUCTION

Welcome

The meeting Chair, T. Worcester, welcomed participants (Appendix 1) to the meeting on contaminant monitoring in the Gully Marine Protected Area (MPA) and did a round of introductions. The Chair provided a brief overview of Department of Fisheries and Oceans' (DFO's) Science Advisory Process (SAP). The Science Advisory Process was initially developed to provide science advice on fisheries, e.g., providing recommendations on the allowable catch. Now, this science process has expanded to help provide advice on a variety of topics, including oceans and habitat issues, ecosystem-based management, and MPAs. At a fisheries SAP meeting, DFO scientists generally present information on the status of a fish population in the form of a working paper. This information is then peer reviewed by a few invited experts (either internal or external to DFO), with opportunity provided for questions from other participants. If the material is accepted as a research document, it is then used to form the basis of science advice to address pre-determined management questions as a Science Advisory Report (SAR). Occasionally, management asks a question that has not previously been addressed through a SAP, or knowledge can change to the extent that an old question could be addressed in a new way. When this happens, a framework is usually conducted. A framework is a meeting or series of meetings to establish *how* an issue should be assessed. For example, what data will be used to assess a new stock, what population model will be used to determine the status of a species at risk, etc. This meeting is the first in a series to develop a Framework for contaminant monitoring in the Gully MPA.

Background

Studies of bottlenose whales have been conducted by Dalhousie University since 1988. Government initially expressed interest in this area in 1992. A Canadian Wildlife Service workshop was held in 1994. In 1998, DFO conducted a SAP to review "Gully Science to Date". The intent of this workshop was to develop a comprehensive ecosystem description, including geoscience and hydrography, chemical and physical oceanography, benthos, fish and fisheries, marine mammals, and seabirds. At this time, it was decided that there was not enough site-specific information to develop an integrated ecosystem description. However, recommendations were made for further research. Another workshop was held in 2001 to review new information. In 2004, the Gully was designated as an MPA under the *Oceans Act*. The Gully MPA is an important part of the Eastern Scotian Shelf Integrated Management (ESSIM) initiative, and it is also relevant to many new initiatives within DFO, including ongoing work on development of a Canadian network of MPAs, development of ecosystem indicators and reference points for management, and ongoing discussions of ecosystem monitoring. It is recognized that while Environment Canada has been given the lead on contaminants in the marine environment, DFO Science has much to contribute. This framework is seen as an opportunity for DFO, Environment Canada, and others to work together towards an effective monitoring program for the Gully MPA.

The Terms of Reference (Appendix 2) for the meeting were reviewed. Objectives are to:

Data Inputs (11 December 2007)

- Review existing sources of contaminant data that have been collected to date by DFO and others in the Gully MPA and surrounding waters, and discuss methods that have been used or could be used for analysis.

- Identify sources of information on biological effects of contaminants that may be relevant to the Gully MPA and surrounding waters, and discuss methods of analysis and application to the Gully MPA.
- Review studies and techniques that have been conducted or used elsewhere, such as in other deep-sea canyons or MPAs, that may be applied to the development of a contaminant monitoring framework for the Gully MPA.
- Identify data gaps that may be relevant to the development of a contaminant monitoring framework for the Gully MPA.

Data Analysis and Framework Development (Spring 2008)

- Review contaminant data that has been collected to date by DFO and others in the Gully MPA and surrounding waters.
- Review information on biological effects of contaminants that may be relevant to the Gully MPA and surrounding waters.
- Identify potential components of a contaminant monitoring program for the Gully MPA in the Maritimes Region, including:
    - Sampling design (including frequency and duration).
    - Data management.
    - Reporting.
    - Linkages to other monitoring programs.

The expected outputs of this series of meetings will be a proceedings, a Science Advisory Report, and a research document.

The proposed agenda for the meeting was briefly discussed.

OCEANS MANAGEMENT CONTEXT

Presenter: P. Macnab

Presentation Highlights

DFO has been working on the Gully for about 12 years. DFO started by asking “is it unique?” and “is it worth protecting?” The answer to these questions was “yes”, and the MPA was created in 2004. The first couple of years were spent looking at what could be done in terms of conservation and protection. Now DFO is asking: “How does it work?” and “What are the pressures?” DFO has worked collaboratively with an advisory committee to develop a Management Plan for the Gully MPA, which is expected to be produced in the next couple of months. A draft Research and Monitoring Strategy has also been developed, and DFO has made a significant investment in Gully science. Contaminants have been identified within the management plan and research strategy as a priority pressure. Now it is time to take action. It would be useful to select and test indicator species and to use the Gully MPA as a living laboratory. There is a diversity of habitats within the Gully. Some work has already been done to examine contaminants in krill, fish, crabs, and sediments. A new challenge for DFO is to conduct science that will contribute knowledge for application within an ecosystem-based management context. Another challenge is to meet the regulatory obligations associated with the Gully MPA. Collection of baseline information and better understanding of the ecological characteristics of the Gully is expected to help inform the regulatory approval process. For example, baseline information would help to determine whether activities occurring outside the Gully MPA are impacting the Gully MPA, which is prohibited by the Gully Regulations. A

contaminant monitoring strategy would also help DFO to take advantage of other research that is being conducted on the Scotian Shelf, i.e., next time someone offers to collect some data, what should DFO ask them to do?

Discussion

P. Macnab was asked whether DFO has a way to get access to the information that non-DFO researchers collect in the Gully. Macnab responded that DFO can request data return from domestic and foreign scientists, but in practice these data are rarely received. Foreign Affairs have been asked to work with DFO to improve this situation, but it is something that is still unresolved. On occasion, approval to conduct research within the Gully is contingent upon DFO receiving a copy of the data collected. It was noted that DFO has been asked to provide data to other countries, when it was collected in their waters. In the case of data associated with Species at Risk, it was noted that you may not get your next *Species at Risk Act* (SARA) permit unless you provide the data collected previously under a SARA permit. This might be a model to look at. It was suggested that one way to get data would be to find the scientists who are interested in the data and tell them who to contact. This would also encourage one-on-one collaboration.

Last week, an indicator framework was presented for the Musquash MPA. This would be useful to look at, but it is a much different environment than the Gully (coastal versus offshore). It is much easier to collect data in the Musquash MPA. The Gully MPA is harder to get to and there are not many pre-existing protocols for data collection.

RELEVANT CONTAMINANT WORK BY DFO MARITIMES SCIENCE

Presenter: P. Yeats

Presentation Highlights

Work on contaminants in the Gully at the Bedford Institute of Oceanography (BIO) started in 1998 with the DFO Gully Science Workshop, but most collections have been done in recent years. Unfortunately, contaminant work in the marine environment seems to take a lot of time, and there are often delays due to lack of funding.

The major sources of contaminants on the Scotian Shelf include the Gulf of St. Lawrence, the offshore, rainfall, Nova Scotia rivers, sewage, and produced water. Estimates of contaminant inputs to the Scotian Shelf have been made for copper (Cu), lead (Pb), and zinc (Zn). Estimates could, and should, also be made for other contaminants. For the Gully, the importance of the various sources changes slightly. Contaminants from the offshore are going to be similar, and contaminants from rainwater and produced water will be an issue for the Gully; however, rivers and sewage will not be important contributors. Dissolved/dispersed oil from tankers is regulated and should be decreasing, but the incidence of oiled birds seems to be staying high or increasing. Polychlorinated byphenyls (PCBs) and Dichloro-Diphenyl-Trichloroethane (DDT) have been found in seals on Sable Island; however, both of these organic compounds are regulated and seem to be decreasing. Copper has been detected in the surface layer and at 50 m depth. These measurements are hard to do, and it is difficult to determine what the trend in copper is over time. If one corrects for salinity, it may be stable or decreasing. Sampling artefacts are possible. Zinc and lead appear to be decreasing, with concerted efforts being made to eliminate lead. In general, many traditional pollutants indicate a downward trend in the marine environment (except possibly in birds), and better practices may be having an effect.

However, some pollutants are increasing. For example, the pH of seawater appears to be decreasing (becoming more acidic) due to higher levels of carbon dioxide (CO_2). Cold environments may be particularly vulnerable, as CO_2 has greater solubility in the cold. Dissociation is also lower in cold water. Corals have calcium carbonate structures, which need calcium. A lower pH of seawater may be problematic for these species. Molluscs also have carbonate shells.

In addition to temporal trend, spatial trends have also been observed. The lead distribution in sediments of the Scotian Shelf was evaluated for the Human Use Atlas (DFO 2005). In this analysis, lead appeared to be higher in basins and lower on sandy banks. This is expected, as metals are more strongly associated with mud (grain size effect rather than a pollution effect). Attempts were made to assess lead concentrations against marine environmental quality guidelines; none of the concentrations were above Canadian Council of Ministers of the Environment (CCME) guidelines. This type of analysis could be done for other metals as well. Water column models show that there are high levels of copper coming out of Gulf of St. Lawrence. This raises a number of questions, including “is a substantial amount coming past the Gully?”, and if so, “is it harmful?” Copper is definitely toxic, but plankton can complex the copper and deal with it.

Within this framework, focus should also be given to new contaminants or specific sources of relevance to the Gully. For example, there are data from H. Whitehead’s lab at Dalhousie and data from the Sable Offshore Energy Project (SOEP) that could be considered. There are some additional DFO water, biota, and sediment samples from the Gully for consideration. However, there is only a very small amount of data that DFO Science is aware of.

Preliminary analysis of Gully data reveals no obvious “smoking guns.” A small amount of work was done on krill in the Gully (3 samples in 2004, 3 in 2006, and 1 in 2007), and it is inappropriate to draw any conclusions from the results, given such a small sample size. Organic analysis revealed some low levels of Polycyclic Aromatic Hydrocarbons (PAH), but it was not possible to quantify the signals. Some snow crab were collected from the area around the Gully, but these have not been analyzed yet. Toxicological studies have not been conducted within the Gully, but some relevant studies have been done outside the Gully.

Discussion

Four other sediment cores were taken this year, and 10 additional cores were taken with the Remotely Operated Platform for Ocean Science (ROPOS), the remotely operated vehicle operated under contract by the Canadian Scientific Submersible Facility. These samples should be analysed in the near future.

P. Yeats was asked why dissolved mercury was not investigated. Yeats responded that they had not felt comfortable asking the people on the ships who were doing the sampling to collect for mercury analysis. In order to do mercury analysis, it would be preferable to have trained DFO staff collect the samples. However, it was recognized that mercury would be an important and useful metal to interpret, as the trends in mercury might be different from the other metals. There is a lot of mercury in coal, and some gas wells have lots of mercury. The SOEP does not seem to have any. It was noted that mercury has been added to the suite of things to be analyzed this year.

A question was asked about how the snow crab were sampled. P. Yeats responded that the fishers collected crab around the Gully. At least a dozen collections were done, with five animals

per site. The hemolymph, hepatopancreas, and muscles would be targeted for analyses. Funding was not received.

RELEVANT CONTAMINANT WORK BY DALHOUSIE UNIVERSITY

Presenter: H. Whitehead

Presentation Highlights

H. Whitehead started by acknowledging that this presentation had been prepared by S. Hooker for a Marine Mammals meeting in Cape Town. S. Hooker started work on her PhD at Dalhousie, but she is now faculty in Scotland. She used H. Whitehead's boat and the National Oceanic and Atmospheric Administration (NOAA) vessel *Delaware II* in 2002. She investigated the genetic differences between the Gully and Davis Strait populations of northern bottlenose whales (Dalebout et al. 2001). Some whales have been seen off Newfoundland, but it is not clear which population they are part of. Biopsy sampling was conducted in 1996-97, and again in 2002-03. Stable isotope analysis, genetic analysis, cyp4501a, fatty acid analysis, PCB analysis, and analysis of hydrocarbons were all conducted. In general, the males were found to be more contaminated than the females.

Analysis of CYP4501A indicated that expression was higher in 2003 than in 1996-97, which is coincident with 10 spills of kerosene and streamer fluid during seismic work near the Gully (June-August 2003). Expression is much higher in Labrador. The reason for this is unclear, but may be related to poor feeding or exposure to PAHs. There appears to be a low level of CYP4501A expression in bottlenose whales compared to other species.

DDTs and trans-nonachlor appear to have increased, but it is not clear what the source of these would be. It is possible that they have been remobilized from sediments. Blubber contaminants are lower than are known to cause health problems. Results of this work are being published in Environmental Pollution (Hooker et al. 2008).

Discussion

H. Whitehead was asked how easy it is to get a biopsy of muscle tissue. He responded that it would require a specialized approach with a long probe that could be a problem. It is theoretically possible, but one would want to do it carefully.

It was noted that whales in the Arctic have high levels of contaminants, and it was suggested that contaminants might be physically transported through the Davis Strait. It was suggested that comparisons should be made with Arctic animals, or analysis should be done of contaminants in the Arctic flow.

It was noted that analysis of blubber contaminants depends upon the thickness of the blubber. H. Whitehead responded that there is some discussion of this in the paper by Hooker et al. (2008). Biopsies are smaller than samples, and sometimes you get extreme stratification in the blubber. This was not observed in more detailed studies of stranded animals. No seasonal change in blubber thickness was seen either. Northern bottlenose whales do not appear to migrate and they may not have strong seasonal patterns of behaviour.

A question was asked about the diet of northern bottlenose whales. H. Whitehead responded that it appears to be primarily squid (largely *Gonatus* in Davis Strait). Fatty acid analysis is

consistent with a diet of *Gonatus.* No stomach content analysis has been conducted, and only indirect evidence of diet is available. There does not appear to be enough primary production to provide energy for that number of whales within the Gully itself. This leads to the speculation that there must be an energy subsidy coming in, possibly in the form of organic matter, such as squid migrating in. If this is the case, then perhaps a contaminant is coming in with the squid (e.g., organic matter washing off of the Scotian Shelf).

SABLE OFFSHORE ENERGY PROJECT CONTAMINANTS WORK

Discussion Leads: M. Tuttle and T. Worcester

Discussion

Gully Area

Some sediment monitoring was done in the Gully MPA prior to designation. Amphipod toxicity tests have been conducted, but these have shown no toxic response. Barium, total petroleum hydrocarbons (TPH), strontium, ammonium, and sulphides have also been investigated. Concentrations of mercury in sediment at all test and reference locations (around the platforms and near the Gully) have been below detection limits. TPH was also below analytical detection limits. Barium concentration results from 1998-2005 (which is a possible indication of drill waste, but is also a natural constituent of many types of clay) at Gully sites have, on occasion, been above baseline. However when Ba/Al ratio in the sediment is taken into account (an analysis recommended by DFO), barium concentrations recorded at the Gully reference sites fall within the range of background or baseline levels. Monitoring at Gully sites was discontinued after 2005 based on historical low measurements of drill waste indicators, as well as completion of drilling in the area, but the 4 exact same sampling sites were sampled in 2007 by DFO.

Platforms Area

Other contaminant monitoring has included: mixed-function oxidase (MFO), gross pathology, and histopathology for cod (*Gadus morhua*) at the platform. Mussel body burden, scallop taint and body burden, and monthly oiled bird surveys have also been part of the SOEP environmental effects monitoring plan. The SOEP sampling protocol used a gradient approach for sediment chemistry and sediment toxicity sampling. Radial grid sampling locations were determined with 8 axes centred over the platform, and samples were taken along the axes at increasing distances, between 250 m and 20 km from the platform. Samples (5) of the marine receiving water adjacent of the produced water discharge caisson at Thebaud platform during July 2001 showed no acute (i.e., three-spine stickleback, *Gasterosteus aculeatus*) or sublethal (i.e., sea urchin fertilization) toxicity. Constituents (i.e., hydrocarbon, ammonia, fatty acids, and total organic carbon) typically found in produced water were not above background concentrations.

Microtox testing, sea urchin fertilization tests, and three-spine stickleback tests are used annually to determine produced water toxicity, and samples are taken directly from the discharge caisson on the platforms (prior to going overboard). In 2005, shellfish taint analysis was performed on scallops sampled from the Sable Bank and the Western Bank areas, and compared with a control sample from the commercial fishery using a sensory evaluation by triangle test. None of the 18 panelists involved in the sensory evaluation reported any off-flavours or odours associated with hydrocarbon taint.

Sable Island Area

Analysis of continuous air emissions monitoring data collected from Sable Island, which includes nitrogen oxides, sulphur dioxide, particulate matter (total and fine), polyaromatic hydrocarbons, and volatile organic compounds, has also been done.

Update by B. Law (DFO)

A large number of sediment core samples have been taken by DFO with cooperation of ExxonMobil on Sable Bank. In 2002 and 2003, sediment core samples were collected around the Venture, Alma, Panuke, and Thebaud platforms. In 2003, work was done around the Thebaud site with a tripod called In-Situ Size and Settling Column Tripod (INNSECT) to determine size and settling velocity relationships of sinking and resuspended particles. This data was not analyzed because it was done by a postdoctoral fellow working on other projects. The 2002 data is in press in the form of a technical report, and will be published in 2008. In both 2006 and 2007, core samples were taken at around the Thebaud platform. The 2006 data has been analyzed for trace metals, and the 2007 data will be shortly. Work will be done to put this all together.

ExxonMobil's environmental effects monitoring data is confidential for five years, but it could be made available after this time. DFO may wish to write ExxonMobil to ask for this data formally.

DISCUSSION OF OTHER RELEVANT WORK

Investigation of floating waste was conducted in 1993, 1998, and 2002-03. Neston net tows were used to collect large waste. These data have been partially worked up, and it would not take much to put this together. The general trend is that large floating waste has declined. Small floating waste increased for 2 years after SOEP started up. The results of this initial study have been published (Dufault and Whitehead 1994).

In July 2007, ROPOS collected bottom core samples 700 to 2500 m. It was focused on the western portion of the Gully. About 10 duplicate cores were collected - epibenthic organisms and for grain size analysis, metals, and organics. Biological collections with high resolution location information were also collected. Species accumulation curves are now being developed.

Samples were also collected in 2007, using a midwater trawl down to 1700 m in the Gully MPA. Three stations were conducted along the mainline, and 1 station was on the wall. Nothing was collected for contaminants, but krill were caught in large quantities, as were fish and squid. Samples could have been collected for contaminant analysis, if a request had been made and a sampling protocol provided. There is a request for ship time and funding for next year. A few *Gonatus* species were caught, including both of the known species. The net being used was not ideal for catching squid, and a commercial herring net with large mesh would have been better suited for that purpose. Also, the *CCGS Templeman* could not tow fast enough at depth to use this type of gear. The *CCGS Teleost* or a Norwegian vessel would be better suited to fill the sampling gap between small and larger species.

Contaminants work being done by Environment Canada is primarily nearshore. Pollutant release information and general source information is available. Contaminant monitoring from Sable Island may not be relevant.

It was suggested that perhaps the Canada Nova Scotia Offshore Petroleum Board (CNSOPB) could dig up chemical use patterns on platforms generally (not currently made public). However, E. Theriault of the CNSOPB did not think there was much information available in their files; however, operators could be approached for details.

LITERATURE REVIEW

Presenter: J. Hellou

Presentation Highlights

J. Hellou looked in the Aquatic Sciences and Fisheries Abstracts (ASFA) for references on monitoring using various types of combined keywords. There were lots using 1 term (222,902), and it was only reduced to a reasonable amount by combining 4 keywords. Using the keywords “monitoring”, “contaminants”, and “protected”, along with a series of additional terms combined, to these, such as fish, mussel, clam, oyster, sediments, toxicity, water, mammal, crustacean, shrimp, crab, lobster, aquatic, hydrocarbons, gave a total of 45 references. Combining “monitoring”, “protected”, “effects”, and a fourth term such as fish, mussel, clam, sediments, water, crab, crustacean, mammal, shrimp, oyster, hydrocarbons, resulted in another series of results totaling 553 references. As examples of this broad mix of material in the literature, there were studies on toxicity covering survival and growth, some studies were on sediments, and many were on metals. According to the titles and abstracts, there is no common specific approach -- it depends on the interests of the country, fisheries priority, concern or threat to be addressed, or specialty of a group of researchers. In order to determine which of these references would be relevant to the Gully, further clarification of the scope of the issue is required (i.e., what contaminants, what level of biological effect). For example, enzymatic activity may be good to study for large animals and fish, but it is not relevant for benthic animals. Spreadsheets of number of references obtained with specific search term combinations of 2, 3, or 4 words were compiled and sent to the meeting Chair. Some examples of topics covered in the references that appeared in the combinations of 4 words are also listed. These can easily be made available if needed.

OCEANOGRAPHIC UPDATE

Presenter: B. Greenan

Presentation Highlights

Four moorings were deployed in April 2006: 2 moorings were placed along the axis of the Gully at 100 m and 1600 m; moorings were also placed on the east and west walls of the canyon near the 1600 m deep mooring. Temperature and salinity had been measured before, but DFO had never placed a current meter in the Gully before. The moorings were recovered in August, and the data is just starting to be processed. Preliminary investigation has shown surprising velocities along the Gully axis (e.g., 80-100 cm/sec). The expectation was that speeds of 20-30 cm/sec would be seen, as on the rest of the shelf. The moorings got knocked over by several hundred meter. This is going to have implications for physical processes within the canyon. This level of currents has not been seen in other canyons, i.e., it is not typical on the eastern or western continental shelf. It does seem to be unique. The intent is to have a lecture on the results in spring.

[Note: Canyon transport in the Western Gulf of Lions, Mediterranean, has shown deep water cascading events, in which currents forcing large quantities of sediment laden cold water down the canyon axis at velocities similar to those observed by the moorings of Greenan and others.]

Discussion

B. Greenan was asked if the currents are reciprocating currents. Greenan responded that they are tidally driven over a two week cycle. There are seasonal signals with currents stronger in the winter. Greenan could not say anything about net transport without further analysis.

The significance of the strong currents was discussed. Canyons generally play a role in processes and transport. What role is the Gully playing? Perhaps it is trapping sediments. The ROPOS imagery showed lots of marine snow (floc), though this can be deceiving as it depends on the lights. Sediment traps in the Gully might be useful to look at sedimentation rates. One had been deployed, but it got sheared off by something and it came back upside down. Sediments were lost.

Settling plates (i.e., 50 pound manufactured brick with a rough surface) have been deployed in the Gully MPA for A. Metaxas, Dalhousie University. These will be collected opportunistically.

It was agreed that a better understanding of squid is hugely important. Biological models can not be employed until more information is collected, as one can only model what one knows. Until it is know what is being dealt with, all speculations are suspect. An expert is currently looking at video footage to determine if squid species can be identified. There does not appear to be a lot of activity in the top 100 m of the water column, but there is lots going on at 1000 m.

COMPONENTS OF A MONITORING FRAMEWORK FOR THE GULLY MPA

Context

The monitoring framework for the Gully MPA should include consideration of chemical, physical, and biological components of the environment. At present, there is a fairly good understanding of the currents and physical drivers, but only a limited understanding of the movement of organic matter. In the biological realm, information is missing about the “middle group”, i.e., those species occupying the middle part of the food web, such as mesopelagic fish and squid. The mesopelagic cruise scheduled for September should contribute to the understanding of this component of the ecosystem, but a report will not likely be available until the spring of 2008. Information on plankton, groundfish, whales, and macrobenthos is more extensive, but the understanding of seasonal trends even of those species groups is incomplete. There is very limited understanding about infauna (although perhaps a few infaunal cores available from K. Baker, Memorial University in Newfoundland), the things that whales feed on, and bacteria. There is also not a very good understanding of other cetaceans, such as dolphins. Information on seabirds is limited (may be clumped in winter).

The essential question is: “Are there critical components of the ecosystem that we need to understand to move forward with contaminant monitoring?” For example, in the context of this meeting, is a better understanding of animal migration only important if these animals serve as a vector for the movement of contaminants? If whales are feeding on squid that live elsewhere, they may generally be in a contaminant-free environment. However, components of the ecosystem cannot just be dismissed just because they are not a pathway. It will be a challenge

to design a monitoring program based on what we do know, but taking into account the parts that we do not.

Scope of Contaminants Framework

It was agreed that the scope of the monitoring framework for the Gully MPA should include:

- Water quality.
- Sediment quality.
- Bioaccumulation and animal health.
- Garbage and plastics.

Air quality was considered to be an important vector, but not something to be included in this framework.

It was agreed that it will be difficult to trace some of the garbage that is found in the Gully MPA. Regulation of garbage will depend upon the source; e.g., if the source is fishing vessels, then DFO will play a role, but if the source is shipping vessels, then Transport Canada will play a role. Gear seen by ROPOS was very old and a map could be produced fairly quickly. When garbage was observed, it was in clumps. Plastic is a serious concern and it is worth capturing within this framework as there is no better home. Theories of retention will play a role. Some work has been done (not in Canada) on microplastics (Thompson et al. 2004). An offer was made by UK researchers to look at microplastics in water samples taken from the Gully. At the Endeavour Hot Vents MPA in the Pacific Ocean, hundreds of plastic ties were left by scientific researchers, and they went back to clean it up.

In the future, the contaminants monitoring framework could include things like benthic community structure and other measures of community effects that would help to better understand ecosystem change as a result of contaminants. However, at present the system is not well enough understood to know what to focus on. In the meantime, contaminant sources and pathways of effects continue to be a key area of focus. A broad geographic scope of data points is required to ensure the appropriate context for the Gully MPA.

MPA Objectives

The objectives of the Gully MPA as stated in the Management Plan are to:

Protect the health and integrity of the Gully ecosystem:

- Protect natural biodiversity.
- Protect physical structures and physical and chemical properties.
- Maintain productivity.

Establish effective management of the Gully:

- Promote collaboration.
- Involve stakeholders.
- Establish cooperative agreements with responsible regulatory authorities.
- Monitor and evaluate the design, management, and effectiveness of the MPA on a regular basis to ensure that it is meeting defined objectives.

Promote stewardship activities:

- Increase understanding of the ecosystem.
- Promote active participation and engagement.

The objectives of the Gully Research and Monitoring Strategy are to:

Develop a better understanding through research and monitoring of natural processes and effects of human activities.

- Increase understanding of the Gully and potential for human impacts.
- Foster collaboration and communication among managers and natural/social scientists.
- Provide managers with accurate and timely information on the state of the Gully ecosystem and potential threats to conservation and management objectives.

Measuring Ecosystem Health

Everyone can agree that a healthy marine environment should be maintained, but how can this be assured? It can be done by setting specific objectives for the quality of the marine ecosystem, and then choosing measurements that indicate whether or not the objectives are being met. If objectives are not met because of the way people use the ecosystem, then use patterns must be modified. There are many examples from around the world and in Canada to guide the choice of good indicators of marine environmental quality (MEQ). The first step in choosing one is to decide upon the general health objectives for the marine ecosystem. The second step is to choose a more operational objective (MEQ Objective) that can be monitored and that will show the state of ecosystem health. A third step is to define a measurable indicator that measures the MEQ objective. The last step is to identify a threshold level of the indicator that will tell us when human use must be modified.

Scientists wanted to get away from this approach because they wanted to do research to better understand how things work. However, indicators that we can measure and monitor are MEQ indicators. MEQ indicators may be a practical way to provide science advice. The *Oceans Act* also mentions MEQ indicators.

What can be said about the state of the Gully ecosystem? At present, only the state of some individuals within the Gully is known. It should be possible to scale this up to the ecosystem level. If there is an ecological “bottom line”, then it should be described. However, there may be other reasons for monitoring that do not require the development of thresholds. For example, tracing the pathway of contaminants may help us to better understand physical processes within the Gully. Prioritization is required.

Money has been allocated within DFO this fiscal year (2008-2009) for development of ecosystem indicators. There is also a National DFO Ecosystem Indicators Working Group that has been established. Additionally, Health of the Oceans (HOTO) funds have been allocated for the development of MPA monitoring plans and protocols.

Some of the sediment and biological samples are showing organic contaminants at levels that may be surprising. These should be investigated further. If there are organochlorine compounds in seals, it may be interesting to see if this trend is also reflected in other species. Confirmation of trends at multiple trophic levels would be useful.

Perhaps a useful goal would be to investigate source of increasing trends and contaminants at higher than expected levels. For example, if contaminants are found in whales, then it would make sense to investigate the source of these contaminants, including potential pathways through prey items, such as squid.

Monitoring of traditional contaminants, such as copper, might not be a high priority, but it may still be useful to collect samples when possible (less frequently).

Contaminant information will also still need to be placed within the broader context of the physical, chemical, and biological process important to the Gully and surrounding area.

Stressors and Interactions

It will be important to be able to link contaminants to plausible "Pathways of Effects" and show the interaction between physical transport, migration, and the food web. It may be useful to complete a matrix of activities versus ecosystem components. Relevant activities should include:

- Petroleum exploration and development.
- Shipping/fisheries.
- Long-range transport.
- Climate change and increased storminess (storms).

Data collected to date may say something about what is happening within the Gully, but may not help with linkages outside the canyon. Developing a numerical model for the Gully would be difficult, and would not be available for this framework. It would require significant additional research to link a Gully "model" to the developing Scotian Shelf model.

Action: The matrix of activities versus ecosystem components should be presented at the next meeting.

Indicators

Biological

Possible indicator species include:

- Brittlestars, which are present throughout the canyon and which might be easy to sample; however, there may be limitations on what can analyzed.
- Anemones and tube worms, which are also present throughout the canyon.
- Corals (could look at contaminants in growth rings?).
- Hard corals (acidification effects on growth rates).
- Myctophid (a squid was seen eating one).
- Bottlenose whales.
- Krill, snow crab, seals, bottlenose whales (tried already).
- Bivalves (limited).
- Birds (but are quite mobile).

Indicator species should reflect both the pelagic and benthic environment, should include short-lived versus long-lived species. Additional feedback is required on this section.

Action: It was agreed that a table should be developed that shows what species have been sampled with each gear and frequency.

Chemical

It would be useful to establish a tracer that could be used to better understand physical transport in the Gully MPA. Barium is used as a tracer for drill muds. It appears to only be

detected close to source, so it may not be a good tracer for longer range transport processes; however, monitoring for barium may not yet have included depositional areas. It will be interesting to see if barium is detected in the ROPOS muddy sediment samples in depositional areas throughout the Gully. It is possible that barium is tracking with sand and not mud. Bentonite, another drill mud, has grain size signatures that can be found far away (i.e., several kilometers from drilling rigs). Mercury is an important indicator, but is expensive to analyze. It is poisonous and is transported by the atmosphere. Cadmium, copper, lead, and zinc have been monitored historically. It would be useful to include an explanation of the importance of these metals, the history of monitoring, and their trends over time (if available).

Possible organics for consideration include hydrocarbons, DDT, PCB, other chlorinated things, and things that are increasing in usage, e.g., polybrominated diphenylethols (PBDEs).

Biological Effects

Possible measures of biological effects include MFO, gross pathology, histopathology, and Microtox. Someone with expertise in this area should be invited to the next meeting.

Garbage

Microplastics is a new and evolving area needing attention.

Whatever indicators are selected will have to be easily collectable and cost effective.

Action: Work of the National Working Group on Ecosystem Indicators should be tracked and incorporated into this framework, where possible.

Targets, Reference Points

Little work has been done on targets and reference points for the various indicators discussed. At present, tracking of trends may be adequate, as well as determining whether something is above background or baseline conditions (assuming this is known). Once a contaminant reaches levels established in formal guidelines (e.g., CCME guidelines), it is really bad. Managers need to be able to take action at levels below this.

Monitoring

The monitoring framework should evaluate monitoring approaches, common practices, and designs. There will be a need to peer review data that is collected and compare with older data sets. It will be important to create informative metadata to accurately describe methodologies used.

New technologies for consideration include: autonomous underwater vehicles (AUVs) with mass spectroscopy; mobile gas chromatography / mass spectrometry (GCMS) in the field; liquid chromatography – mass spectrometry in the laboratory; and acoustic tagging (response of biota to stressors).

The spatial and temporal variability of the indicators being measured will be critical. Sampling design and statistical significance will also be important, as will sampling frequency.

Action: J. Hellou to prepare a presentation for the next meeting.

Evaluation / Reporting

Direction may be coming from National DFO Headquarters on this.

Action: Keep track of any new developments out of Ottawa.

Data Management

At present, much of the contaminants information is stored in the BIOCHEM database, but it is not very accessible. BIOCHEM does not include any sediment data, and there is no priority to add new contaminant data to this warehouse.

ROPOS data is currently in a Microsoft Access database, but eventually it should go to the Ocean Biogeographic Information system (OBIS).

It is important both to archive data, as well as to provide good daily access to it, especially when there are a variety of internal and external participants involved in a project. The use of Geographic Information Systems (GIS) is expanding within DFO, but this is not easily accessible to everyone yet.

The Virtual Data Centre is an Oracle-based tool that allows access to much of the DFO research survey data and other biological datasets but only to DFO users.

Funding for management of Gully contaminants data would be useful, including money to help put all the different relevant data sources for this project into a common format (e.g., shape files) and make it accessible to participants.

Resources

DFO's best resource right now is its people. For this project, a fairly decent reference list is available. The amount of $40,000 has been allocated to DFO Maritimes Science for the Gully. There is an expectation that indicators will be developed. To do any of this would take significant resources. However, if other projects are relied upon to provide support, progress will be slow.

NEXT STEPS

It was agreed that the highest priority next step was the analysis of new samples for organics and metals, including the SOEP data. If money becomes available, there is other analysis that could be done.

Send The Gully Marine Protected Area Management Plan, Research Strategy, Technical Report (Gordon and Fenton 2002), and Harrison and Fenton's (1998) research document to A. Cogswell.

Send P. Yeats any new analysis, e.g., analysis done by the Centre of Offshore Energy Research (COOGER), and T. Milligan's work.

Send a formal letter to SOEP asking for data/analysis for the working paper. When the letter is sent to SOEP, remember to include E. Theriault. Also, acknowledge that the five year confidentiality agreement is understood, but say that newer data is required.

Find someone to present important biological interactions in the Gully at the next meeting.

Contact J. Payne (NFLD) or S. Bard (Dalhousie University) about contributing information on biological effects. Contact C. Greer (Natural Resources Canada) about bacteria. Contact R. Thompson (University of Plymouth, UK) about plastics.

Refine the working paper for the next meeting (P. Yeats, T. Worcester, J. Hellou, and B. Law). Request additional participants by email to assist with this, if required.

It was proposed that the next meeting be held at the end of April or beginning of May 2008.

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Appendix 1. List of Participants

Framework for Contaminant Monitoring in the Gully MPA – Data Inputs
Maritimes Region Science Advisory Process

Bedford Institute of Oceanography
Dartmouth, Nova Scotia

11 December 2007

ATTENDEES

NAME	AFFILIATION
Cogswell, Andrew	DFO Maritimes / Science, Ecosystem Research Division
Doherty, Penny	DFO Maritimes / Ocean, Habitat, and Species at Risk
Ernst, Bill	Environment Canada
Greenan, Blair	DFO Maritimes / Science, Ocean Sciences Division
Hellou, Jocelyne	DFO Maritimes / Science, Ecosystem Research Division
Herbert, Glen	DFO Maritimes / Oceans, Coastal Management Division
Horsman, Tracy	DFO Maritimes / Oceans, Coastal Management Division
Kenchington, Trevor	Gadus Associates
King, Thomas	DFO Maritimes / Science, Ecosystem Research Division
Law, Brent	DFO Maritimes / Science, Ecosystem Research Division
MacDonald, Adrian	Environment Canada
MacDonald, Carl	Fishermen and Scientists Research Society (FSRS)
Macnab, Paul	DFO Mariitimes / Oceans, Coastal Management Division
Milligan, Tim	DFO Maritimes / Science, Ecosystem Research Division
Robinson, Brian	DFO Maritimes / Science, Ecosystem Research Division
Rutherford, Les	Environment Canada
Theriault, Eric	Canada-Nova Scotia Offshore Petroleum Board (CNSOPB)
Tuttle, Megan	ExxonMobil Canada
Whitehead, Hal	Dalhousie University, Department of Biology
Worcester, Tana (Chair)	DFO Maritimes / Science, Centre for Science Advice, Maritimes
Yeats, Phil	DFO Maritimes / ERD

Appendix 2. Terms of Reference

Framework for Contaminant Monitoring in the Gully MPA – Data Inputs
Maritimes Region Science Advisory Process

Bedford Institute of Oceanography
Dartmouth, Nova Scotia

11 December 2007

TERMS OF REFERENCE

Context

The Gully is the largest marine canyon in eastern North America. Located offshore Nova Scotia near Sable Island, the Gully contains a rich diversity of marine habitats and species, including deep-sea corals and northern bottlenose whales. The area is nationally and globally acknowledged as a unique and important marine habitat. The Gully ecosystem has long been important for fishing, and more recently, the surrounding waters have witnessed growth in oil and gas exploration and development. The health of the Gully is closely linked to that of the surrounding area. Large scale currents and smaller scale water movements carry suspended particles into the canyon. Oceanographic processes and retention within the Gully may make it susceptible to accumulation of contaminants.

The Gully became a Marine Protected Area (MPA) under the *Oceans Act* in 2004, with accompanying regulations. A Management Plan is currently under review, which includes consideration of contaminants.

The proposed meeting would be the first in a series of meetings to develop a framework for contaminant monitoring in the Gully. It is expected that this framework would inform management decisions in the coming years. The first meeting (11 December 2007) will review existing information and data sources available to inform the discussion of contaminants in the Gully MPA.

Objectives

Data Inputs (11 December 2007)

- Review existing sources of contaminant data that has been collected to date by DFO and others in the Gully MPA and surrounding waters, and discuss methods that have been used or could be used for analysis.

- Identify sources of information on biological effects of contaminants that may be relevant to the Gully MPA and surrounding waters, and discuss methods of analysis and application to the Gully MPA.

- Review studies and techniques that have been conducted or used elsewhere, such as in other deep-sea canyons or MPAs, that may inform the development of a contaminant monitoring framework for the Gully MPA.

- Identify data gaps that may be relevant to the development of a contaminant monitoring framework for the Gully MPA.

Data Analysis and Framework Development (Spring 2008)

- Review contaminant data that has been collected to date by DFO and others in the Gully MPA and surrounding waters.

- Review information on biological effects of contaminants that may be relevant to the Gully MPA and surrounding waters.

- Identify potential components of a contaminant monitoring program for the Gully MPA in the Maritimes Region, including:
    - Sampling design (including frequency and duration).
    - Data management.
    - Reporting.
    - Linkages to other monitoring programs.

Outputs

CSAS Science Advisory Report
CSAS Proceedings
CSAS Research Document(s)

Participation

DFO Science
DFO Oceans and Habitat
Environment Canada
Canada - Nova Scotia Offshore Petroleum Board
Universities
Offshore Oil and Gas Industry (SOEI)
Non-Government Organizations
Fishing Industry
Nova Scotia Provincial Representatives
Aboriginal Communities / Organizations