REVIEW OF A MONITORING FRAMEWORK FOR THE ST. ANNS BANK AREA OF INTEREST

Context

A Marine Protected Area (MPA) is a coastal or oceanic area given special status to conserve and protect its habitat and wildlife under Section 35 of Canada's Oceans Act. Under the Health of the Oceans (HOTO) Initiative, DFO identified a series of Areas of Interest (AOI) for candidate MPAs located in different regions across Canada, with a goal of designating an additional six MPAs.

In the Maritimes Region, an AOI, referred to as the St. Anns Bank AOI, (Figure 1), located off Scatarie Island, Cape Breton, Nova Scotia, has been selected. The St. Anns Bank AOI includes part of St. Anns Bank, Scatarie Bank, and a portion of the Laurentian Channel. These marine areas provide diverse habitats for a range of commercial fish species (e.g., redfish and halibut), non-commercial marine species (e.g., sponges, corals, and anemones) and several at-risk marine species. The area also lies astride a key migration route for many marine mammals and commercial and non-commercial fish species. The AOI was identified as an area with high biological and habitat diversity, and contributes to the MPA network strategic objective of protecting representative examples of all major habitats in the bioregion (DFO 2012). A Regional Science Peer Review was conducted in January 2012 to review the proposed conservation objectives and risk assessment methodology for this AOI (DFO 2012).

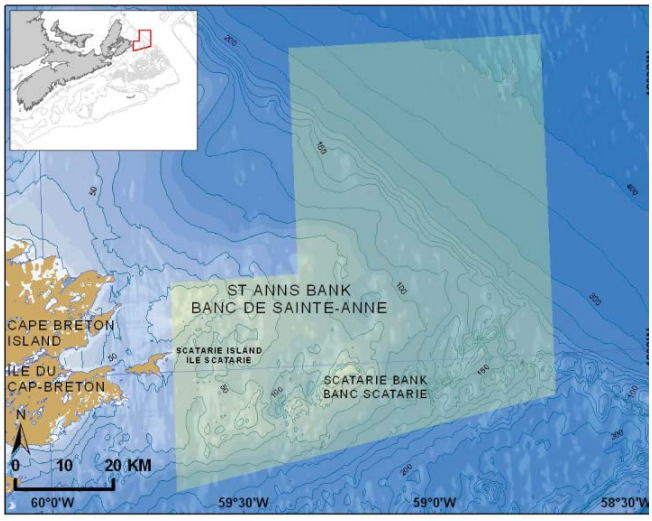

Figure 1: Location and extent of the St. Anns Bank AOI (in green tint). The boundaries shown are for information, study and consultation purposes only.

Under HOTO, DFO Science is required to deliver indicators, protocols and strategies for monitoring the conservation objectives of established MPAs and identified AOIs. Monitoring of biological and ecological indicators (and related threats) is essential for:

- incorporating an ecological component into broader MPA monitoring programs,
- tracking indicator status, condition and trends to determine if MPAs are effective in achieving their conservation objectives,

- aiding managers in the adjustment of MPA management plans to achieve conservation objectives, and
- reporting to Parliament and Canadians. Selection of indicators and protocols for collection and analysis of data must be scientifically defensible (DFO 2010).

A draft monitoring framework has been prepared for the St. Anns Bank AOI, including indicators, protocols and strategies for monitoring those draft conservation objectives. This Science Response Report results from the Science Response Process (SRP) of 8-9 November 2012 on the Review of the Draft St. Anns Bank Area of Interest (AOI) Monitoring Framework. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Summary

The context for the monitoring framework was provided by a review of the main physical, geological, and ecological (primary production, pelagic fauna, and benthic fauna) components of the AOI ecosystem. This review, based on available data, contributed to the selection of the monitoring indicators.

The recommendations offered within the draft monitoring framework are generic and present the steps needed to design a monitoring plan, rather than an outline of the plan itself. Fifty one ecological indicators were proposed in the framework, while a rationale for each indicator and outline protocols for determining indicator values were provided. As baseline information is advanced and knowledge of ecosystem function is strengthened, these indicators may require further analysis to provide more specificity and detail, or be divided into multiple sub-indicators. Therefore, a regular review and evaluation of the monitoring program is advised to identify and implement changes required to improve monitoring based on newly generated knowledge and analyses.

Background

The draft monitoring framework created for the St. Anns Bank AOI closely adheres to the process that was followed for the Gully MPA Monitoring Framework (Kenchington 2010). The framework offers an account of the ecosystems to be monitored over and around St. Anns Bank, some discussion of the likely objectives of an MPA in the area, and consideration of particular challenges confronting the monitoring activities. A monitoring strategy is then proposed, rationales for the recommended indicators are provided and approaches for their monitoring outlined. The St. Anns Bank AOI framework incorporated the recommendations of the Gully MPA Monitoring Framework (Kenchington 2010), but was modified to match the requirements, opportunities and ecosystems of a candidate MPA that extends into near-coastal waters.

At the time of this process, the designation of the St. Anns AOI as an MPA was on-going, thus its specific conservation objectives and geographic boundaries were not finalised. In addition, the scientific research required to characterize the ecosystems of the AOI ahead of a potential MPA designation was also still in progress. Therefore, the monitoring framework presents a list of generic indicators, protocols, and strategies that would support a monitoring plan, rather than an outline of the plan itself.

Unlike previous Canadian MPA monitoring frameworks, the monitoring framework for the St. Anns Bank AOI explicitly addresses the requirement for socio-economic monitoring, alongside the ecological and threat-oriented indicators. The socio-economic section was developed based on the recommendations of Bunce et al. (2000), Pomeroy et al. (2004) and

IOC (2006). This portion of the framework goes beyond the HOTO commitments of the Department's Science sector, and hence the SSRP did not review it.

Analysis and Response

Ecosystem Overview for the St. Anns Bank AOI

The ecosystem overview section of the monitoring framework describes some key aspects of the local ecosystems of the AOI as a foundation for the monitoring recommendations that follow. It should not be considered a final or definitive account of the structure and function of the AOI ecosystems, and should not be relied upon for such purposes. This section serves to provide an overview of the ecosystem as a whole rather than focusing on specific components.

The main physical, geological, and ecological components of the AOI ecosystem are reviewed in more detail, based on the data available (Ford and Serdynska 2013, Kenchington, 2013). Bathymetry was briefly described extending from the near shore areas off Scaterie Island to the Laurentian Channel. Surficial geology was also reviewed; however, available data specific to the AOI were limited. In general, bedrock patches usually occur in shallow areas (with some present at depth), the banks are usually covered in coarse sediments, from boulders to gravel and coarse sand, with St. Anns Bank itself having a mix of sand and gravel fractions. Finer sediments typically represent a higher percentage of total sediment loads as depth increases. Ongoing efforts continue to improve the understanding of sediment data via multibeam echosounder of the ocean floor in the AOI with the goal to complete the habitat characterization for the area.

The hydrodynamic review of the area was primarily based on regional data since data collection in the AOI has been minimal. Currents that move through the AOI are vertically stratified and dominated by the Gulf of St. Laurence outflow known as the Cape Breton Current. Once past Cape North, the bulk of the current continues along the Laurentian Channel, passing Sydney Bight, with some models suggesting a lesser southeastward flow over the banks within the Bight while other models suggest a clockwise gyre. In the AOI, much of the water proceeds towards Banquereau, where it becomes a principal contributor to the southwest-flowing Shelf Break Current. However, portions of the surface layer and cold intermediate layer (CIL) turn around Scatarie and down the coast as the Nova Scotia Current. These currents are usually less than 0.25 $m.s^{-1}$ or 0.5 knots and result in a typical water parcel moving from Cape North towards Banquereau passing through the AOI in approximately three days. Tidal currents, meteorological-driven flows, and, on rare occasions, ice cover also affect water movement.

Primary production in the AOI is dominated by phytoplankton, with a spring diatom bloom occurring from March to May. Macroalgae are found on Scaterie Bank at 45m depth; however, they do not represent a significant source of energy production for the AOI. In addition to local primary production, most of the energy coming into (and out of) the AOI results from energy fluxes across its boundaries. Such fluxes result from phytoplankton originating outside the AOI, floating detritus, and the biomass of migrant animals. This is a consequence of a small AOI with primarily unidirectional flow.

The pelagic fauna in the AOI has a high proportion of *Calanus* spp and euphausid krill at the lower trophic levels, and herring at the mid-trophic levels. There are a number of populations of herring that frequent or migrate through the area. For example, the Nova Scotia Atlantic coast and Bay of Fundy spawners overwinter in Sydney Bight. In addition, there is evidence suggesting that the Laurentian Channel portion of the AOI has a mesopelagic ecosystem with characteristic species and trophic interactions.

Much of the fish biomass in the AOI is comprised of migrant species, including long distance migrants, such as, sharks, tuna, and mackerel, and intra-regional migrants such as herring, cod, and other ground fish. There are some resident fish populations, such as cod, where the young juveniles spend time in the shallow waters and the older juveniles in the deeper bank waters that are characteristic in the AOI.

The benthic ecosystems in the AOI have resident benthic fauna, particularly shellfish (bivalves and crustaceans), as well as finfish, such as wolfish. Other distinctive benthic features of the AOI include a macroalgal patch (mentioned above), pock marks (hydrocarbon seeps), a sea pen field, crinoid patch, sponge patch, and a possible herring spawning bed. Finer scale detail of the benthic system requires spatially-specific information, which currently is absent.

The AOI is on the migration route for many species, such as baleen whales, tuna, seals, and leatherback turtles, to and from feeding and/or breeding grounds in the Gulf of St. Lawrence. Furthermore, many marine birds have colonies in the area and likely feed in the AOI during breeding season.

Knowledge of the current structure and function of the AOI ecosystem is poor, and less is known about earlier states of the system. There have been large scale human-induced pressures, such as mass exploitation of large groundfish, which have resulted in altered ecosystem structure and function. However, the transient nature of energy flows into and out of the system driven by the hydrodynamics of the area has not changed.

Although many of the ecological processes and characteristics described above extend beyond the AOI boundaries, the AOI can be considered representative of these ecological processes and characteristics. Furthermore, the flux across the AOI boundaries makes it difficult to ascertain the importance of the AOI as a source-sink. Thus, monitoring the impacts of the AOI as part of a larger MPA network would provide a measure of its benefits in the context of the bioregion.

For additional information on the ecosystem components of the AOI refer to Ford and Serdynska (2013) and Kenchington (2013).

A Monitoring Framework for the St. Anns Bank AOI

Conservation Goals and Objectives of the St. Anns Bank AOI

The conservation goals of the proposed MPA are to:

(i) protect and, where appropriate, restore biodiversity, ecosystem function, and the special natural features of the St. Anns Bank MPA (this includes communities, habitats, species, and populations, as well as the physical, chemical, biological and ecological processes on which they are dependent);
(ii) conserve, and ensure the ecologically sustainable use of living marine resources in the St. Anns Bank MPA; and
(iii) enhance ecosystem health and resilience, and support the ecologically sustainable use of living marine resources beyond the geographic boundaries of the proposed St. Anns Bank MPA.

Goal (ii) reflects the desire to support the sustainable use of living marine resources through low impact activities within certain parts of the MPA (providing they do not compromise the primary goal), whereas Goal (iii) reflects the intention for the MPA to provide ecological and economic benefits outside its geographic boundaries, as part of an MPA network.

As noted above, the ecosystem functions of the St. Anns Bank AOI are not well-understood, which poses a challenge for measuring progress toward the primary goal and highlights the need to develop more specific objectives for measurable components of the ecosystem.

Furthermore, certain species require special attention because they are sensitive to disturbance, are depleted, or play a particularly important role in the ecosystem. The conservation objectives presented below focus on components of the ecosystem for which reliable information exists – physical features, habitats, and certain priority species. The objectives are organized under the headings of *habitat*, *biodiversity*, and *productivity* to be consistent with DFO's Ecosystem Approach to Management Framework. They also reflect the conservation priorities recommended by DFO Science (DFO 2012).

Habitat

Protect, conserve and, where appropriate, restore:

- representative examples of all major benthic, demersal and pelagic habitats within the St. Anns Bank MPA along with their associated physical, chemical, geological and biological properties and processes;
- distinctive physical features and their associated ecological characteristics; and
- the structural habitat provided by seapen and sponge concentrations.

Biodiversity

Protect, conserve and, where appropriate, restore biodiversity at the community, species, population and genetic levels within the St. Anns Bank MPA, including, but not limited to:

- priority species[1] and their habitats; and
- the identified area of high fish diversity.

Productivity

Protect, conserve and, where appropriate, enhance productivity across all trophic levels so that they are able to fulfill their ecological role in the ecosystems of the St. Anns Bank MPA.

Monitoring Concepts and Strategy

The monitoring framework for the St. Anns Bank AOI is based around four groups of indicators: (i) background indicators to provide information on the natural drivers which will aid the interpretation of observed changes in other indicators; (ii) indicators of anthropogenic pressures and impacts to provide information on the scope and intensity of pressures impacting the ecosystem;(iii) effectiveness indicators to provide information on the effectiveness of management actions; and (iv) socio-economic indicators to provide information on the socio-economic effects of the MPA, should one be designated.

The principle task for the monitoring program is to track temporal changes (of the components / pressures that are being monitored) and to distinguish temporal changes due to anthropogenic pressures from natural variations. To accomplish this, the monitoring program requires appropriate indicators that can provide required information on the ecosystem structures and functions that are to be protected, as well as adequate sampling locations and sample size. Consistency and continuity in data collection, including the details of the sampling protocols, are essential for any monitoring program. This ensures that trends can be detected overtime without confusion caused by methodological changes, staff turnover, changing research interests, and evolving Departmental priorities. Furthermore, a monitoring program needs to be supported by baseline monitoring and a research program that will generate an understanding of the ecosystems of the MPA and, hence, a context for interpretation of the monitoring results.

[1] Priority species include those that were identified as Conservation Priorities at the Regional Science Advisory Process meeting in January 2012. They may be priorities because they are considered at risk or because they play an important role in the ecosystem (e.g., as a top predator or essential prey). Examples of priority species include: Leatherback Turtle, Atlantic Wolffish, Atlantic Cod, and Porbeagle Shark. The lists of species may be reviewed on a periodic basis.

An ideal monitoring plan would have sufficient indicators and data to capture all relevant changes occurring in the ecosystem, but such a plan would be prohibitively expensive. Therefore, selected indicators are required to provide adequate information about the state of the ecosystem, as well as the pressures that are likely to have an impact. However, caution is required for such a reductionist approach as there is an inherent risk that chosen indicators may miss important trends and changes in ecosystem structure and function. The most cost effective scenario for MPA monitoring is when data collected from other monitoring programs are useful and available. Another scenario is the extension or adaptation of existing field programs to serve the needs of MPA monitoring. When new field programs are required for collecting MPA monitoring data on a regular schedule, the costs can become prohibitive.

Anticipated Anthropogenic Pressures on the Ecosystem

There has been no comprehensive analysis of anthropogenic pressures acting on the ecosystems within the AOI but some of the more significant are likely to be:

- extractive use of fish and invertebrate populations by commercial and recreational fisheries, as well as during research and monitoring;
- disturbance of seabed habitats by bottom fisheries, research and monitoring sampling, pipelines and cables, industrial development (e.g., oil and gas activities), and vessel anchoring;
- entanglement of whales, seabirds, turtles, etc., by fishing gears;
- shipping traffic and the associated pressures of ship strikes and noise;
- release of chemical (e.g., oils), biological (e.g., organic garbage) and other (e.g., plastics) contaminants from vessels and industrial activities; and
- release and spread of aquatic invasive species, originating from vectors such as ballast water exchange.

It was also recognized that pressures within the proposed MPA originating from human activities outside the MPA need to be considered within the monitoring plan for the area.

Designing the Monitoring Framework

The St. Anns Bank monitoring framework was designed and developed to enable the effective management of the proposed MPA in the context of ensuring the draft conservation objectives are upheld. Since these conservation objectives are broad, the resulting monitoring framework is generic in nature and focused on the state of the ecosystem as a whole, rather than specific monitoring targeting identified conservation priorities.

In proposing the monitoring indicators for the framework, criteria, based on the recommendations of Kabuta and Laane (2003), Pomeroy et al. (2004), Wilson and Tsang (2007) and Kenchington (2010), were employed. These criteria suggested each indicator should be:

- capable of being monitored by non-invasive methods – causing neither harm nor disruption to the MPA's ecosystem,
- readily, swiftly and directly measurable, using simple, existing, proven instruments and analytical methods,
- capable of being monitored at an appropriate frequency to detect changes over time scales relevant to management,
- able to provide a signal that is detectable amidst the inevitable natural variability, without excessive cost,
- sensitive to the effects of management actions, with responses that are specific to known causes,
- relevant to management objectives or stakeholder concerns,

- cost efficient, maximizing the information gained while minimizing costs to Canadian taxpayers,
- solidly founded in scientific theory,
- supported by the scientists who will conduct the fieldwork and analyses,
- understandable to the public,
- selected in partnership with stakeholders,
- integral to the management process, and
- accompanied by a pre-existing baseline.

While all thirteen of the criteria were considered, the identification of indicators needs to consider an affordable means by which to approach effective monitoring of progress towards the proposed MPA objectives and the factors expected to influence that progress. Thus, cost is an important criterion to consider when selecting indicators for a monitoring framework. However, the proximity to shore and the relatively shallow depths of much of the AOI open the possibility of collaborating with local stakeholders, academia, and citizens in implementing aspects of the monitoring program.

When selecting indicators, it would be ideal to identify some component or aspect of an ecosystem that is sensitive to one class of anthropogenic pressures and easy to monitor with adequate precision at low cost. If monitoring showed no unacceptable change it could be concluded that the rest of the ecosystem was even less affected by that class of pressures. However, in MPA monitoring, the prime interest lies in ensuring protection of broad ecosystem attributes from a variety of anthropogenic pressures. As a result, it may be more difficult to identify such sensitive variables and monitor them affordably.

For management purposes, reference limits for the indicators should be identified to indicate where management intervention is required; however, it is not advised at this early stage to set reference limits for each indicator for use in rule-based decision making. The development of such reference limits requires comprehensive data relating to specific indicators and such data sets are currently unavailable for St. Anns Bank. Since MPA monitoring deals with whole complex ecosystems, the change in one indicator may not represent the need for management intervention; rather a change in a suite of indicators may be necessary prior to management action. The process requires adequate time for interpretation of monitoring results and for considered management responses to be designed and implemented. It also requires an understanding of the sensitivity and response time of the indicators.

The Recommended Monitoring Framework

Once fully developed, the recommended monitoring program for the proposed St. Anns Bank MPA is envisioned as comprising:

- the set of monitoring indicators, each accompanied by details specifying the data-collection protocols to be followed,
- the data collection,
- a secure and accessible archive (using new or existing managed databases) of all monitoring data, and
- a regular review, analysis and reporting of the monitoring information and associated scientific interpretations to MPA managers.

Baseline monitoring of the AOI is critical for the success of the monitoring program. It is advised that a wide variety of short-duration studies be completed to address the knowledge gaps in ecosystem structure and function. This information would support interpretation of observed trends in the monitoring data and their potential causes. The proposed monitoring framework is primarily focused on trend monitoring, though some suggestions for baseline monitoring are

offered. The lack of a more detailed analysis of baseline studies in this framework should not be misread as being any indication of their relative importance.

The final monitoring plan will evolve over time. At the completion of the proposed monitoring framework in November 2012, knowledge of the ecosystem structure and functions of the AOI was rudimentary and not sufficient to develop a final suite of indicators for monitoring. Some of the indicators may require methodological refinement and as baseline information is advanced and knowledge of ecosystem function in the AOI is increased, further analysis providing more specificity and detail, or perhaps shifts to multiple sub-indicators, may be required. Regular review and evaluation of the monitoring program is advised to identify and implement changes required to improve monitoring based on newly generated knowledge and analyses.

The list of indicators proposed in this monitoring framework (Table 1) is recommended as a suite of indicators that could capture the information required for MPA management in a cost-effective manner. While the list may be improved, any future alterations should be reviewed to ensure that the amended list still meets the minimum requirements for management purposes.

Selection of Appropriate and Meaningful Indicators as Related to the Conservation Objectives

The indicators presented in Table 1 were identified as a suite of indicators, grouped in various categories, to assess the Conservation Objectives for the proposed St. Anns Bank MPA.

Table 1: Recommended Monitoring indicators for the proposed St. Anns Bank MPA.

Background Indicators	
1	Temperature, salinity, oxygen concentration, light levels, chlorophyll, pigments, nutrients and zooplankton within the AOI and both upstream and downstream, as measured on the AZMP's Cabot Strait and Louisbourg lines, plus an additional line in the AOI.
2	Physical (e.g., temperature, salinity, wind, sea-surface height) and biological (e.g., ocean colour) sea surface properties in the MPA and the surrounding region.
3	Weather conditions at the Sydney Airport and Fourchu Head weather stations, including wind direction and speed, air pressure and sea-level air temperature.
4	Extent of ice cover within and around the MPA.
5	Fluxes, other than those of nekton, across the boundaries of the MPA.
6	Bentho-pelagic exchanges.
7	Phytoplankton production and the timing and intensity of the spring bloom in the MPA and the surrounding region.
8	Mesozooplankton community composition within the AOI and both upstream and downstream, as measured on the Atlantic Zone Monitoring Programs (AZMPs) Cabot Strait and Louisbourg lines, plus an additional line in the AOI.
9	Blooms of harmful algal in or near the MPA.

Effectiveness Indicators – Benthic Environments	
10	Diversity and community composition of the benthos, abundance or biomass and size composition of selected benthic taxa, and characteristics of surficial geology at selected sampling stations, distributed across the seabed environment types represented in the MPA (with particular emphasis on the habitats of species named in the objectives of the MPA, such as wolffish), as determined from selected dredge, grab, core, video and/or diver sampling methods.
11	Diversity and community composition of the benthos, abundance or biomass and size composition of selected benthic taxa and characteristics of surficial geology at comparable sampling stations outside the MPA, as determined from the same sampling methods used within the MPA.
12	Diversity and community composition of the benthos and characteristics of surficial geology at selected sampling stations located in the identified distinctive seabed features of the AOI, plus abundance or biomass and size composition of the defining benthic taxa of those features, as determined from selected dredge, grab, core, video and/or diver sampling.
13	Spatial extent of identified distinctive seabed features of the AOI.

Effectiveness Indicators – Fish and Fishery Resources	
14	Population-wide abundances and size distributions of those populations of resource species which utilize the MPA, as determined by fishery stock assessments.
15	Relative abundances, biomasses, size distributions and population fecundities of selected groundfish and invertebrates, plus diversity and community composition of trawl-vulnerable species, in appropriate portions of the MPA, as determined by groundfish and snow-crab trawl surveys.
16	Relative abundances, biomasses, size distributions and population fecundities of selected longline-vulnerable species in appropriate portions of the MPA, as determined by sentinel-fishery and halibut surveys.
17	Relative abundances, biomasses and size distributions of selected mesopelagic nekton and micronekton species in the Laurentian Channel portion of the MPA, as determined by midwater-trawl surveys.
18	Relative abundances, biomasses, size distributions and population fecundities of selected groundfish and invertebrates, plus diversity and community composition of trawl-vulnerable species, in comparable areas outside the MPA, as determined by groundfish and snow-crab trawl surveys.
19	Relative abundances, biomasses, size distributions and population fecundities of selected longline-vulnerable species in comparable areas outside the MPA, as determined by sentinel-fishery and halibut surveys.

Effectiveness Indicators – Fish and Fishery Resources	
20	Abundance of large wolffish in subtidal rocky areas along the coastline adjacent to the MPA, as determined by diver transect surveys.
21	Fluxes of fish and other nekton across the boundaries of the MPA.

Effectiveness Indicators – Marine Mammals, Seabirds, and Marine Reptiles	
22	Distributions, relative abundances, diversity, community composition and activities of mammals, birds and reptiles in the MPA, as determined by visual observation from boats, using standardized survey methodology.
23	Cetacean presence and activity in the MPA, year-round.
24	Grey and harp seal breeding in the vicinity of the AOI.
25	Seabird nesting in the vicinity of the AOI.

Effectiveness Indicators – Other	
26	Trophic relationships in the MPA.
27	Ecosystem function in the MPA.
28	Data inputs to the MARXAN analysis.

Anthropogenic Pressure and Impact Indicators	
29	Number and speeds of transits of, or past, the MPA by vessels other than pleasure craft, broken down into naval vessels, fishing vessels not fishing in the MPA, and other vessels.
30	Hours of operation within the MPA by vessels other than commercial fishing vessels or pleasure craft, broken down into research and monitoring vessels, other government vessels, ecotourism vessels, and all others.
31	Commercial and recreational fishing effort within the MPA.
32	Commercial and recreational fishing effort in close proximity to the MPA boundary.
33	Unauthorized fishing activity within the MPA.
34	Seabed area within the MPA swept by bottom-tending mobile commercial fishing, research and monitoring gears, both as a total and subdivided by zone or seabed habitat type.

Anthropogenic Pressure and Impact Indicators	
35	Seabed area within the MPA occupied by bottom-set commercial fishing, research and monitoring traps, both as a total and subdivided by zone or seabed habitat type.
36	Length of bottom-set fixed commercial fishing, research and monitoring lines set within the MPA, both as totals and subdivided by zone or seabed habitat type.
37	Number of vertical lines and length of midwater lines set within the MPA as part of commercial fishing, research or monitoring gears, both as a total and subdivided by zone.
38	Quantities and types of baits introduced to the MPA as part of commercial fishing, research or monitoring gears, both as a total and subdivided by zone.
39	Quantities of target and bycatch organisms removed from or discarded within the MPA by commercial, recreational, research and monitoring fishing, subdivided by type of organism and the nature of the human activity.
40	Number and types of seabed cables, offshore-petroleum exploration and development activities, other mineral exploration and development activities, channel dredging projects or other large-scale engineering works in the general vicinity of the MPA, including any within the MPA itself.
41	Incidents of vessels anchoring within the MPA.
42	Number of ballast-water exchanges within or in proximity to the MPA.
43	Number, quantities and types of other discharges from vessels of all kinds[2] or from offshore installations within or in proximity to the MPA.
44	Number, quantities and type of discharges from coastal sources within or in proximity to the MPA.
45	Types and concentrations of contaminants (including organic chemicals, heavy metals and plastics) in the biota, water column and seabed of the MPA, including contaminants derived from unexploded ordinance.
46	Quantity of large floating anthropogenic debris in the MPA.
47	Quantity of anthropogenic debris on the seabed of the MPA.
48	Incidents of whale or turtle entanglement, ship strikes or other interactions with humans in the MPA.
49	Incidents of whale or turtle strandings adjacent to the MPA.

[2] In the context of Indicator 43, “vessel” has the same meaning as in the International Collision Regulations, where it refers to any watercraft from small boats to large ships.

Anthropogenic Pressure and Impact Indicators	
50	Reports of known invasive species in the MPA and spread of established invasive species towards the MPA.
51	Characterization of deep-water natural and anthropogenic noise within the MPA.

Details on the rationale for each indicator and the protocols / methodologies for determining the indicator values are provided in Kenchington (2013).

Socio-economic considerations were not discussed at the meeting, although a suite of socio-economic indicators were proposed in Kenchington (2013). However, having robust socio-economic indicators were recognized as a required element for the monitoring program (e.g., cost-benefit analysis, goods and services analyses, etc.) to carry out a complete valuation of the MPA.

In addition to the 51 indicators, a number of additional monitoring indicators and surveys (Table 2), were considered and subsequently excluded during the development of this framework. The reasons for their exclusion are detailed in Kenchington, 2013.

Table 2: Monitoring indicators considered but rejected for the St. Anns Bank AOI.

	Indicator	**Reason for Rejection**
i	Phytoplankton production within the MPA	Costs due to multiple sampling efforts required to estimate brief spring bloom. Usefulness questionable due to flow through nature of water masses.
ii	Meroplanktonic egg and larval surveys	Costs to effectively survey. Usefulness of data from transitory fish species questionable; data from benthic invertebrates costly to capture.
iii	Seasonal trawl surveys	Costs of mounting additional surveys, and ice in winter and spring would be potentially hazardous.
iv	Acoustic surveys for redfish and other groundfish species	New monitoring program required over full range of species distribution that likely would be cost prohibitive.
v	Surveys for large and small pelagic fish	New monitoring program required that likely would be cost prohibitive. Monitoring sharks would impose unacceptable mortality rates to these species.
vi	Benthos on navigation buoys	No navigation buoys in the AOI and none in vicinity except close to shore.
vii	Distributions of species	May be more sensitive than abundance for detecting ecosystem change but likely cost prohibitive if routine effort required.
viii	Intra-specific genetic diversity	The costs of routine DNA analyses needed to monitor genetic diversity seem excessive for the information gained.

	Indicator	Reason for Rejection
ix	External connectedness	Requires extensive monitoring outside the MPA for potentially little gain except perhaps for sessile benthic organisms.
x	Vulnerable species	Will be important to consider as knowledge of the AOI ecosystem increases but currently not part of present framework.
xi	Anthropogenic marks on the seabed	The pressures causing such marks are recommended for monitoring, but at present the data expected from surveying the marks and their potential recovery is not deemed worth the cost.

Sources of Uncertainty

At the time of this process, conservation objectives and boundaries for the AOI were not finalized; thus identified indicators were general in nature. The selection of indicators, protocols and strategies for the MPA monitoring plan should only be developed once conservation objectives or priorities have been clearly identified and boundaries/management zones are outlined. Without these in place, it is unclear which ecosystem components will fall within the boundaries, and which threats/activities will be of concern. Thus the table above is a demonstration of the range of indicators that could be used to monitor the natural drivers, anthropogenic pressures and impacts and the effectiveness of management actions. The final set of indicators will a sub-set of these based on criteria such as tractability, redundancy and parsimony.

The implementation of a monitoring plan is highly influenced by the cost and allocated resources for MPA monitoring.

Conclusions

The monitoring framework document provided an overview of the St. Anns Bank AOI ecosystem upon which the future monitoring program should be based. Following a similar process used in the development of the Gully MPA monitoring framework, 51 broad categories of ecological indicators were proposed based on a set of criteria. The indicators were grouped into:

(i) background indicators (9);
(ii) effectiveness indicators related to the benthic environment (4);
(iii) effectiveness indicators related to the fish and fishery resources (8);
(iv) effectiveness indicators related to marine mammals, seabirds, and marine reptiles (4);
(v) other effectiveness indicators (3); and
(vi) activity and threat indicators (23).

The St. Anns Bank Monitoring Framework was designed and developed to enable the effective management of the proposed MPA in the context of ensuring the draft conservation objectives are met. Since those objectives are broad, the resulting monitoring framework is generic in nature and focused on the state of the ecosystem as a whole, rather than specific monitoring targeting identified conservation priorities. Baseline studies of the AOI are critical for the success of the monitoring program in order to establish baseline values for indicators, upon which management actions can be based.

Once fully developed, it is recommended that the monitoring program for the proposed St. Anns Bank MPA include:

- the set of monitoring indicators (i.e., a more refined set of the monitoring indicators outlined in Table 1), each accompanied by details specifying the data-collection protocols to be followed;
- data collection;
- a secure and accessible archive (using new or existing managed databases) of all the monitoring data; and
- a regular review, analysis and reporting of the monitoring information and associated scientific interpretations to MPA managers.

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