REVIEW OF ST. ANNS BANK MARINE PROTECTED AREA MONITORING: SELECTED RESEARCH ACTIVITIES, INDICATORS, AND GUIDANCE ON NEXT STEPS

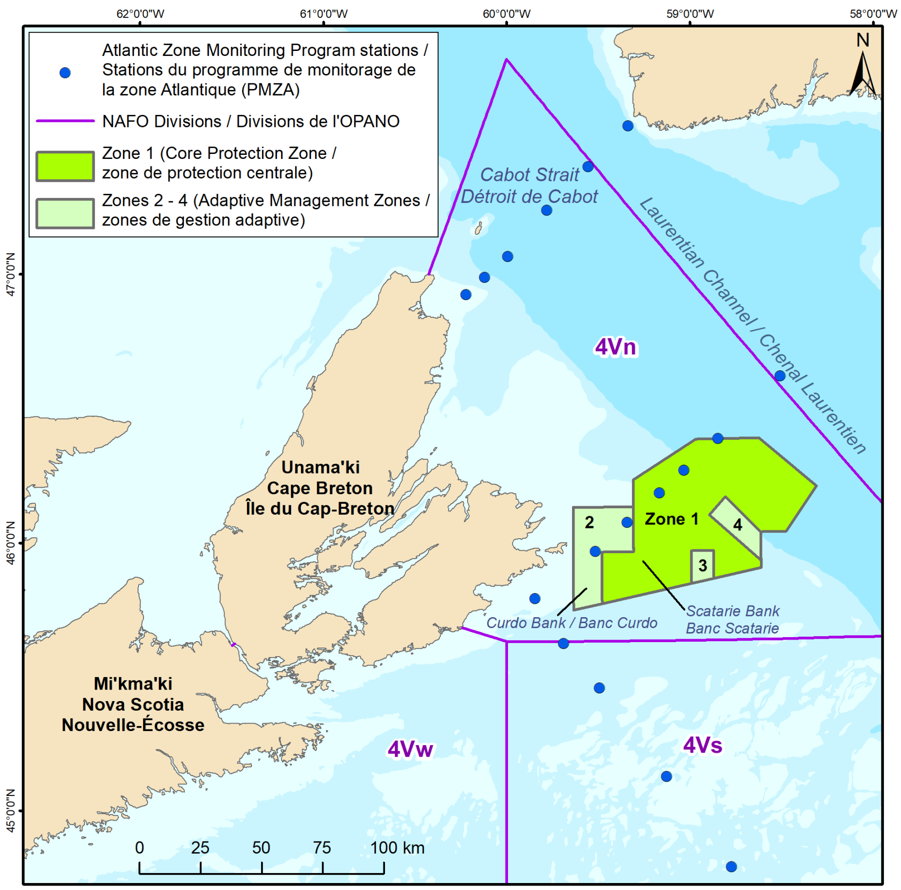

Figure 1. St. Anns Bank Marine Protected Area (green polygon) and its four management zones within the Scotian Shelf bioregion.

Context:

Fisheries and Oceans Canada (DFO) and partners implement monitoring programs in support of Marine Protected Areas (MPA) management. St. Anns Bank MPA was established as an MPA offshore of Cape Breton, Nova Scotia, in 2017. Active monitoring programs in the St. Anns Bank MPA have been underway since its establishment. A review of this scientific monitoring is needed to support the development and implementation of a long-term monitoring program. This meeting focused on reviewing several existing monitoring programs within the MPA and their utility for evaluating the conservation objectives of the site. Advice is provided on selected monitoring priorities, key monitoring gaps, and recommendations for modification of selected existing monitoring programs.

The objectives of this meeting were to review several monitoring and long-term data streams, evaluating their ability to determine if the MPA is meeting its conservation objectives and to provide advice on continued use and any modifications to enhance efficacy. The outcomes of the meeting provide an enhanced examination of the monitoring framework described in Kenchington (2014) in addition to updates on previously collected ecological information (Ford and Serdynska 2013). These objectives were accomplished through reviewing the following data collected from within and around the MPA:

- *Acoustic telemetry data collected by DFO and the Ocean Tracking Network;*
- *The DFO enhanced snow crab survey, including bycatch and diet data;*
- *DFO's data on cetacean occurrence, primarily from passive acoustic monitoring (PAM) efforts;*
- *Oceanographic data collection by the Maritimes Region Atlantic Zone Monitoring Program (AZMP) within the St. Anns Bank MPA, and trends in major physical (e.g., temperature, salinity), chemical (e.g., nutrients), and/or biological (e.g., ocean colour, zooplankton) oceanographic conditions within and upstream (Cabot Strait Line) and downstream (Louisbourg Line) of the MPA; and*
- *Other current and ongoing information and data streams including preliminary results where possible, from within and external to DFO, and how these data and information may contribute to the MPA's monitoring programs and ongoing management.*

This Science Advisory Report is from the regional peer review on the Review of St. Anns Bank Marine Protection Areas Monitoring: Selected Research Activities, Indicators, and Guidance on Next Steps held March 5–6, 2024 (and reconvened on June 17, 2024).

SUMMARY

- St. Anns Bank Marine Protected Area (MPA) was designated under Canada's *Oceans Act* in 2017. A data review was conducted to examine baseline data and ongoing survey data contributions towards monitoring the MPA's conservation objectives. Long-term data sources reviewed include the Atlantic Zone Monitoring Program's (AZMP) oceanographic and biological data, passive acoustic monitoring for cetaceans, acoustic telemetry to examine fish movement and diversity in and around the MPA, and the Maritimes Region's Snow Crab Survey.
- St. Anns Bank is situated in the outflow of the Gulf of St. Lawrence and shows similar year-to-year variability in oceanographic conditions when compared to areas upstream and downstream as measured on the inshore stations of the AZMP's Cabot Strait and Louisbourg monitoring lines, respectively. Annual satellite sea surface temperatures across the MPA have increased since 2012. St. Anns Bank water column temperatures from near-surface to bottom recorded during the fall have also increased since 2012, with most record highs observed post-2020, which is consistent with areas upstream and downstream.
- St. Anns Bank showed high variability in *in situ* chlorophyll-*a* and nutrient concentrations, which for surface conditions is partially related to the timing of sampling relative to the phytoplankton spring bloom. A statistically significant increasing trend has been observed in surface satellite chlorophyll-*a* concentrations time series, with above-normal anomalies occurring in the fall in recent years.
- Since 2012, emerging trends in biogeochemical properties in St. Anns Bank (e.g., decreasing zooplankton size structure, mostly at- or lower-than-normal *Calanus finmarchicus* abundance, although returning to above-normal abundances of *C. finmarchicus* in 2023) appears to be related to the shift to a warmer-water environment. The 3-year carbonate chemistry dataset suggests that the bottom waters of St. Anns Bank are susceptible to ocean acidification and should continue to be monitored.

- Comparative analysis of the physical, chemical, and lower-trophic level biological conditions in St. Anns Bank in relation to the inshore stations on core AZMP lines, Cabot Strait and Louisbourg, revealed spatial and temporal similarities among these areas. Given limited resources for direct environmental monitoring, it is feasible to infer environmental conditions in St. Anns Bank from data collected by satellite observations and nearby stations. However, to maintain a comprehensive understanding and ensure accurate monitoring of the MPA, continued AZMP monitoring of St. Anns Bank is advised.
- Catch and diet data were analyzed from the annual Maritimes Snow Crab Survey between 2015, when dedicated MPA stations were added, and 2023. Species richness of fishes and invertebrates based on catch data is comparable inside and immediately outside the MPA and appears to be stable over this time period. Diet data collected from fish stomachs by the survey increased the species richness captured in the MPA compared to the trawl catch alone. Diet composition largely overlaps in individuals of a given species captured inside versus outside the MPA, and appears relatively stable over time.
- From 2015 to 2023 the size structure for most fish species remained stable, with the exception of Atlantic Wolffish and Snow Crab, which both exhibited an increase in average size. These size increases corresponded with a rise in the biomass for each species. Although the abundance of Atlantic Wolffish and Snow Crab remained relatively stable, the increase in biomass implies a shift in the overall size structure at the survey stations.
- The Maritimes Snow Crab Survey using current dedicated stations appears adequate for detecting changes in fish and invertebrate species richness and abundance in the MPA. A more comprehensive examination of the MPA’s biodiversity and abundance of American Plaice and Snow Crab in particular would require additional survey effort. To reliably detect small changes in abundance inside and immediately outside the MPA using this survey would require either doubling the number of stations, as informed by the power analyses. Complementary, alternative, and non-invasive monitoring methods may also provide data to detect changes in abundance.
- A diverse assemblage of 19 cetacean species was detected through a combination of passive acoustic monitoring and opportunistic sightings in and around (within 50 nautical miles) St. Anns Bank MPA.
- Between 2015 and 2023, passive acoustic monitoring of six baleen whale species from five stations in the MPA revealed spatial and seasonal variability in occurrence. Blue, Fin, Sei, and Humpback Whales were detected year-round, while Minke and North Atlantic Right Whales were more sporadic and seasonal. Blue and Fin Whales occurred more commonly at deeper stations and call presence peaked in fall and winter. Humpback Whales occurred more commonly at on-shelf stations and call presence peaked in spring, and again in fall and winter. Sei Whales occurred at all stations and call presence peaked in summer. North Atlantic Right and Minke Whale calls occasionally occurred at almost all stations, mainly in fall.
- Relatively consistent acoustic presence at on-shelf stations suggests regular use of these areas by some species (e.g., Humpback Whales). Seasonal patterns in acoustic occurrence at deeper stations is likely linked to the broader scale movements of some species (e.g., Blue and Fin Whales) into and out of the Gulf of St. Lawrence.
- Continuing passive acoustic monitoring will enable assessment of year-round presence of cetacean species, particularly baleen whales, in selected areas of the MPA. This method offers near-continuous and seasonal information on species occurrence. To support

assessment of long-term trends in cetacean occurrence, future monitoring recommendations involve establishing consistent passive acoustic monitoring stations over time in both deeper and on-shelf waters of the MPA.

- The St. Anns Bank MPA tagging program (2015–2023) has provided information on the residency and movement of Atlantic Cod, Atlantic Halibut, and Atlantic Striped Wolffish within and through the MPA. Simultaneously, 33 other tagging projects have contributed to the monitoring of 13 species, including the following species that have sufficient data to examine long-term trends in species seasonal residency within and movement through the MPA: Atlantic Salmon, Bluefin Tuna, Blue Shark, Atlantic Cod, and White Shark.
- Tagged species detected include species resident in the MPA for most of the year (Atlantic Cod, Atlantic Halibut, Atlantic Wolffish), occurrence throughout summer-fall (Pelagic sharks, Bluefin Tuna), and short-term annual summer occurrence (Atlantic Salmon). Scatarie Bank was identified as a residency hotspot for the majority of species that have sufficient data to examine spatial trends, with the exception of Atlantic Salmon detected primarily in the east.
- To improve assessment of species' directional movement and spatial and temporal use of the MPA as it relates to the conservation objectives, the current acoustic telemetry array and tagging program should be re-evaluated and redesigned.
- The meeting independently reviewed long-term data sources. Future analysis can integrate these data for a more comprehensive understanding of the MPA that may reveal connections between the AZMP's oceanographic and biological data, cetacean monitoring through passive acoustics, fish movement and diversity using acoustic telemetry in and around the MPA, and the Maritimes Snow Crab Survey. Additionally, potential new long-term data sources may be explored to align with the MPA objectives.
- The utility and expectations of data streams within the MPA with a focus on their long-term reliability for effective monitoring, including their ability to evaluate trends over time, were reviewed with the intention of establishing realistic expectations for sustainable monitoring not only within the MPA but also across other conservation sites. This was an opportunity to reconcile the long-term data streams of current monitoring efforts with previous advice on indicators, thereby aligning the reliability of long-term data streams with the MPA's conservation objectives.
- Meeting participants recommended partnering with Rightsholders and Indigenous organizations to conduct monitoring initiatives in accordance with the vision outlined in the St. Anns Bank Marine Protected Area Management Plan.

BACKGROUND

St. Anns Bank (herein SAB) Marine Protected Area (MPA) was designated under Canada's *Oceans Act* in June 2017. SAB is a relatively large MPA (4,364 km^2) situated in the Eastern Scotian Shelf, offshore of Cape Breton Island, Nova Scotia (Figure 1). The MPA is divided into four management zones, comprising one core conservation zone (no-take) and three mixed-use areas where certain fishing activities are permitted, subject to specific regulations and restrictions. The ecological features of this area were summarized by Ford and Serdynska (2013) in an ecological overview of the then SAB Area of Interest (AOI), classifying the area into three benthic habitats: shallow inshore bank, the mid-depth continental shelf, and the continental slope descending into the Laurentian Channel. Important ecosystem components identified by Ford and Serdynska (2013) included diverse habitat features, high benthic and demersal fish diversity, and areas of diverse invertebrates including corals, sponges, echinoderms, and crustaceans. Benthic and demersal fish species typically found in abundance in the MPA include Atlantic Cod (*Gadus morhua*), American Plaice (*Hippoglossides platessoides*), Witch Flounder (*Glyptocephalus cynoglossus*), redfish (*Sebastes* spp.), Atlantic Wolffish (*Anarhichas lupus*), White Hake (*Urophycis tenuis*) and Silver Hake (*Merluccus bilinearis*), Smooth Skate (*Malacoraja senta*), and Thorny Skate (*Amblyraja radiata*). The MPA also forms part of the migration corridor from the Atlantic Ocean into the Gulf of St. Lawrence used by animals such as groundfish, tuna, sharks, cetaceans, and Leatherback Turtles (*Dermochelys coriacea*).

As an MPA designed for conserving diverse habitat types and associated species assemblages, SAB has the following conservation objectives structured around three thematic elements (DFO 2023):

1. Habitat

   Conserve and protect all benthic, demersal, and pelagic habitats in the MPA, the distinctive physical features and their associated ecological characteristics, and the structural habitat provided by sea pens and sponges in the MPA.

2. Biodiversity

   Conserve and protect marine areas of high biodiversity at the community, species, population and genetic levels within the SAB MPA, including:
   - Priority species and their habitats (including Leatherback Turtle, Atlantic Wolffish, Atlantic Cod, and American Plaice); and
   - Area(s) of high fish diversity within the site.

3. Productivity

   Conserve and protect biological productivity across all trophic levels so that they can fulfill their ecological role in the ecosystems of the SAB MPA.

Kenchington (2014) recommended 76 monitoring indicators to assess the effectiveness of SAB in achieving its proposed conservation objectives, which were similar to the conservation objectives provided above (DFO 2023). These indicators were chosen based on their feasibility for obtaining high-quality data in a cost-efficient manner, maximizing information gained while minimizing overall costs. Of these, 28 were categorized as “Background” and “Effectiveness” indicators, referring to primarily oceanographic and physical indicators and ecological indicators, respectively. The remaining indicators were related to anthropogenic pressures and socio-economic indicators. It was suggested that the monitoring needed to address the Background and Effectiveness indicators would be led by science programs within the federal government, but with the assistance of partners in Indigenous organizations, academia, other agencies and levels of government, and industry.

SAB MPA provides a unique opportunity to design and implement research and monitoring programs using various knowledge systems, including the principle of Etuaptmumk, or two-eyed seeing, where equal recognition and value is given to Mi’kmaq and empirical science knowledge systems. This is an important part of treaty obligations, nation-to-nation relationship building, co-governance of ocean environments, and Canada’s commitment to reconciliation and United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). Incorporating Indigenous perspectives is crucial for prioritizing and implementing long-term research and monitoring in the MPA. Working directly with Indigenous communities and organizations, particularly knowledge keepers and scientists provides greater expertise and a more holistic view of the ecosystem to put towards monitoring the MPA, benefitting both Fisheries and Oceans Canada (DFO) and Indigenous partners.

This SAB monitoring review presented here considered four primary research programs collected over multiple years by the federal government, that were intended to address a number of Background and Effectiveness indicators proposed by Kenchington (2014). A data review was conducted to examine baseline data and ongoing survey data contributions towards monitoring the MPA's conservation objectives. Long-term data sources reviewed include the Atlantic Zone Monitoring Program's (AZMP) oceanographic and biological data, passive acoustic monitoring for cetaceans, acoustic telemetry to examine fish movement and diversity in and around the MPA, and the Maritimes Region's Snow Crab Survey. Information obtained from these four research programs were evaluated to determine their utility for evaluating the MPA effectiveness, and to make recommendations for improvements to future monitoring efforts.

ANALYSIS

Atlantic Zone Monitoring Program

Trends in the main physical, chemical, and lower trophic-level biological conditions within the SAB MPA as measured by DFO's AZMP were evaluated from 2011 to 2023 and compared to the conditions both upstream and downstream of the MPA from inshore stations on AZMP's Cabot Strait and Louisbourg monitoring lines, respectively. Datasets evaluated included continuous vertical profiles of temperature, salinity, and density measured from Conductivity-Temperature-Depth (CTD) deployments and discrete samples of chemical (bottom pH and aragonite, chlorophyll-*a* and nutrient concentrations) and biological (zooplankton abundance and biomass) parameters collected seasonally during the AZMP's spring and fall missions and/or on DFO's Maritimes Summer Ecosystem Research Vessel Survey. Sea ice, sea surface temperature, and chlorophyll-*a* conditions derived from satellite data were also evaluated.

St. Anns Bank is situated in the outflow of the Gulf of St. Lawrence and shows similar year-to-year variability in oceanographic conditions when compared to areas upstream and downstream as measured on the inshore stations of the AZMP's Cabot Strait and Louisbourg monitoring lines, respectively. Annual satellite sea surface temperatures across the MPA have increased since 2012. St. Anns Bank water column temperatures from near-surface to bottom recorded during the fall have also increased since 2012, with most record highs observed post-2020, which is consistent with areas upstream and downstream. Although sea ice is not formed in the SAB MPA but is advected from its source in the Gulf of St. Lawrence, the first occurrence of sea ice in the area is shifting to later and the last occurrence earlier, resulting in a lower total duration of ice in the area.

St. Anns Bank showed high variability in *in situ* chlorophyll-*a* and nutrient concentrations, which for surface conditions is partially related to the timing of sampling relative to the phytoplankton spring bloom. A statistically significant increasing trend has been observed in surface satellite chlorophyll-*a* concentrations time series, with above-normal anomalies occurring in the fall in recent years. Since 2012, emerging trends in biogeochemical properties in St. Anns Bank (e.g., decreasing zooplankton size structure, mostly at- or lower-than-normal *Calanus finmarchicus* abundance, although returning to above-normal abundances of *C. finmarchicus* in 2023) appear to be related to the shift to a warmer-water environment. The 3-year carbonate chemistry dataset suggests that the bottom waters of St. Anns Bank are susceptible to ocean acidification and should continue to be monitored.

Comparative analyses of the physical, chemical, and lower-trophic level biological conditions in St. Anns Bank in relation to the inshore stations on core AZMP lines, Cabot Strait and Louisbourg, revealed spatial and temporal similarities among these areas. Given limited resources for direct environmental monitoring, it is feasible to infer environmental conditions in

SAB MPA from data collected by satellite observations and nearby stations. However, to maintain a comprehensive understanding and ensure accurate monitoring of the MPA, continued AZMP monitoring of St. Anns Bank is advised.

Maritimes Snow Crab Survey

Catch and diet data were analyzed from the annual Maritimes Snow Crab Survey between 2015, when dedicated MPA stations were added, and 2023. Species richness, accumulation curves, and analyses of community structure among stations and benthoscape classes were conducted. Species richness per sample was calculated as the number of unique taxa, including species, genus, family, and class levels. Species richness of fishes and invertebrates based on catch data is comparable inside and immediately outside the MPA and appears to be stable over this time period. Diet data collected from fish stomachs by the survey increased the species richness captured in the MPA compared to the trawl catch alone. Diet composition largely overlaps in individuals of a given species captured inside versus outside the MPA, and appears relatively stable over time.

The Maritimes Snow Crab Survey sweeps an average area of approximately 0.004 km^2 per set. Two stations occur in management Zone 2 of the MPA, while the rest occur in Zone 1, with no sets in Zones 3 and 4. From 2015 to 2023 the size structure for most fish species remained stable, with the exception of Atlantic Wolffish and Snow Crab, which both exhibited an increase in average size. These size increases corresponded with a rise in the biomass for each species. Although the abundance of Atlantic Wolffish and Snow Crab remained relatively stable, the increase in biomass implies a shift in the overall size structure at the survey stations. Species richness is slightly higher inside the MPA relative to outside, even when accounting for differences in sampling effort. Species accumulation curves show that the number of unique species found both inside and outside the MPA continues to increase. Overall species richness appears stable over time within the MPA but shows a slight decline across the five stations outside the MPA. Species richness both inside and outside the MPA increased with depth but was slightly higher within the MPA relative to outside.

Catch per unit effort (CPUE) as numbers caught per km^2 over time for the six most abundant species and overall species richness captured by the survey were modeled using a generalized linear mixed effects model with a negative binomial distribution. Following the model fitting using the survey data, the dependent values for each model was simulated using the negative binomial theta value extracted from the model for each species. The dataset for each species were simulated and modeled 1,000 times with varying power and effect sizes to determine the overall impact on the number of sampling stations on the ability to detect changes in species richness and CPUE over time. Species richness and abundances of most species can be adequately monitored with approximately 15 stations per year, but other species that are in high abundance in the MPA (e.g., American Plaice) may require additional sampling to adequately monitor changes in abundance.

Diet data from fish stomachs collected in the Maritimes Snow Crab Survey from 2015–2022 were also examined for species richness and differences in prey composition inside and outside the MPA. While diet data from the Maritimes Snow Crab Survey revealed higher species richness in the MPA relative to the trawl catch alone, it is unknown whether predators are feeding within or outside the MPA. Thus, it remains difficult to determine if this greater species richness is reflective of the MPA itself, or the broader northwest Atlantic.

The Snow Crab survey does not have any sampling stations in Zones 3 and 4 of the MPA, and thus, whether species richness and community structure are impacted by these management zones is unknown. Adding a station to each of these relatively small zones may be of benefit for monitoring but should avoid the "gravel with crinoids" benthoscape class due to the density of these organisms in these areas and the high potential for damage to them. The Snow Crab and other research trawl surveys do not effectively capture pelagic fish and invertebrates such as squid, jellyfish, euphausiids, and other plankton (Choi et al. 2018). While this survey can incidentally capture pelagic and planktonic species, such as Atlantic Herring and Mackerel, it is not a reliable source of data for these species. Trawl nets can also be less efficient for catching some taxa, such as sea pens. Imagery from remotely-operated vehicles or drop cameras can be more effective and accurate for monitoring diversity and abundance of sessile invertebrates at fine spatial scales.

The Maritimes Snow Crab Survey using current dedicated stations appears adequate for detecting changes in fish and invertebrate species richness and abundance in the MPA. A more comprehensive examination of the MPA's biodiversity and abundance of American Plaice and Snow Crab in particular would require additional survey effort. To reliably detect small changes in abundance inside and immediately outside the MPA using this survey would require doubling the number of stations, as informed by the power analyses. Complementary, alternative monitoring methods may also provide data to detect changes in abundance. Complementing trawl surveys with non-invasive approaches, such as camera and eDNA surveys, especially in regions with particularly sensitive benthic environments, may help to increase power to detect changes in a cost-efficient manner.

Cetacean Research and Monitoring Program

Cetacean occurrence in and around SAB MPA was assessed using opportunistic sightings and passive acoustic monitoring (PAM) data collected by the Climate Related Monitoring Program (CRMP) within DFO Maritimes Region Science Branch.

Sightings records were obtained from the DFO Maritimes Region Whale Sightings Database (WSDB)—a repository for sightings records collected from vessels of opportunity and dedicated cetacean surveys across the Maritimes and other regions. All sightings obtained from the WSDB were treated as opportunistic, since observation effort has not been quantified and reliability of the records may vary. The distribution of cetacean sightings in the WSDB thus largely reflects observer effort and cannot be used to estimate true species distribution or abundance. However, these sightings data provide valuable information on the diversity of cetacean species occurring within and around the SAB MPA.

Cetacean sightings were examined within an area extending 50 nautical miles in each direction from the MPA boundaries, to provide broader spatial context for species occurrence within the MPA and allow for comparison to the previously published ecological overview of SAB (Ford and Serdynska 2013). A diverse assemblage of 19 cetacean species was detected through a combination of passive acoustic monitoring and opportunistic sightings in and around (within 50 nautical miles) SAB MPA. Within the boundaries of the MPA, there were 73 sightings of 9 species. Long-finned Pilot Whales (*Globicephala melas*) and Common Dolphins (*Delphinus delphis*) were the most frequently identified species. Blue (*Balaenoptera musculus*), Fin (*B. physalus*), Sei (*B. borealis*), Humpback (*Megaptera novaeangliae*), Minke (*B. acutorostrata*), and North Atlantic Right (*Eubalaena glacialis*) whales were each identified within the MPA at least once, and Minke and Humpback Whales were the most frequently identified baleen whale species.

PAM was conducted using bottom-mounted recorders deployed at various locations within the SAB MPA between June 2015 and August 2023. A total of 9 mooring deployments were conducted at five recording stations: two stations located in deeper waters (> 300 m) in the Laurentian Channel and three stations located in shallower on-shelf waters (< 100 m). Not every station was sampled every year throughout the study period, with deployment recording durations ranging from slightly over one month to more than one year. Between 2015 and 2023, passive acoustic monitoring of six baleen whale species from five stations in the MPA revealed spatial and seasonal variability in occurrence. Blue, Fin, Sei, and Humpback Whales were detected year-round, while Minke and North Atlantic Right Whales were more sporadic and seasonal. Blue and Fin whales occurred more commonly at deeper stations and call presence peaked in fall and winter. Humpback Whales occurred more commonly at on-shelf stations and call presence peaked in spring, and again in fall and winter. Sei Whales occurred at all stations and call presence peaked in summer. North Atlantic Right and Minke whale calls occasionally occurred at almost all stations, mainly in fall.

To determine the daily occurrence of calls produced by baleen whale species, acoustic datasets were processed using automated detectors, designed to identify the species-specific calls of Blue, Fin, Sei, Humpback, and North Atlantic Right Whales. The automated detectors were designed to minimize the chances of missing target calls, but also generated false autodetections. To verify daily presence of each species, spectrograms were visually and aurally reviewed when autodetections were present, to confirm the presence of correctly identified calls. No automated detector was available for Minke Whales; instead, all acoustic data were visually reviewed using long-term spectral averages, which facilitated the identification of Minke Whale calls.

There are several general caveats associated with the PAM data: most recordings were collected using duty-cycled recording schedules, which included non-recording periods; automated detectors likely miss some calls; anthropogenic noise can mask whale calls on the recordings, or cause whales to call less frequently; detection ranges from each recording station vary with species, call type, and ambient noise conditions; and whales may be present in an area but not calling, and thus be missed. These data, therefore, provide a record of minimum call presence, and the absence of calls should not be interpreted to mean an absence of individuals.

All six species of baleen whales were present in the acoustic recordings, and all except North Atlantic Right Whales were recorded at least once at every recording station. Blue and Fin Whale calls were most prevalent at the deeper stations within the Laurentian Channel (present on 59–73% of recording days) and were recorded less frequently at the shallower on-shelf stations (3–48% of days). By contrast, Humpback Whale calls were recorded less frequently at the deeper stations (18% of days) and were more prevalent at the on-shelf stations (> 42% of days). Calls produced by Sei, Minke, and North Atlantic Right Whales were recorded more sporadically across stations, with no clear spatial patterns observed.

Seasonally, Blue Whale calls were recorded year-round in the MPA, with highest daily occurrence in fall. Fin and Humpback Whale calls were also recorded almost year-round: Fin Whale calls were present consistently throughout fall and winter followed by reduced occurrence in the summer; Humpback Whale call presence peaked in spring, and again in fall and winter. Although Sei Whale calls were recorded less frequently, they were generally present throughout the year with a peak in summer and a decline in winter. North Atlantic Right Whales and Minke Whales were recorded primarily between July and December.

These results revealed spatial and seasonal variability in species occurrence within the MPA. Relatively consistent acoustic presence at on-shelf stations suggests regular use of these areas by some species (e.g., Humpback Whales). Seasonal patterns in acoustic occurrence at deeper stations is likely linked to the broader scale movements of some species (e.g., Blue and Fin Whales) into and out of the Gulf of St Lawrence.

The results presented here demonstrate the significance of SAB within the broader distribution of cetaceans in eastern Canada, supporting its role as part of cetacean migration routes. Sightings data provide information on species diversity in the area, while PAM data provides means of assessing species occurrence throughout the year. Continuing passive acoustic monitoring will enable assessment of year-round presence of cetacean species, particularly baleen whales, in selected areas of the MPA. This method offers near-continuous and seasonal information on species occurrence. To support assessment of long-term trends in cetacean occurrence, future monitoring recommendations involve establishing consistent passive acoustic monitoring stations over time in both deeper and on-shelf waters of the MPA.

Acoustic Telemetry Monitoring Program

Since 2015, acoustic receivers have been deployed in SAB MPA under various configurations with two primary objectives. Firstly, to ascertain the movement and residency patterns of marine animals tagged within SAB, most of which are likely to be temporarily or permanently resident within the area. Secondly, to determine the movement and residency of animals tagged by other projects (DFO and external) that are detected by receivers in the MPA in collaboration with the Ocean Tracking Network (Dalhousie University, Halifax, NS) that bring data holders together and provide a database for sharing data. These animals predominantly utilize the habitats of the MPA when transiting between the Gulf of St. Lawrence and the Atlantic Ocean.

Acoustic telemetry is a technique used for tracking aquatic animal movement and residency whereby electronic transmitters are attached to the animal and the animal is detectable using acoustic telemetry receivers that are placed in fixed positions close to the seabed, on glider drones, or large animals using recoverable packages (Hussey et al. 2017). When a tagged animal moves near a receiver, the sequence of transmissions from the tag is recorded by the receiver, providing a unique identifier for each individual, the time and date of detection with the location of the receiver, and data from tags that have sensors (e.g., temperature, depth). Receivers were re-deployed annually, and data offloaded from 2015–2023. In 2015 two lines (“gates”) were deployed composed of 26 receivers, 13 in each line. In 2016–2021, there were 46–48 receivers split equally between two lines. In 2021, the array of receivers was redesigned into one long line with a bend in the middle.

Atlantic Halibut, Atlantic Cod, and Atlantic Wolffish were collected and tagged by the SAB MPA fish tagging program while adhering to approved Animal Care protocols using traps or longline. The tag was inserted using minor surgery, and the fish released in the MPA. In addition to tag detections recorded from tags deployed as part of the MPA tagging project, data were also summarized from detections of fish tagged by other projects outside the MPA that were collected opportunistically.

Detections and metadata were first uploaded to the Ocean Tracking Network (OTN) data portal where they underwent quality control and entered the global detection database. The data were then filtered to remove improbable detections including single detections and based on the timing and location of detections relative to the animals expected swim speed. Detection data were then split into 12-hour detection bins and metrics calculated including the timing of detections in each bin, residency (days detected), and the number of individuals and locations detected. Analysis of Variance was used to compare metrics between locations and years. Linear models were used to examine potential trends in annual and seasonal residency with fixed effects month, year, hourly depth, hourly bottom temperature (both recorded by the receivers), and habitat type from benthoscape habitat classification. Individual ID was included as a random effect in the models. Only species with a sample size (individuals detected) of five or greater were included in the models.

Since the initial deployment of an acoustic telemetry array in SAB in 2015 to the latest data offload in August 2023, the SAB MPA tagging program has provided information on the residency and movement of Atlantic Cod, Atlantic Halibut, and Atlantic Striped Wolffish within and through the MPA. Simultaneously, 33 other tagging projects have contributed to the monitoring of 13 species, including the following species that have sufficient data to examine long-term trends in species seasonal residency within and movement through the MPA: Atlantic Salmon, Bluefin Tuna, Blue Shark, Atlantic Cod, and White Shark. Tagged species detected include species resident in the MPA for most of the year (Atlantic Cod, Atlantic Halibut, Atlantic Wolffish), occurrence throughout summer-fall (pelagic sharks, Bluefin Tuna), and short-term annual summer occurrence (Atlantic Salmon). Scatarie Bank (Figure 1) was identified as a residency hotspot for the majority of species for which there are sufficient data to examine spatial trends, with the exception for Atlantic Salmon detected primarily in the east.

Detections of tagged animals by the SAB acoustic telemetry array provided direct evidence of species use of the MPA as a seasonal migratory corridor. The timing and location of latitudinal pathways used by multiple fish species was identified with connectivity to the Gulf of St. Lawrence, Nova Scotian south shore, Newfoundland coast, the United States eastern seaboard, and eleven freshwater systems throughout Canada and the United States. This information adds to previous findings that support the priority of connectivity including the 2013 Mi'kmaq Traditional Use Study (Membertou Geomatics Solutions unpublished[1]), the establishment of a new Indigenous Protected and Conserved Area (IPCA) and National Wildlife Area (NWA) in the area, and species at risk detection.

The acoustic telemetry data collected to date from the two array designs indicated that to improve assessment of species' directional movement and spatial and temporal use of the MPA as it relates to the conservation objectives, the current acoustic telemetry array and tagging program should be re-evaluated and redesigned. For example, implementing multiple gates would provide directional movement through the MPA and a grid would allow for the utilization of probabilistic movement models to assess spatial coverage and efficacy relative to specific features of the MPA. Any redesign should also consider balancing short-term experimental use of acoustic telemetry to address specific research questions (e.g., habitat use) versus the deployment of arrays in consistent locations for evaluating long-term trends.

Tracking fish residency and movement using acoustic telemetry is dependent on the tagging work completed and the location of receivers that detect the tags. Tagging in the MPA has primarily occurred closer to land in the western part of the array due to logistical constraints. It is recommended to increase tagging in the eastern part of the array to verify residency over Scatarie Bank. In contrast, tags from other projects that were also primarily detected over Scatarie Bank were tagged beyond the MPA boundaries, thus providing more robust evidence of the importance of the bank for these species. The value of this technology as a monitoring tool is partly dependent on ongoing tagging efforts of other projects and it is fortunate that there is a high frequency of tagging conducted throughout the west Atlantic to support the current conclusions, including species such as Bluefin Tuna, White Shark, and Atlantic Salmon with tagging programs spanning almost a decade that allow for monitoring of long-term trends.

[1] Membertou Geomatics Solutions. Unpublished. Mi'kmaq Traditional Use Study St. Anns Bank Area of Interest. Final Contract Report March 20, 2013 submitted to Fisheries and Oceans Canada.

Making full use of detections of externally tagged individuals for monitoring involves tracking down associated metadata from projects with various data use policies. For example, total individuals tagged for each species is not immediately available from other projects and would be required to better contribute to assessment of trends in diversity and abundance. There is momentum towards fully open access telemetry data in conservation research to facilitate monitoring, through collaboration with the Ocean Tracking Network, DFO data management, and regional and international leads of other projects.

Sources of Uncertainty

Most climatologies calculated for the AZMP's core monitoring lines are based on 30 years of data, which are necessary to interpret shorter-term climate variability from longer-term climate change. The climatology developed for the SAB MPA was based on a limited time series (2011–2023), and gaps in the survey data prevented a full outlook on trending environmental conditions in the MPA. While increasing trends in surface and water column temperatures in the MPA were evident, it remains unknown how the ecosystems of SAB will respond to warming conditions and climate change. As the research programs presented at this meeting were analysed independently, trends in ocean conditions were not compared with animal diversity or abundance metrics. The biological impacts of climate change specific to this MPA remain uncertain, but may include species range shifts, reduced fitness, and reduced capacity for growth in species requiring calcium carbonate, such as molluscs, crustaceans, and corals. Future effort should be placed on identifying present day environmental envelopes of key species residing in the MPA, to serve as a basis for which to judge future climate change impacts.

Some parts of the MPA, particularly the northernmost parts of Zones 1 and 2 remain largely unsampled, as does the deepest portion of the MPA (i.e., the slope and Laurentian Channel). These areas lack multibeam data that could be used to fill in the benthoscape maps created for the MPA, and are not sampled by the Maritimes Snow Crab Survey, and only rarely by the Maritimes Summer Ecosystem Research Vessel Survey. Efforts in the future could focus on these under sampled areas to characterize benthic habitats and macrophyte and animal diversity. In the deeper portions of the MPA in the channel habitat (> 250 m depth), acoustic telemetry, camera, and eDNA surveys may be more suitable than trawl sets. To increase the cost efficiency of a mission to the deep habitats of the MPA, efforts could be shared with the nearby and similarly deep Laurentian Channel MPA monitored by Newfoundland and Labrador Region.

CONCLUSIONS AND ADVICE

The meeting independently reviewed long-term data sources. Future analysis can integrate these data for a more comprehensive understanding of the MPA that may reveal connections between the AZMP's oceanographic and biological data, cetacean monitoring through sightings and passive acoustics, fish movement and diversity using acoustic telemetry in and around the MPA, and the Maritimes Snow Crab Survey. Additionally, potential new long-term data sources may be explored to align with the MPA objectives. The utility and expectations of data streams within the MPA with a focus on their long-term reliability for effective monitoring, including evaluating trends over time where possible, was assessed. The intent of this assessment was to establish realistic expectations for sustainable monitoring not only within the MPA but also across other conservation sites. This is an opportunity to reconcile the long-term data streams of current monitoring efforts with previous advice on indicators, thereby aligning the reliability of long-term data streams with the MPA's conservation objectives.

Trends in the data from four research programs were examined when time series were available, but due to the nature of some sampling stations changing (e.g., cetacean PAM sites and fish acoustic telemetry lines) this was not always possible. A recommendation common to each of these data streams, and other data sources that become available (e.g., the Maritimes Summer Ecosystem Research Vessel Survey), is to maintain fixed stations for sampling and instrument deployment to create long-term time series to more easily identify trends over time. Specific to the four research programs analyzed, the recommendations include:

1. For AZMP, to continue the survey as it exists within the MPA and the Cabot and Louisbourg Lines to provide longer-term data to monitor climate change, and integrate these data with any identified biological trends;
2. Moving or adding trawl stations into management Zones 3 and 4, where no stations exist, while still avoiding sensitive benthic habitats. Alternatively, non-invasive methods such as underwater imagery or eDNA surveys could complement the trawl survey data without the addition of new stations;
3. Long-term PAM mooring sites, that do not change over time, should be established in different parts of the MPA (e.g., in shallow water and in the deep channel portion) to monitor cetacean presence in and around the MPA; and
4. The current line of 46 acoustic receivers used to detect animal movements through the MPA should be maintained, and could be expanded to include more receivers or fine-scale grids of receivers in some locations to better understand animal movements and behaviour on finer spatial and temporal scales.

Suggested modifications to the monitoring effort also include establishing a secure and accessible archive, utilizing either new or existing managed databases, to house all monitoring data (or metadata, if more appropriate) in an Open Data format. Additionally, a routine review, analysis, and reporting of the monitoring information, along with associated scientific interpretations, should be conducted to provide timely insights to MPA managers and external stakeholders.

A science-focused workshop following the CSAS was held to present and discuss new and short-term research and monitoring projects occurring in SAB. The utility of these newer data streams for monitoring the MPA were discussed. For instance, collaboration with Mi’kmaq guardians could support the expansion of species-specific efforts and data collection which meets the conservation goals of Indigenous communities and DFO.

Monitoring programs must align with MPA objectives and management decisions to effectively support conservation efforts. The SAB conservation objectives are generalized to protecting biodiversity, habitats, and productivity, a synoptic monitoring program will require the contributions of numerous research programs focusing on physical, oceanographic, and biological systems. Investments, modifications, or expansions in monitoring programs should prioritize providing precise information tailored to the specific management needs and objectives of the site, namely the preservation of species and habitat diversity. Beyond SAB, monitoring efforts could be harmonized and shared among nearby or similar MPAs. For example, the Laurentian Channel MPA sits only 40 km from SAB, and the Banc-des-Américains MPA (Figure 2) shares many similarities with SAB in terms of habitat types and communities. As Marine Conservation Targets are met regionally and nationally, it becomes important for monitoring programs to adapt to the evolving management context of conservation areas.

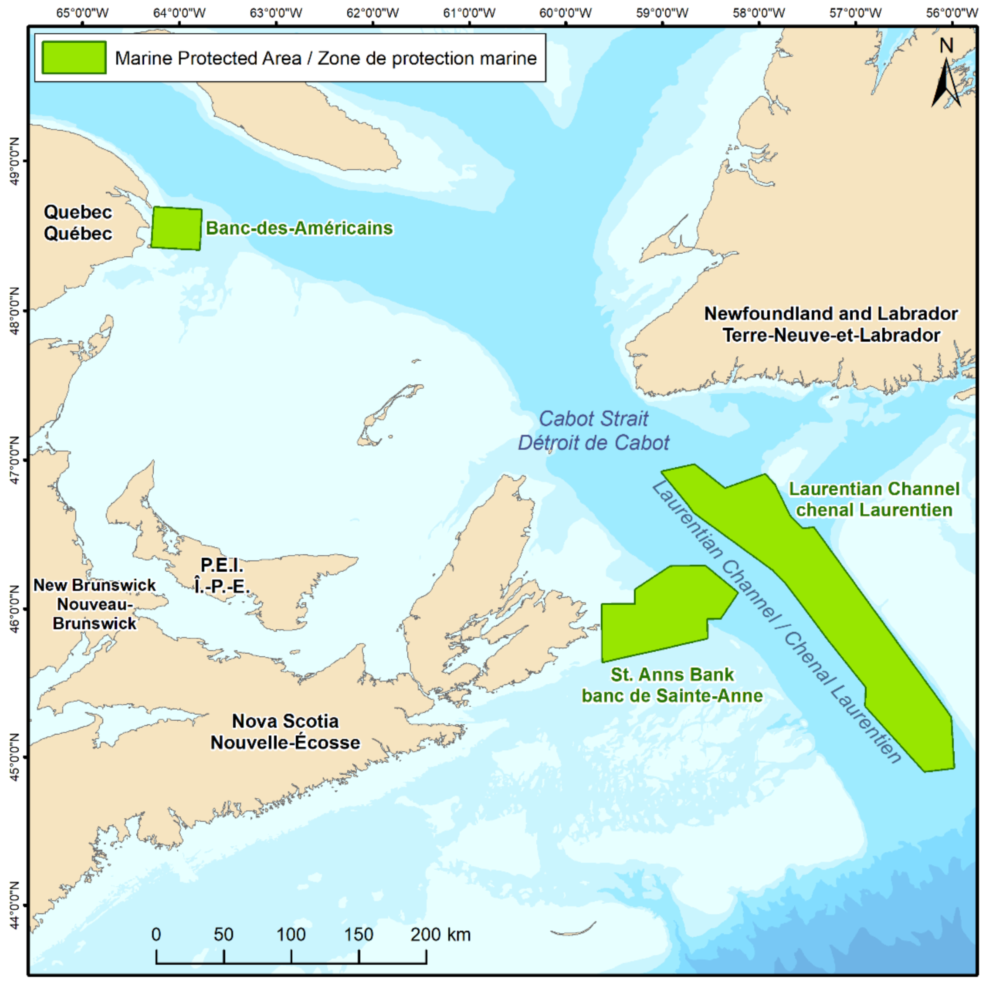

Figure 2. Map showing the St. Anns Bank Marine Protected Area geographic location in relation to Banc-des-Américains and Laurentian Channel Marine Protected Areas.

Mi'kmaq Rights and Title

Meeting participants recommended partnering with Mi'kmaq Rightsholders to conduct monitoring initiatives in accordance with the vision outlined in the SAB MPA Management Plan. This inclusion aligns with the Prime Minister's Mandate Letters to the Minister of Fisheries, Oceans and the Canadian Coast Guard and DFO's broader obligations under the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP 2007), as well as, associated Canadian legislation, such as the *United Nations Declaration on the Rights of Indigenous Peoples Act* (UNDA). This recommendation for partnering also reflects the commitment to upholding Indigenous peoples' rights to self-governance and participation in decision-making as stated in the DFO-Coast Guard Reconciliation Strategy and DFO's commitments to advancing co-governance of SAB with the Mi'kmaq of Nova Scotia. SAB stands out for its pioneering efforts in advancing co-governance with the Mi'kmaq of Nova Scotia, making it imperative to include Indigenous knowledge and perspectives in the shared decision-making process regarding monitoring strategies and priorities within the MPA.

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SOURCES OF INFORMATION

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