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Ecosystems and Oceans Science / Sciences des écosystèmes et des océans

Newfoundland and Labrador Region

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Science Response 2017/030

GUIDANCE ON THE LEVEL OF PROTECTION OF SIGNIFICANT AREAS OF COLDWATER CORALS AND SPONGE-DOMINATED COMMUNITIES IN NEWFOUNDLAND AND LABRADOR WATERS

Context

Fisheries and Oceans Canada (DFO) has identified Significant Benthic Areas (SBAs) as ecologically and biologically significant cold-water coral or sponge-dominated regional habitats (DFO 2017). Within these areas, Sensitive Benthic Areas (SeBAs, not to be confused with SBAs) are defined based on their exposure to proposed or ongoing fishing activities. Mitigation of impacts of fishing in SeBAs, or avoidance of serious or irreversible harm to sensitive marine habitat, communities and species due to fishing activities is managed through DFO's Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas (hereafter referred to as "SeBA Policy"). Management decisions to address the impacts of fishing in SeBAs will be based on precautionary and ecosystem approaches, and take into account socio-economic considerations (DFO 2009). Recent science advice has identified SBAs and estimated their degree of overlap by fishing activities in Atlantic Canada and the Eastern Arctic (DFO 2017). However, further guidance is required for the operational implementation of the SeBA Policy regarding what level of protection to SBAs is sufficient to deliver the conservation goals of this policy.

At the present time there are no National guidelines on this topic. Given the ongoing process for implementing the SeBA Policy in the Newfoundland and Labrador (NL) Region, Ecosystems Management requested that Science provide guidance and advice on the level of protection that would be deemed sufficient to mitigate impacts of fishing on SBAs or to avoid impacts of fishing that are likely to cause serious or irreversible harm to SBAs in the NL bioregion. The NL bioregion is defined as Northwest Atlantic Fisheries Organization (NAFO) Subareas 2 and 3, also denoted as "NL waters", even though some analyses also required the inclusion of Div. 0B to preserve ecological integrity of some of the features considered. This guidance should, whenever possible, consider:

1. The fraction of the SBA area and/or biomass that needs to be protected to avoid serious or irreversible harm.
2. The spatial arrangement of the potential closure areas.
3. The potential impacts of current fishing effort within SBAs.

This Science Response Report results from the Science Response Process of April 19, 2017 on the Guidance on the Level of Protection of Significant Areas of Coldwater Corals and Sponge-Dominated Communities in Newfoundland and Labrador Waters.

Background

Cold-water coral and/or sponge-dominated habitats are Significant Benthic Areas (SBAs) in the context of the SeBA Policy (DFO 2017), but they also constitute examples of Vulnerable Marine Ecosystems (VMEs) in the context of the United Nations (UN) Food and Agriculture Organization (FAO) International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (hereafter referred to as “FAO Guidelines”, FAO 2009).

The FAO Guidelines were developed as a tool for implementing the 2006 UN General Assembly Resolution 61/105, which called Regional Fisheries Management Organizations and member states to enact protection of VMEs from significant adverse impacts of bottom-contacting fishing gears.

In international waters, addressing UN General Assembly Resolution 61/105 has led NAFO to identify the footprint of its fisheries (including enacting more stringent protocols for exploratory fishing outside the fishing footprint), delineate VMEs, and establish closures to bottom contacting gears for their protection (NAFO 2016, 2017). As part of its efforts, NAFO conducted its first assessment of the impacts of bottom fishing activities on VMEs in 2016, and has committed to continued assessments every five years (NAFO 2016, 2017).

The process of addressing UN General Assembly Resolution 61/105 in Canadian waters led DFO to develop its Sustainable Fisheries Framework and the policies within, including the SeBA Policy. Implementation of the SeBA Policy has involved the design of management tools like DFO *Ecological Risk Assessment Framework for coldwater corals and sponge dominated communities* (DFO 2013), as well as a series of Science Advisory Processes dealing with the impacts of mobile and fixed gears on habitats and communities (DFO 2006, 2010a), the characterization, occurrence, location, and susceptibility to fishing of vulnerable benthic habitats (DFO 2010b), encounter protocols (DFO 2011), and the delineation of SBAs and their overlap with fishing activities in Atlantic Canada and the Eastern Arctic (DFO 2017). At the present time, the only area-based protection measure for SBAs in Canadian waters adjacent to NL is the Division 3O coral protection zone, which straddles domestic and international waters.

Although the processes towards protecting cold-water coral and/or sponge-dominated habitats have advanced differently in DFO and NAFO, and some of the details of these processes differ, the fundamental ecological features and key definitions are consistent across jurisdictions. With respect to cold-water coral and sponge-dominated habitats, the concepts of SBA and VME are equivalents. Similarly, the notion of serious or irreversible harm (SIH) used by DFO is analogous to significant adverse impact (SAI) used by NAFO. Also, the functional groups used to define SBAs and VMEs are consistent between DFO and NAFO. This consistency in principles and approaches provides a robust basis for coherent management practices at functional ecosystem scales, irrespective of legal boundaries, as well as cross applications and inferences from analyses done in both jurisdictions.

Analysis and Response

Considering coverage and spatial arrangement of closures: Summary of the NAFO approach to assess Significant Adverse Impacts on Vulnerable Marine Ecosystems

NAFO provides a relevant precedent for protection of VMEs in international waters. The 2007 amended NAFO convention commits the organization to apply an ecosystem approach to fisheries. The ongoing plan for its implementation is summarized in the “Roadmap towards implementing ecosystem approach to fisheries for NAFO” (NAFO 2010a,b, 2012, 2013), which in its initial stages has been heavily focused on developing and enacting measures for VME protection. This process has led to the creation of 15 coral and sponge closure areas (i.e. fisheries closures to bottom contacting gears) within the NAFO fishing footprint, including the Division 3O coral protection zone which extends into Canadian waters (Figure A1), six seamount closures outside the NAFO fishing footprint, encounter protocols for corals and sponges, and the commitment to regular assessment of the impacts of bottom fishing activities on VMEs every five years (NAFO 2017). The first assessment of SAIs on VMEs in the NAFO Regulatory Area was conducted in 2016 (NAFO 2016).

NAFO’s full assessment of SAI was guided by the six criteria for significance and scale of impacts described in the FAO Guidelines (FAO 2009):

i. *“The intensity or severity of the impact at the specific site being affected.*

ii. *The spatial extent of the impact relative to the availability of the habitat type affected.*

iii. *The sensitivity/vulnerability of the ecosystem to the impact.*

iv. *The ability of an ecosystem to recover from harm, and the rate of such recovery.*

v. *The extent to which ecosystem functions may be altered by the impact.*

vi. *The timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life-history stages.”*

The NAFO SAI-VME assessment mostly addressed criteria i-iii, which together characterize the direct impacts of fishing. Criteria iv-vi address functionality of VMEs and were of secondary focus in the assessment due to data and knowledge limitations, including the difficulty of properly quantifying VME ecological functionality. However, these function-focused criteria were still considered with qualitative data such as descriptions of communities associated with VMEs, transitions in VME communities with depth, comparisons with non-VME areas, observations of specific associations between fish and VMEs, observations of lack of recovery in specific locations within the study period, and available studies on coral growth rates.

A central piece of the NAFO SAI-VME analysis was the identification of areas considered to be at low risk of SAI (i.e. portions of VMEs currently protected by closures or outside the NAFO footprint), areas at high risk of SAI (portions of VMEs exposed to levels of fishing effort which are still consistent with the occurrence of VME taxa with higher biomass densities), and impacted areas (portions of VMEs exposed to high enough levels of fishing effort so that occurrence of VME taxa is characterized by very low biomass densities; NAFO 2016). The discrimination between high risk and impacted areas was based on the analysis of cumulative VME biomass curves as a function of average fishing effort within delineated VMEs using a 1x1 nautical mile grid, and where the effort cut-off point between high risk and impacted was defined by the 95th percentile of the cumulative biomass curve (Fig. 1, NAFO 2016).

In addition to this characterization, the NAFO SAI-VME analysis also considered the spatial arrangement of VME units within the ecosystem and the level of protection provided to the entire VME distribution, the co-occurrence of multiple VME types in a given area, the relative tolerance of different VME types to fishing, and the stability/variability of fishing impacts on VMEs (NAFO 2016).

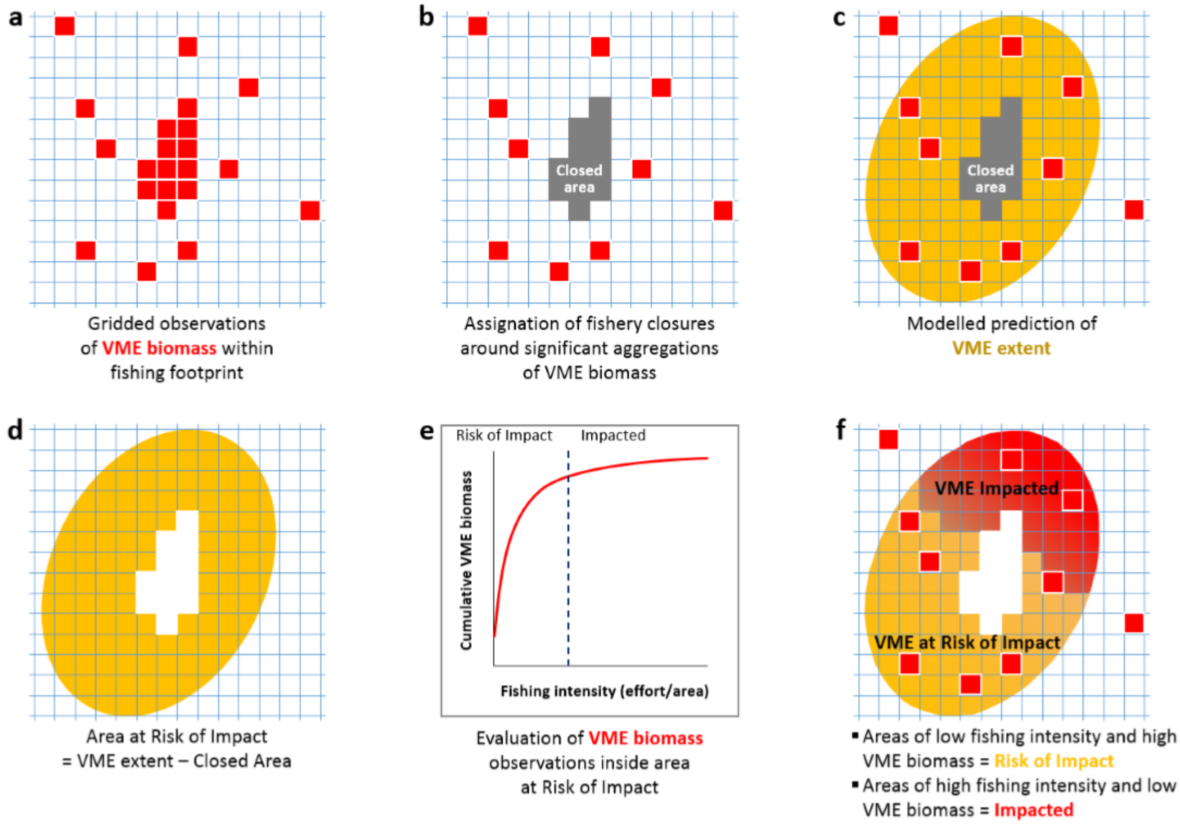

Figure 1. Workflow of the analysis as seen in NAFO 2016: a) cells that have values for research survey biomasses and presence of commercial fishing are selected; b) cells within closure areas are excluded and deemed "low risk" of SAI; c) cells that fall within a VME habitat are selected; d) size of the at-risk area is calculated; e) cells are ordered by increasing fishing effort and the cumulative VME biomass is plotted. The level of effort that corresponds to 95% of the cumulative biomass is the cut-off value, i.e. the index of sensitivity; f) VME areas are portioned into "high risk" and "impacted" categories depending on whether they have fishing effort below or above the cut-off value, respectively.

The NAFO assessment covered multiple VME types, but the focus of the SAI-VME analysis were sea pen, large gorgonian, and sponge VMEs for which more information was available. The assessment found that sea pens were at high risk of SAI, largely due to the low percentage of their overall area (16%) and biomass (19%) in the "low risk" category, and over 36% percent of their area (39% of biomass) at impacted levels. Sea pen VMEs also had 26% of their discrete units unprotected, and the distribution of fishing within was variable from year to year compared to fishing in sponge and large gorgonian VMEs. Variable fishing from year to year increases the likelihood of areas subject to first-exposure which is typically considered the most impactful. Sea pens had the lowest proportion of their area overlapping with other VMEs and thus protection offered to other groups did less to benefit sea pens.

Despite higher indices of sensitivity, large gorgonians and sponges were both found to have low overall risk of SAI, largely because most of their area (56% and 65%) and biomass (63% and 73%) was within fisheries closures, most VME units in their respective spatial distributions were protected, and the areas exposed to fishing showed lower variability, indicating a lower likelihood than sea pens to first-exposure.

The extensive work on the NAFO SAI-VME assessment is informative to the NL bioregion because it considers VMEs on the international portion of the Grand Banks ecosystem which contains the same taxa as in Canadian waters. Also, the general process leading to the NAFO SAI-VME analysis was developed over a decade and was refined to the extent possible given the availability of data, constituting a robust template for DFO Science to use for SBAs in NL.

Considering potential impacts of fishing in the NL bioregion: Initial assessment of risk of Serious or Irreversible Harm to Significant Benthic Areas

DFO Science has defined four SBA types among cold-water corals and sponges based on dominant taxa:

1. Sponges (phylum Porifera);
2. Sea pens (order Pennatulacea);
3. Small gorgonians (order Alcyonacea); and
4. Large gorgonians (order Alcyonacea).

Sponges are sessile animals with characteristic spicules that create the structure for their porous bodies. Sea pens are soft coral suspension feeders that have a feather-like shape and a specialized polyp that anchors them on sandy or muddy substrate. The small gorgonian taxa are typically found on soft bottom substrates and have a variety of structures: bushy, bamboo-like, or whip-like shapes. Large gorgonian taxa are species that are more commonly attached to hard rocky bottoms and include branching and bushy shapes. These four SBA types only represent habitats of SBA taxa that aggregate and do not represent other non-aggregating sensitive species groups such as black corals and bryozoans.

Current SBA units have been identified and delineated in Atlantic Canada and Eastern Arctic waters using species distribution models and kernel density estimation based on observations from trawl surveys, video/photographic research surveys, and records from fisheries observer programs (Kenchington et al. 2016, DFO 2017). SBAs do not correspond to the entire distribution of the defining taxa, they represent regional habitats that contain SBA taxa as a dominant and defining feature. The individual delineated habitats (or “polygons”) in an SBA will be referred to SBA units herein.

SBA habitats have been present in NL ecosystems for millennia (Murillo et al. 2016). Their defining and dominant taxa are typically slow growing species (Sherwood and Edinger 2009, Neves et al. 2015a), and repeated observations of SBAs impacted by fishing typically show no indications of recovery after 10 or more years of impact (Neves et al. 2015b). Given the long history of fishing in NL, current SBAs are considered to be the remnants of the “original” habitats. Historical accounts from fisheries observers in the NL bioregion indicate high prevalence of SBA taxa in some of these areas (Gass and Willison 2005).

Although the functionality and ecosystem services of these habitats are difficult to quantify, existing studies in the Northwest Atlantic have documented that SBAs are associated with enhanced diversity and abundance of benthic macrofauna (Barrio-Froján et al. 2012, Beazley et al. 2013), show distinct fish associations (Baker et al. 2012a, Kenchington et al. 2013), display transitions in community structure with local physical gradients like temperature, salinity, and depth (Edinger et al. 2011, Baker et al. 2012b, Kenchington et al. 2014, Beazley et al. 2015), and appear associated with larvae/juvenile stages of fish species (e.g. redfish associate with sea pens), suggesting they could constitute nursery areas (Baillon et al. 2012).

Evidence from studies around the world is also mounting on the important role of SBA habitats as hotspots for biogeochemical cycles, and nutrient recycling (van Oevelen et al. 2009, Kutti et al. 2013, Cathalot et al. 2015, Rix et al. 2016). These types of ecosystem services are a function of the areal extent of the SBA habitats, and hence, significant reductions in areal extent would have direct impacts on these processes. Depending on the scale of the impacts and the original size of the SBA habitat, these perturbations could affect overall ecosystem productivity.

Existing DFO Science Advice indicates that fishing activity in Atlantic Canada and Eastern Arctic waters is highly aggregated in space, and that most fishing activity is exerted outside SBAs. However, the percent of the SBA overlapped by fishing activities in the NL bioregion is 37%, 38%, 57%, and 72% for sponges, large gorgonians, sea pens, and small gorgonians respectively for all fisheries combined (excluding pelagic fisheries; DFO 2017).

These levels of overlap suggest that impacts of fishing on SBAs are likely, but the potential risk of impacts will be a function of both the cumulative fishing activity exerted in a given location by all fisheries, and the type of gears used by the different fisheries. This potential risk of impact was assessed by considering specific gear risk factors. The multiplication of these risk factors by the fishing activity (hours/km^2) allows the development of a simple index of risk of impact. Gear specific risk factors were derived from previously published studies (Table 1; Chuenpagdee et al. 2003, Fuller et al. 2008), and the resulting values of the impact index were displayed by grouping them into quartiles representing a relative scale of low, medium-low, medium-high, and high risk categories (Figs. 2 and 3). As with the distribution of effort, the distribution of risk is highly aggregated, with a small proportion of the SBAs exposed to the highest risk.

The analysis of potential risk of impact provides an approximation of location of relative impact level, and constitutes a useful step towards a full assessment of the risk of SIH in the NL bioregion.

Table 1. Risk factors for various gears. Values were obtained from Chuenpagdee et al. 2003 and Fuller et al. 2008, and averaged and converted to a score between ten and ninety for each gear.

Gear	Risk factor
bottom trawl	90
dredge	90
bottom gillnet	60
bottom longline	50
pot and trap	50
hook and line	20
midwater trawl	10
pelagic longline	10
purse seine	10
midwater gillnet	10

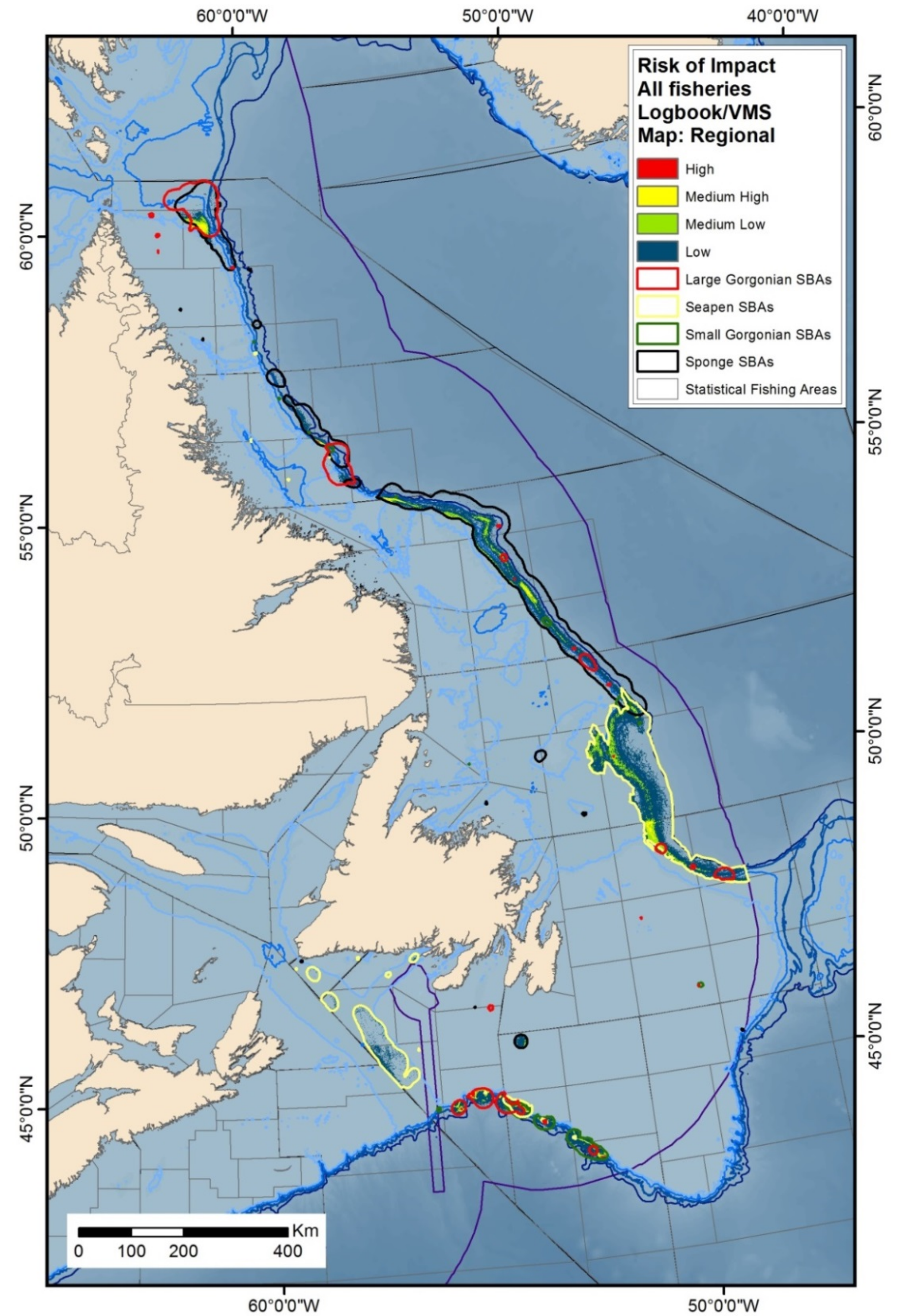

Figure 2. Potential risk of impact to SBAs in the NL bioregion. In SBA areas with no risk categorization, there is no observed fishing. Risk categories for fishing areas outside of SBAs are not shown.

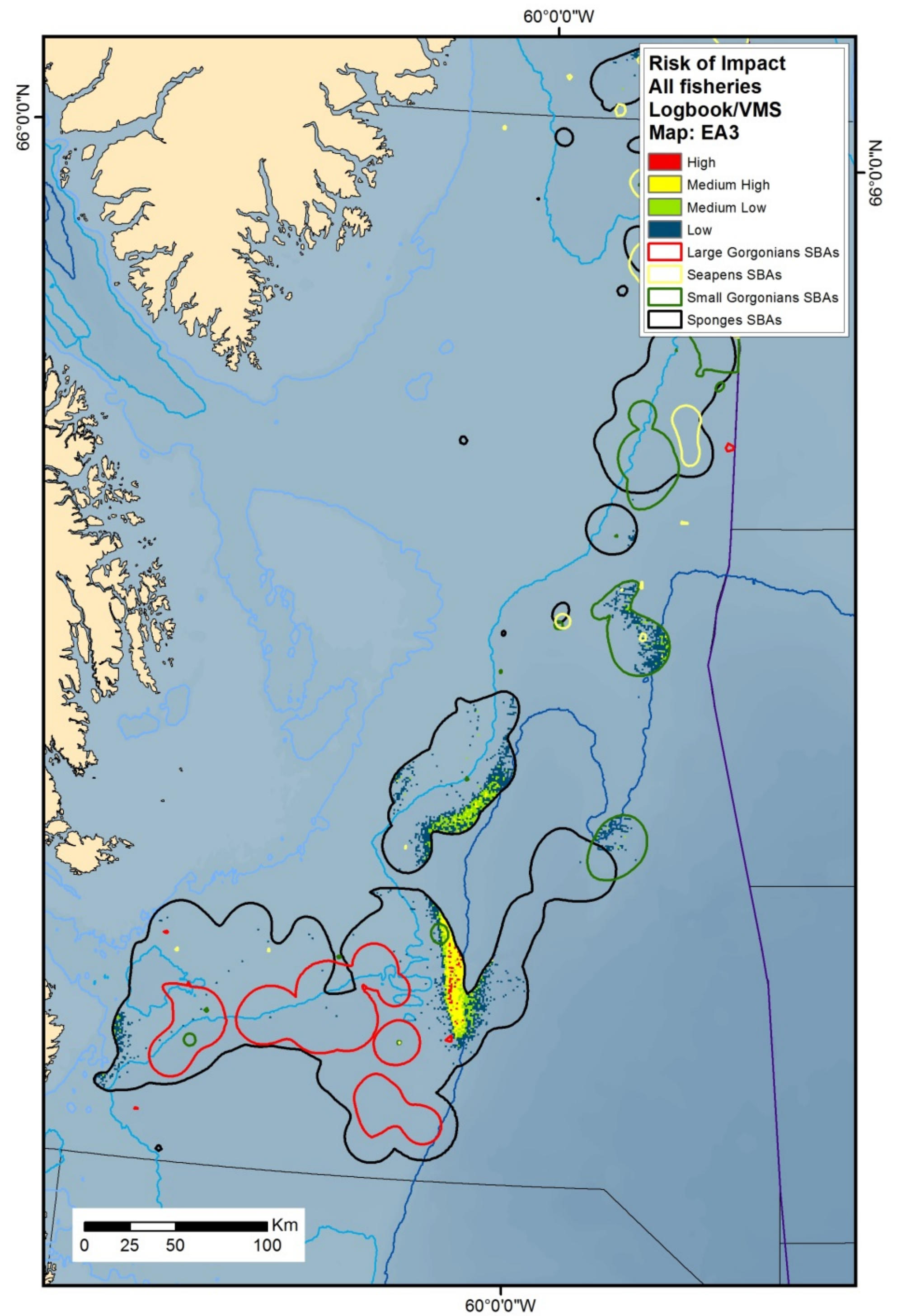

Figure 3. Potential risk of impact to SBAs in Division 0B. In SBA areas with no risk categorization, there is no observed fishing. This portion of the Eastern Arctic is shown due to the Hatton Basin areas straddling across the NL and Eastern Arctic regions. Risk categories for fishing areas outside of SBAs are not shown.

Although a full assessment of the risk of SIH has yet to be conducted in the NL bioregion, an analysis similar to the one done by NAFO to categorize SBAs as “low risk”, “high risk” and “impacted” has been carried out as described herein. For this analysis, the relationship between cumulative biomass of SBA taxa from research trawl surveys and mean annual commercial fishing activity considered two study areas, NAFO Divisions 0B2G and 2HJ3KLNOP. This partition, and the inclusion of the southern portion of the Eastern Arctic (0B), is because the Hatton Basin spans the regional boundary of the NL and the Eastern Arctic. For these analyses, a grid of 1x1 km and the 2005-14 fishing activities were considered. As in the NAFO SAI-VME analysis, the fishing activity level corresponding to the 95th percentile of the cumulative SBA biomass curve was used to define the threshold for which SIH may be occurring. Areas exposed to fishing activities below the threshold are considered to be at “high risk”, whereas areas exposed to fishing activities above the threshold are considered “impacted”. Areas that fell within the Division 3O coral protection zone were considered to be at “low risk” due to the protection provided by the closure. The significance of fishing activities as a driver of the cumulative SBA biomass distributions was evaluated using randomization tests (Table 2).

With the only exception of large gorgonians, fishing activity emerged as a consistent and significant driver of the SBA biomass density distributions in Divisions 2HJ3KLNOP, while in the northern region (Divisions 0B2G) fishing activity does not appear to be a significant driver (Table 2). These results are consistent with the ones observed in the NAFO SAI-VME analysis (NAFO 2016), supporting the idea that fishing activity has a significant effect in shaping current SBA biomass density distributions. Furthermore, the lack of significance in Divisions 0B2G suggests that fishing activity in these areas has yet to reach the level required to impact SBA biomass distributions.

Table 2. Statistical significance of fishing activity as a driver of SBA biomass density based on randomization tests for two regions, NAFO Divisions 2HJ3KLNOP and 0B2G. Note that for sea pens in 0B2G there was no fishing activity in any of the cells with biomass data, and hence, the test could not be conducted.

SBA taxa	2HJ3KLNOP p-value	0B2G p-value
Large gorgonian	0.503	0.164
Sea pen	< 0.001	N/A
Small gorgonian	0.049	0.796
Sponge	0.025	0.622

The results obtained for large gorgonians are puzzling. Fishing activity was not a significant driver of the biomass density distribution in either region (Table 2), but the randomization test for Divisions 0B2G had a much lower p-value than the one for Divisions 2HJ3KLNOP. Also, the total large gorgonian biomass recorded in Divisions 0B2G was an order of magnitude higher than in the southern area despite the lower sample size (Figs. 4 and 5). These observations, together with the known high sensitivity of large gorgonians to first-exposure impacts and their low growth rates, suggest that the lower biomass and p-values associated with Divisions 2HJ3KLNOP, a region that has a much longer and intense history of fishing than Divisions 0B2G, are more an indication of past impacts than a lack-thereof. This means most of the impacts in Divisions 2HJ3KLNOP for large gorgonians would be associated with first-exposures to fishing gears and lack of recovery. If this interpretation is correct, current large gorgonian SBAs may represent true relicts from a formerly much larger presence of these SBAs in the NL bioregion (also suggested in Edinger et al. 2007). Some historical records indicating that large gorgonians were "common off the fishing banks off Newfoundland" (Deichmann 1936) may give additional credence to this interpretation.

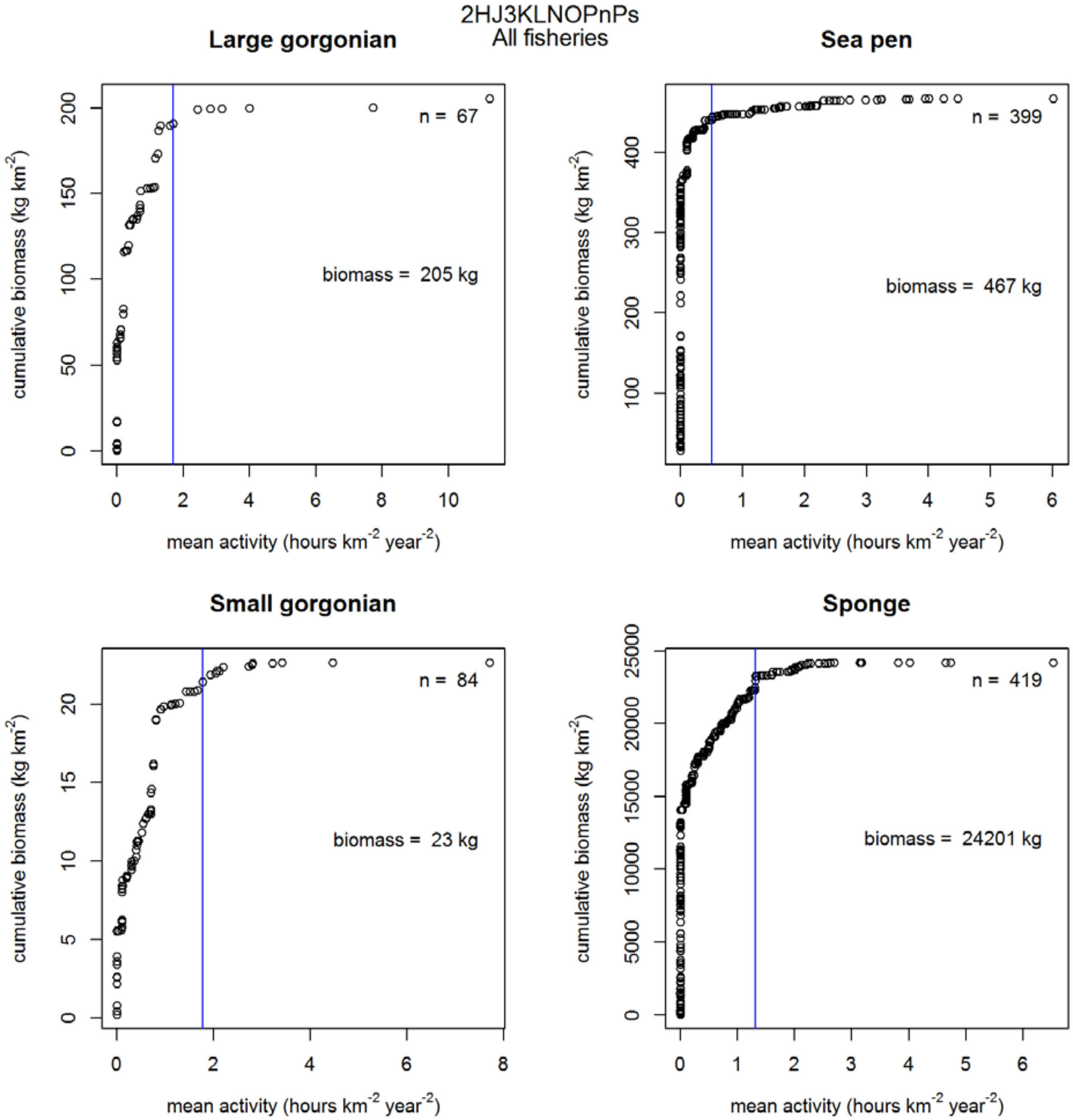

Figure 4. The cumulative biomass of SBA taxa vs. mean annual fishing activity in the NL bioregion between 2005-14 (except Division 2G, shown in Fig. 5). The vertical blue line indicates the 95th percentile of the cumulative biomass distribution.

The threshold values obtained for each SBA type in Divisions 2HJ3KLNOP (Fig. 4) were applied to map areas that are low risk, high risk, and impacted for the entire region. The maps in Figs. 6 to 9 show the risk of serious or irreversible harm by SBA type. Combined maps for all SBAs together are shown in Figs. A2 to A5.

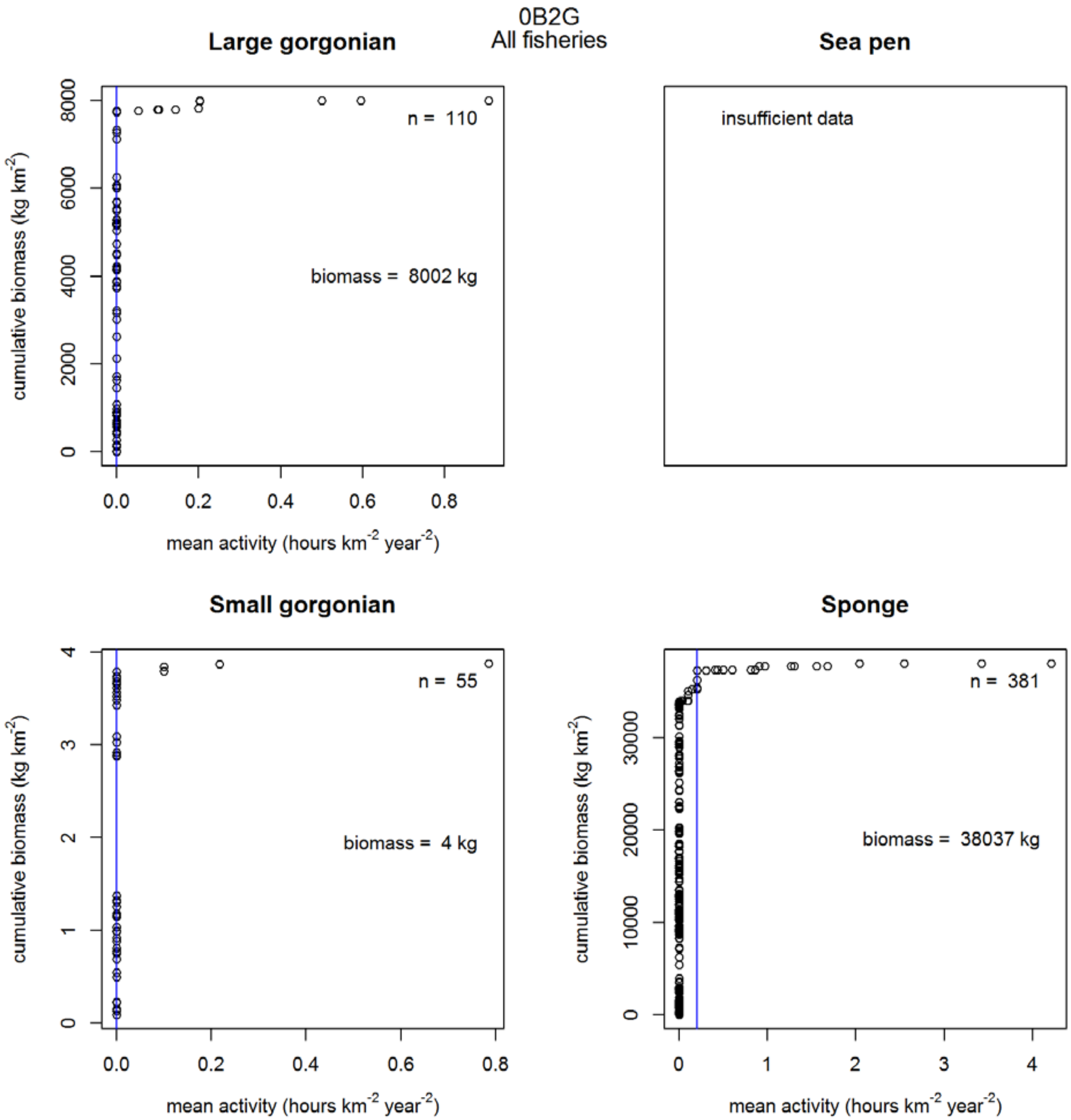

Figure 5. The cumulative biomass of SBA taxa vs mean annual fishing activity between 2005-14 in Divisions 0B2G. The vertical blue line indicates the 95th percentile of the cumulative biomass distribution.

In the NL bioregion, low risk areas are those that fall within the Division 3O coral protection zone. This closure protects 38% of small gorgonian SBAs in NL, and negligible amounts of the remaining SBA taxa. Although there are sea pen and small gorgonian SBAs within the general area of this closure, the shallow boundary of the Division 3O coral protection zone is too deep to offer protection to these other SBA types. Even for small gorgonians which have 38% of their area protected, the shallower regions of the SBA remain unprotected, and these areas may differ in features and/or species assemblages. This example illustrates the importance of having proposed conservation measures evaluated by DFO Science after stakeholder consultation – to assess the degree to which the proposed action continues to meet its stated conservation goal.

Sea pens have the greatest proportion (26%) of their area considered as impacted. The other SBAs have 10% or less of their currently remaining area in the impacted category. These low percentages of impacted SBA area, perhaps with the only exception of sea pens, suggest that although SBAs already have signs of impact, SIH at ecosystem scales may not yet be at play in the NL bioregion. However, the historical pre-fishing SBA extent is unknown and given the long history of fishing in the NL bioregion, assessments based on currently observed SBA extent would be expected to underestimate impact levels.

Most of the area within NL SBAs appears at high risk of SIH (Table 3); therefore, implementing closures for these areas would help prevent future impacts. Priority should be given to high risk areas over impacted areas, but closures on impacted areas would provide locations for monitoring and research of SBA recovery processes. In particular, closure of impacted sea pen SBAs would be the most promising. Among SBA taxa, sea pens are often considered relatively more resilient than other corals due to their shorter life spans and quicker growth rates; therefore they are believed to have the greatest potential for recovery with expected timescales of decades rather than centuries.

While there is a voluntary industry coral closure in the Hatton Basin, in Division 0B there is no mandatory coral and/or sponge closure area, and hence, there are no “low risk” areas in Division 0B at the present time. Virtually all the SBAs in Division 0B are considered “high risk” except for sponges which were considered to have 1% of their area in the impacted category.

Table 3. The breakdown of SBA by risk of exposure to serious irreversible harm, in terms of area and percentages. Note that in this table the results for the NL bioregion (including Division 2G) are shown together and Division 0B is showed separately. LG = large gorgonian, SG = small gorgonian.

Bioregion	Risk Level	LG Area (km^2)	Sea pen Area (km^2)	SG Area (km^2)	Sponge Area (km^2)	LG (%)	Sea pen (%)	SG (%)	Sponge (%)
NL	**Low Risk**	387	358	1,896	0	2	1	38	0
NL	**High Risk**	13,730	27,335	2,579	40,392	88	73	52	93
NL	**Impacted**	1,426	9,772	513	3,078	9	26	10	7
NL	**Total**	15,543	37,465	4,988	43,470	100	100	100	100
EA (Division 0B only)	**Low Risk**	0	0	0	0	0	0	0	0
EA (Division 0B only)	**High Risk**	6,282	2,307	6,284	33,173	100	100	100	99
EA (Division 0B only)	**Impacted**	0	0	0	248	0	0	0	1
EA (Division 0B only)	**Total**	6,282	2,307	6,284	33,421	100	100	100	100

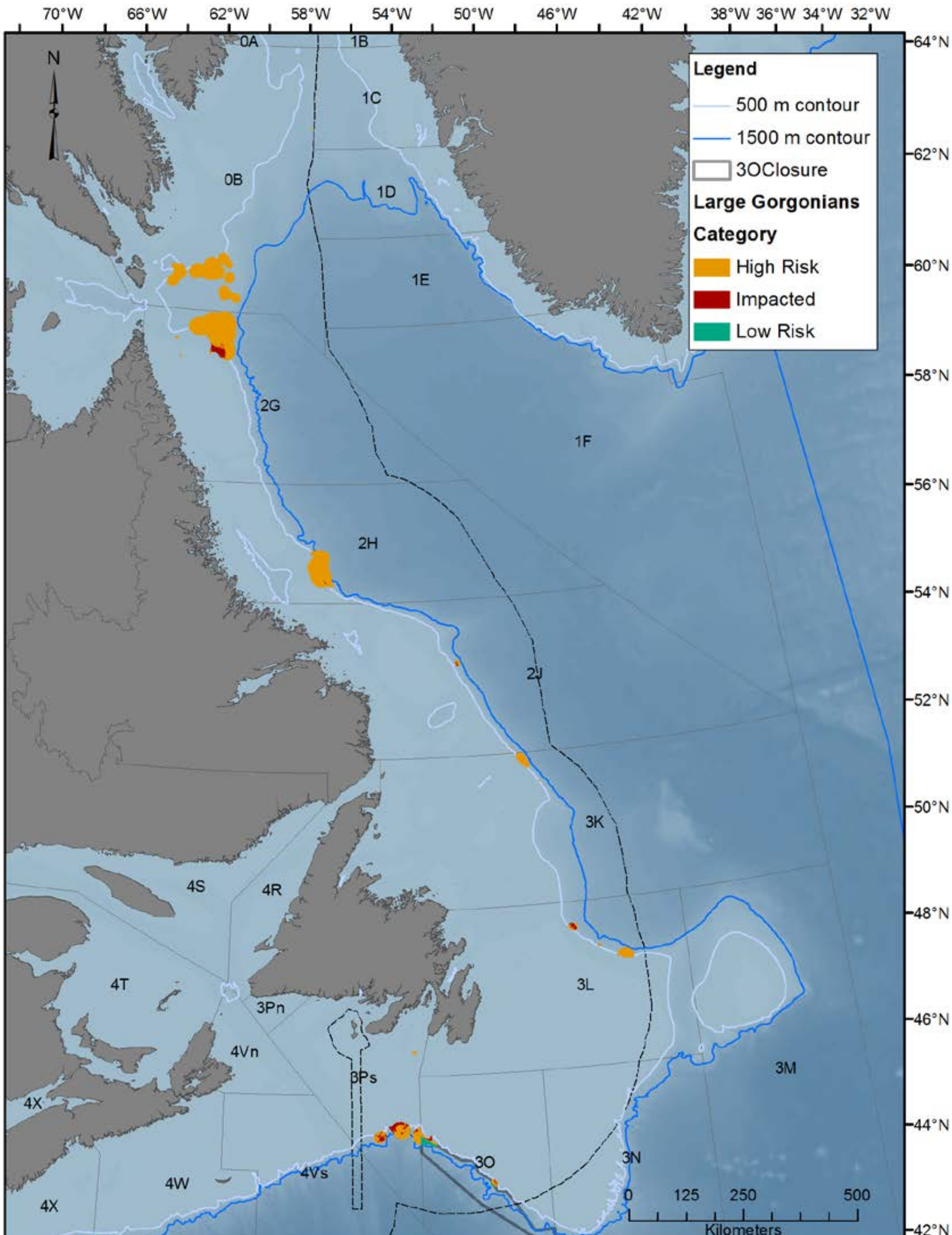

Figure 6. Areas of risk of serious or irreversible harm to large gorgonians in the NL bioregion and Division 0B.

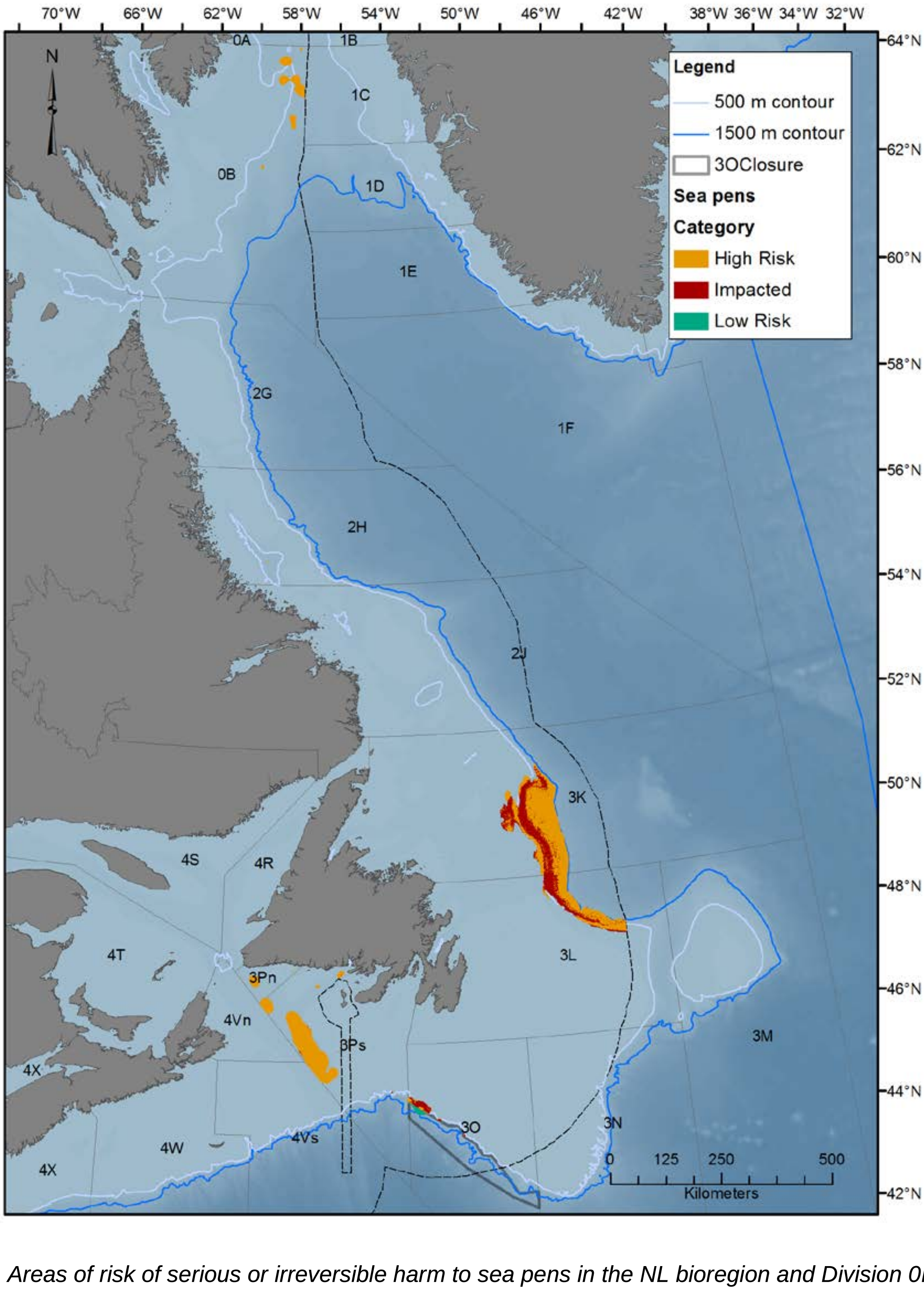

Figure 7. Areas of risk of serious or irreversible harm to sea pens in the NL bioregion and Division 0B.

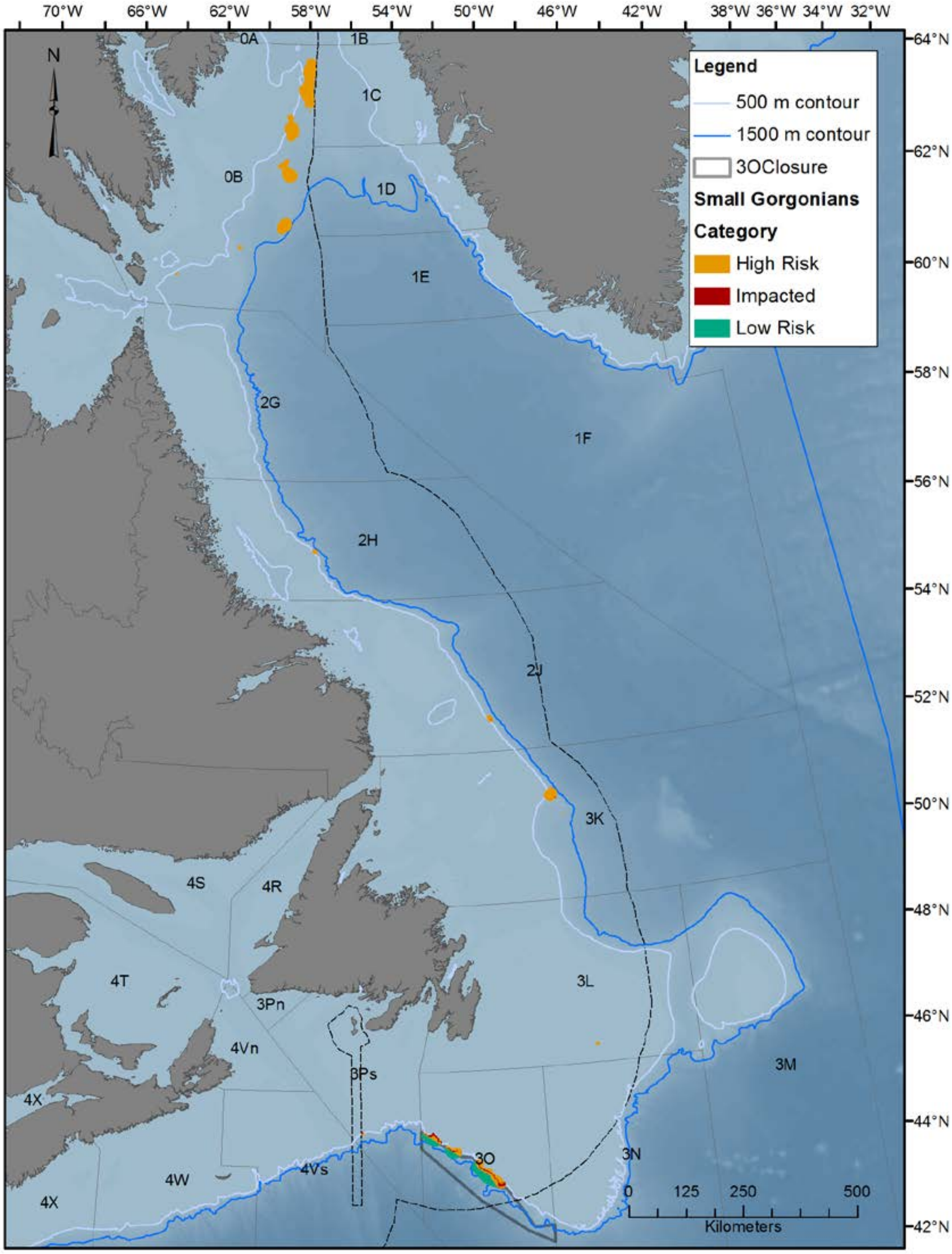

Figure 8. Areas of risk of serious or irreversible harm to small gorgonians in the NL bioregion and Division 0B.

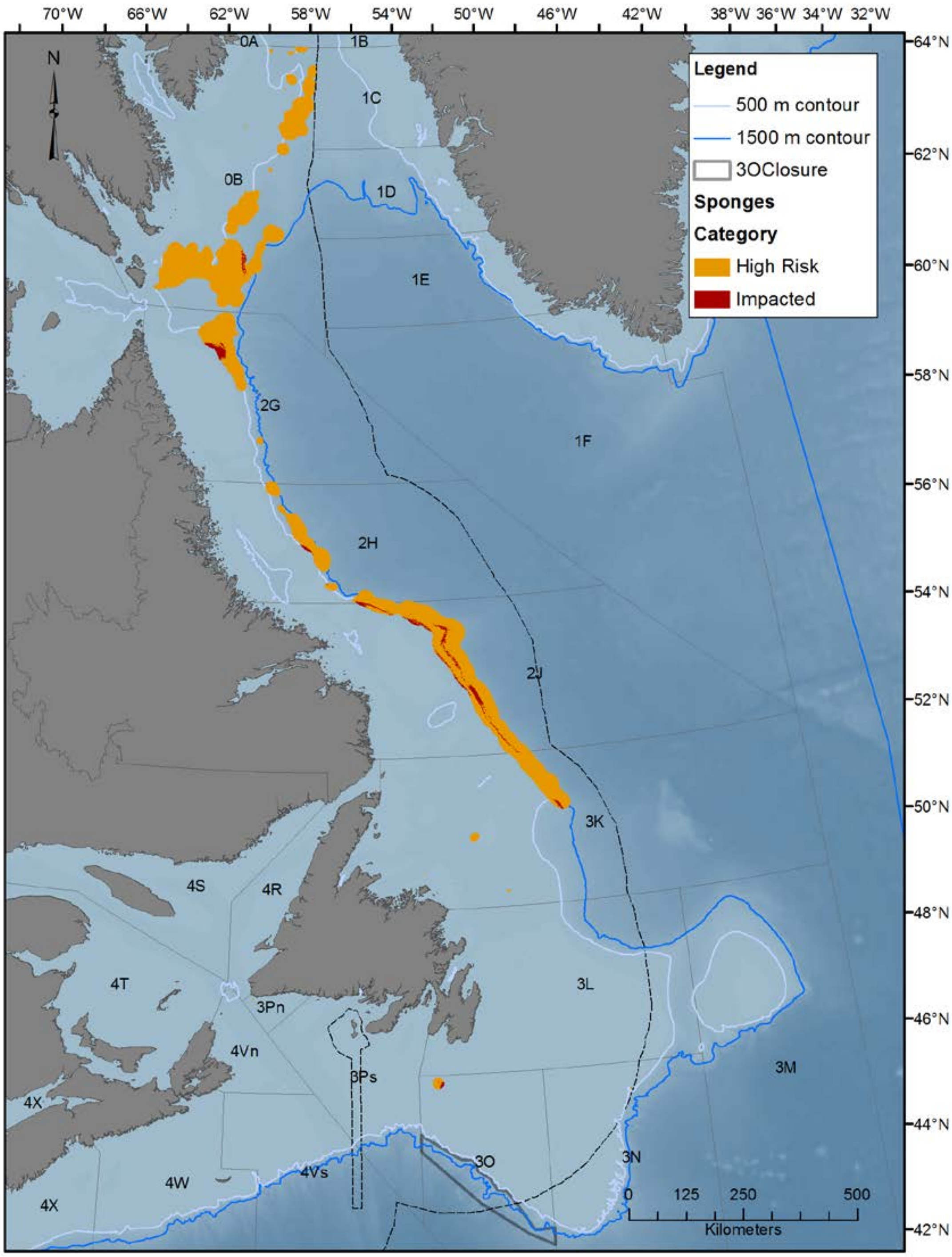

Figure 9. Areas of risk of serious or irreversible harm to sponges in the NL bioregion and Division 0B. There is no category for "low risk" because the Division 3O coral protection zone does not protect any sponge SBA unit.

Conclusions

- The purpose of the SeBA Policy is two-fold:
  1. Manage fisheries to mitigate impacts of fishing on SBAs.
  2. Avoid impacts of fishing that are likely to cause serious or irreversible harm to sensitive marine habitat, communities and species.

The first element recognizes that SBAs are likely to be already impacted by fishing, and hence, the impacts should be prevented from expanding, and ideally recovery should be promoted. The second element addresses the ecosystem services provided by SBAs, and aims to prevent fishing from causing long-term disruptions of SBA functionality.

- Given the vulnerability of SBAs to bottom contacting gear, mitigation of local impacts can be achieved by:
  1. Removing fishing activities from an SBA.
  2. Preventing fishing activities from expanding within an SBA (i.e., freezing the fishing footprint).
  3. Switching to fishing gears with reduced impact on SBAs, recognizing that while fixed gears may pose less risk than mobile gears, they still exert damage to SBAs.
  4. Enacting a combination of all the above.
- From a practical and operational perspective, preventing SIH on SBAs requires closures to all fishing activities that encompass sufficient habitat to allow for the SBA ecosystem services to be maintained. At present, precise and quantitative definitions of the necessary amount are not possible.
- Available analyses and studies, together with general ecological understanding of these taxa and their habitats, can be used to generate a practical set of guidelines that can be employed to assess the potential effectiveness of proposed closures. The aim of these guidelines would be to describe fisheries closure characteristics that would be expected to be associated with an overall low risk of SIH.

Guidelines

1. **The current observed SBA extent may represent remnant areas of habitat after long periods of exploitation, rather than a pristine state. This is suggested by comparing the full distribution of the species and their associated predictive models based on habitat characteristics to the much smaller SBA areas defined by contemporary distributions of biomass. Therefore:**
   a. Under the precautionary approach, 100% of SBAs should be protected. Where socio-economic reasons justify less than complete protection, it should be strived to achieve the maximum protection possible.
   b. As an interim precautionary measure, when 100% of the area cannot be protected, protection of 70% of each SBA total extent in the NL bioregion would be expected to be sufficient to maintain ecosystem functionality (lower limit). At present, there is little understanding of the ecological function of the SBA types occurring in NL and adjacent bioregions beyond their role in locally increasing biodiversity. However, international research on ecosystem services provided by corals and sponges is growing and it is

expected that the importance of SBAs as fish habitat, biogeochemical processing, and in benthic pelagic coupling will soon be advanced enough to allow for quantitative evaluations of SIH. Until such data are available, expert opinion based on existing analyses suggests that low risk of SIH appears associated with protection of ~70% (or more) of each bioregion's SBAs.

c. Priority should be given to protect areas with confirmed presence of SBAs (i.e. ground-truthed areas).

d. Priority should be given to target areas at risk (less damaged), but it should be recognized that impacted areas provide avenues for assessing re-colonization and recovery and hence the effectiveness of closures.

2. **Different SBA types constitute different habitats, and hence, provide different suites of ecosystem services. Protecting some SBA types at the expense of others is not ecologically sound. Therefore:**

   a. SBA types are not interchangeable; increased protection for one SBA type does not compensate for low protection of another.

   b. Priority should be given to protect areas that have overlapping SBA units because the protection will benefit more than one benthic community.

3. **Current SBA types are defined as very broad classes (e.g. sponges, sea pens, small and large gorgonians), but species compositions of individual units within each class are expected to have differences. Therefore:**

   a. It is important that each individual SBA unit be considered independently as sufficient knowledge of the connectivity within and among SBAs is not yet available.

   b. The spatial arrangement of the closure areas should be designed to cover the entire range of the distribution of the SBA type which may involve identification of areas that are not currently SeBAs, but are identified as SBAs. This would also contribute to maintain connectivity across individual SBA units.

4. **Species assemblages within an individual SBA unit are expected to show differences in spatial distribution along local gradients (e.g. salinity, temperature, depth). Therefore:**

   a. The protection provided to individual units should cover the entire range of any locally relevant gradient. Species distribution models used in Kenchington et al. 2016 can provide guidance on the parameters and boundaries for delineation of gradients.

5. **Management must consider socio-economic issues in addition to conservation objectives, and these processes can be iterative. Therefore:**

   a. Final closure areas boundaries and spatial distribution would require science evaluation to assess the adequacy of these areas to prevent SIH.

6. **For socio-economic reasons some SBA-fishery interactions will require ongoing scientific research. Targeted research could be undertaken to refine the proposed boundaries of closure areas, as has been done in other regions. Therefore:**

   a. The boundaries of closure areas should be open to refinement as research emerges.

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Appendix

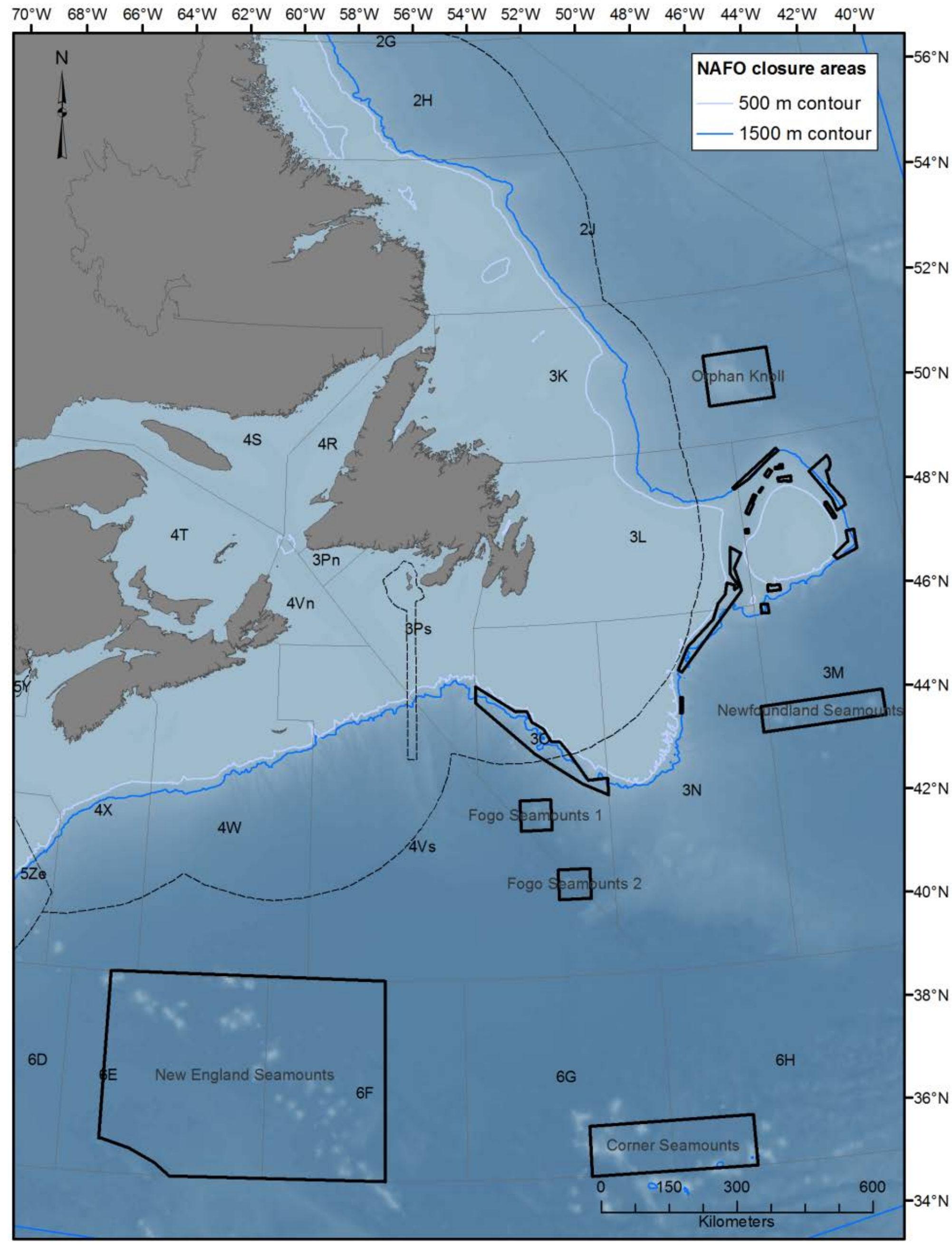

Figure A1. NAFO vulnerable marine ecosystem and seamount closure areas (thick black outline) from the 2017 NAFO Conservation and Enforcement Measures (NAFO FC Doc. 17-01 Serial No. N6638).Seamount closure areas are labelled by name.

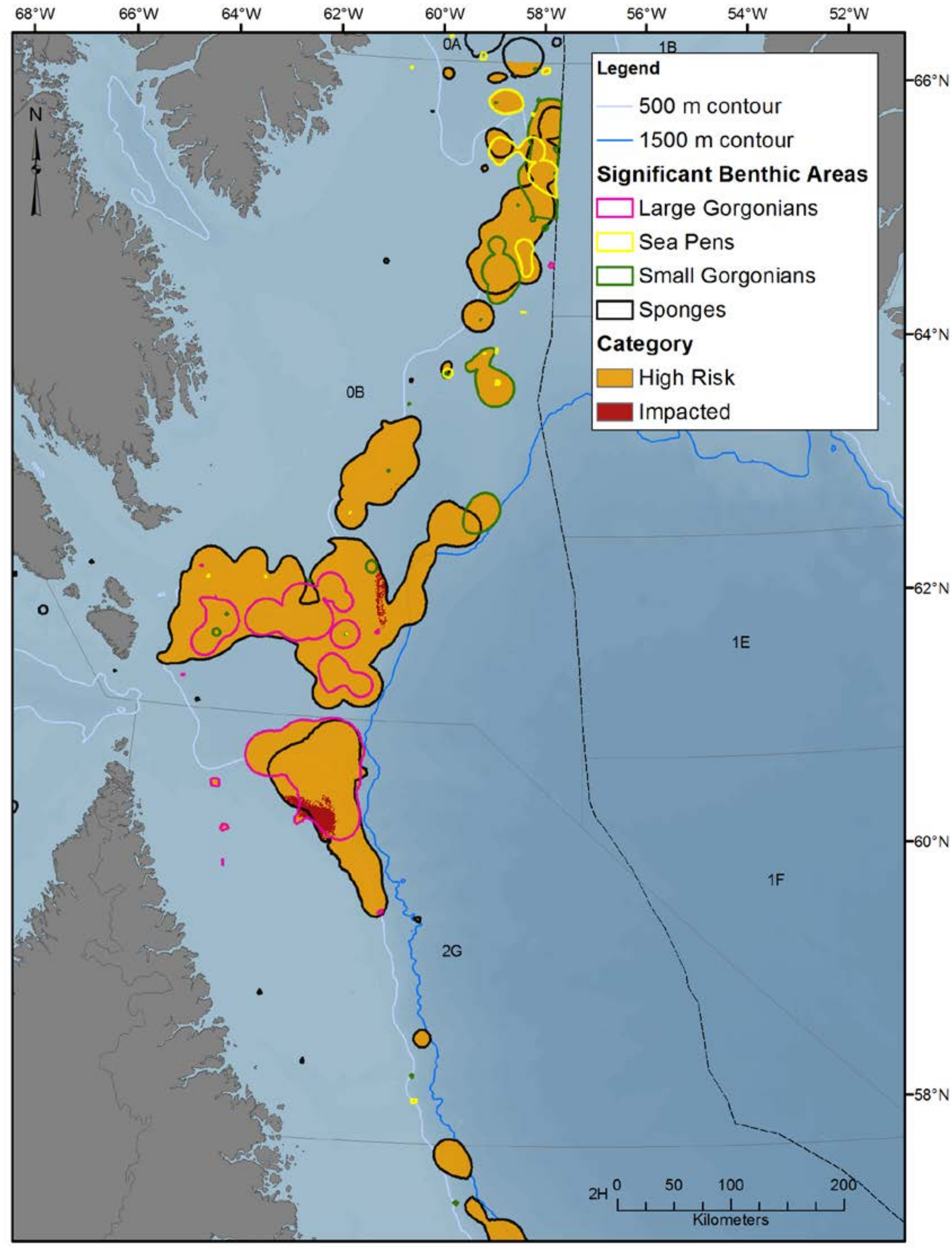

Figure A2. Areas of risk of serious or irreversible harm for all SBAs combined centered in the NAFO Divisions 2G and 0B. In those areas where multiple SBAs overlap, a grid cell is designated as "impacted" if any one of the SBAs surpassed their corresponding threshold value. There is no presence of category for "low risk" because the Division 3O coral protection zone does not protect any SBAs in this area.

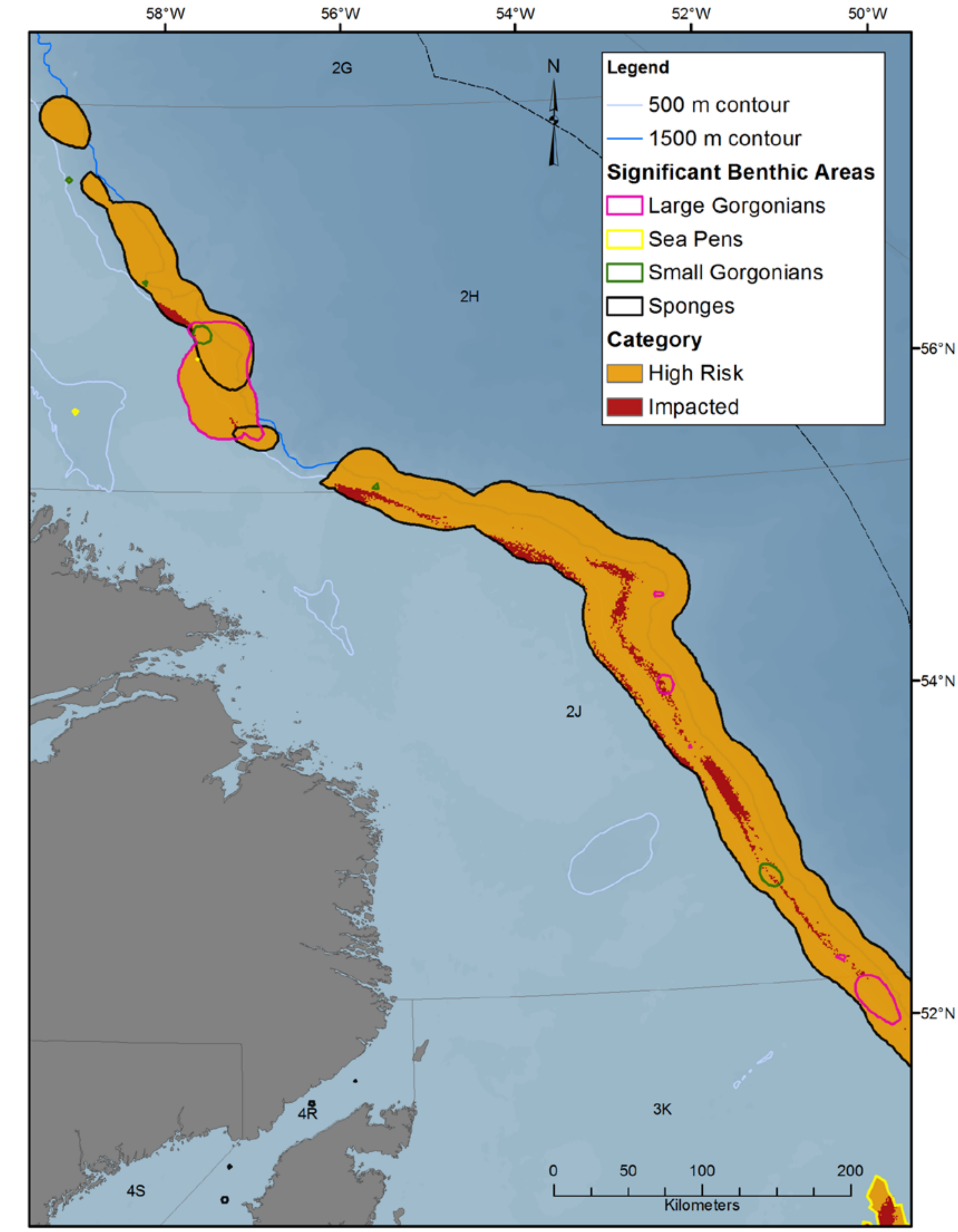

Figure A3. Areas of risk of serious or irreversible harm for all SBAs combined centered in the NAFO Divisions 2HJ. In those areas where multiple SBAs overlap, a grid cell is designated as "impacted" if any one of the SBAs surpassed their corresponding threshold value. There is no presence of category for "low risk" because the Division 3O coral protection zone does not protect any SBAs in this area.

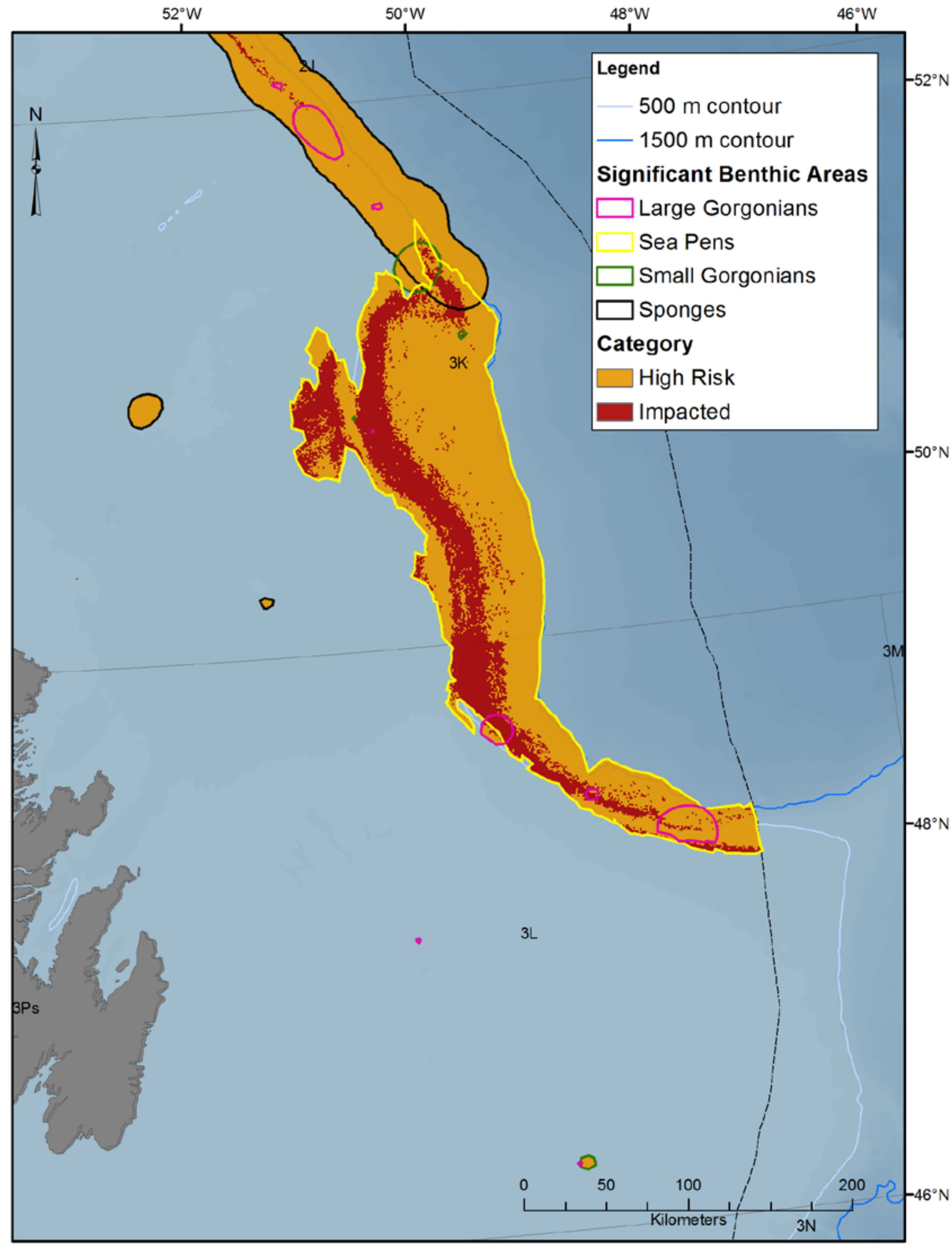

Figure A4. Areas of risk of serious or irreversible harm for all SBAs combined centered in the NAFO Divisions 3KL. In those areas where multiple SBAs overlap, a grid cell is designated as "impacted" if any one of the SBAs surpassed their corresponding threshold value. There is no presence of category for "low risk" because the Division 3O coral protection zone does not protect any SBAs in this area.

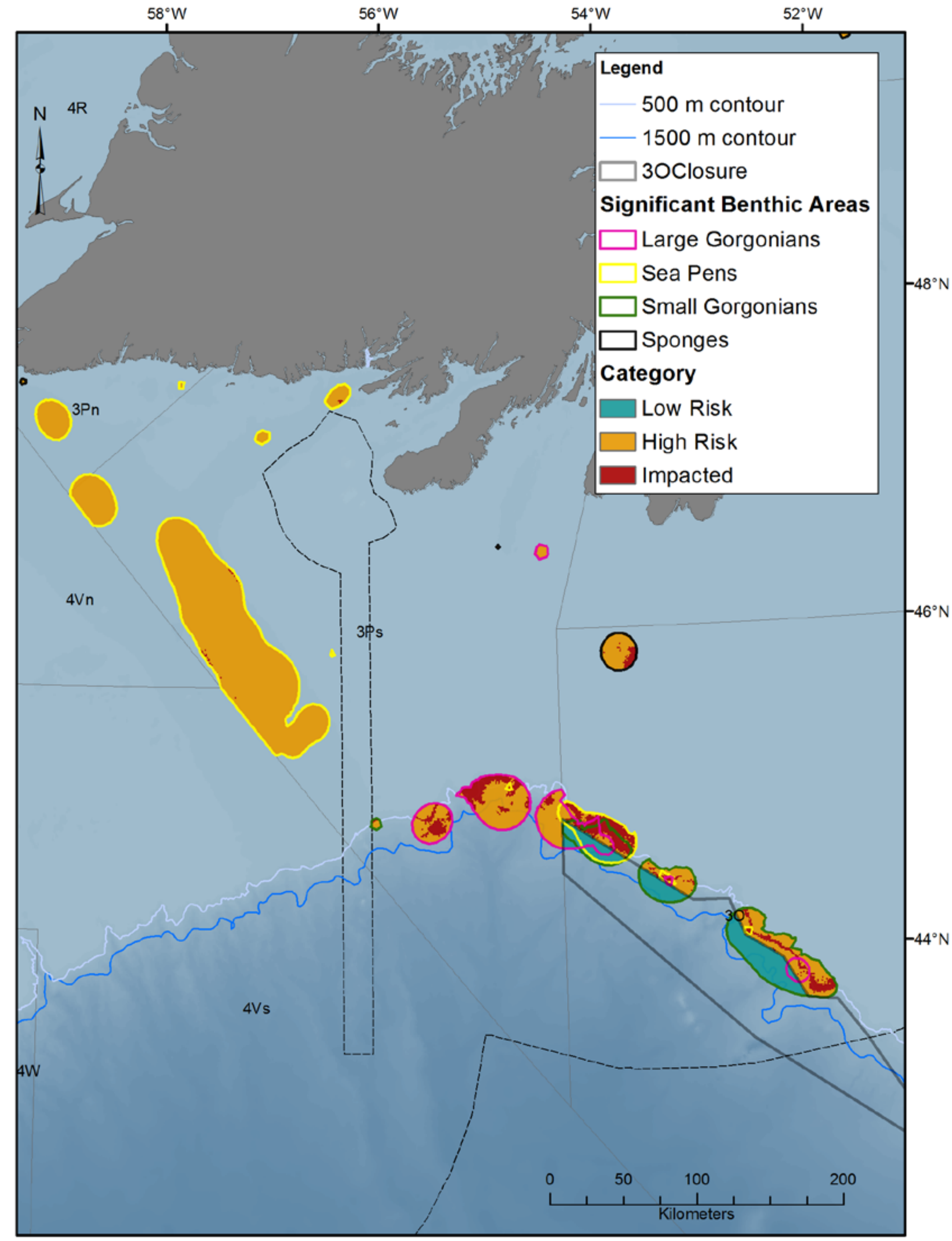

Figure A5. Areas of risk of serious or irreversible harm for all SBAs combined centered in the NAFO Divisions 3PO. In those areas where multiple SBAs overlap, a grid cell is designated as "impacted" if any one of the SBAs surpassed their corresponding threshold value. This map also shows the protection provided by the Division 3O coral protection zone within Canadian waters.

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