AN ASSESSMENT TO SUPPORT DECISIONS ON AUTHORIZING SCIENTIFIC SURVEYS WITH BOTTOM-CONTACTING GEARS IN PROTECTED AREAS IN THE NEWFOUNDLAND AND LABRADOR BIOREGION

*Figure 1. Examples of cold-water benthic taxa found within protected areas in the Newfoundland and Labrador (NL) Region. Main species depicted are: A) Large gorgonians (*Primnoa resedaeformis *and* Paragorgia arborea*) and sponges (*Geodia *sp. and* Asconema *sp.); and B) the sea pen* Pennatula aculeata*. Courtesy B. Neves.*

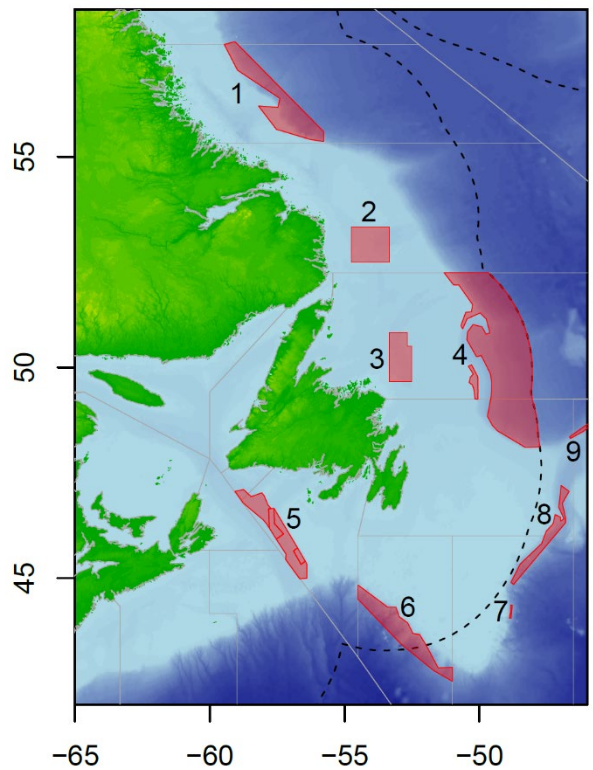

Figure 2. Map of the protected areas (marine refuges, marine protected areas, and Northwest Atlantic Fisheries Organization [NAFO] closed areas) in the NL Region considered in this report. Closure numbers correspond to those in Table 1.

Context:

Canada is committed to protecting vulnerable benthic taxa and fish habitat from the potential damaging impacts of anthropogenic activities. The rapidly increasing number of protected areas in Canada's marine and coastal areas has created a need for approaches to determine what human activities will be allowed within these areas. This includes a review of scientific research activities. Fisheries and Oceans Canada (DFO) and its research partners conduct scientific surveys using bottom-contacting gears that overlap spatially with many of these protected areas. These surveys are crucial tools in ecosystem monitoring and the provision of science advice, but also have the potential to damage *vulnerable benthic taxa, such as corals and sponges. Managers must evaluate the impacts vs. benefits of scientific surveys in relation to these closures in order to determine if the operation of these surveys within protected areas pose an unacceptable risk relative to the conservation objectives of those areas.*

DFO has developed a national "Framework to support decisions on authorizing scientific surveys with bottom-contacting gears in protected areas with defined benthic conservation objectives" (DFO 2018). This framework is intended to guide the Regions in 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. Here, these guidelines are applied to an evaluation of scientific survey activities within protected areas in the NL Region.

This Science Advisory Report is from the Regional Peer Review process of October 5–9, 2020 on An Assessment to Support Decisions on Authorizing Scientific Surveys With Bottom-Contacting Gears In Protected Areas In The Newfoundland And Labrador Bioregion. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Bottom-contacting fishing gears have impacts on benthic populations, communities, and habitats. These include direct impacts by damaging and removing organisms, and indirect impacts resulting from lost ecosystem services provided by these organisms and the biodiversity they may support.
- It is recognized that bottom-contacting scientific surveys have impacts on corals, sponges, and other benthic fauna. The level and nature of these impacts are taxon and gear dependent, however the first pass of bottom-contacting gear results in the greatest removal of and damage to specimens and biogenic features. The extent of these localized impacts on biodiversity and ecosystem function are not known.
- The recovery time for individual corals and sponges is expected to range between decades and centuries in the NL Region. While bottom-contacting survey gear can cause localized damage, the average recurrence time of scientific surveys in protected areas is orders of magnitude higher (~up to tens of thousands of years) than estimated recovery times. This suggests that individual corals and sponges would be expected to have sufficient time to recover between survey bottom contact events. The habitats they create (e.g., sponge grounds or gorgonian coral forests) would have much longer recovery times (possibly thousands of years). In comparison, the recurrence time for bottom-contacting commercial fishing gear in the NL Region is, on average, 10 years.
- The cumulative percentage of area impacted per year by bottom-contacting surveys was found to be less than 0.04% for each of the protected areas considered in the analysis.
- Retrospective analyses examined the effect of completely excluding bottom-contacting scientific survey data from protected areas on various time series data regularly used in the provision of science advice. These analyses illustrated that the exclusion of surveys in protected areas would be likely to introduce bias in some time series data, and would, in some cases, hinder the ability to provide reliable science advice on a broad range of topics (e.g., on stock assessments, ecosystem assessments, climate studies, long-term monitoring).

- Shifts in species distributions and trends are expected in association with directional changes in the environment (e.g., climate change), therefore, excluding sets from protected areas may hinder the ability to reliably track future ecological and environmental changes.
- Avoiding protected areas with benthic conservation objectives is the only way to completely eliminate the impact of bottom-contacting gears on these features. However, given that (1) survey recurrence times are high and the proportion of protected areas impacted is low, (2) excluding surveys from these areas will hinder ecosystem monitoring and, (3) from a multispecies perspective, there is currently no suitable alternative to bottom trawl surveys, a blanket exclusion of research surveys from all protected areas is not recommended at this time. If excluding research survey sets from protected areas with benthic conservation objectives is not an option, it is recommended that methods to minimize the potential impacts of these surveys be fully explored. Potential proactive mitigation measures can include: (1) the reduction of sampling intensity within closures, (2) the identification of zones for research trawls within closures to avoid locations with known high densities of corals or sponges, and (3) the offsetting of survey impacts by expanding closed areas.
- DFO should develop a framework to assist in the selection and implementation of appropriate mitigation measures for protected areas with benthic conservation objectives.
- An important associated measure is the development of enhanced sampling protocols to maximize the information gathered relating to benthic conservation objectives in protected areas.
- The establishment and delineation of protected areas has relied in part on data from bottom-contacting scientific surveys. Going forward, it may be possible to monitor fish and shellfish communities within protected areas with bottom-contacting surveys, but these are not the most appropriate methods to undertake long-term monitoring of vulnerable benthic taxa. For these taxa, alternative, less-destructive methods like seafloor visual surveys (e.g., remotely operated vehicles [ROVs], drop cameras) are more appropriate. Yet, the removal of bottom-contacting surveys would hinder the provision of advice relating to some conservation objectives.

INTRODUCTION

In response to international conservation targets, Canada set and surpassed a goal of protecting 10% of the country’s marine and coastal areas and is currently working toward protecting 25% of the country’s oceans by 2025, and 30% by 2030. In the Newfoundland and Labrador (NL) Region, a number of closures have been established to protect fish habitat and ecologically vulnerable benthic taxa and features, some of which may be easily damaged by and slow to recover from bottom-contacting fishing activities such as bottom trawling.

These closures were generally implemented with the intent to protect portions of significant benthic areas (SiBAs, defined as *“a regional habitat that contains cold water corals and sponges as a dominant and defining feature,”* [DFO 2017a,b]) from potentially harmful commercial and industrial activities. However, many regularly occurring scientific surveys employed by Fisheries and Oceans Canada (DFO) and its research partners also use bottom-contacting gears, with the potential to have adverse impacts on significant benthic areas and/or important fish habitats, and to therefore influence the achievement of conservation objectives. On the other hand, science surveys played an important role in identifying these ecologically and biologically important areas that have now been protected, and the surveys may be valuable for monitoring closure success going forward. Furthermore, they also collect data that are critical in determining population status and trends for commercial and non-commercial species in the broader ecosystem and underpin Canada's sustainable management of its fisheries (Benoît et al. 2020a). Managers tasked with making decisions on whether or not to permit scientific activities within protected areas will therefore need to evaluate not only the potential impacts of the survey bottom-contacting gear, but also the potential consequences of not allowing surveys to operate within these areas, such as impacts on the provision of science advice for aquatic resources in the broader ecosystem context.

DFO has implemented spatial closures in the NL Region under two pieces of Canadian legislation. Closures under the *Oceans Act* are referred to as Marine Protected Areas (MPAs) and are the responsibility of DFO's Ecosystem Management Branch. Closures under the *Fisheries Act* are referred to as Marine Refuges (MRs) and are the responsibility of DFO's Resource Management and Indigenous Fisheries Branch. In 2019, the Government of Canada adopted new national protection standards for MPAs and MRs. In MPAs, these standards prohibit four industrial activities: oil and gas, mining, dumping, and mobile bottom trawling. In MRs, DFO will use a risk-based approach for prohibiting or limiting activities, which will be assessed on a case-by-case basis. In both types of areas, some activities may be allowed if they are consistent with the conservation objectives of the area. For example, proposed scientific activities will be assessed by Regional managers based on the risk posed to the conservation objectives and will require approval of an Activity Plan, which outlines the sampling methods, impacts to the area, and mitigation strategies.

DFO has produced a National Framework to guide the evaluation of ongoing recurrent scientific activities (surveys) within protected areas (DFO 2018, Benoît et al. 2020a) and this framework is now being used to help develop science advice to support decisions regarding the operation of scientific surveys within specific Regions/closures (DFO 2020, Benoît et al. 2020b). Here we apply aspects of the framework to examine closures in the NL Region in an effort to provide managers with the advice they need to make informed decisions about ongoing research activities in relation to closures in this Region.

In addition to the MPAs and MRs within Canadian waters, numerous closures have been established to protect Vulnerable Marine Ecosystems (VMEs) outside Canada's Exclusive Economic Zone (EEZ) on the nose and tail of the Grand Bank (Figure 2). These closures fall under the regulatory jurisdiction of the Northwest Atlantic Fisheries Organization (NAFO) since they are located all or partially within the NAFO Regulatory Area (NRA). Many of the marine resources (e.g., fish stocks) that Canada is responsible for managing extend into these closed areas, and vice versa, with some NAFO-managed stocks having distributions that overlap with closures inside the Canadian EEZ. It is also important to note that some Canadian surveys extend outside the Canadian EEZ and overlap with both Canadian and NAFO closures. Any examination of potential survey impacts and consequences for excluding surveys from protected areas in the NL Region should therefore include both Canadian and NAFO closures. Here we consider that regulatory differences between the closures established to protect vulnerable benthic taxa inside and outside the Canadian EEZ are secondary to the objective of the closure. We therefore include Canadian MPAs and MRs, as well as NAFO VME closures, in our analyses and refer to them collectively as 'protected areas'.

ASSESSMENT

Protected Areas

Only protected areas in the NL Region that overlap with one of the regularly occurring bottom-contacting scientific surveys (see below) are discussed in this report. This includes one MPA and four MRs established by DFO, as well as four NAFO closures established outside Canada's EEZ (Figure 2, Table 1). Other (primarily coastal) protected areas exist in the Region but are not included in the subsequent analyses since they do not overlap with ongoing bottom-contacting scientific surveys. Additionally, the Hatton Basin MR, which overlaps NAFO Division 2G, was not considered here. This MR is co-managed by DFO-Ontario and Prairie and DFO-NL, but it does not overlap with ongoing recurrent bottom-contacting scientific surveys from DFO-NL Region. It should also be noted that recurrent surveys conducted by Spain and the European Union on the nose and tail of the Grand Bank are not included in these analyses.

Of primary concern here were closures established to protect vulnerable benthic taxa. Protected areas were given a general classification as being established to protect either A: Sponges and Gorgonian Corals, or B: Sea Pens (but note that many of these closures have additional conservation objectives related to other taxa). In instances where multiple vulnerable benthic taxa were present, the area was categorized based on the taxon considered the most vulnerable to bottom-contacting fishing gear. For example, the Northeast Newfoundland Slope is considered here to be a closure to protect Sponges and Gorgonian Corals, even though the area also has conservation objectives related to the protection of Sea Pen aggregations. Likewise, the Laurentian Channel is considered here to be a closure to protect sea pens, even though there are also conservation objectives related to fish. There is little to no justification to prevent scientific surveys from continuing in protected areas that do not have benthic conservation objectives. However, upon request, it was agreed to also include protected areas generally established to protect C: Fish Habitat.

It is worth noting that many SiBAs in the NL Region are only partially contained within the protected areas that have been established and therefore activities outside these protected areas may have equal or larger impacts on vulnerable benthic taxa than activities within the boundaries of the protected areas. The objective of the current assessment, however, is not to evaluate the efficacy of these protected areas or how they were established, but simply to examine the potential impacts of research activities that take place within the boundaries of the protected areas.

Table 1. Details of the protected areas in the NL Region considered in this report. Note that closure numbers correspond to those shown in Figure 2.

Closure Number	Protected Area	Jurisdiction	Approximate Size (km^2)	Closure Type	General Closure Classification
1	Hopedale Saddle	Canada	15,375	MR	A: Sponge / Gorgonian
2	Hawke Channel	Canada	8,838	MR	C: Fish Habitat
3	Funk Island Deep	Canada	7,284	MR	C: Fish Habitat
4	Northeast Newfoundland Slope	Canada	55,655	MR	A: Sponge / Gorgonian
5	Laurentian Channel	Canada	11,608	MPA	B: Sea Pens
6	3O Coral Closure	Canada/NAFO	14,091*	VME	A: Sponge / Gorgonian
7	Tail of the Bank	NAFO	145	VME	A: Sponge / Gorgonian
8	Flemish Pass / Eastern Canyon	NAFO	5,472	VME	A: Sponge / Gorgonian
9	Sackville Spur	NAFO	1006	VME	A: Sponge / Gorgonian

* A portion of the NAFO 3O Coral Closure (10,422 km^2) is located within the Canadian EEZ and in 2017 was also designated as a Marine Refuge by Canada.

Bottom-Contacting Scientific Surveys

There are five recurring scientific surveys employing bottom-contacting gears that overlap with one or more of the protected areas listed above (Figure 3). These include the DFO-NL spring and fall multispecies RV stratified random bottom trawl surveys, the collaborative post-season (CPS) Snow Crab trap survey, and the DFO-industry Unit 2 Redfish survey. The longline Halibut survey that is run collaboratively by industry and DFO-Maritimes Region also overlaps with multiple protected areas in the NL Region and is therefore included here. Further details on these surveys are provided in Rideout et al. (In Prep[1]) and references cited therein. While other recurring scientific surveys take place in the NL Region, they are not included here because they either do not use bottom-contacting gear or do not overlap with any of the protected areas being considered.

Potential Significant Adverse Impacts of Scientific Surveys

It is well recognized (e.g., Kaiser et al. 2006; Clark et al. 2016) that bottom-contacting fishing gears can damage benthic taxa, communities, and habitats via both direct (i.e., removal of key species, physical damage) and indirect means (e.g., smothering due to increased suspended sediment concentration, smoothing of the seascape). In the case of bottom trawling, commercial fishing is expected to have a larger footprint than scientific trawl surveys. We compared the swept area (i.e., area of direct bottom contact) within protected areas by commercial bottom otter trawls and RV bottom trawl surveys in the NL Region. The available commercial bottom trawl data was limited to a 10-year period (2005–14) and the same time period of RV survey data was used for comparison. The results indicate that the cumulative area impacted by scientific survey trawling over that 10-year period was less than 0.15% in each of the protected areas examined, whereas commercial trawling impacted as much as 5% of the protected area over the same time period (Table 2).The trawling footprint for RV surveys within protected areas is an order of magnitude smaller than that of commercial trawling in areas that were traditionally trawled areas (Table 2). However, it should be noted that commercial trawling footprints are also relatively small in some of these protected areas, likely because these areas were not suitable for commercial trawling (too deep, rocky bottom, etc.), or because the boundaries of the protected areas were established in such a way as to have minimal impacts on commercial fishing activities, such as in the case of the Laurentian Channel MPA (Muntoni et al. 2019), as well as the Hopedale Saddle closure (Koen-Alonso et al. 2018) and the Flemish Pass/Eastern Canyon closure (NAFO 2013). It should also be emphasized that the estimates presented here represent an underestimate of area impacted by commercial fishing in protected areas, since the impacts of gears other than bottom otter trawl were not considered.

[1] Rideout, R.M., Warren, M., Skanes, K., Pantin, J., Neves, B.M., Wareham-Hayes, V., Munro, H., Cyr, F., Rogers, B., and Koen-Alonso, M. In Prep. Reviewing impacts and benefits of scientific surveys with bottom-contacting gears inside protected areas in the Newfoundland and Labrador Region. DFO Can. Sci. Adv. Sec. Res. Doc.

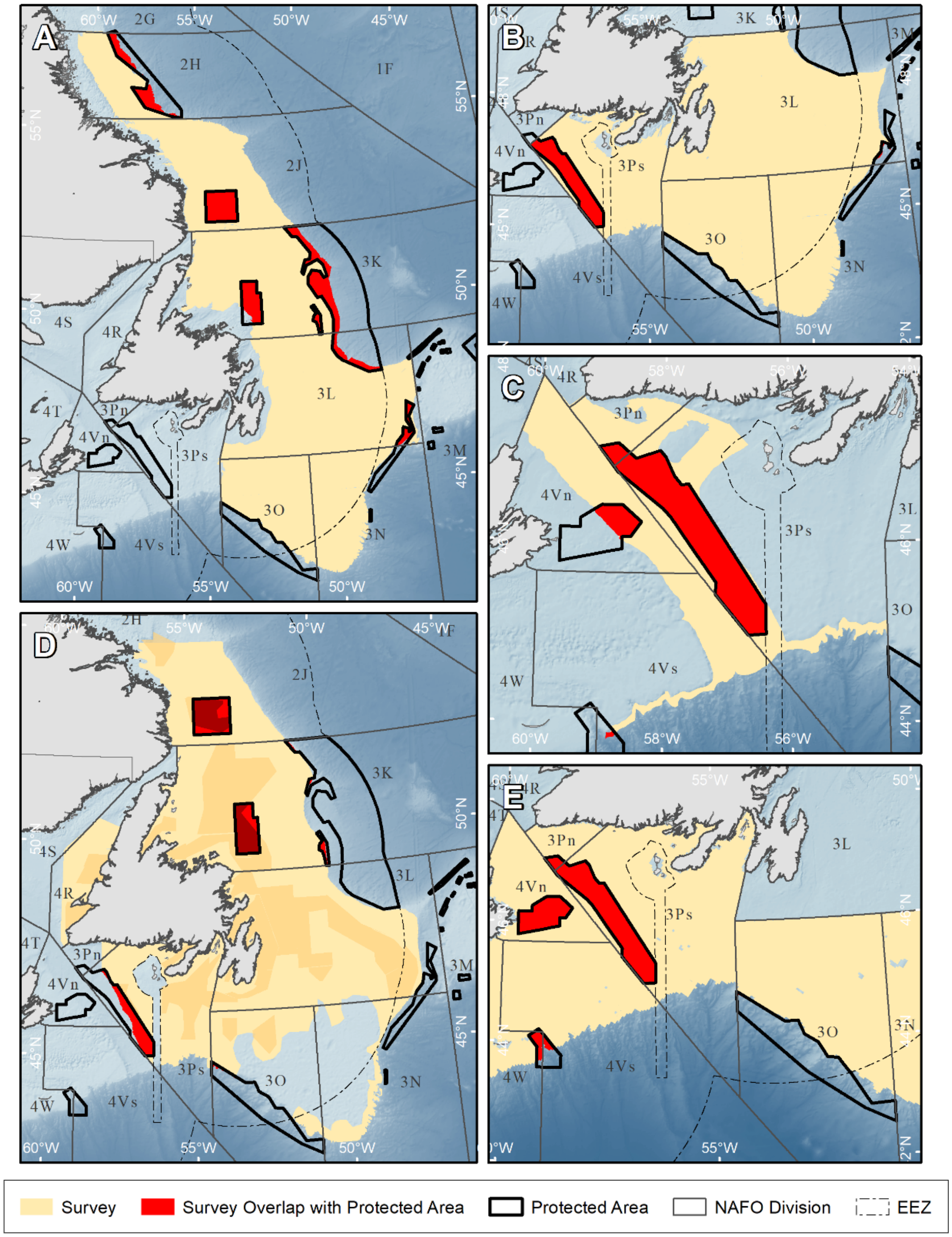

Figure 3. Maps demonstrating the five recurring bottom-contacting scientific surveys considered in this report and the degree to which they overlap with protected areas in the NL Region: (A) DFO fall multispecies bottom trawl survey, (B) DFO spring multispecies bottom trawl survey, (C) DFO-industry Unit 2 Redfish bottom trawl survey, (D) collaborative post-season Snow Crab trap survey, (E) Halibut longline survey. The survey domain is indicated in yellow (darker yellow areas within the domain of the Snow Crab trap survey represent index strata currently used in the Snow Crab assessment), protected areas are indicated by black outlined polygons, and the red areas indicate the overlap between the survey domain and the protected area.

Table 2. Comparison of cumulative swept area of RV multispecies bottom trawl surveys (Spring and Fall combined) versus commercial bottom trawling in each of the protected areas over a 10-year period (2005–14). Values represent the total area trawled as a percentage of the total protected area. Numbers in parentheses represent the total cumulative swept area.

Protected Area	RV Surveys	Commercial Trawling
Laurentian Channel	0.153 % (17.7 km^2)	5.164 % (599.4 km^2)
Northeast Newfoundland Slope	0.028 % (15.4 km^2)	1.279 % (711.9 km^2)
3O Coral Closure	0.031 % (4.4 km^2)	0.312 % (43.9 km^2)
Hopedale Saddle	0.064 % (9.8 km^2)	0.122 % (18.8 km^2)
Flemish Pass/Eastern Canyon	0.064 % (3.5 km^2)	0.048 % (2.6 km^2)
Funk Island Deep	0.068 % (5.0 km^2)	NA[1]
Hawke Channel	0.075 % (6.6 km^2)	NA[1]

[1]These areas were closed to commercial fishing for part or all of the time period examined.

Impacts of bottom-contacting gears can vary depending on bottom type and the species composition of the area being impacted. Areas containing species with a high degree of structural complexity (e.g., large branching corals, *Geodia* sponge complexes) are particularly vulnerable to damage caused by bottom-contacting gear, primarily on the initial pass. A small number of sea pen species may have some capacity to recover from trawling damage (e.g., upright themselves) (e.g., Malecha and Stone 2009) or even withdraw into the substrate (e.g. Chimienti et al., 2018, Ambroso et al. 2021) and avoid an oncoming trawl, although this has not been examined yet. Nevertheless, large bycatches of these sea pens in some survey tows in the NL Region emphasize their susceptibility and vulnerability to trawling. Physical damage (e.g., fractured skeletons) caused by bottom-contacting gears may also result in direct or indirect (e.g., increased susceptibility to predation and parasitism) mortality of sea pens that come into contact with, but are not captured by the gear. Furthermore, published modeling of sediment transport suggests that trawl-induced sediment plumes can affect vulnerable benthic taxa, such as sponges, more than two kilometers away from the trawl path (Grant et al. 2019).

Significant adverse impacts (SAI) on VMEs are those impacts that “compromise the ecosystem integrity (structure and function), i.e., impairs the ability of populations to replace themselves, degrades the long-term natural productivity of the habitat, or causes significant loss of species richness, habitat or community type on more than a temporary basis, and should be evaluated individually, in combination, and cumulatively” (FAO 2009, 2016). A full assessment of SAI takes six factors into consideration: 1) intensity or severity of the impact, 2) spatial extent of the impact, 3) sensitivity/vulnerability of the ecosystem, 4) ability of an ecosystem to recover, and the rate of such recovery, 5) extent to which ecosystem functions may be altered, and 6) timing and duration of the impact (FAO 2009).

In terms of cold-water coral and sponge habitats, the concept of VME used in international documents and agreements is considered analogous to the SiBA concept used by DFO within Canadian waters. Similarly, SAIs are considered analogous to the notion of Serious and Irreversible Harm (SIH) used by DFO in its regulations, frameworks, and policies (DFO 2017b).

The assessment of SAIs by bottom fishing activities on VMEs (SAI-VME) is an integral part of the NAFO Roadmap for an Ecosystem Approach to Fisheries (Koen-Alonso et al. 2019). As such, NAFO assesses SAIs on VMEs on a five-year cycle, with the first assessment conducted in 2016 (NAFO 2016). While methods and approaches continue to improve, the initial SAI-VME in the NAFO Regulatory Area (NRA) used a combination of scientific survey and fishing Vessel Monitoring System (VMS) data (NAFO 2016). From the analysis of the first factor (i.e., intensity or severity of the impact), sea pens were considered vulnerable, while sponges and gorgonians were considered extremely vulnerable. However, when the analysis considered other factors (i.e., VME area protected by closures, spatial extent of the impact - including an index of VME sensitivity) sponge grounds and gorgonian VMEs were rated as low overall risk of SAI, while sea pens were rated as having a high risk of SAI. This was related to the exposure of sea pen VMEs to fishing activities (i.e., sea pens are primarily associated with areas of soft substrate and shallower depths, which are more suitable for trawling, while large gorgonians and sponges tend to be found on rocky/mixed bottoms and at greater depths), the low sea pen area/biomass protected by closures, and the spatial distribution of these closures. This NAFO SAI-VME approach was used to inform the guidance on level of protection for cold-water corals and sponges in the NL Bioregion, which identified impacted and at-risk zones in relation to commercial fishing activities within the SiBAs (DFO 2017b). This assessment was done prior to the establishment of the more recent series of protected areas in 2017 and could serve as a potential baseline for analyses in relation to commercial fishing activities.

DFO’s National Framework (DFO 2018) proposes a general methodology to evaluate whether scientific surveys with bottom-contacting gears pose a major threat to benthic communities. The approach is based on expressing the recurrence time interval (the average number of years between two sampling events at a particular location) relative to the expected recovery time (resilience) of the biological component(s) of interest. Recurrence time is estimated as the inverse of the proportion of a protected area that is swept by sampling gear annually across all surveys. Unfortunately, recovery times from disturbance for cold-water corals and sponges are not well understood. The framework suggests that a proxy for the expected recovery time is the longevity of the benthic or demersal ecological components of interest. It is known that certain coral communities have existed for at least 2,000 years and there is evidence of high longevity and slow growth rates for certain species. Sea pen longevities can range between 10–80 years, while some large gorgonian corals can be 100 years in age or more. Estimates of sea pen VME recovery time based on recent modelling using commercial fishing effort for the NL Bioregion and NRA indicated recovery times ranging between 15–25 years and up to 50–100+ years depending on the location and fishing intensity (NAFO 2019), which are comparable to estimated ranges of longevity for some sea pens. Even less is known about sponge longevity and growth rates since they do not lay down growth rings/bands like corals.

The average annual percentage of each protected area that was impacted by bottom-contacting science surveys was very low in all cases. The combined total area impacted by all surveys was <0.01% for all but one of the protected areas (Table 3). The protected area with the maximum coverage was the Laurentian Channel, with an average of 0.04% of the protected area impacted by science surveys on an annual basis (Table 3). These low percentages translate into large estimates of recurrence time (Table 4; i.e., the estimated number of years it would take for a given location within the protected area to be sampled again). Generally, for protected areas in the NL Region, the cumulative impacts of all surveys combined resulted in recurrence times of ~9,000–13,000 years (Table 4). In comparison, the recurrence time for bottom-contacting commercial fishing gear within the entire NL Region is, on average, 10.3 years (Koen-Alonso et al. 2018). According to the national framework (DFO 2018), 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. Protected areas in the NL Region clearly meet this criterion. Among the NL protected areas, the lowest recurrence time was ~2,600 years for the Laurentian Channel (Table 4). Despite the low value relative to other NL protected areas, the Laurentian Channel also clearly meets the “order of magnitude” guideline, since individual sea pens that this area was established to protect are thought to have lifespans ranging 10–80 years.

Table 3. Average annual percentage of each protected area impacted by bottom-contacting scientific surveys. NA indicates that the survey did not overlap with the corresponding protected area.

Protected Area	Spring RV	Fall RV	Industry Redfish	CPS Trap	Halibut Longline	Total
Laurentian Channel	0.02	NA	<0.01	<0.01	0.01	0.04
3O Coral Closure (complete)[1]	<0.01	<0.01	NA	NA	<0.01	<0.01
3O Coral Closure (Canada)[2]	<0.01	<0.01	NA	NA	<0.01	<0.01
Flemish Pass / Eastern Canyon	<0.01	<0.01	NA	NA	NA	<0.01
Northeast Newfoundland Slope	<0.01	<0.01	NA	<0.01	NA	<0.01
Funk Island Deep	NA	<0.01	NA	<0.01	NA	<0.01
Hawke Channel	NA	<0.01	NA	<0.01	NA	<0.01
Hopedale Saddle	NA	<0.01	NA	NA	NA	<0.01
Tail of the Bank	NA	<0.01	NA	NA	NA	<0.01
Sackville Spur	NA	<0.01	NA	NA	NA	<0.01

[1] analyses based on entire 3O coral closure; [2] analyses based on only the portion of the 3O coral closure within Canadian EEZ

Table 4. Estimated recurrence time intervals (years) for bottom-contacting science surveys within each of the protected areas. NA indicates that the survey did not overlap with the corresponding protected area.

Protected Area	Spring RV	Fall RV	Industry Redfish	CPS Trap	Halibut Longline	Total
Laurentian Channel	5717	NA	14916	1604532	6994	2612
3O Coral Closure (complete)[1]	2757	10704	NA	NA	6033	8884
3O Coral Closure (Canada)[2]	2757	10343	NA	NA	6033	8734
Flemish Pass / Eastern Canyon	3674	13322	NA	NA	NA	10695
Northeast Newfoundland Slope	4819	9658	NA	1179123	NA	9616
Funk Island Deep	NA	13461	NA	590047	NA	13171
Hawke Channel	NA	11508	NA	924386	NA	11385
Hopedale Saddle	NA	6705	NA	NA	NA	6705
Tail of the Bank	NA	11891	NA	NA	NA	11891
Sackville Spur	NA	11612	NA	NA	NA	11612

[1] analyses based on entire 3O coral closure; [2] analyses based on only the portion of the 3O coral closure within Canadian EEZ

Potential Implications of Restricting/Prohibiting Bottom-Contacting Scientific Surveys In Protected Areas

Scientific trawl surveys represent the cornerstone and foundation of most science advisory processes and constitute an essential source of data for the diversity of scientific studies that build our shared knowledge and understanding of the NL Bioregion marine ecosystems. While describing in detail the multitude of uses of the data collected by scientific surveys is not necessary here, highlighting some key applications and considerations can provide some necessary context. In a general sense, the design of scientific surveys, including the gear/equipment used and the areas/locations subject to sampling, is intended to provide calibrated and repeatable estimates of many variables, so that changes of these variables in space and/or time can be described with an acceptable -and measurable- level of accuracy and precision. The standardized methods and sampling designs used by scientific surveys is what allows using the resulting metrics to test alternative hypotheses to explain observed changes through statistical analyses and modelling studies. Some common examples of these analyses include the characterization of the ocean climate and conditions in the NL shelves, the description and monitoring of changes in the fish communities, the evaluation of the status of commercial stocks and their expected responses to fishing and environmental drivers, as well as the identification, characterization, and delineation of benthic habitats, including cold-water coral and sponge SiBAs/VMEs. These studies provide the basic information for the science advice that informs fisheries and ecosystem management, marine conservation targets, and marine spatial planning decisions. However, bottom-contacting surveys do damage bottom habitats, and when conducted within protected areas these impacts can hinder the conservation objectives for these areas. Therefore, achieving these objectives may require limiting the research activities that can occur within protected areas, which in turn, could negatively affect Science ability to provide advice on the many subjects described above. Properly addressing these emerging trade-offs requires understanding of what we have to gain, and lose, under alternative courses of action.

Therefore, a fully informed decision regarding whether to allow research survey activities within protected areas should not be made without also considering the potential consequences of not surveying within those areas. The potential impacts of excluding scientific surveys from protected areas were simulated here by 1) resampling existing survey data to remove any data that were collected within protected areas, 2) recalculating the relevant data time series estimates without these data, and then 3) comparing these estimates to the original time series (i.e., including data collected within the protected areas, referred to here as the 'baseline').

Of particular concern was the potential for introducing time-varying biases in the data time series which could result in a misinterpretation of population trends and consequently reduce the efficacy of management actions (Benoît et al. 2020a). Such time-varying biases could result, for example, from temporal shifts in species' habitat selection and spatial distribution.

The existence of time-varying bias as a result of excluding surveys from protected areas was determined by analyzing the ratio of time series with and without data in the protected areas using a generalized additive model (GAM) with year as a covariate; if this ratio changed significantly over time (i.e. year was significant at $p<0.05$) then time-varying bias was present.

The time series data explored here included physical oceanography data (i.e., bottom temperature), indicators of ecosystem status, and species-specific indicators of abundance for demersal fish and shellfish stocks. Analyses were not performed for individual protected areas. Instead, protected areas were analyzed in groups based on the general classifications previously described (i.e., A: Sponges and Gorgonian Corals, B: Sea Pens, C: Fish Habitat). In instances where the survey in question overlapped with more than one category of protected area, the combined impacts of losing data from all closure categories was also explored.

Survey indices were calculated here in the same manner as they are for typical resource assessment purposes. Ecosystem-based indices and species-specific demersal fish indices were based on stratified estimates. In instances where the removal of data from protected areas resulted in only a single set for some strata, multiple strata were merged and treated as a single stratum in order to meet the criteria needed (i.e., minimum 2 sets per stratum) to obtain stratified estimates. For shellfish, non-parametric ogive mapping methods were used (OGMAP for RV surveys, OGTRAP for trap survey) to obtain estimates of stock size.

Physical Oceanography

The vast majority of data used to determine average bottom conditions and thermal habitats in the NL Region are obtained during DFO RV multispecies bottom trawl surveys by way of a Conductivity-Temperature-Depth sensor (CTD) installed on the trawl. In theory, these data could be collected within protected areas with no or reduced benthic impact via more traditional methods (e.g., vertical CTD casts). In reality, however, severe time constraints on these surveys in recent years suggest that it is highly unlikely that survey time could be re-allocated for additional sampling beyond standard survey trawl tows. The analyses here therefore focus on the simple exclusion of temperature observations from the protected areas.

Excluding bottom temperature data collected from within protected areas had the largest influence on estimates for Div. 2H, where data are scarcer than in other Divisions. For Div. 2H the lack of data from protected areas (noting that the only protected area in Div. 2H is the Hopedale Saddle) resulted in annual temperature estimates changing by -7% to +5% (average of 2.9%) and the general characterization of the temperature regime changing from "normal" to "warmer than normal" or "colder than normal" in several years. For all other Divisions (see Rideout et al. In Prep[1]), the exclusion of data collected from protected areas resulted in smaller differences in estimated bottom temperature (less than 2% on average) and did not change the advice. The removal of sets from the closures however resulted in colder temperature estimates than the baseline scenario. This is because most protected areas in the Region are located in troughs, channels, or along the slopes, in depth ranges below the cold intermediate layer, and thus in waters warmer than those on the top of the shelf.

Ecosystem Assessments

Ecosystem trends in the NL Region are described in terms of four Ecosystem Production Units (EPUs): the Labrador Shelf (2GH), the Newfoundland Shelf (2J3K), the Grand Bank (3LNO), and southern Newfoundland (3Ps). Species of interest are grouped into fish functional groups based on general body size and feeding habits: small, medium, and large benthivores, piscivores, plank-piscivores, planktivores, and commercial shellfish. Three survey indices (biomass, abundance, biomass/abundance ratio) were examined for each of the functional groups in each of the 4 EPUs based on data from the Spring and Fall RV surveys. The various combinations of EPUs, surveys, functional groups, and indices resulted in a total of 105 data time series being examined (Rideout et al. In Prep[1]).

Ecosystem trends are based on only a set of 'core strata' that exclude both deep-water strata and inshore strata that were added to the survey design in the 1990s (Koen-Alonso et al. 2010). The largest impacts of excluding data from protected areas were observed for Div. 2H and Subdiv. 3Ps, where the amount of spatial overlap between the core strata and the protected areas is largest. For the 3Ps EPU, the exclusion of data from protected areas (note that the Laurentian Channel is the only protected area in this EPU) resulted in significant time-varying biases in 11/21 (52%) of the time series analyzed within this EPU (Rideout et al. In Prep[1]), making this the EPU most affected by the removal of sets. For example, removing data collected from the Laurentian Channel protected area resulted in a temporal increase in bias over time (i.e., survey indices becoming increasingly larger over time) for piscivore abundance (Figure 4).

Overall, most functional groups tend to show relatively small absolute discrepancies in their indices between the scenario and base runs, but many of these small discrepancies still show biases across time, indicating that excluding sets from protected areas has the potential for impacting ecosystem advice, especially because fish functional groups are impacted differently within an EPU, potentially distorting the perception of changes at the fish community level. The fact that bias across time is rather pervasive across fish functional groups and EPUs suggests that changes over time in the use of habitats, including those within protected areas, is a common ecological process. If these types of changes in habitat utilization continue, distortions that could be considered minor today may become more important in the years to come.

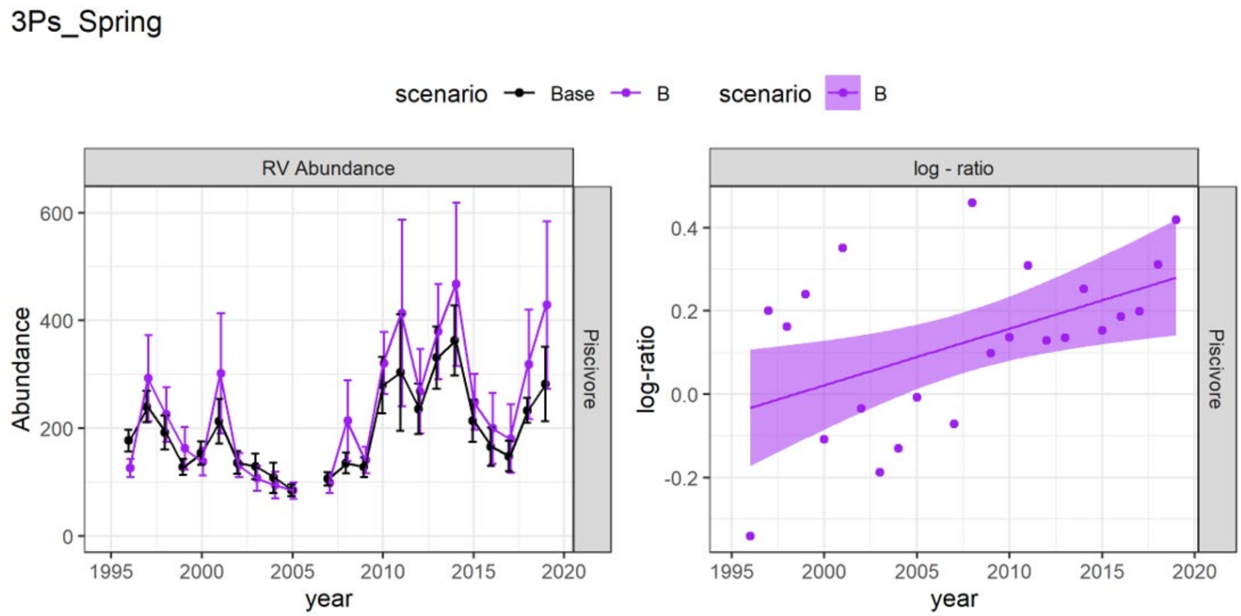

Figure 4. Example of impacts of excluding NL research vessel multi-species bottom trawl surveys from protected areas using data for piscivores in the 3Ps EPU. The 'Baseline' scenario represents the status quo approach (i.e., no exclusion of survey data from protected areas) and scenario B represents the removal of data from within the sea pen protected area. Error bars in the index plot are ±1 standard deviation. The log-ratio plot indicates the relative bias caused by removing data from the protected areas.

Demersal Fish Assessments

Stratified estimates were recalculated for 47 demersal fish time series (14 species, 31 stocks). This list includes stocks that are managed by Canada, some that are jointly managed by Canada and France, and some that are managed by NAFO. Some are species of commercial interest, while others are species at risk.

For demersal fish stocks that overlap spatially with A: sponge and gorgonian coral protected areas, 6 of the 22 (16%) survey time series were subject to time-varying biases when data collected from the protected areas were excluded. Exclusion of data from B: Sea Pen protected areas resulted in 5 of the 12 (42%) time series demonstrating time-varying biases. Exclusion of data collected from C: fish habitat protected areas resulted in time-varying biases for four of the 10 (40%) time series. When data from all types of protected areas were excluded, the combined impact resulted in significant time-varying bias for seven out of the 14 (50%) time series examined.

The impacts that the exclusion of data from within protected areas had on each of the fish stocks examined are provided by Rideout et al. (In Prep[1]). However, detailing the specifics of each of these stock comparisons is not the objective here. It is emphasized that the retrospective simulations performed here cannot forecast which stocks would result in biased survey indices going forward, only that such a practice would have caused biased indices for many stocks in the past. It is important to recognize that changes in species distributions and habitat associations are likely to occur in response to climate change, as well as other environmental and anthropogenic drivers, and therefore the impacts of excluding scientific surveys from protected areas may well extend beyond those demonstrated here. Given that species distribution patterns vary over time, sometimes in conjunction with changes in stock size, it is also possible that extending these analyses further back in time (when population size was much higher for many stocks) could have resulted in a larger number of significantly biased results. In the case of Witch Flounder in Divs. 2J3KL, the stock has shown consistent growth over the abbreviated time series analyzed here (Figure 5). As this stock has grown the bias introduced by excluding data from protected areas became increasingly negative. Such biases could be problematic for the effective assessment and management of these resources.

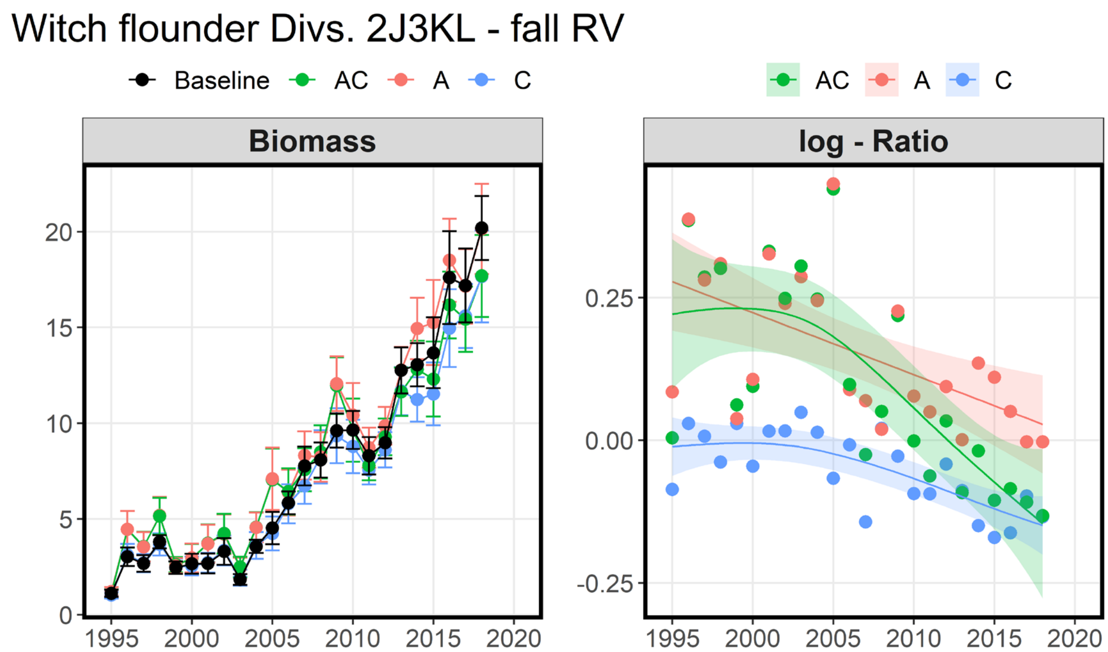

Figure 5. Example of impacts of excluding NL research vessel multi-species bottom trawl surveys from protected areas using data for Witch Flounder in Divs. 2J3KL. The 'Baseline' scenario represents the status quo approach (i.e., no exclusion of survey data from protected areas) and the other scenarios represent the removal of data from within the protected areas, where A = sponge and gorgonian coral protection areas, C = fish habitat protection areas. Error bars in the index plot are ±1 standard deviation. The log-ratio plot indicates the relative bias caused by removing data from the protected areas.

Shellfish Assessments

Analyses were conducted on both Snow Crab and Northern Shrimp. Snow Crab is assessed based on Assessment Divisions (AD) 2HJ, 3K, 3LNO, and 3Ps and uses data from both the RV bottom trawl surveys and the CPS trap survey. Excluding RV data collected from protected areas resulted in a significant time varying bias for three out of the four ADs. For example, simulating the exclusion of the fall RV survey from protected areas in AD 2HJ resulted in survey indices becoming biased increasingly lower over the time series (Figure 6). Simulating the exclusion of the CPS trap survey from protected areas also resulted in time-varying bias for one (AD 3K; Figure 6) out of the four ADs. There were no significant time-varying biases detected for Northern Shrimp indices in Shrimp Fishing Areas 5 and 6.

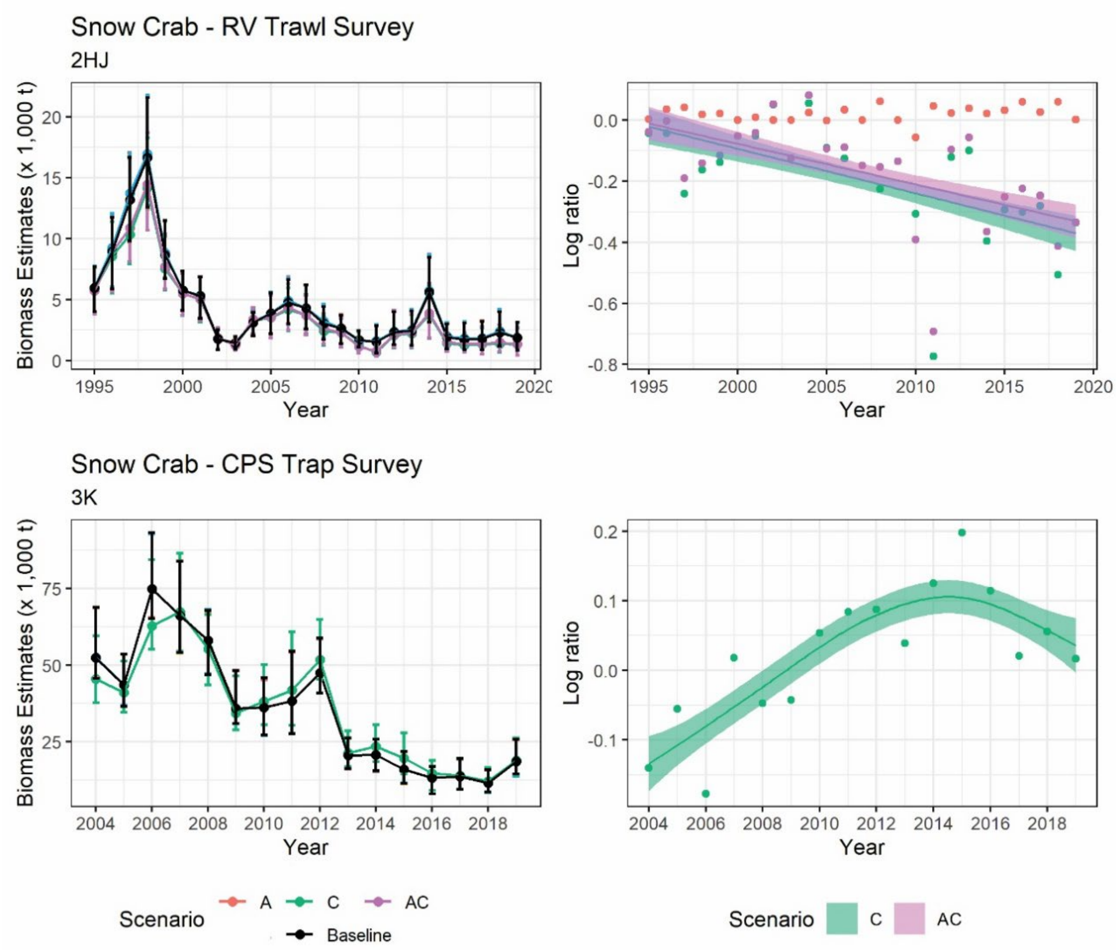

Figure 6. Examples of impacts of excluding the NL fall research vessel multi-species bottom trawl survey (top) and CPS trap survey (bottom) from protected areas using data for Snow Crab in Assessment Divs. 2HJ (top) and 3K (bottom). The 'Baseline' scenario represents the status quo approach (i.e., no exclusion of survey data from protected areas) and the other scenarios represent the removal of data from within protected areas, where A = sponge and gorgonian coral protection areas, C = fish habitat protection areas, and AC = both protected areas. Error bars in the index plot are 95% confidence intervals. The log-ratio plot indicates the relative bias caused by removing data from the protected areas.

Redfish (Unit 1 and 2) Assessment

The Unit 2 Redfish bottom trawl survey is the only survey that covers the entirety of Unit 2. Technical issues that could not be resolved in time for the science advisory meeting prevented a full analysis of the Unit 2 Redfish survey data. These analyses will be completed prior to the next assessment of Unit 1 and 2 Redfish. As a preliminary analysis, however, it was demonstrated here (using inverse distance weighting) that on average ~16% of the Unit 2 Redfish biomass was located within the Laurentian Channel protected area during previous surveys. Given that stock size and distribution have changed dramatically in recent years (Figure 7), the exclusion of this survey from the protected area is very likely to influence survey estimates and, therefore, these analyses should be completed as soon as possible to support decisions regarding this survey going forward. It should be noted that this survey also partially overlaps with two protected areas in the Maritimes Region, which typically amount for less of the Redfish biomass estimate (~5% for St. Anns Bank, 0.1% for the Gully).

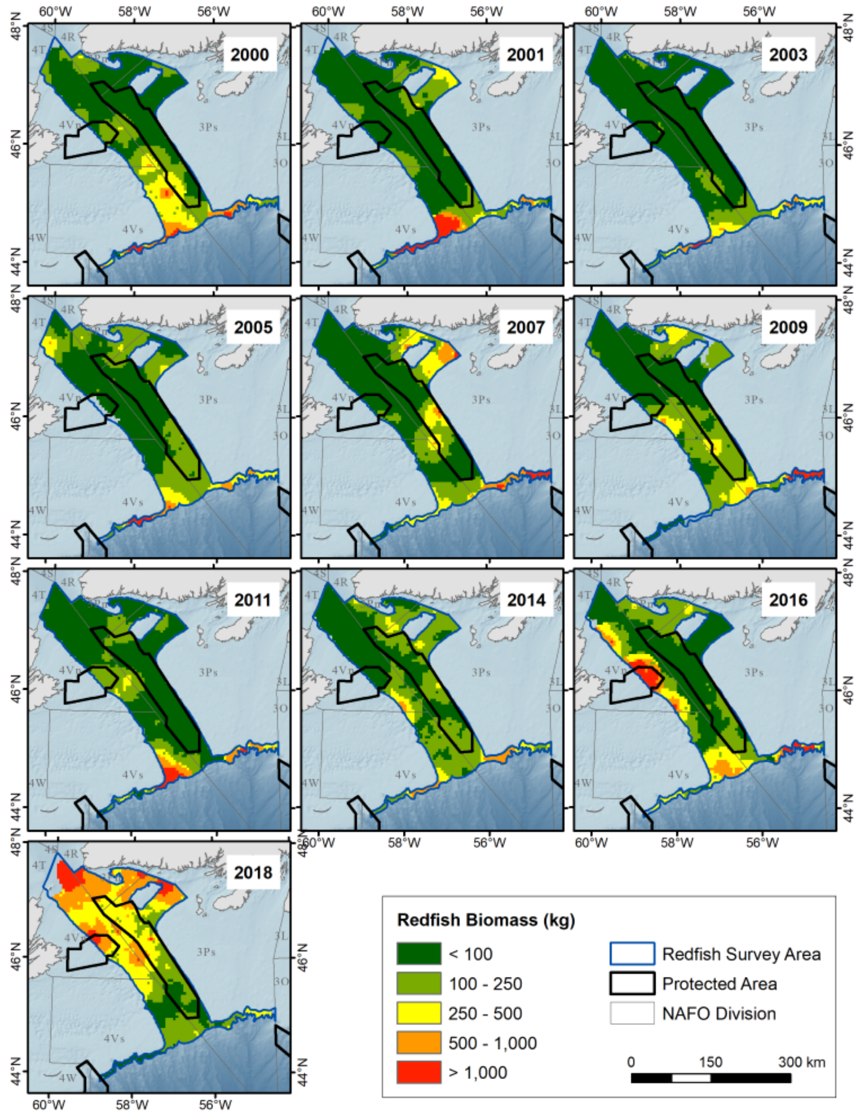

Figure 7. Annual estimates of Inverse distance weighted (IDW) interpolated biomass for the Unit 2 Redfish survey.

Potential Mitigation Measures

Despite the sensitive nature of benthic species, the analyses presented here do not support a blanket exclusion of research surveys from all protected areas. Survey recurrence times in relation to expected recovery times suggest that bottom-contacting science surveys do not pose a major long-term threat to benthic ecosystems in the protected areas assessed here. It was also demonstrated that, any such decision to completely exclude scientific surveys would be likely to bias data sources that play a crucial role in ecosystem monitoring and resource assessment for demersal fish and shellfish stocks.

Mitigation measures should still be explored, however, to potentially minimize the impacts of survey activities that do operate within protected areas. For a mitigation measure to be effective and applicable it should not only reduce the impact on benthic taxa, but also do so without compromising the quality of the survey data collected. While many of the measures that have been proposed elsewhere would potentially accomplish the goal of reducing impacts on benthic taxa (e.g., changing survey gear to have less bottom contact or modifying gear to minimize bottom impact), such changes to survey design would influence survey catchability for some, if not all, species and invalidate new observations with respect to existing time series data. While some of these potential mitigation measures are theoretically valid, the need for comprehensive comparative fishing experiments (i.e. huge financial and time investments) that are not guarantee to be successful are almost certain to result in many of these measures not being feasible. Given the general conclusion that the scientific surveys analyzed here likely do not represent a major long-term threat to benthic ecosystems, the goal here is to discuss plausible effective mitigation measures that might serve to reduce benthic impacts while not compromising these crucial data sources.

Benoît et al. (2020a) reviewed mitigation measures that could potentially reduce the impacts of survey activities in protected areas and concluded that there is currently no suitable alternative survey method that can replace trawling in a multispecies context. The most plausible mitigation measures for such surveys include 1) re-allocating sets to areas outside protected areas or to ‘less sensitive’ regions within protected areas, 2) reducing the number of survey fishing sets within protected areas, and 3) reducing the length of survey fishing sets within protected areas. However, there are potential complications that need to be considered for any of these measures.

Bottom trawl surveys conducted in the NL Region are stratified-random surveys, meaning that set locations are selected randomly within each stratum prior to the start of the survey. There is typically a tolerance level (≤2 nm) to allow the survey to deviate slightly from the chosen survey set location if the bottom in that location is not considered to be trawlable (e.g., jagged, rocky bottoms are likely to result in damage to the survey gear and render the data from the tow as ‘invalid’). In instances where survey sets are positioned within protected areas but close to the area boundary, it might be possible to relocate the sets just outside the area boundary within the acceptable tolerance level. In instances where set locations are within protected areas and not close to the area boundary, moving them outside of the protected area would be a violation of the survey design. To account for the potential of untrawlable bottom, however, alternate set locations are also randomly selected for each stratum during the survey design process. In some instances, survey set locations that fall within protected areas could potentially be replaced with one of the alternate set locations, if those fall outside of the protected areas. However, it must be emphasized that always excluding set locations from the protected areas is equivalent to the exclusion of surveys from these areas. The analyses presented here clearly demonstrate that such extreme measures are not warranted and would cause reliability issues for resource assessments in the broader ecosystem context. It might be possible to only exclude bottom-contact surveys from the most sensitive regions within protected areas (e.g., areas that have the highest densities of vulnerable benthic taxa) rather than the entire protected area. It is known that the distribution of high-density locations of vulnerable benthic taxa is not uniform within the habitats they define (NAFO 2013), and therefore it can be inferred that their distribution will not be uniform within protected areas. However, any such movement of set locations should still obey survey design parameters, as discussed previously. It is also important to consider that setting aside large regions within protected areas as high-vulnerability areas should be accompanied by analyses similar to those conducted here for the entire protected area(s) in order to understand potential implications regarding survey data quality.

Another potentially plausible mitigation measure for bottom trawl surveys is the reduction of the footprint of individual trawl tows by reducing the tow duration. Reducing tow length towards the minimum acceptable length (typically no less than 70% of a target standard tow length), however, could result in more tows violating the minimum length criteria, and thus being invalid.

Furthermore, previous analyses have demonstrated virtually no difference in quantities of corals and sponges caught in 15- vs. 30-minute tows (NAFO 2008, 2009) suggesting that catch rates are not linearly related to tow duration. Following from that, reductions in tow duration will not necessarily result in reduced impacts on benthic taxa. In the case of stratified survey designs, one could also potentially explore reducing the number of sampling events (i.e., survey sets) per stratum to reduce the overall benthic impact within protected areas. For DFO RV bottom trawl surveys, however, many of the strata that overlap with the current set of protected areas already contain the minimum allowable number of sets (i.e., 2) to enable stratified estimates to be calculated. Some strata that overlap with the Laurentian Channel closure contain a larger number of allocated sets, so slight reductions could be possible in that area. However, such decisions should not be made haphazardly. The design of these surveys allocates the number of sets proportional to the stratum area and careful consideration needs to be given to the impact of any alteration to survey design on the uncertainty of subsequent data analyses.

The potential for video surveys to replace Snow Crab trap surveys in protected areas has been suggested as something worth exploring in other regions (Benoît et al. 2020b). However, video surveys would not be capable of capturing critical biological data currently collected by at-sea observers as part of the standard sampling procedures for the post-season Snow Crab trap survey. The at-sea observers sample Snow Crab of all sizes and much of the biological data collected through at-sea sampling and used in the stock assessment (shell condition, male claw height to determine maturity, presence of Bitter Crab Disease, female maturity, and egg stage) would not be possible with video surveys. There would also be many logistical issues related to the fact that these surveys are conducted by industry (in collaboration with DFO) and the vessels used may not be able to be adapted for camera deployment. In addition, the need to calibrate with survey densities sampled by traps outside protected areas, and the extra time and cost associated with processing video data render this option inviable at present (Benoît et al. 2020a; b).

The cumulative footprint (and potential impacts on SiBAs) of multiple, spatially overlapping surveys could be reduced by limiting the number of surveys that sample the same areas. In the NL Region this would particularly apply to the areas that are covered by both the spring and fall DFO RV surveys (i.e., Divs. 3LNO). The nose and tail of the Grand Bank extend outside Canada's EEZ and are also covered by EU-Spain bottom trawl RV surveys, in addition to the two Canadian trawl surveys. In theory, these surveys could be intercalibrated such that the data from one survey could be substituted for another (and then one or more of the surveys could be discontinued). However, differences in survey design (e.g., vessel, survey gear, timing of the survey, etc.) are almost certain to translate into differences in catchability for some or all of the species sampled during these multispecies surveys. For this reason, the intercalibration of multispecies surveys for the suite of species monitored would be an extremely difficult task and would require substantial time and resource investments. It is also not guaranteed that such intercalibrations would even be possible for some species/surveys.

One final potential mitigation measure that is seldom discussed elsewhere would be to compensate for any potential impacts of scientific surveys on SiBAs by slightly expanding the size of the protected areas. Most protected areas with benthic conservation objectives do not encompass the entirety of the SiBAs identified in that area, and hence some portions of the SiBAs are not protected by these spatial closures. A slight expansion of the protected area would remove the larger scale impacts of commercial fishing (or other anthropogenic activities) from those areas, while maintaining lower impact scientific surveys.

Monitoring Protected Areas Using Bottom-Contacting Surveys

The establishment and delineation of the current set of protected areas has relied in part on data from bottom-contacting scientific surveys. Going forward, it may be possible to monitor fish and shellfish communities within protected areas with bottom-contacting surveys, but these are not the most appropriate methods to undertake long-term monitoring of vulnerable benthic taxa. For these taxa, alternative, less-destructive methods like seafloor visual surveys (e.g., ROV, drop cameras) are more appropriate. The use of environmental DNA (eDNA) could also be considered to complement these methods. Additionally, any bottom-contacting scientific surveys that do take place within protected areas should at least employ enhanced sampling protocols that will maximize the amount of information being collected on vulnerable benthic taxa. Most protected areas also have conservation objectives related to other species (fish, marine mammals, etc.) and the removal of bottom-contacting surveys could hinder the provision of advice relating to some of those conservation objectives, but these have not been evaluated here.

Sources of Uncertainty

The time required for cold-water corals and sponges to recover from anthropogenic disturbances is not well understood. Limited knowledge regarding coral and sponge larval biology, population dynamics, and connectivity in the NL Region add uncertainty to analyses of recovery potential. In addition, while certain coral species are known to reach longevities of decades or centuries, longevity of sponges and corals at the habitat level is mostly unknown. DFO's national framework (DFO 2018) proposes the method used here of comparing lifespan and trawling recurrence times to estimate recovery time. The framework also acknowledges the degree of uncertainty in this approach, by suggesting a precautionary buffer of an order of magnitude to minimize the risk of overestimating recovery potential. However, the framework focuses on the potential recovery of individuals and does not acknowledge uncertainties regarding the timelines for the recovery of biogenic features associated with these benthic taxa, and the key role that some of these features play. For example, certain coral and sponge communities are known to have been in place for thousands of years, and recovery at the individual level might not necessarily reflect habitat recovery (i.e., numerical recovery of a species might not be immediately associated with recovery of its ecological functions and ecosystem services provided).

The analyses presented here and elsewhere (e.g., Benoît et al. 2020ab, Koen-Alonso et al. 2018) likely represent underestimates of the impacts of both commercial and scientific survey trawling on vulnerable benthic taxa. Such analyses have been based only on the footprint of the trawl (i.e., only consider physical damage due to direct contact with the fishing gear) and do not consider the indirect impacts, such as those caused by sediment resuspension. The data to accurately account for these indirect impacts do not currently exist. However, it has been demonstrated that sediment plumes from trawl deployments can travel >2 km from their source (Grant et al. 2019). The impacts of this re-suspended sediment on benthic taxa would be difficult to quantify but it has been demonstrated that increased sedimentation can clog coral feeding polyps and hamper sponge filtration activities. In addition, the much larger area potentially impacted by sediment clouds relative to the immediate trawl path would also suggest that benthic taxa are likely to be impacted by survey trawling at higher frequencies than reported here.

Recurrence times were calculated here based on the size of the footprint of the fishing gear in relation to the total area of the protected area, but this is an average estimate, and it does not preclude that, given the random nature of sampling locations, survey trawls can occur on a particular location more frequently. Also, because bottom trawl survey set locations are randomly selected (vs. the targeted locations of commercial trawling), the analysis of recurrence times presented here indicate that scientific trawling occurs more often at previously non-impacted areas, where the first trawl pass causes the most damage.

Finally, it is important to keep in mind that, at least for some cold-water corals and sponges, the current SiBAs likely represent the relics of former distributions resulting from decades of fishing impacts. Therefore, estimates of impact based on current coral and sponge distributions and/or densities are expected to be underestimates as the historical impacts on these benthic habitats have not been quantified.

CONCLUSIONS AND ADVICE

It is known that bottom-contacting scientific sampling gears can have similar damaging impacts on vulnerable benthic taxa as commercial fishing gears, although at vastly reduced scales. However, the analyses presented here do not support a blanket exclusion of research surveys from all protected areas. Survey recurrence times in relation to expected recovery times suggest that bottom-contacting science surveys do not pose a major long-term threat to benthic ecosystems. In addition, any such decision to completely exclude scientific surveys would be likely to bias data sources that play a crucial role in ecosystem monitoring and resource assessments for demersal fish and shellfish stocks. These scientific surveys also play an important role in monitoring some of the conservation objectives of the protected areas. While bottom-contacting surveys are not the best option for monitoring vulnerable benthic taxa, efforts should be made to improve sampling protocols to maximize the information gathered from these surveys relating to benthic taxa in protected areas. And although the bottom-contacting scientific surveys described here may not pose long-term threats to benthic taxa, mitigation measures (e.g., avoiding smaller areas of high densities of benthic taxa within the protected areas) should be explored in order to minimize harm.

Management Considerations

It is important to emphasize here the difference between commercial trawling and trawling conducted during multispecies sampling on scientific surveys. For example, it was demonstrated that the area impacted by commercial trawling within protected areas in the NL Region is often a magnitude higher than it is for scientific survey trawling, even though the boundaries of protected areas were often explicitly drawn to minimize the displacement of fishing activities, and hence, encompass little fishing effort within them. It is important that these differences are communicated to DFO’s clients and the general public.

Although the analyses presented here suggest that scientific surveys in the NL Region do not likely have long-term impacts on benthic taxa in protected areas, the vulnerable nature of these species, and uncertainties related to aspects of their biology that could influence recovery time, suggest that efforts should still be made to minimize the impacts of scientific surveys to the extent possible. However, many mitigation measures that are commonly discussed would have large impacts on the utility of data used to monitor marine resources and could essentially mark the end of long-standing data time series that are the foundation of resource assessments. Even changes to survey sampling that are considered small by some, can represent violations to the principles of survey design and have far-ranging implications for data analyses. It is therefore vital that managers in charge of protected areas (and the achievement of their conservation objectives) work closely with Science when it comes to advising on measures intended to mitigate the impacts of bottom-contacting surveys on vulnerable benthic taxa in protected areas. To that end, the next logical step would be for managers and scientists to collaborate on the development of a framework to assist in the selection and implementation of appropriate survey mitigation measures for protected areas. Such a framework could, for example, focus on the development of a practical hierarchy of options related to mitigation measures in order to provide objective operational guidance for evaluating and potentially modifying survey practices in protected areas with benthic conservation objectives.

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SOURCES OF INFORMATION

This Science Advisory Report is from the Regional Peer Review process of October 5–9, 2020 on An Assessment to Support Decisions on Authorizing Scientific Surveys With Bottom-Contacting Gears In Protected Areas In The Newfoundland And Labrador Bioregion. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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