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GULLY MARINE PROTECTED AREA MONITORING INDICATORS, PROTOCOLS AND STRATEGIES

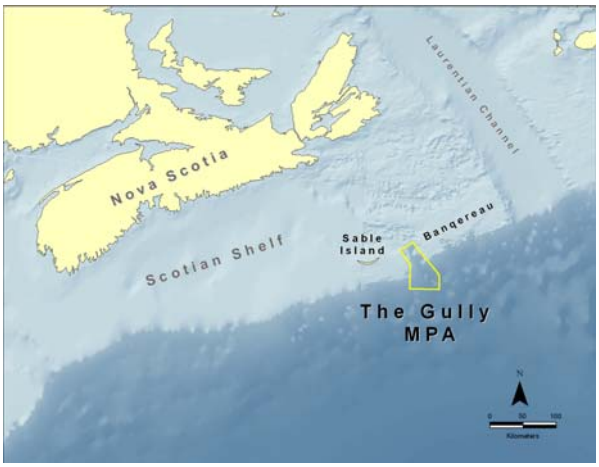

Figure 1: Location of Gully Marine Protection Area (MPA).

Figure 2. Outer boundary and zonation of the Gully MPA.

Context:

In support of the Health of the Oceans Initiative, DFO Science is required to deliver indicators, protocols and strategies for monitoring the individual conservation objectives of established Marine Protected Areas (MPAs). Monitoring of biological, chemical, physical, and ecological indicators (and related threats) is necessary for: A) incorporation into broader MPA monitoring "plans" or "programs"; B) tracking status, condition and trends to determine if MPAs are effective in achieving their conservation objectives; C) aiding mangers in the adjustment of MPA management plans to achieve conservation objectives; and D) reporting to Parliament and Canadians. The selection of indicators and the protocols for collection and analysis of data must be scientifically defensible.

The Gully is a large submarine canyon located along the edge of the Scotian Shelf, which was designated as an MPA under the Oceans Act in May 2004. Management of the Gully MPA is conducted in accordance with the Gully Marine Protected Area Regulations and The Gully Marine Protected Area Management Plan. Research and monitoring activities have been conducted in the Gully since the mid-1900s, but little routine monitoring focused on evaluation of the Gully MPA has yet been undertaken and no monitoring plan yet exists. It was necessary to develop a suite of indicators that would address the conservation objectives of the Gully MPA in a cost-effective manner, while incorporating existing monitoring programs, with their indicators, protocols and strategies, to the extent possible.

A Maritimes Region Science Advisory Process to review a full suite of indicators, protocols, and strategies for monitoring of the Gully MPA was conducted in February 2010, the results of which are contained within this Science Advisory Report.

SUMMARY

- Monitoring activities within and in close proximity to the area of the Gully MPA are ongoing. These include the Atlantic Zonal Monitoring Program (AZMP), DFO's multispecies research vessel surveys, halibut longline surveys, cetacean surveys, bird surveys, and meteorological record-keeping.

- Twenty-nine indicators are recommended for monitoring the conservation objectives of the Gully MPA; an additional 18 indicators are recommended for monitoring of pressures on the Gully MPA that may impact one or more of its conservation objectives.

- To achieve efficiency and cost-effectiveness, it is recommended that the indicators be monitored through a number of separate "component programs", most of them based around a single platform and, where possible, utilizing existing routine deployments such as the AZMP or DFO's multispecies research vessel surveys.

- Due to the Gully's offshore location and the necessity to use large and expensive research vessel surveys to conduct most forms of monitoring there, the monitoring of indicators within the Gully MPA would largely rely on monitoring by DFO and government partners. However, other partners, such as universities, non-governmental organizations and industry partners, many whom have made valuable contributions in the past, may also play a role in the ongoing monitoring of the Gully MPA.

BACKGROUND

Rational for Assessment

In support of the *Health of the Oceans Initiative*, DFO Science has been asked to recommend scientifically defensible indicators, protocols and strategies for monitoring the individual conservation objectives of established Marine Protected Areas (MPAs).

Monitoring of biological, chemical, physical, and ecological indicators (and related threats) is essential for:

A. Incorporation into broader MPA monitoring "plans" or "programs."
B. Tracking status, condition and trends to determine if MPAs are effective in achieving their conservation objectives.
C. Aiding managers in the adjustment of MPA management plans to achieve conservation objectives.
D. Reporting to Parliament and Canadians.

These indicators, protocols and strategies are not intended to address potential social, economic, or governance indicators and related protocols or strategies, though indicators related to monitoring of anthropogenic pressures on the MPA's ecosystem are included. It should be noted that the science recommendations provided in this report will need to be evaluated against fiscal and other considerations and do not represent a commitment to carry out this work.

A Maritimes Regional Science Advisory Process to review contaminant monitoring relevant to the Gully MPA (including results from the Sable Offshore Energy Project Environmental Effects Monitoring (EEM), contaminant monitoring by Dalhousie University, as well as monitoring by

DFO) was completed in July 2008. The results of the meeting are contained within a Science Advisory Report (DFO 2009). A Science Advisory Process to review a full suite of indicators, protocols, and strategies for monitoring of the Gully MPA was conducted in February 2010, the results of which are contained within this Science Advisory Report. Participation included DFO, Environment Canada, Defence Research and Development Canada, Nova Scotia Fisheries and Aquaculture, universities, fishing and petroleum industry, non-governmental organizations.

Description of the MPA

The Gully is a large submarine canyon (the largest in Atlantic Canada), roughly 40 km long by 16 km wide with water depths exceeding 3000m, that is located at the edge of the Scotian Shelf, 30 km east of Sable Island (Figure 1). There are a number of substantial feeder canyons running into the main canyon, mostly from the west and predominantly around the canyon head, which connects to a large shallow basin in the Central Scotian Shelf (sometimes called the Trough). The Gully seabed includes a wide variety of sediments, such as bedrock, boulders, gravel, sands, and fine silts.

The Gully supports a unique and highly diverse ecosystem, including a high diversity of whales (including an endangered population of northern bottlenose whales) and benthic habitats, the latter including some of the highest diversity of coral species known in Canadian waters. This area has been a focus of conservation interest since the 1970s and was designated as a Marine Protected Area under the *Oceans Act* in May 2004. Management of the MPA is conducted in accordance with the *Gully Marine Protected Area Regulations* and *The Gully Marine Protected Area Management Plan* of 2008.

There is much that remains unknown about the Gully ecosystem, which is highly variable both spatially and temporally. The current limited understanding of the structure and function of the ecosystem limits the ability to identify key pathways or components that might be used as indicators for monitoring.

Conservation Objectives

The conservation-related goals of the Gully MPA at the broadest scale, as outlined in *The Gully Marine Protected Area Management Plan*, are to:

Protect the health and integrity of the Gully ecosystem:

a) Protect the natural biodiversity of the Gully,
b) Protect the physical structure of the Gully and its physical and chemical properties,
c) Maintain the productivity of the Gully ecosystem,

The Gully Marine Protected Area Management Plan also describes priority conservation issues, which are intended to be the focus of monitoring in the near term:

1) Protecting cetaceans from impacts caused by human activities,
2) Protecting seafloor habitat and associated benthic communities from alteration caused by human activities,
3) Maintaining or restoring the quality of the water and sediments of the Gully, and
4) Conserving other commercial and non-commercial living resources.

Current and Potential Pressures

Given existing management measures in place for the Gully MPA, current and potential pressures on the Gully ecosystem include (not necessarily in priority sequence):

- Extraction of fish and invertebrates.
- Disturbance of cetaceans, corals, and seabed habitats (including extraction of biological material).
- Entanglement of cetaceans and other animals.
- Vessel traffic resulting in:
    - Cetacean strikes,
    - Emitted sound, with effects on cetaceans and other animals, including sound emitted outside the MPA boundary that enters the area at biologically-significant intensities,
    - Potential release of contaminants, including contaminants released outside the MPA which enter the area, and
    - Potential introduction of invasive species.
- Noise from aircraft transitting the Gully MPA.
- Retention and concentration of contaminants.
- Sound emitted by acoustic surveys, sonar, and fish-finding equipment, either inside or outside the MPA boundary but entering the area at biologically-significant intensities.
- Changes in the oceanographic climate of the northwest Atlantic (including acidification).

ASSESSMENT

Indicators for Monitoring

Current State of Monitoring Activities

A variety of monitoring activities within and in close proximity to the area of the Gully MPA are ongoing. Many broader-area programs (e.g., satellite monitoring) encompass the Gully, and the following list is not comprehensive. It does not include directed research (e.g., research on corals), or project-specific EEM (e.g., for the Sable Offshore Energy Project), being limited to those activities that involve ongoing, longer-term routine data collection.

The Atlantic Zonal Monitoring Program (AZMP) was implemented in 1998 to detect and monitor seasonal and interannual variability of biological, chemical and physical properties of coastal waters of eastern Canada. Stations were sampled opportunistically inside the Gully by DFO until about 2005, when four stations within the Gully were identified to be sampled annually in April and October. A wide variety of oceanographic variables are monitored.

From research vessels associated with the AZMP, Environment Canada monitors the distribution and abundance of seabird species within and beyond the Gully MPA. Surveys within the Gully MPA have been conducted by the Canadian Wildlife Service since 2006 in both April and October.

DFO has conducted an annual multispecies research vessel (RV) survey in the Region using bottom trawl gear each July since 1970. This stratified random survey has periodically included stations within the boundaries of the Gully MPA, the last one being in 2005.

A halibut longline fixed station survey was designed in 1998 to generate an index of abundance from stations selected based on commercial catch data. The survey is conducted from industry vessels in cooperation with DFO. One of these stations is located in the Gully, and several are in close proximity to its boundary. A commercial-index survey is conducted by industry at fishing locations of their choosing, many within the MPA, using similar protocols to the fixed station survey.

Cetacean surveys in the Gully MPA have been conducted by the Whitehead Laboratory at Dalhousie University since 1988. Biopsy sampling of northern bottlenose whales for genetic analysis and organic contaminants was also conducted by the Whitehead Laboratory in 2002-2003. Surveys of floating debris were conducted in the Gully in 1990, 1996/1997, and 1999.

Meteorological record-keeping on Sable Island began in 1871 and has been continuous since 1891, under Environment Canada. Activities at the Sable Island Station include collection of surface weather and aerological observations (e.g., measurements of temperature, humidity, visibility, barometric pressure, wind speed and direction, precipitation, icing, snow depth, sunshine, sky and global radiation, and lightning and thunder), as well as studies of atmospheric pollution.

Selection of Appropriate and Meaningful Indictors as Related to Conservation Objectives

Twenty-nine indicators are recommended for monitoring the conservation objectives of the Gully MPA; an additional eighteen indicators are recommended for monitoring of pressures on the Gully MPA that may impact one or more of its conservation objectives (Table 1). Additional information is provided in Table 1 on the current state of data collection related to these indicators, as well as who information is currently being collected by (if any). Additional detail on each indicator, including the rationale for its selection, is provided in the supporting Research Document (Kenchington 2010).

Table 1. Proposed monitoring indicators for the Gully MPA, including the current state of monitoring.

		Current State of Monitoring	**By Whom**
Protect Cetaceans from Impacts Caused by Human Activities			
1	Abundance of the Scotian Shelf population of northern bottlenose whales.	Ongoing	Dalhousie University
2	Use of the Gully MPA by northern bottlenose whales, measured as the percentage of the Scotian Shelf northern bottlenose population within the Gully MPA.	Data collected but not analyzed for Gully MPA monitoring	Dalhousie University
3	Size, age, and sex structure of the Scotian Shelf population of northern bottlenose whales.	Ongoing	Dalhousie University
4	Percentage of individuals in the Scotian Shelf northern bottlenose population showing fresh scars.	Ongoing	Dalhousie University
5	Genetic diversity within the Scotian Shelf population of northern bottlenose whales.	Initiated	Dalhousie University
6	Levels of contaminants in the blubber of individuals in the Scotian Shelf population of northern bottlenose whales.	Initiated	Dalhousie University
7	Relative abundances of cetaceans (other than northern bottlenose whales) in the Gully MPA.	Ongoing	Dalhousie University
8	Cetacean presence and activity in the MPA, year-round.	Occasional (not year-round)	Dalhousie University / DFO

9	Number of reported strandings of Scotian Shelf northern bottlenose whales.	Data collected but not analyzed for Gully MPA monitoring	Marine Animal Response Society
10	Number of reported ship strikes on cetaceans in or near the Gully, and of strikes on Scotian Shelf northern bottlenose whales elsewhere.	Not currently collected for Gully MPA monitoring	DFO
11	Number of reported gear entanglements of cetaceans in or near the Gully, and of entanglement of Scotian Shelf northern bottlenose whales elsewhere.	Not currently collected for Gully MPA monitoring	DFO
12	Number of reports of other interactions between human activities and cetaceans in or near the Gully, and of interactions with Scotian Shelf northern bottlenose whales elsewhere.	Not currently collected for Gully MPA monitoring	DFO
Protect Seafloor Habitat and Associated Benthic Communities			
13	Coral distribution, density and size structure by species at selected monitoring sites within the MPA.	Occasional	DFO
14	Coral diversity at selected monitoring sites within the MPA.	Occasional	DFO
15	Proportions of live and dead corals, by species, at selected monitoring sites within the MPA.	Not conducted	
16	Proportion of live corals at selected monitoring sites within the MPA that show zooanthid over-growths and the extent of over-growth in any affected colonies.	Not conducted	
Conserve Commercial and Non-Commercial Living Resources			
17	Relative abundances, size distributions, and diversity of selected groundfish and trawl-vulnerable invertebrate species in Zone 3 of the MPA.	Data collected but not analyzed for Gully MPA monitoring	DFO
18	Relative abundances, size distributions, and diversity of selected longline-vulnerable species in Zones 2 & 3 of the MPA.	Data collected but not analyzed for Gully MPA monitoring	Fishing Industry / DFO
19	Relative abundances, size distributions, and diversity of selected trap-vulnerable species in Zones 1 & 2 of the MPA.	Not conducted	
20	Relative abundances, size distributions, and diversity of selected mesopelagic nekton in Zones 1 & 2 of the MPA.	Occasional	DFO
Maintain the Quality of the Water and Sediments of the Gully			
21	Temperature, salinity, oxygen concentration, alkalinity, pH, light levels, chlorophyll pigments and nutrients in the water column within the MPA, including in close proximity to the seabed.	Ongoing	DFO (AZMP)
22	Temperature, salinity, oxygen concentration, light levels, chlorophyll pigments and nutrients in waters flowing into and past the MPA, as measured on the Louisbourg Line, the Halifax Line, and the Extended Halifax Line.	Ongoing	DFO (AZMP)
23	Physical (temperature, salinity, wind, height) and biological (ocean color) sea surface properties in the MPA and the surrounding region.	Data collected but not analyzed for Gully MPA monitoring	Archived by DFO
24	Weather conditions at the Sable Island weather station and at the Banquereau and Laurentian Fan weather-buoy sites, including wind direction and speed, air pressure and sea-level air temperatures, plus, for the buoy sites, sea surface	Ongoing	Environment Canada

	temperatures, wave height, and dominant wave period.		
25	Three-dimensional distribution and movements of water masses within and around the MPA.	Not conducted	
26	Phytoplankton production, community composition and the timing of the spring bloom in the MPA and the surrounding region.	Data collected but not analyzed for Gully MPA monitoring	DFO
27	Zooplankton biomass, community composition, and the biomass of selected species (e.g., *Calanus* spp. and carbonate forming) within the MPA.	Data collected but not analyzed for Gully MPA monitoring	DFO
28	Acoustic scattering in the water column within the MPA (as a measure of mesopelagic and zooplankton densities and distribution).	Occasional	DFO
29	Distribution and abundance of seabird species within the MPA, including an index of planktivorous seabird species.	Ongoing	Environment Canada
Indicators to Monitor Pressures			
30	Number of transits through the MPA by vessels other than pleasure craft, such as mercantile vessels, surface naval vessels, and fishing vessels not fishing in the area.	Not conducted	
31	Hours of operation within the MPA by vessels other than commercial fishing vessels or pleasure craft, such as research and monitoring vessels, other government vessels, and ecotourism vessels.	Not conducted	
32	Commercial fishing effort within the MPA.	Data collected but not analyzed for Gully MPA monitoring	DFO
33	Commercial fishing effort in close proximity to the MPA boundary.	Data collected but not analyzed for Gully MPA monitoring	DFO
34	Suspected and confirmed unauthorized fishing activity within or in close proximity to the MPA.	Ongoing	DFO
35	Quantities of corals removed from or discarded within the MPA by commercial fishing and by research activities.	Occasional	DFO / Fishing Industry
36	Quantities of target organisms removed from or discarded within the MPA, and of bycatch organisms (other than corals) removed from the MPA by commercial fishing.	Data collected but not analyzed for Gully MPA monitoring	DFO / Fishing Industry
37	Quantities of organisms (other than corals) removed from or discarded within the MPA by research activities.	Data collected but not analyzed for Gully MPA monitoring	DFO / Other
38	Seabed area swept by bottom-tending mobile research and monitoring gear within the MPA, both as a total and subdivided by seabed habitat type.	Occasional	DFO
39	Length of lines of, and seabed area occupied by, bottom-set fixed commercial fishing, research and monitoring gear set within the MPA, both as a total and subdivided by seabed habitat type.	Not conducted	
40	Number and types of offshore-petroleum exploration and development activities (e.g., number of wells, platforms, etc.) on the Eastern Scotian Shelf.	Ongoing	CNSOPB
41	Number, quantities and type of discharges from offshore-petroleum installations and activities on the Eastern	Ongoing	CNSOPB

	Scotian Shelf.		
42	Number of ships' ballast-water exchanges in close proximity of the MPA and the quantities of ballast exchanged.	Ongoing	Transport Canada
43	Number, quantities, and types of other discharges from shipping within or in close proximity to the MPA.	Not conducted	
44	Quantity of floating debris (i.e., large objects) in the Gully MPA.	Ongoing	Dalhousie University
45	Quantity of anthropogenic debris at selected monitoring sites in the Gully MPA.	Not conducted	
46	Reports of known invasive species in the Gully MPA.	Not conducted	
47	Quantitative characterization of anthropogenic sound within the MPA.	Occasional	DFO / Dalhousie University

Programs and Protocols for Monitoring

To achieve efficiency and cost-effectiveness, it is recommended that the indicators described in the previous section be monitored through a number of component programs, one of which would involve compiling data already collected for other purposes. Most of the proposed component monitoring programs are based around a single platform and several utilize existing routine deployments, such as the AZMP or DFO's multispecies bottom trawl survey. Where new deployments are unavoidable, wherever possible they have been chosen as extensions of existing programs to better use expertise and equipment already routinely deployed by DFO and to facilitate the combination of Gully data with wider datasets from the Eastern Scotian Shelf. The associations between indicators and component programs are summarized in Table 2.

Table 2. Association between proposed indicators and component programs. Indicators in brackets are those that the component program could potentially contribute towards.

Component Program	**Related Indicator or Indicators**
Cetacean Surveys	1, 2, 3, 4, 5, 6, 7, (44)
Acoustic Recorders	8, 47, (7)
Coral Surveys	13, 14, 15, 16, (45)
Trawl Surveys	17, (35, 37, 46)
Longline Surveys	18, (35, 37, 39, 46)
Trap Surveys	19, (37, 39, 46)
Mesopelagic Surveys	20, (37, 46)
Seabird Surveys	29
Environmental Monitoring: Shipboard	21, 22, 25 (in part), 27, 28
Environmental Monitoring: Satellite	23, 25 (in part), 26
Weather Stations / Buoys	24, 25 (in part)
AIS Monitoring of Vessel Activity	30
Enhanced Logbook Reporting	
Fishing vessels	35, 36, 39

Component Program	Related Indicator or Indicators
Research vessels	31, 35, 37, 38, 39, 46
Other permitted vessels	31
Compilation of Existing Records	
Strandings (MARS)	9
Vessel activity (Transport Canada, Coast Guard)	34, 42, 43
Petroleum industry activity (CNSOPB)	40, 41
Fishing industry logbooks	32, 33, 36
Other miscellaneous reports (DFO)	10, 11, 12

Many of the existing surveys (e.g., cetacean surveys, trawl surveys, longline surveys) have protocols that would need to be upgraded, standardized, and documented to ensure appropriateness and continuity for Gully MPA monitoring purposes. New or modified surveys would necessarily require development, standardization, and documentation of survey protocols.

Cetacean Surveys

It is recommended that cetacean surveys to monitor Indicators 1-4 be conducted every 4 years following the photo identification survey protocols established by the Whitehead Laboratory at Dalhousie University (Whitehead and Wimmer 2005), with each abundance estimate requiring surveys over two consecutive years (i.e., two years on and two years off). Experience has shown that this approach generates much more precise population and trend estimates of northern bottlenose whales than do transect surveys, whether aerial or shipboard. Monitoring surveys for Indicator 1 should be of sufficient intensity to track northern bottlenose population trends with a precision of ±5%, not simply in the Gully but also in adjacent Shortland and Haldeman canyons. It is recommended that, if collected, genetic (Indicator 5) and contaminant (Indicator 6) samples be taken from live whales through blubber biopsy using a sampler fired from a crossbow (Hooker et al. 2001) at eight-year intervals or as required. It is recommended that cetaceans other than northern bottlenose whales continue to be recorded when seen in the Gully MPA (Indicator 7). In addition, it is recommended that observations of floating debris (Indicator 44) continue to be made during cetacean surveys. Cetacean survey protocols developed by the Whitehead Laboratory will need to be upgraded, standardized, and documented to facilitate use by other operators.

Acoustic Recorders

Protocols for long-term monitoring of Indicators 8 and 47 require further development but would likely involve continuous deployment of passive, seabed acoustic recorders, such as the Cornell “pop-up” recorders that have been used in the Gully in the past. Recorders or, if necessary, suites of recorders, should be selected to cover all frequencies from 10 Hz to 50 kHz; low frequencies will be used for monitoring ship noise and the high frequencies for monitoring the hunting sonar activity of bottlenose whales and other toothed whales. It is recommended that the recorders be released and recovered on a “ship of opportunity” basis, by research vessels working in the Gully.

A workshop of acousticians and others with specialist knowledge of acoustic monitoring design should be convened to assist in the development of protocols and strategies for monitoring of Indicators 8 and 47 (with possible consideration of 7). A library of acoustic recordings from the Gully during both summer and winter over the period of 2005-2007 currently exists. These recordings could be used to help develop Indicators 8, 47, and possibly 7, though they have not yet been analyzed for this purpose.

Coral Surveys

It is recommended that coral surveys to monitor Indicators 13-16 be conducted following the methodology of the 2007 coral study in the Gully. The transect established in 2007 on the western side of the canyon should be re-surveyed, a similar transect should be established on the eastern side, probably in the vicinity of the "Southwest Prong" of Banquereau, while a third transect established in the area of the moraines was surveyed in 2008. Thereafter, the surveys should be repeated at those three sites at ten-year intervals. In addition, it may be appropriate to conduct coral surveys after severe storms and accidental events, as well as before and after planned bottom-contacting activities that may cause damage to corals. Reporting of coral material that may be collected during coral surveys would be expected to contribute to Indicator 35. Once a video survey for corals is deployed, it would also be possible to record observations of any anthropogenic material seen on the seabed (Indicator 45). Protocols for reporting and analysis of these observations would need to be developed.

Trawl Surveys

Further work is required to determine the portions of Zone 3 of the MPA that may not be suitable for periodic bottom trawling by DFO research vessel (RV) surveys. It is recommended that the stratification of the surveys then be modified to exclude these areas, while annual sampling (last station conducted in 2005) continues according to standard survey protocols (Hatt and Clark 2007; Clark and Emberley 2009). The small number of randomly-located stations selected annually within the MPA would, however, preclude the tracking of temporal changes in groundfish within Zone 3 in the presence of spatial variation. Thus, it is recommended that two fixed stations, one each on Banquereau and Sable Island Bank, be identified. These stations should be sampled each year as part of the annual summer RV survey. Sampling during the summer RV survey (compared to other times of the year) is preferred since the long data series (currently 40 years) will provide the best available baseline, while the better weather in summer minimizes the uncertainties resulting from lost ship time. Annual sampling limited to two fixed stations would not produce reliable estimates of abundance changes from year to year but may allow longer-term trends in the groundfish of Zone 3 (Indicator 17) to be monitored. Reporting from RV surveys would be expected to contribute to Indicators 35, 37, and 46.

Longline Survey

As described previously, a halibut industry longline survey is currently conducted on the Scotian Shelf, with one fixed station within the Gully MPA (Zone 2) and two fixed stations immediately adjacent to the Gully MPA. Commercial halibut longline index stations may also be surveyed within Zones 2 and 3 of the Gully MPA. Standardized protocols have been developed in association with these surveys. However, the current station locations, data collected, and protocols have not yet been evaluated in terms of their potential usefulness for monitoring of Indicator 18. Reporting from current and potential future longline surveys would be expected to contribute to Indicators 35, 37, 39, and 46.

Trap Survey

While occasional crab trap sampling has been conducted on the Scotian Shelf in the past, survey design would need to be developed to established appropriate protocols for Gully monitoring of Indicator 19. Reporting from trap surveys would also be expected to contribute to Indicators 37, 39, and 46.

Mesopelagic Survey

Protocols for midwater-trawl surveys of the meso- and bathypelagic nekton (Indicator 20) of the Gully have been developed in recent years, building on the initial experience of Kenchington et al. (2009). Additional surveys will be required to determine the patterns of seasonal variation in catches, while extensive analysis will be necessary for the development of a baseline description of the system. Once this work is complete, a reduced survey design suited to routine monitoring on Indicator 20 should be developed. Reporting from any future mesopelagic surveys would also be expected to contribute to Indicators 37 and 46.

Seabird Surveys

It is recommended that seabird surveys follow the protocol developed by the Canadian Wildlife Service (CWS) of Environment Canada (Wilhelm et al. 2009). Currently, seabird observers employed by CWS participate in all AZMP oceanographic missions and survey for seabirds when the vessel is in transit (along transects and between sampling stations). In addition to AZMP missions in April and October, CWS seabird observers conduct opportunistic surveys from vessels both within and beyond the Gully MPA using the CWS protocol. Reporting from seabird surveys would be expected to contribute to Indicator 29.

Environmental Monitoring: Shipboard

Oceanographic Monitoring

Protocols for shipboard monitoring of temperature, salinity, oxygen, light levels, chlorophyll, photosynthetic pigments, and plant nutrients have been developed and are used annually by the AZMP. These are considered adequate and appropriate for continued monitoring of Indicators 21 and 22. Zooplankton sampling has been conducted as part of the AZMP, which could serve as the basis for development of Indicator 27 (zooplankton biomass, community composition, and distribution of selected species), though additional work would be required to select zooplankton species that would provide meaningful information for MPA managers. In addition, phytoplankton sampling has been conducted as part of the AZMP, which would provide background information for the development of Indicator 26 (phytoplankton community composition), though ongoing pursuit of methods for determining the composition of phytoplankton communities from ocean-colour data is recommended (see Environmental Monitoring: Satellite).

The AZMP has regularly monitored one station at the head of the Gully since 1999 and has recently (2005) added four additional stations at the mouth of the Gully, in addition to sampling along the Halifax and Louisbourg Lines. An additional station at 43° 52.7′N 58° 56.3′W, over the canyon thalweg in the centre of the northern bottlenose-whale distribution, would add value for the Gully MPA monitoring program. It is recommended that AZMP protocols also be expanded to include monitoring of alkalinity and pH in the deep waters of the Gully (to at least 500 m depth and preferably deeper) to cover the potential effects of increased dissolved carbon dioxide on deepwater corals. Oceanographic information, such as temperature and salinity should be used

to develop a synthetic index of the three-dimensional distribution and movements of various water masses within the Gully MPA (Indicator 25).

Acoustic Backscatter

Acoustic backscatter measurements have occasionally been taken from the same ship-based platform as the AZMP. For the purposes of monitoring Indicator 28 (mesopelagic and zooplankton densities and distribution within the MPA), the capture of acoustic data could be expanded to include one or more transects within the Gully MPA, standardized in time (date and point in the diel cycle) and space.

Environmental Monitoring: Satellite

Satellite imagery of sea surface temperatures and ocean colour in the northwest Atlantic, including those over the Gully, is routinely archived by DFO at the Bedford Institute of Oceanography. Continued analysis and reporting of this information in the context of the Gully MPA is recommended to address Indicators 23 and 26, as well as to contribute to Indicator 25. Use of satellite information to develop an index of phytoplankton composition (e.g., ratio of diatoms to dinoflagellates) may be challenging but is encouraged (Indicator 26).

Weather Stations and Buoys

While the physical oceanography of the Gully remains poorly understood, there are reasons to suspect that the deeper waters within the canyon undergo major movements, with meteorological forcing being one primary driver. Extensive databases are required, first for baseline studies linking measured movements to weather patterns and subsequently either to explain observed events or, potentially, to allow routine monitoring of the water through observations of the meteorological conditions that affect it. Observations from the Sable Island weather station and nearby weather buoys are important information sources that can be used to develop and monitor Indicator 24. Data is currently collected by Environment Canada. To make use of this information for Gully MPA monitoring, DFO would have to obtain copies of this information, archive it, and unite this data with others in analysis and assessment of the state of the Gully MPA. This data would also likely be used to contribute toward the development of indicator 25.

AIS Monitoring of Vessel Activity

Cost-effective monitoring of the traffic of large vessels through the MPA is now possible through routine reception of Automatic Identification System (AIS) transmissions from the vessels themselves. While AIS is intended as an aid in collision avoidance, the transmissions provide data on ships' identities, positions, courses and speeds. All large surface vessels are now required to carry the equipment. There are a number of options for receiving AIS transmissions from ships in the Gully MPA and for transmitting those data to shore. They include mounting the receiver at the weather station on Sable Island or at the East Light (though either may be further from the Gully MPA than the effective range of the system), or utilizing an existing satellite-mounted receiver. Once routine monitoring is in progress, additional work would be required to develop optimal formats for display and reporting of the data to address Indicator 30. It should be noted that the voluntary corporate Code of Practice for the Gully MPA restricts petroleum-related industry vessels from transiting the Gully.

Enhanced Logbook Reporting

Fishing Vessels

For any commercial fishing vessels within the Gully MPA, it would be useful to distinguish removals of target organisms from those of unintended bycatch, even though the distinction between those two is often unclear (Indicator 36). Currently, a proportion of commercial fishing trips carry observers who record more detailed information on bycatch species caught. Provisions should also be made to record the locations of any coral captured (Indicator 35) in the Gully MPA to a high precision, which is typically only possible on observed fishing trips. It may become necessary to set minimum levels of observer coverage for fishing trips into the Gully MPA. Protocols for reporting on the length of lines or seabed occupied by bottom-set fixed gear would have to be developed to support Indicator 39, as well as methods for reporting by seabed habitat type. These protocols should be consistent with those developed for research and monitoring activities to allow for aggregation of this data.

Research and Other Permitted Vessels

For research and other permitted vessels within the Gully MPA but without AIS (including fishing vessels that are conducting research activities), it is recommended that permit conditions be expanded to require reporting of transits through the Gully MPA, including hours of operations within the MPA (Indicator 31), with reports submitted to DFO for compilation into annual summary statistics.

For vessels that may be conducting research that involves the collection or removal of biological material (i.e., in addition to those surveys already described), enhanced logbook reporting is recommended to support Indicators 35 (removal of corals) and 37 (removal of other organisms). Protocols for reporting of removals would need to be developed and should be consistent for all research activities.

Protocols for reporting of information on the seabed area swept by bottom-tending mobile research or monitoring gear (Indicator 38), as well as the length of lines or seabed occupied by bottom-set fixed gear (Indicator 39), would also have to be developed, as well as methods for reporting by seabed habitat type.

Scientists working in the Gully MPA should be encouraged to report any observations of invasive species (Indicator 46). Should any such reports be received, they should be added to the Gully MPA's monitoring archive.

Compilation of Existing Records

Strandings

Cetacean strandings in the Maritimes Region are currently recorded by the Marine Animal Response Society. These records are considered to be an appropriate data source of relevance to Indicator 9; however, additional work will be required to develop this indicator for Gully MPA monitoring purposes.

Vessel Activity

Unauthorized fishing activity within the MPA is, by its nature, inadequately recorded. However, when such activities are detected by DFO in the vicinity of the Gully MPA, reports should be forwarded to the MPA managers and included in the monitoring archive (Indicator 34).

As with unauthorized fishing activity, shipping discharges in the Gully MPA may not be reported. However, when discharges are detected by DFO, Transport Canada, or others, the information should be gathered into the Gully MPA monitoring archive (Indicator 43).

Most cargo ships entering Canadian waters are required to exchange their ballast water while in open ocean in order to minimize the risk of invasive species being introduced when the ballast is discharged in port. There is an authorized area for ballast exchange west of Sable Island and in water depths exceeding 1,000 m. Transport Canada currently gathers detailed data on ballast-water exchanges. Work would be required to develop reporting protocols for use in Gully MPA monitoring (Indicator 42).

Petroleum Industry Activity

The CNSOPB currently tracks the number and types of offshore petroleum exploration and development activities on the Scotian Shelf, as well as the quantities and types of discharges from offshore petroleum installations and activities. Compilation of these data as contextual information for the Gully MPA would be considered an important source of information for development and monitoring of Indicators 40 and 41.

Industry Logbooks

Fishing vessels operating within the Gully, along with other commercial fishing vessels in Canadian waters, are required to maintain logbooks recording fishing effort and the resulting catches (Indicators 32, 33, and 36).

Other Miscellaneous Reports

Any reports of ship strikes (Indicator 10), gear entanglements (Indicator 11), and other interactions (Indicator 12) with cetaceans in or near the Gully MPA should be gathered into the Gully MPA monitoring archive.

Strategies for Monitoring

Due to the Gully's offshore location and the necessity to use large and expensive research vessel surveys to conduct most forms of monitoring there, the tracking of indicators within the Gully MPA would largely rely on monitoring by DFO and other government partners such as Natural Resources Canada or Defence Research and Development Canada (e.g., acoustic monitoring). Monitoring of meteorological indicators on Sable Island and at weather buoys would require support by Environment Canada, as does the ongoing monitoring of marine birds within the Gully MPA and surrounding areas. Monitoring by non-government partners, such as Dalhousie University's Whitehead Laboratory, the Marine Animal Response Society, and the Sable Offshore Energy Project is currently being conducted. These partnerships have provided significant contributions to our understanding of the Gully MPA in the past, and are encouraged in the future, but they may need to be formalized to ensure standardized protocols and reporting procedures are used to track progress on achievement of the Gully MPA conservation objectives.

Much of the data collected by the recommended monitoring programs would reside in existing databases currently used by the various component programs. However, development of a web-based data-management system could serve as the Gully MPA monitoring archive and a portal through which the data (in both raw form and as processed summaries) are made available to managers, to scientists working in the area, and to stakeholders. Support would be required for the on-going management of the website and databases – not least for quality-control checks on uploaded data.

The current lack of understanding of the structure and function of the Gully ecosystem prevents the identification of key pathways or components that could be selected as efficient monitoring indicators. Hence, at present, truly effective monitoring of this MPA would require an impractically-expensive broad-brush approach. Available research-vessel and scientific resources will be better utilized on characterization studies that provide the knowledge needed to later identify the key pathways, while confining routine monitoring in the short and medium terms to only the most cost-effective extensions of existing programs.

CONCLUSIONS

Twenty-nine indicators for monitoring the conservation objectives of the Gully MPA, and an additional 18 indicators for monitoring of pressures on the Gully MPA that may impact one or more of its conservation objectives, have been identified. Information that would contribute to many of these indicators is already being collected (e.g., Indicators 1, 3, 4, 7, 9, 21, 22, 23, 24, 29, 40, 41, 42, 44), while others are new (e.g., Indicators 8, 15, 16, 19, 25, 30, 31, 39, 45, 46). Additional development would be required for many of the indicators (e.g., Indicators 2, 17, 18, 20, 26, 27, 28, 32, 33, 38, 47).

Once selected, it is recommended that the suite of indicators identified for monitoring of the Gully MPA conservation objectives be maintained unchanged for long periods, since short runs of monitoring data will not detect slow changes and are usually an inefficient use of resources. Each indicator must have its own standardized monitoring protocol, based on the type of statistical analysis that will be applied to the data, which must be applied consistently over the long term. However, it is important to retain the flexibility to discard uninformative indicators, to adopt new ones relating to emerging threats, and to correct faulty methodology. Hence, it is essential to have a system for managing the monitoring program that can achieve an appropriate balance between stability and change.

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