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Quebec and Gulf Regions **Science Response 2020/013**

ASSESSMENT TO SUPPORT DECISIONS ON AUTHORIZING SCIENTIFIC SURVEYS WITH BOTTOM CONTACTING GEARS IN PROTECTED AREAS IN THE ESTUARY AND GULF OF ST. LAWRENCE

Context

Canada is rapidly increasing the number of protected areas in its coastal and marine waters to meet international conservation targets. This has created an urgent need for approaches to determine which human activities will be allowed within these areas in light of site-specific conservation objectives and monitoring requirements. Scientific activities contribute information that can support conservation-related management decision-making within protected areas and in the broader ecosystem (e.g., advice for sustainable fisheries, species recovery, and ecosystem status). However, these same scientific activities can harm organisms, populations, assemblages and habitats within protected areas and therefore can hinder the achievement of conservation objectives. Fisheries and Oceans Canada's (DFO) national "Framework to support decisions on authorizing scientific surveys with bottom-contacting gears in protected areas with defined benthic conservation objectives" (DFO 2018) guides the impact-benefit evaluation of ongoing recurrent scientific activities (surveys) within protected areas. The Framework evaluates four main elements: 1) the potential impact of recurring survey activities within protected areas, 2) potential mitigation measures to reduce their impact, 3) benefits of survey activities to the management of protected areas, and 4) potential consequences to the scientific understanding and management of species and communities in the broader ecosystem caused by excluding sampling in protected areas.

This Science Response Report results from the Science Response Process of September 12, 2019 on the application of the framework to support decisions on authorizing scientific surveys with bottom-contacting gears in protected areas with defined benthic conservation objectives in the Estuary and Gulf of St. Lawrence (EGSL). The evaluation includes Marine Protected Areas (MPA) designated under the Oceans Act and fishery area closures under the Fisheries Act that qualify as "other effective area-based conservation measures", also termed marine refuges. A more detailed evaluation is presented in Benoît et al. (2020a).

The assessment and advice arising from this process will be used to inform decision-making on authorizing recurring scientific surveys using bottom-contacting gears in marine protected areas and marine refuges in the EGSL. These decisions are under the purview of DFO's Oceans and Resource Management sectors and will be made in consultation and collaboration with DFO's Science Branch.

Background

National framework

The national framework to guide the evaluation of ongoing recurrent scientific activities (surveys) within protected areas comprises four main elements (DFO 2018).

1) An evaluation of the potential impact of survey activities within protected areas.

Scientific activities should not compromise achieving the area-wide conservation objectives established for the protected areas. This evaluation is most reliably achieved through direct before-after-control-impact (BACI) type experiments. Oftentimes, such experiments have not yet occurred in the area of interest, and proxies of impact and the potential of benthic communities to recover from impacts are required. The national framework proposed the proportion of a protected area swept by sampling gear annually across all surveys as an important metric of impact on benthic habitat, as well as benthic and demersal taxa. The inverse of this metric is the recurrence time interval of impacts, i.e., the average number of years between two sampling events at a particular location. A measure of the potential for long term harm caused by sampling is the recurrence time interval of the activity relative to the expected recovery time (resilience) of the biological components of interest. A proxy for the expected recovery time is the longevity of the benthic or demersal ecological components of interest. Activity recurrence time intervals that are at least one order of magnitude greater than the longevity of the least resilient taxon or benthic feature are assumed to not result in long-term harm and therefore should not compromise achievement of protected area conservation objectives. In the absence of information on longevity, other factors such as reproductive patterns and the breadth of distribution and environmental tolerance can provide an indication of resilience.

2) An evaluation of potential mitigation measures that could reduce the impact of scientific activities in the protected areas.

These measures could include using less damaging gear, modifying other sampling procedures to reduce benthic impacts, reducing the swept area of individual survey hauls, and reducing the sampling density, including by reducing the number of surveys that operate in an area.

3) An evaluation of the benefits of survey activities to the management of protected areas.

This is of particular importance for the permitting of scientific activities in Marine Protected Areas under the Oceans Act, where such benefits are a requirement. These benefits could include sampling within and outside protected areas that allows for a determination of the efficacy of protected areas for the conservation of key taxa (e.g., Kerr et al. 2019), sampling to better understand the distribution of taxa and diversity within protected areas, or the collection of samples to better understand the identity and biology of taxa in the areas.

4) An evaluation of the potential consequences of excluding survey sampling in protected areas.

These consequences include the generation of biases in abundance indices for taxa in the broader ecosystem which are used to produce scientific advice for the management of fishery resources and depleted species, including species at risk, and for ecosystem monitoring and reporting. A particular concern is that exclusion could lead to time-varying biases in abundance indices. The main method for evaluating the likelihood of this outcome is by retrospective analyses, in which original abundance indices are compared to recalculated indices in which data for sampling sets with geographic coordinates occurring within the boundaries of the protected area(s) are excluded.

All four elements were evaluated for the relevant protected areas and surveys in the Estuary and Gulf of St. Lawrence (EGSL) following the methods outlined in DFO (2018) and detailed in Benoît et al. (2020a).

Protected areas in the EGSL

The protected areas in the EGSL include Marine Protected Areas (MPA) designated under the Oceans Act and fishery area closures under the Fisheries Act that qualify as “other effective area-based conservation measures”, also termed marine refuges. There are currently 19 marine refuges and two MPAs in the EGSL. Five marine refuges and the Basin Head MPA were excluded from this assessment as they either do not have defined conservations objectives aimed at protecting benthic species, assemblages or benthic habitat features, or there are no recurring scientific surveys employing bottom-contacting gear within their boundaries.

The geographic locations of the 14 marine refuges and the Banc-des-Américains MPA in the EGSL relevant to this report are shown in Figure 1. The following acronyms are used with respect to the marine refuges:

- SFA – scallop fishing area,
- CCA – coral conservation area,
- SCA – sponge conservation area, and
- CSCA – coral and sponge conservation area.

The conservation objectives, referred to as ‘ecological components of interest’ for refuges and prohibitions for the relevant marine refuges in the EGSL are summarized in Appendix Table 1.

The Banc-des-Américains MPA comprises two zones (Fig. 1). Zone 2 is divided into two parts, northeast and southwest of Zone 1, which are collectively referred to as zone 2 in this report. The purpose of this MPA is to promote the productivity and diversity of fishery resources on the Banc-des-Américains and the plains adjacent to it, as well as the recovery of species at risk (Appendix Table 1).

Of relevance to the present report, article 10(1) of the Banc-des-Américains MPA regulations (SOR/2019-50) requires Ministerial approval for scientific research or monitoring activities in the MPA. The completion of a research plan for activities in a MPA, the elements of which are defined by regulation, is required. The information provided to complete the evaluation in this Science Response Report using the National Framework (DFO 2018) will be useful for the development of the MPA research plans but it does not cover all the elements required for consideration of authorization of research activities in the MPA.

In contrast to MPAs, there is currently no requirement for a formal activity plan for proposed scientific activities in marine refuges. Permitting of scientific activities that result in the removal of fish, including within marine refuges, is done under section 52 of the Fishery (General) Regulations (SOR/93-53), administered by DFO Fisheries and Aquaculture Management Branch.

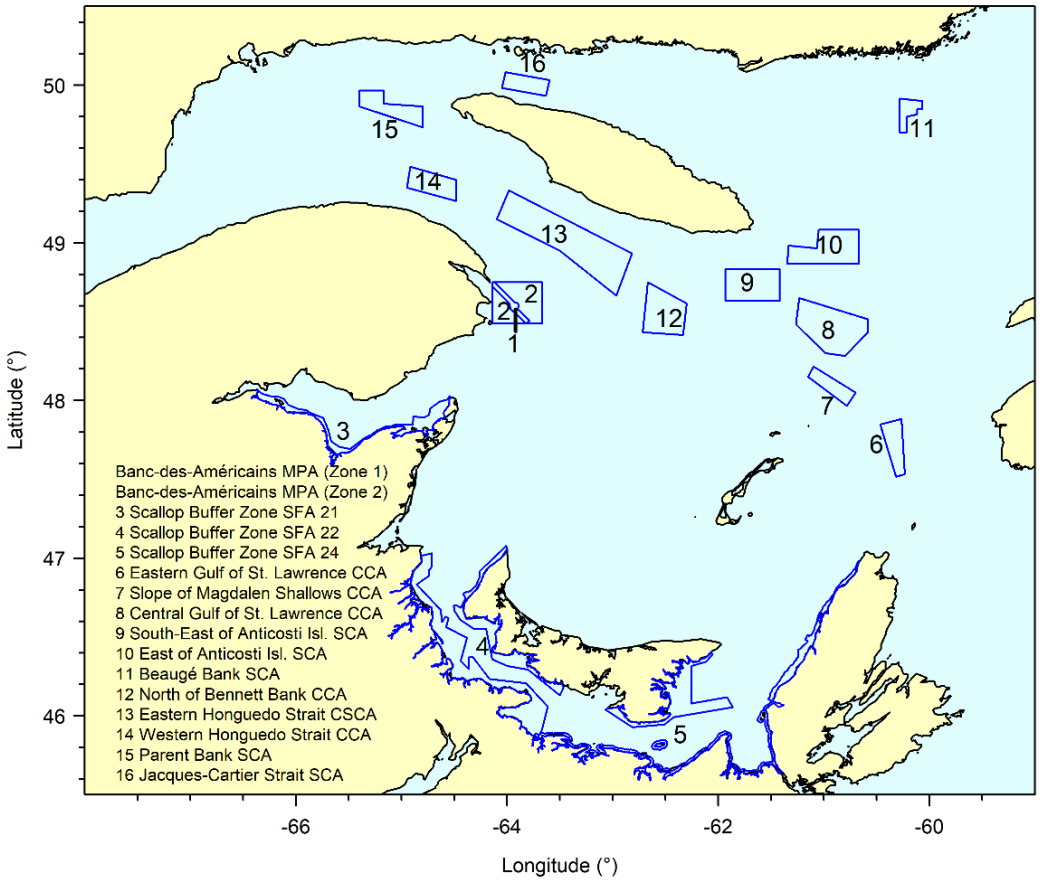

Figure 1. Map of the marine refuges and the marine protected area (Banc-des-Américains MPA) with defined benthic conservation objectives of the Estuary and Gulf of St. Lawrence considered in this report.

Recurring scientific surveys in the GSL

There are eight recurring surveys employing bottom-contacting gears that occur in one or more of the protected areas in the EGSL. A summary of the main characteristics of these surveys is presented in Table 1 and a more detailed description is available in Benoît et al. (2020a).

Ten recurring surveys employing bottom-contacting gear were excluded from the evaluation as they do not, or will no longer as of 2019, occur in any of the protected areas (details in Benoît et al. 2020a).

Analysis and Response

Every protected area in the EGSL is substantially or completely overlapped by one or more survey study areas (Table 2). This overlap is calculated based on the coordinates of survey areas. It does not necessarily reflect realized past sampling but rather where sampling could take place in any given year. Maps of the survey areas and stratification schemes for each of the eight recurring surveys of interest are available in Benoît et al. (2020a).

Direct studies of potential impacts and resilience

Scallop buffer zones

LeBlanc et al. (2015) conducted a study of the impact of scallop dredging on benthic taxa in two study sites, one within the SFA 21 scallop buffer zone and one just outside the SFA 22 scallop buffer zone. While the species relevant to the objectives for this marine refuge (Appendix Table 1) were not directly addressed in the study, the endo- and epi-benthic organisms in habitat used by these species were sampled immediately after, and a year after scallop dredging. Few taxa were significantly affected by the dredging both immediately and a year following. In contrast, short-term natural abundance fluctuations across experimental plots were much more prevalent and were of a magnitude similar to that estimated to be produced by fairly intense fishing, i.e., by the commercial scallop fishery. The authors concluded that the lack of severe impact caused by scallop dredges reflects the resilient nature of the taxa that occur in the buffer zone areas which are adapted to living in these high energy habitats exposed to currents, storms, potentially rapid changes in temperature, and ice scour during the winter.

The results of the LeBlanc et al. (2015) study suggest that limited scientific sampling using a scallop dredge would not result in large impacts to benthic habitat in the scallop buffer zone marine refuges. Furthermore, because scallop dredges are generally considered to be more harmful to benthic habitats than bottom trawls (Collie et al. 2000; Hiddink et al. 2017; Sciberras et al. 2018), the impacts of scientific bottom trawling in these marine refuges with high energy habitats are also expected to be minor.

Sea pen (coral) conservation areas

Trawling experiments combined with benthic imagery surveys were conducted in sea pen fields just north of the Gaspe peninsula in August 2015, with follow-up monitoring in October 2015, August 2016 and October 2016 (B. Sainte-Marie, DFO Quebec Region, unpublished data). The four species of sea pens of the EGSL occur in this area, though the study area is most densely populated by *Pennatula aculeata*. The experiments involved four passes of a commercial shrimp trawl in three replicated corridors.

Preliminary results of the experiment indicate that although many *P. aculeata* appeared to pass under the trawl footgear undamaged during the first pass, which replicates survey-like conditions, nearly all were removed or had burrowed in the sediment after four passes. Following the disturbance, the site was repopulated rapidly by some *P. aculeata*, which may have reemerged from the sediment or have crawled along the bottom, an ability lacking in the other sea pen species. In 2016, the site was found to be at least partially recolonized by both small, presumably recruiting, and large, presumably crawling, *P. aculeata*. The recovery of the other species has yet to be established since analyses of the experiment are ongoing. However, *P. aculeata* is undoubtedly much less vulnerable to trawling than the three other sea pen species due to its small size and known burrowing behavior, which make it much less catchable and possibly less susceptible to injury by fishing gear.

The trawling intensity employed in this study was greater than that produced by a scientific survey using a trawl since surveys employ a single pass. The removal of and damage to individual sea pens may therefore be less for a survey haul. Partial recovery within a short time frame suggests that *P. aculeata* is likely to be resilient to disturbances by current scientific sampling protocols that result in a recurrence time frame of hundreds to thousands of years.

Table 1. Ongoing bottom-contacting surveys undertaken in the Gulf of St. Lawrence (GSL) and Estuary that overlap with the protected areas retained for this report. Surveys are identified by the lead DFO region (Gulf or QC- Quebec), survey name, targeted species, location, the initial year for the survey, the gear employed (OTB – otter trawl or bottom trawl, LLS – bottom set longline, DRB – bottom dredge and pots), the sampling design employed in the survey (F - fixed station, R – random, SR - stratified random), the survey frequency (Freq.: A - annual or R - rotational), the mean number of hauls per complete survey in recent years (Hauls), the estimated swept area per average haul (Haul swept area; km^2), the area of the survey study area (km^2), annual average total survey swept area (km^2), and the recurrence interval (years).

DFO Region	Survey	Species	Location	Initial year	Gear	Design	Freq.	Hauls	Haul swept area (km^2)	Survey study area (km^2)	Survey swept area (km^2)	Recurrence interval (years)
Gulf	Sea scallop dredge survey	Sea scallop	southern GSL	2012	DRB	SR	R: 5 yr	500 [1]	0.0004	23,520	0.20	534,545
Gulf	Snow crab trawl survey	Snow crab	southern GSL	1988	OTB	F	A	355	0.0083	57,840	3.3	17,527 [2]
Gulf	Multi-species trawl survey	Various	southern GSL	1971	OTB	SR	A	180	0.1402	73,182	25.2	2,900
Gulf	Northumberland Strait multi-species survey	Various	Northumber-land Strait (southern GSL)	2001	OTB	SR/R	A	110	0.0347	11,925	3.8	3,122
QC	Atlantic Halibut survey	Atlantic Halibut	GSL	2017	LLS	SR	A	125	0.2250	~115,000	28.1	4,089
QC	Post-season snow crab trap survey (zones 12C & 16)	Snow crab	Estuary & northern GSL	1994	POTS	F	A	335	0.0001	~15,000	0.04	376,250 [2]
QC	Sentinel bottom-trawl survey	Various	northern GSL	1995	OTB	SR	A	287	0.1085	129,221	31.1	4,149
QC	Multi-species trawl survey	Various	Estuary & northern GSL	1984	OTB	SR	A	180	0.0684	125,780	12.3	10,216

[1] Represents the total number of hauls for a complete five-year cycle of the rotational survey.

[2] For fixed design surveys, the recurrence interval is shown assuming the same calculation as for random and stratified-random surveys.

Table 2. Summary of the proportion of each protected area that overlaps with the survey area for the eight relevant surveys and with all surveys. Surveys are as follows: Halibut – halibut survey, SCsGSL – snow crab bottom-trawl survey (sGSL), NSMS – Northumberland Strait multi-species survey, SCALsGSL – scallop dredge survey (sGSL), MSsGSL –multi-species bottom-trawl survey (sGSL), SCnGSL - snow crab post-season trap survey (nGSL), MSnGSL –multi-species bottom-trawl survey (nGSL & Estuary), and SENnGSL – Sentinel bottom-trawl survey (nGSL). Protected areas are shown in Figure 1.

Protected area	Halibut	SCsGSL	NSMS	SCALsGSL	MSsGSL	SCnGSL	MSnGSL	SENnGSL	All surveys
Banc-des-Américains MPA (Zone 1)	0.190	1.000	0	0	0.196	0	0	0	1.000
Banc-des-Américains MPA (Zone 2)	0.781	0.995	0	0	0.816	0	0	0	0.999
Scallop Buffer Zone SFA 21	0.094	0	0	0.450	0.018	0	0	0	0.469
Scallop Buffer Zone SFA 22	0.004	0	0.639	0.719	0.056	0	0	0	0.857
Scallop Buffer Zone SFA 24	0.338	0.044	0.375	0.569	0.246	0	0	0	0.622
Eastern Gulf of St. Lawrence CCA	0	0	0	0	0	0	1.000	1.000	1.000
Slope of Magdalen Shallows CCA	0	0.211	0	0	0.355	0	1.000	1.000	1.000
Central Gulf of St. Lawrence CCA	0	0	0	0	0	0	1.000	1.000	1.000
South-East of Anticosti Isl. SCA	0.086	0	0	0	0	0	1.000	1.000	1.000
East of Anticosti Isl. SCA	0.851	0	0	0	0	0	0.953	0.953	0.957
Beaugé Bank SCA	0.048	0	0	0	0	0.040	1.000	1.000	1.000
North of Bennett Bank CCA	0	0.116	0	0	0.199	0	1.000	1.000	1.000
Eastern Honguedo Strait CSCA	0.010	0.148	0	0	0.146	0	0.997	0.997	0.997
Western Honguedo Strait CCA	0	0	0	0	0	0	0.998	0.998	0.998
Parent Bank SCA	0.591	0	0	0	0	0	0.710	0.710	0.733
Jacques-Cartier Strait SCA	0.495	0	0	0	0	1.000	1.000	1.000	1.000

Metrics of potential impacts and resilience

The main information available to evaluate the potential impacts on, and resilience of, valued taxa to recurring scientific surveys in the protected areas of the EGSL is summarized in three tables.

Table 3 summarizes for each protected area and survey the average annual proportion of the area of overlap that is swept (impacted) annually by the survey (details in Benoit et al. 2019a). This metric is hereafter termed proportion impact density in that it measures average impact only for the portion of a protected area where a survey occurs (refer to Table 2). The overall average annual proportion impact density, cumulated over all co-occurring surveys is also provided. This measure reflects impact in those portions of protected areas where one or more surveys occur.

Table 4 summarizes the average recurrence times (years) of survey activities at any particular location in each protected area, by survey and only where the survey occurs, and overall for all co-occurring surveys, where one or more surveys occur. The values in Table 4 are approximately but not simply the inverse of the values in Table 3. The spatially resolved recurrence time calculations and maps for each protected area are provided in Benoît et al. (2020a).

Appendix Table 2 summarizes the key biological and ecological characteristics that help assess the potential resilience of the demersal and benthic ecological components of interest for the Banc-des-Américains MPA and the marine refuges. Longevity is noted for each taxon where the information was available as are other life-history characteristics associated with resilience to impacts from bottom-contacting survey gear.

Table 3. The average proportion of each protected area that is impacted annually (impact density) by each of the eight relevant surveys, and overall. The impact density is based only on the portion of the protected area that is overlapped by the survey(s). Surveys are as follows: Halibut – halibut survey, SCsGSL – snow crab bottom-trawl survey (sGSL), NSMS – Northumberland Strait multi-species survey, SCALsGSL – scallop dredge survey (sGSL), MSsGSL –multi-species bottom-trawl survey (sGSL), SCnGSL - snow crab post-season trap survey (nGSL), MSnGSL – multi-species bottom-trawl survey (nGSL & Estuary), and SENnGSL – Sentinel bottom-trawl survey (nGSL). The acronym "na" in the table means the survey does not overlap with the protected area. For interpretation, the proportion 3.30E-04 equates to 0.0330%. Protected areas are shown in Figure 1.

Protected area	Halibut	SCsGSL	NSMS	SCALsGSL	MSsGSL	SCnGSL	MSnGSL	SENnGSL	Overall
Banc-des-Américains MPA (Zone 1)	3.30E-04	5.24E-05	na	na	2.72E-04	na	na	na	1.68E-04
Banc-des-Américains MPA (Zone 2)	3.19E-04	5.24E-05	na	na	2.72E-04	na	na	na	5.24E-04
Scallop Buffer Zone SFA 21	2.96E-04	na	na	3.85E-06	3.18E-04	na	na	na	7.11E-05
Scallop Buffer Zone SFA 22	2.71E-04	na	3.57E-04	1.78E-06	2.81E-04	na	na	na	2.87E-04
Scallop Buffer Zone SFA 24	2.54E-04	5.24E-05	3.57E-04	2.01E-06	2.92E-04	na	na	na	4.78E-04
Eastern Gulf of St. Lawrence CCA	na	na	na	na	na	na	8.20E-05	1.16E-04	1.98E-04
Slope of Magdalen Shallows CCA	na	5.24E-05	na	na	3.20E-04	na	9.83E-05	1.59E-04	3.80E-04
Central Gulf of St. Lawrence CCA	na	na	na	na	na	na	6.37E-05	1.84E-04	2.47E-04
South-East of Anticosti Isl. SCA	2.38E-04	na	na	na	na	na	8.35E-05	1.84E-04	2.84E-04
East of Anticosti Isl. SCA	2.41E-04	na	na	na	na	na	9.48E-05	2.04E-04	5.13E-04
Beaugé Bank SCA	2.51E-04	na	na	na	na	8.94E-05	2.40E-04	5.06E-04	7.65E-04
North of Bennett Bank CCA	na	5.24E-05	na	na	2.66E-04	na	8.76E-05	1.27E-04	2.74E-04
Eastern Honguedo Strait CSCA	2.38E-04	5.24E-05	na	na	2.83E-04	na	9.48E-05	1.80E-04	3.26E-04
Western Honguedo Strait CCA	na	na	na	na	na	na	9.18E-05	1.51E-04	2.43E-04
Parent Bank SCA	2.35E-04	na	na	na	na	na	1.23E-04	2.03E-04	5.03E-04
Jacques-Cartier Strait SCA	2.61E-04	na	na	na	na	2.60E-06	1.10E-04	1.65E-04	4.05E-04

Table 4. The average recurrence time (years) of survey activities at any particular location in each protected area, by survey where a survey occurs, and overall when one or more surveys occur. Surveys are as follows: Halibut – halibut survey, SCsGSL – snow crab bottom-trawl survey (sGSL), NSMS – Northumberland Strait multi-species survey, SCALsGSL – scallop dredge survey (sGSL), MSsGSL –multi-species bottom-trawl survey (sGSL), SCnGSL - snow crab post-season trap survey (nGSL), MSnGSL –multi-species bottom-trawl survey (nGSL & Estuary), and SENnGSL – Sentinel bottom-trawl survey (nGSL). The acronym "na" in the table means the survey does not overlap with the protected area. Protected areas are shown in Figure 1.

Protected area	Halibut	SCsGSL[1]	NSMS	SCALsGSL	MSsGSL	SCnGSL[1]	MSnGSL	SENnGSL	Overall
Banc-des-Américains MPA (Zone 1)	3,028	19,092	na	na	3,681	na	na	na	14,586
Banc-des-Américains MPA (Zone 2)	3,145	19,092	na	na	3,680	na	na	na	4,548
Scallop Buffer Zone SFA 21	3,411	na	na	480,011	3,161	na	na	na	381,627
Scallop Buffer Zone SFA 22	3,762	na	2,802	564,987	3,560	na	na	na	148,498
Scallop Buffer Zone SFA 24	3,949	19,092	2,802	574,701	3,507	na	na	na	115,427
Eastern Gulf of St. Lawrence CCA	na	na	na	na	na	na	12,196	8,611	5,047
Slope of Magdalen Shallows CCA	na	19,092	na	na	3,250	na	11,176	7,580	3,753
Central Gulf of St. Lawrence CCA	na	na	na	na	na	na	15,691	5,449	4,045
South-East of Anticosti Isl. SCA	4,193	na	na	na	na	na	12,404	5,431	3,615
East of Anticosti Isl. SCA	4,150	na	na	na	na	na	11,030	5,046	2,091
Beaugé Bank SCA	3,983	na	na	na	na	11,192	5,800	2,394	1,573
North of Bennett Bank CCA	na	19,092	na	na	3,763	na	11,528	8,114	4,278
Eastern Honguedo Strait CSCA	4,193	19,092	na	na	3,530	na	10,644	5,926	3,398
Western Honguedo Strait CCA	na	na	na	na	na	na	10,895	6,941	4,204
Parent Bank SCA	4,246	na	na	na	na	na	8,500	4,934	2,098
Jacques-Cartier Strait SCA	3,827	na	na	na	na	384,023	11,910	9,115	2,913

[1] The results in the table were obtained assuming a random or stratified random distribution of survey hauls in the survey area. These surveys are in fact fixed gear surveys for which, technically-speaking, recurrence time at and around the fixed station locations is annual or near annual, and the survey does not occur elsewhere. However, because of annual variation in the exact placement of hauls and the potential for changes in station location as survey designs are modified, a random placement assumption is probably closer to what occurs in practice.

Potential impacts of surveys in the protected areas based on the metrics

Across all protected areas, the average percentage of the protected area overlapped by the survey areas that is impacted annually (impact density) for individual surveys was ≤ 0.05% and the overall percentage impact densities were < 0.08% (Table 3). Average recurrence times for locations where a survey occurs were all greater than or equal to 2,400 years for individual surveys, with typically long recurrence times of > 10,000 years for the sGSL snow crab trawl, sGSL scallop dredge, nGSL snow crab trap, and nGSL multispecies surveys (Table 4). The shortest overall estimated recurrence time of 1,573 years occurred in the Beaugé Bank SCA, while the other coral and/or sponge conservation areas and Zone 2 of the Banc-des-Américains MPA experience an estimated recurrence times ranging from 2,000 to 5,000 years. Recurrence times were very long for the scallop buffer zone refuges as a result of the very small swept areas for the sGSL scallop dredge survey (Table 1) and the low to moderate degree of overlap by the other surveys that occur there (Table 2). At finer spatial scales within protected areas, local recurrence times were all 1,000 years or more, with the exception of 0.2% of the overlapped area of the scallop buffer zone SFA 24 refuge, where recurrence times ranged between 600 and 1,000 years (details in Benoît et al. 2020a).

Biological and ecological characteristics of demersal and benthic ecological components of interest for the protected areas of the EGSL other than sponges are such that they should not be vulnerable to impacts by surveys associated with recurrence times greater than 1,000 years (DFO 2018; Appendix Table 2). These characteristics include observed or predicted longevities less than 100 years, high likelihood of survival following capture and release, and elevated growth or reproductive rates. For example, longevities for the four species of sea pen corals of the EGSL are estimated to be on the scale of decades (Appendix Table 2), thus at least one order of magnitude less than survey recurrence times in EGSL protected areas.

The resilience of sponges in the EGSL is poorly known. The presence of sponge aggregations of unknown species composition at sites in the EGSL where intensive shrimp fishing activities occurred during the 1980s but where few activities have occurred since (e.g., west of Anticosti Island) suggests that sponge aggregations can be established within decades following disturbance (DFO 2012), although the successional nature of sponge species recruitment in the region is unknown. In contrast, recovery periods much longer than a decade following perturbation by a single trawl pass have been inferred for *Mycale loveni* for example (Malecha and Heifetz 2017). This species, however, does not occur in the EGSL and exhibits growth forms that are different from *Mycale* species in the EGSL. The results of that study may not accurately reflect recovery potential for this bioregion (Curtis Dinn, DFO Gulf Region, pers. comm.).

Potential impacts to survey series if survey activities are not permitted in the protected areas

The exclusion of survey activities in protected areas could compromise monitoring results and have knock-on effects for the conservation of marine taxa in the broader ecosystem. Given that DFO's conservation mandate includes fishery resources, species at risk as well as ecological components of interest in protected areas, potential impacts on broader scale scientific monitoring and advice should be part of the considerations in the decision-making process regarding monitoring in protected areas.

Of particular concern is the potential for introducing time-varying biases in the monitoring time series which would result in a misinterpretation of population trends and consequently reduce the efficacy of management actions (Benoît et al. 2020b). Retrospective analyses of survey time

series calculated with samples and excluding samples from protected areas were undertaken to evaluate the potential for time-varying biases. The analyses did not cover an exhaustive list of species or populations, but rather focused on a small number of case studies. These include selected species of commercial interest, species of ecological (conservation) interest in protected areas, and species most susceptible to time-varying biases, the latter resulting from for example temporal shifts in habitat selection and spatial distribution. The retrospective analyses were restricted to surveys with at least a five year history, thereby omitting the halibut longline and sGSL scallop dredge surveys.

Only surveys and species for which a case study was undertaken and for which there is the potential for generating time-varying biases by excluding sampling from within protected area boundaries are discussed below. The full evaluation is available in Benoît et al. (2020a).

Northumberland Strait multi-species survey

About a quarter of the area and sets of the Northumberland Strait multi-species survey are within the boundaries of scallop buffer zones 22 and 24. Removing these sets results in a large increase in annual variability and the potential for large time-varying biases in abundance indices for two key species; Winter Skate (*Leucoraja ocellata*), a population in the sGSL assessed as endangered by COSEWIC, and American lobster (*Homarus americanus*), an important fishery resource (Fig. 2). The Northumberland Strait multi-species survey is the only survey that currently covers the majority of the remaining and severely contracted range of the sGSL Winter Skate and thus can be used to monitor its dynamics (Swain et al. 2019).

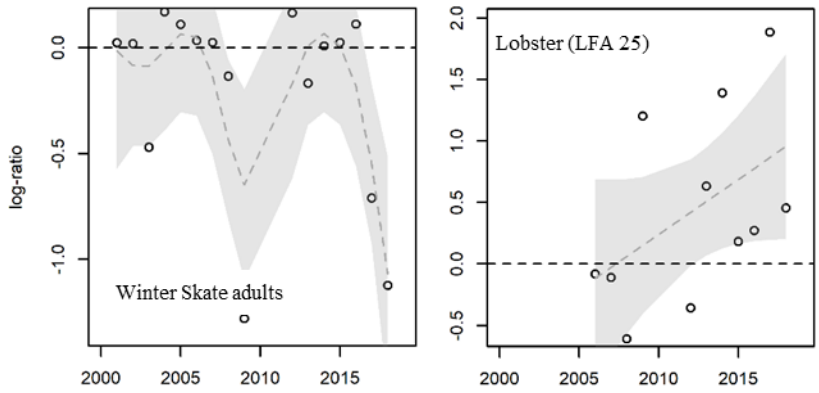

Figure 2. Summary of potential impacts to time series for Winter Skate adults (left panel) and American lobster in Lobster Fishing Area (LFA) 25 (right panel) of excluding the Northumberland Strait multi-species survey activities from the Scallop Buffer Zone marine refuges. The points are the log of the ratio of the abundance index calculated using all data and the index calculated using only data outside the marine refuges; a value of 0 indicates the index values are the same. An absence of time varying bias would be indicated by a horizontal line. The grey dashed line and grey band indicate the trend and 95% confidence interval for the smoother of a general additive model through the points.

sGSL multi-species bottom-trawl survey

Three series of potential exclusions were evaluated for the sGSL multi-species survey: from the Banc-des-Américains MPA, from three CCAs as an ensemble (Slope of Magdalen Shallows, North of Bennett Bank, and Eastern Honguedo Strait) and from three scallop buffer zone refuges as an ensemble (SFAs 21, 22, and 24). The exclusion of survey sets in the Banc-des-Américains MPA results in a time-varying bias for the adult American Plaice (*Hippoglossoides platessoides)* index, with a negative bias around 1980 when abundance was high, and a positive bias around 2010 during the current period of low abundance (Fig. 3). The exclusion of

survey sets from the CCAs results in a time-varying bias for the adult White Hake (*Urophycis tenuis*) index and to a lesser extent for the adult Thorny Skate (*Amblyraja radiate)* index (Fig. 3). These three example species are of fisheries management and species-at-risk conservation concern. No biases were generated when survey sets were excluded from the scallop buffer zone refuges.

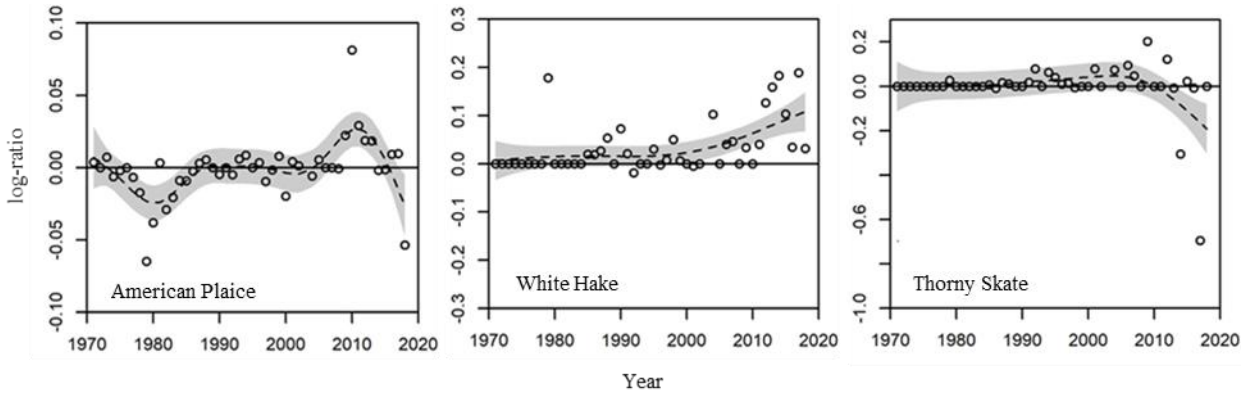

Figure 3. Summary of potential impacts to time series indices of excluding sGSL multi-species survey activities from the Banc-des-Américains MPA for American Plaice (left panel), and from the coral conservation areas for White Hake (center panel) and Thorny Skate (right panel). The points are the log of the ratio of the abundance index calculated using all data and the index calculated using only data outside the marine refuges; a value of 0 indicates the index values are the same. An absence of time varying bias would be indicated by a horizontal line. The grey dashed line and grey band indicate the trend and 95% confidence interval for the smoother of a general additive model through the points.

nGSL multi-species bottom-trawl and nGSL Sentinel surveys

For the nGSL multi-species survey and the nGSL Sentinel survey, the consequences of exclusion from the CCAs+CSCAs as an ensemble, the SCAs+CSCAs as an ensemble, and all coral and/or sponge areas were evaluated. The potential for time-varying biases was found for the Long-fin Hake (*Urophycis chesteri*) and Marlin-spike Grenadier (*Nezumia bairdi*) series when survey sets occurring across all coral and/or sponge conservation areas were removed from the nGSL multi-species survey (Fig. 4). Time-varying biases were identified for Sentinel survey series for Silver Hake (*Merluccius bilinearis*) and American Plaice when sets were excluded from CCAs+CSCAs and from all coral and/or sponge areas, and for Longfin Hake and White Hake when sets were excluded from SCAs+CSCAs (Benoît et al. 2020a; results not shown).

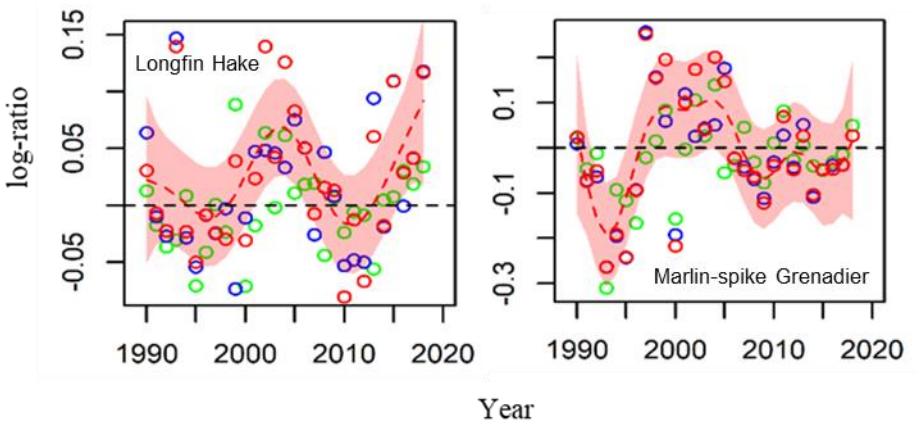

Figure 4. Summary of potential impacts to time series indices for Longfin Hake (left panel) and Marlin-spike Grenadier (right panel) of excluding nGSL multi-species survey activities from different combinations of marine refuges. The exclusion scenarios shown are as follows: blue points – exclusion from coral conservation areas, green points - exclusion from sponge conservation areas, red points - exclusion from all coral or sponge conservation areas). The points are the log of the ratio of the abundance index calculated using all data and the index calculated using only data outside the marine refuges; a value of 0 indicates the index values are the same. An absence of time-varying bias would be indicated by a horizontal line. Based on the same colour scheme as for the points, the coloured dashed line and coloured band indicate the trend and 95% confidence interval for the smoother of a general additive model through the points when that smoother was statistically significant for the scenario of exclusion from all conservation areas.

Potential mitigation measures other than excluding surveys

Benoît et al (2020b) review a number of potential measures to mitigate the impacts of survey activities in protected areas. These mitigation measures could include a change in survey design, a change to less impactful gear, and a reduction in the footprint of individual sets. Furthermore, within protected areas, survey activities could be sited such as to avoid particularly sensitive geographically-restricted features.

Fixed station surveys may result in frequently disturbed sites with reduced potential for local recovery embedded in a landscape of less or unperturbed sites, whereas random-based surveys spread out perturbations in space and time resulting in a landscape of varying degrees of recovery. Notwithstanding the difficulty in weighting the relative conservation benefits of the two designs, a change from one design to the other could require considerable standardization depending on the number of stations involved and the mobility and habitat dependency of the taxa that are the focus of the monitoring.

In their review, Benoît et al. (2020b) could not identify alternative survey methods that can replace trawling in a multi-species context involving mobile demersal or benthic species or when a broad range of sizes of organisms must be sampled. The only potential exception is for scallops for which video surveys may have the potential to replace dredge surveys (Stokesbury 2002; Singh et al. 2014), though independent reviews have recommended against dropping dredge surveys completely because the latter are still considered superior for estimating length composition, distinguishing live and dead scallops, and obtaining information on physiological and life-history attributes (such as age and condition) of individual scallops, amongst other considerations. Video-surveys might be able to replace the stations sampled in protected areas by the nGSL post-season snow crab trap survey given that only larger crab are sampled. However a number of factors including cost, collaborative delivery of the surveys by DFO and

industry with vessels that may not be adapted for camera deployment, and the need to calibrate with survey densities sampled by traps outside the protected areas, presently preclude the use of these alternative methods.

It might be possible to shorten survey trawl hauls to reduce activity footprints in protected areas, though these reductions would have to remain within the boundaries of defined acceptable haul durations and distances, which tend to be no less than 70% of the values for a target standard tow. However, systematically reducing haul duration would require extensive calibration trials as catch rates likely do not scale linearly with haul length and may be species-specific (Somerton et al. 2002). Forthcoming comparative fishing (calibration) experiments associated with a change in the vessels that undertake the sGSL and nGSL multi-species surveys provide an opportunity to also calibrate for a change to a bottom-trawl associated with a smaller swept area. In the sGSL multi-species survey, the change in vessel will be associated with a change to a smaller trawl that is fished at a lower speed (3.0 instead of 3.5 knots) and for a shorter time (20 rather than 30 minutes) resulting in a swept area footprint that is less than half the current haul footprint (0.062 km^2 rather than 0.1403 km^2). For a constant sampling (haul) density, this will more than double recurrence times for this survey.

The cumulative footprint of multiple and spatially overlapping surveys could be reduced by limiting the number of surveys that sample the same areas. This is already being done voluntarily as of 2019 by DFO Science in the Gulf Region by removing sampling stations for all sGSL Sentinel survey hauls falling within protected area boundaries. The greatest potential for further reduction is for the three southern CCAs (Slope of the Magdalen Shallows, North of Bennett Bank, and Eastern Honguedo Strait CCAs) which are presently overlapped by four surveys along their southern margins: the sGSL snow crab and sGSL multi-species surveys, and the nGSL multi-species and Sentinel surveys. In all cases, it is important that the surveys be intercalibrated to ensure constant relative catchability in data analyses for the suite of species monitored, before activities can be dropped to avoid potential biases. Research is presently underway to intercalibrate these various surveys such that eventually there may not be a need to have them all sample the same areas. However, given a forthcoming change in survey vessel for the sGSL and nGSL multi-species surveys, and a change in survey gear for the former, it will be important to maintain the overlap for at least a few years to allow for the intercalibration.

Potential benefits provided by surveys for the understanding and management of the protected areas and taxa of conservation importance

The bottom-trawl surveys of the EGSL can potentially provide data that can contribute to scientific understanding and efficacy monitoring for the protected areas (details below). Similar benefit stemming from the sGSL scallop dredge could not be identified at this time and no benefits from the nGSL snow crab trap single species surveys were identified (Benoît et al. 2020a).

SGSL snow crab bottom-trawl survey

A key advantage of this survey is that the Nephrops trawl gear is particularly suited to sampling soft bottom benthic species. Given the high set density and small individual haul footprint (Table 2) this survey could provide data on benthic taxon density within and outside protected areas that is conducive to a BACI type analysis for testing the efficacy of the protected areas. The most notable area for which this might be beneficial is the Banc-des-Américains MPA Zone 2 that is completely circumscribed by the survey area, comprises habitat that is well sampled by this gear, and where a moderate number of sets are made annually within and just outside the area (see Table 9 and Fig. 3 in Benoît et al. 2020a).

Northumberland Strait multi-species survey

The Northumberland Strait multi-species survey is the only large scale coastal survey in Atlantic Canada. It provides sampling within and just outside scallop buffer zone marine refuges SFA 22 and 24. This survey has the potential to provide data that could aid in gauging the efficacy of the refuges through monitoring the abundance and distribution of juvenile lobster, the main conservation objective for these refuges. Furthermore, it is currently the only survey that can monitor abundance trends for Winter Skate, which is identified as a secondary ecological component of interest for the SFA 22 refuge and generally of heightened conservation concern given the poor and deteriorating status of this species (Swain et al. 2019).

Large scale multi-species bottom-trawl surveys

Compared to video-based methods, trawl surveys are unlikely to be the best means to monitor the efficacy of protected areas with respect to conservation objectives for sessile benthic species such as corals and sponges. However, trawl surveys are well suited to identifying areas of concentration of these taxa for follow-up monitoring including the collection of biological material for biometric measurements (size, age) and taxonomy (Chimienti et al. 2018; Murillo et al. 2018). Enhanced taxonomic resolution for the benthic invertebrates has resulted in a considerable increase in information collected in the sGSL and nGSL surveys for a number of species. These efforts will improve knowledge on the species being protected by the marine refuges and the surveys may therefore provide a broad-scale sampling platform to better understand the distribution of these species within protected areas and in the broader ecosystem.

The large scale multi-species surveys are particularly adapted to monitoring the abundance and distribution of mobile demersal species, including wolffish and skates, which are a focus of ecological interest for many of the marine refuges and the Banc-des-Américains MPA. These surveys have provided population-wide sampling for many years and are therefore well suited for monitoring changes in abundance and distribution in the EGSL ecosystem as well as within the protected areas.

Conclusions

Every protected area in the EGSL is substantially or completely overlapped by one or more survey study areas. The annual swept area by all surveys on average does not exceed 0.08% of the areas of overlap for any protected area. Average recurrence times for areas of overlap were all greater than or equal to 2,400 years for individual surveys. Concerning the cumulative impact over all surveys, the shortest overall recurrence time (1,573 years) was calculated for the Beaugé Bank SCA, while survey activities in the other coral or sponge conservation areas and Zone 2 of the Banc-des-Américains MPA have estimated average recurrence times of 2,000 to 5,000 years. At finer spatial scales, all locations of overlap between surveys and protected areas are associated with recurrence times >1,000 year, except for the scallop buffer zone of SFA 24 in which 0.2% of the zone of overlap is associated with a recurrence time of 600 to 1,000 years.

Based on before-and-after-impact (BACI) experiments in the EGSL, for certain species (*Pennatula aculeata)* and benthic communities in high energy benthic habitats such as the scallop buffer zones, the recovery times are likely or certainly on the order of a decade or less.

According to DFO (2018), activity recurrence time intervals that are at least an order of magnitude greater than the longevity of the least resilient taxon or benthic feature are assumed to not result in long-term harm and therefore should not compromise achievement of protected area conservation objectives. With the exception of sponges, the estimates of recurrence

intervals of scientific surveys (> 1000 years) are one order of magnitude or more greater than the inferred recovery period of the defined benthic components in protected areas of the EGSL, based on longevity or other life-history characteristics that affect resilience.

The potential impacts of survey activities on sponges in SCAs are difficult to evaluate because information on longevity and resilience is lacking for sponge species which occur in the EGSL. The continuation of current scientific survey activities would improve knowledge on the species composition, distribution, and biological characteristics within and outside the conservation areas. BACI-type disturbance experiments, like those undertaken for sea pens but with long-term follow-up monitoring, would provide information on the resilience of sponges to disturbance by scientific bottom-contact gears in the EGSL. The assessment of the impacts of survey activities in the SCAs should be reviewed as new knowledge is accumulated.

Retrospective analyses of survey data demonstrated the potential for time-varying biases in some species trends of abundance should certain surveys be excluded from protected areas. This is of particular concern for those surveys that monitor the status of species that are at high risk of extinction, for example, the Northumberland Strait multi-species survey with respect to Winter Skate, and the sGSL multi-species survey with respect to White Hake and Thorny Skate. In the case of the Northumberland Strait multi-species survey, excluding survey activities from the scallop buffer zone marine refuges would compromise the ability to monitor the status of juvenile American lobster, the main ecological component of interest for these refuges, and American lobster in general, the target of a large commercial fishery in the sGSL.

Various approaches to reducing scientific survey impacts are discussed in this report and the supporting research documents including reducing survey redundancies, alternative survey designs, station relocations, reducing swept areas by shortening tow times, and changes in gear types. The forthcoming change in the survey trawl for the sGSL multi-species survey will result in a swept area that is less than half, and a recurrence time that is more than double, compared to the present situation. There may be opportunities to reduce haul durations in protected areas in other surveys; research on the potential consequences of making such a systematic change needs to be done before making such changes.

The evaluation presented in this document should be valid until one or more of the following conditions occur:

- there are changes to benthic conservation objectives of protected areas,
- there are changes in the status of valued ecological components of interest that suggest that a change in the degree of precaution is warranted (more precaution with worsening status, less if status improves considerably),
- there are changes in survey design, procedures or gear that alter the area impacted by surveys and recurrence time in such a way that permitting decisions might change,
- there is new information that allows for a better evaluation of the resilience of ecological components of interest, and
- new protected areas are defined that might further limit where scientific activities take place and potentially compromising the ability of surveys to monitor the broader ecosystem in support of evidence-based decision making by resource managers (DFO 2018).

Such changes could motivate a re-evaluation for one or more surveys in one or more protected areas.

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Appendix

Table 1. List of the protected areas (Banc-des-Américains MPA and marine refuges) in the estuary and Gulf of St. Lawrence bioregion considered in this report, along with their conservation objectives (ecological components of interest) and the associated prohibitions and restrictions. All refuges were defined on the basis of a primary ecological component of interest that is the aim of conservation efforts. For some refuges, additional secondary components of interest have been identified.

Protected area name	Conservation objectives (ecological components of interest)	Prohibitions and restrictions
Banc-des-Américains MPA	Conserve and protect benthic (seabed) habitats Conserve and protect pelagic (water column) habitats and forage species (prey) Promote the recovery of at-risk whales and wolfish Based on these general objectives, particular indicator species chosen (see Appendix Table 2)	Activities that disturb, damage, or remove living marine organisms or any part of their habitat, unless exempted.
Scallop Buffer Zone SFA 21	Primary: protect juvenile American lobster. Secondary: scallop and Winter Flounder	Scallop dredging
Scallop Buffer Zone SFA 22	Primary: protect juvenile American lobster. Secondary: the last remaining area in which the Winter Skate (endangered designation by COSEWIC) is found during the summer, unique population of lady crab (suspected endemic), and rock crab.	Scallop dredging
Scallop Buffer Zone SFA 24	Primary: protect juvenile American lobster. Secondary: scallop and Winter Flounder	Scallop dredging
Eastern Gulf of St. Lawrence Coral Conservation Area	Protect cold-water corals, notably *Pennatula grandis* and *Anthoptilum grandiflorum* sea pens.	All fishing that uses bottom-contacting gear
Slope of Magdalen Shallows Coral Conservation Area	Protect cold-water corals, notably *P. grandis* and *A. grandiflorum* sea pens.	All fishing that uses bottom-contacting gear
Central Gulf of St. Lawrence Coral Conservation Area	Primary: protect cold-water corals, notably *A. grandiflorum* sea pen. Secondary: Protect *Flabellum alabastrum* hard corals, which have a restricted range. This conservation area also includes other biologically important features, such as a high concentration of *Duva florida* soft corals, the presence of the large structure-providing *Asconema foliatum* sponge, and at least three species of rays and wolffish.	All fishing that uses bottom-contacting gear
South-East of Anticosti Island Sponge Conservation Area	Primary: protect cold-water sponges. Secondary: area also includes other biologically important features, such as high concentrations of *D. florida* soft corals and *A. grandiflorum* sea pens, the large structure-providing *A. foliatum* sponge, and at least three species of rays and wolfish.	All fishing that uses bottom-contacting gear
East of Anticosti Island Sponge Conservation Area	Primary: protect cold-water sponges. Secondary: The area also includes other biologically important features, such as a high concentration of *D. florida* and *Gersemia rubiformis* soft corals, the presence of the large structure-providing *Hemigellius arcofer* sponge, and at least three species of rays and wolffish.	All fishing that uses bottom-contacting gear

Protected area name	Conservation objectives (ecological components of interest)	Prohibitions and restrictions
Beaugé Bank Sponge Conservation Area	Primary: protect cold-water sponges. Secondary: The area also includes other biologically significant features, such as a high concentration of *Duva* sp. and *G. rubiformis* soft corals, the presence of the large structure-providing *H. arcofer* sponge, and at least four species of rays and wolffish	All fishing that uses bottom-contacting gear
North of Bennett Bank Coral Conservation Area	Primary: protect cold-water corals, notably *A. grandiflorum* sea pen and the three other species of sea pen, *Pennatula aculeata, Pennatula grandis* and *Halipteris finmarchica*. Secondary: area has at least three species of rays and wolffish.	All fishing that uses bottom-contacting gear
Eastern Honguedo Strait Coral and Sponge Conservation Area	Primary: protect cold-water sponges and corals, notably *Halipteris finmarchica, Anthoptilum grandiflorum, Pennatula grandis* and *Pennatula aculeata.* Secondary: *Duva florida* soft corals, the presence of one large structure-providing sponge species, *Mycale sp.*, and at least two species of rays.	All fishing that uses bottom-contacting gear
Western Honguedo Strait Coral Conservation Area	Primary: protect cold-water corals, notably *P. aculeata, P. grandis* and *A. grandiflorum*. Secondary: at least two species of rays.	All fishing that uses bottom-contacting gear
Parent Bank Sponge Conservation Area	Primary: protect cold-water sponges. Secondary: area also includes other important biological features, such as a high concentration of *P. aculeata* sea pens, and *D. florida* and *G. rubiformis* soft corals. The area also contains the large structure-providing *Mycale sp.* sponge, and at least three species of rays and wolffish.	All fishing that uses bottom-contacting gear
Jacques-Cartier Strait Sponge Conservation Area	Primary: protect cold-water sponges. Secondary: The area also includes other important biological features, such as a high concentration of *G. rubiformis* soft corals, and the presence of the large structure-providing *H. arcofer* sponge. This is an area known for its high biodiversity; it is home to many benthic species and used by birds and marine mammals.	All fishing that uses bottom-contacting gear

Table 2. Demersal and benthic ecological components of interest by taxon/group and the characteristics that help define their resilience to perturbation for the marine refuges and the Banc-des-Américains MPA in which scientific surveys recur. Literature references for the characteristics are provided in Benoît et al. (2020a).

Taxon	Marine refuges	Characteristics
Fish and decapod crustaceans		
American lobster (juvenile)	Scallop Buffer Zones	Based on growth rates and contemporary sizes at maturity in the sGSL (between 70-80 mm), lobster mature around 7-9 years of age, the 'longevity' of the juvenile stage. Furthermore, lobster in the sGSL are presently very productive and not limited by recruitment.
Giant scallop	Scallop Buffer Zones SFA 21 & 24	In the sGSL, scallops reach maturity around 4-5 years of age and maximum observed ages are below 20 years
Lady crab	Scallop Buffer Zone SFA 22	Information on growth and longevity could not be found. The species occupies very warm waters and expected to be relatively fast growing and not particularly long-lived. Related species, *Ovalipes punctatus* and *O. catharus* develop to maximum size in <4 years at colder summer temperatures but warmer winter temperatures than in Northumberland Strait.
Rock crab	Scallop Buffer Zone SFA 22	Longevity is around 8 years
Winter Flounder	Scallop Buffer Zones SFA 21 & 24	Longevity is greater than 12 years. The sGSL stock is depleted and the main cause is elevated adult mortality. Individuals released alive after capture have a high likelihood of survival.
Winter Skate	Scallop Buffer Zone SFA 22	The sGSL population is designated as Endangered by COSEWIC. The main threat to the population is elevated natural morality among adults. Longevity in the sGSL is above 12 years. Individuals released alive after capture have a high likelihood of survival.
Smooth Skate	Central Gulf of St. Lawrence CCA, S-E of Anticosti Isl. SCA, East of Anticosti Isl. SCA, North of Bennett Bank CCA, Eastern Honguedo Strait CSCA, Parent Bank CCA	Designated as Special Concern by COSEWIC. Longevity is not known, but age at 50% maturity for this species was found to be 10 years and 12 years for females and males. The main treat to the population is elevated natural morality among adults. Individuals released alive after capture have a high likelihood of survival.
Thorny Skate	Central Gulf of St. Lawrence CCA, S-E of Anticosti Isl. SCA, East of Anticosti Isl. SCA, North of Bennett Bank CCA, Eastern Honguedo Strait CSCA, Parent Bank CCA	Designated as Special Concern by COSEWIC. The main treat to the population is elevated natural morality among adults. Longevity is over 20 years. Individuals released alive after capture have a high likelihood of survival.
Wolffish species generally and Atlantic Wolfish Spotted Wolfish Northern Wolffish	Central Gulf of St. Lawrence CCA, S-E of Anticosti Isl. SCA, East of Anticosti Isl. SCA, North of Bennett Bank CCA, Parent Bank CCA, Beaugé Bank SCA, Banc-des-Américains MPA	Designated as Special Concern (Atlantic Wolffish) or Threatened (Spotted Wolffish and Northern Wolffish) by COSEWIC. Fishing is considered a main threat. Though allowable harm that these species can sustain cannot be quantified currently, current levels of harm appear sustainable. Larger individuals released alive after capture have a high likelihood of survival. Observed maximum ages for Atlantic Wolffish and Spotted Wolffish are around or above 20 years.

Taxon	Marine refuges	Characteristics
Cold-water corals		
Anthoptilum grandiflorum	Eastern Gulf of St. Lawrence CCA, Slope of Magdalen Shallows CCA, Central Gulf of St. Lawrence CCA, S-E of Anticosti Isl. SCA, North of Bennett Bank CCA, Eastern Honguedo Strait CSCA, Western Honguedo Strait CCA	Estimated ages range from 5 and 28 years for *A. grandiflorum* colonies outside the Gulf. Based on mean lengths in colonies in the sGSL and nGSL multi-species surveys, this would correspond to colonies 15-16 and approximately 21 years old respectively. Estimated maximum ages fall within previously published ranges for pennatulids of between 15 and 50 years.
Halipteris finmarchica	Eastern Honguedo Strait CSCA, North of Bennett Bank CCA	Estimated age at maturation and maximum observed age in the Northwest Atlantic of 4 and 22 years, respectively.
Pennatula aculeata	Eastern Honguedo Strait CSCA, , North of Bennett Bank CCA, Western Honguedo Strait CCA, Parent Bank CCA	Estimated ages ranging between 2 and 21 years for *P. aculeata*. Mean colony lengths observed in the sGSL surveys correspond to *P. aculeata* colonies younger than 9 years old. Estimated maximum ages fall within previously published ranges for pennatulids of between 15 and 50 years. Known to be able to burrow and crawl, which may afford some protection from trawling and potential for rapid recolonization of disturbed areas.
Pennatula grandis	Eastern Gulf of St. Lawrence CCA, Slope of Magdalen Shallows CCA, Eastern Honguedo Strait CSCA, Western Honguedo Strait CCA, North of Bennett Bank CCA	Longevity not known. However, the published range of maximum ages for pennatulids is between 15 and 50 years.
Soft corals		
Duva florida	Central Gulf of St. Lawrence CCA, S-E of Anticosti Isl. SCA, East of Anticosti Isl. SCA, Eastern Honguedo Strait CSCA, Parent Bank CCA	Resillient to environmental variability, in that they survive and reproduce successfully under laboratory conditions. Studies suggest that when fertile colonies are damaged or torn by anthropogenic activities (e.g., bottom trawling), planulae that become free may grow into viable offspring. Nevertheless, growth of primary polyps is slow.
Gersemia rubiformis	East of Anticosti Isl. SCA, Parent Bank CCA, Jacques-Cartier Strait SCA, Beaugé Bank SCA	Widespread. Colonies grow by vegetative budding and sexual reproduction. Generally not considered a vulnerable species.
Hard corals		
Flabellum alabastrum	Central Gulf of St. Lawrence CCA	Growth is sensitive to environmental conditions. Estimates indicate that the largest individuals sampled along the southwest Grand Banks were at least 45 years old.
Sponges		
Multiple species (identification pending)	S-E of Anticosti Isl. SCA, East of Anticosti Isl. SCA, Parent Bank SCA, Beaugé Bank SCA, Jacques-Cartier Strait SCA, Eastern Honguedo Strait CSCA	Measures of resiliency of the sponge species in the Gulf of St. Lawrence require further investigation.
Asconema foliatum	Central Gulf of St. Lawrence CCA, S-E of Anticosti Isl. SCA	Glass sponge (Class Hexactinellida) which grows as a complex bouquet of tubes. Measures of resiliency of this species requires further investigation.
Hemigellius arcofer	Beaugé Bank SCA, Jacques-Cartier Strait SCA	Large, fan-shaped sponge with a coarse fibrous structure. Whole North Atlantic distribution Measures of resiliency of this species requires further investigation.

Taxon	Marine refuges	Characteristics
Mycale sp.	Eastern Honguedo Strait CSCA, Parent Bank CCA	Most *Mycale* specimens in the GSL have been identified as *Mycale lingua.* Results from a single pass trawling experiment in the Gulf of Alaska suggest a reduction of 15% in the density of *Mycale loveni* sponge and incremental damage rate of around 32% of individuals that persisted at least 13 years post-trawling. However it is important to note that growth forms of *M. loveni* are different from those of *Mycale* species in the Gulf and the results of this study may not accurately reflect recovery potential here (Curtis Dinn, DFO Gulf Region, pers. comm.).
Other taxa		
Metridum senile (anemone)	Banc-des-Américains MPA	Can reproduce sexually and asexually (binary fission). Growth rate is rapid. These factors suggest resilience to disturbance.
*Urticina feline (*anemone)	Banc-des-Américains MPA	Can reproduce sexually and asexually. Occurs in dynamic subtidal environments. These factors suggest resilience to disturbance.
Ophiopholis aculeata (brittle star)	Banc-des-Américains MPA	Ubiquitous broadcast-spawning species, suggesting resilience to benthic disturbance.
Ophiacantha bidentata (brittle star)	Banc-des-Américains MPA	Widespread arctic-boreal ophiuroid with a circumpolar distribution, suggesting resilience to benthic disturbance.
*Stomphia coccinea (*anemone)	Banc-des-Américains MPA	A widespread species that is able to detach itself, drift and reattach, suggesting resilience to benthic disturbance.
Boltenia ovifera (tunicate)	Banc-des-Américains MPA	Estimated to live an average of 3 years based on growth rates measured within the first year, suggesting resilience to disturbance.
Halocynthia pyriformis (tunicate)	Banc-des-Américains MPA	Widespread in north Atlantic shallow waters suggesting resilience to disturbance.

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