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Preliminary results from a desk-based study on activities other than fishing in the NRA: Interactions between oil and gas activities, deep-sea fisheries and VMEs - NEREIDA Task 3

by

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Abstract

This document compiles the preliminary results of a desk research on activities other than fishing taking place in the NAFO Regulatory Area, presented to the Scientific Council during the June 2024 meeting (NEREIDA Task 3). The main natural and socioeconomic ecosystem components were mapped. Spatial overlap (user-environment; user-user) and trends (period 2018-2024) were identified, focusing on offshore oil and gas, deep-sea fisheries and Vulnerable Marine Ecosystems (VMEs). In addition, the role of area-based management tools (i.e., NAFO closure No. 10) was emphasized, as well as the implications of multisectoral areas for the process of identifying, assessing and reporting other effective area-based conservation measures (OECMs). Finally, some key findings from the relevant scientific literature on the environmental impact of oil and gas activities, of interest in the context of NAFO, were summarized.

Keywords: Activities other than fishing, closures, deep-sea fisheries, impacts, NAFO Regulatory Area, protection, offshore oil and gas, other effective area-based conservation measures, Vulnerable Marine Ecosystems.

1. Introduction

1.1 Activities other than fishing: Oil and gas exploration, production and decommissioning

Oil and gas activities sequentially include the phases of (i) exploration, (ii) production and (iii) decommissioning. Not all phases are always completed, as this depends on multiple factors (e.g. characteristics and viability of discoveries, etc.). Nevertheless, seismic surveys and exploratory drilling are fundamental tools for oil and gas explorations, which can negatively affect the ecosystem (see section 3.3). In recent years, there has been exploration activity in the NAFO convention area. For example, on the Grand Banks of Newfoundland, starting in 1999, operators began exploring further afield, and the most recent decade has seen another wave of exploratory activity (Kaiser, 2020).

1.2 Activities other than fishing: A concern for the international community

United Nations General Assembly. United Nations General Assembly (UNGA) Resolution 71/123, adopted in 2016, reflects the international community' concern about the potential impacts of non-fishing activities. Specifically, paragraph 184 states that *Notes with concern that vulnerable marine ecosystems may also be impacted by human activities other than bottom fishing, and encourages in this regard States and competent international organisations to consider taking action to address such impacts*. Although Resolution 71/123, like the previous resolutions, focuses on sustainable fisheries, it also addresses the need to implement conservation measures for Vulnerable Marine Ecosystems (VMEs) in relation to human activities other than bottom fishing. This concern is reiterated in the following resolutions (Table 1). In this context, it is noteworthy that, the participants of the last workshop[1] to review the implementation of UNGA resolutions (64/72, 66/68 and 71/123) on sustainable fisheries, held at UN headquarters in August 2022, *acknowledged a concern that management actions taken by RFMO/As were unable to address potential impacts resulting from other activities taking place in the same area, thereby affecting the effectiveness of ecosystem-based approaches*. In particular, NAFO's contribution[2] to the review workshop, pointed out *that there are a number of non-fishing activities occurring in the Regulatory Area that have the potential to impact fisheries resources and the ecosystem*. NAFO also expressed its concern about non-fishing activities (specifically mentioning oil and gas as an example) and confirmed that these remain on the agenda of the NAFO Commission during its annual meetings (e.g., 2023 Annual meeting: *Commision Request #9*) [3].

Table 1. UNGA Resolutions on sustainable fisheries that included the issue of the impacts of non-fishing activities, indicating the date of adoption and the number of the *ad-hoc* paragraph about this issue.

UNGA Resolution	Date of adoption	*ad-hoc* paragraph about impacts of non-fishing activities
71/123	07 December 2016	184
72/72	05 December 2017	188
73/125	11 December 2018	197
74/18	10 December 2019	204
75/89	08 December 2020	203
76/71	09 December 2021	203
77/118	09 December 2022	217
78/68	05 December 2023	226

Convention on Biological Diversity. The Decision 14/8 adopted by the conference of the parties of the Convention on Biological Diversity (CBD), provides guidance about cross-sectoral coordination in relation to other effective area-based conservation measures (OECMs). In this context, mapping is essential to identify which areas are multi-sectoral, in order to further advance the process for nomination and recognizing OECMs (CBD, 2018; NAFO, 2023). According to the FAO handbook for fisheries OECMs, in the case of multi-sectoral areas (Figure 1), i.e. areas where many uses exist (e.g., Closed Area No.10), the optimal approach is to carry out cross-sectoral identification, assessment and reporting of OECMs (FAO, 2022). García *et al.*, (2020) suggest that a bilateral collaboration between two sectors may be enough to make an OECM operational and even to establish cross-sectoral OECM outcomes. They noted the need for international collaboration in the case of transboundary OECMs (areas where different jurisdictions overlap), suggesting that Regional Fisheries Management Organizations (RFMOs) could be used to promote effective OECMs. They also point out the importance of considering non-fishing impacts (cumulative impacts) and describing the potential contribution to connectivity.

BBNJ Agreement. The *Agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction* (BBNJ Agreement) was adopted in June 2023. It is organized around four areas: (i) marine genetic resources; (ii) establishment of a network of Area-Based Management Tools (ABMTs); (iii) Environmental Impact Assessments (EIA); and (iv) capacity-building. The Agreement shall be interpreted and applied in a manner that does not undermine relevant legal instruments, frameworks and sectoral bodies. Moreover, it applies to Areas Beyond National Jurisdiction (ABNJ). There are a number of challenges that could influence cross-sectoral aspects in the future,

[1] https://digitallibrary.un.org/record/3988731?ln=es
[2] See pp.14 *In*: NAFO Input to the 2022 Workshop to discuss the implementation of UNGA resolutions (64/72, 66/68, 71/123). 16 March 2022. NAFO/22-096. 15 pp. https://www.un.org/depts/los/bfw/NAFO__2022.pdf
[3] NAFO Commission Request #9: Continue to monitor and provide updates resulting from relevant research related to the potential impact of activities other than fishing.

especially those related to the implementation of ABMTs and EIA. Most RFMOs have established area-based measures, such as bottom fishery closures to protect VMEs. Lothian (2024) suggests that these protected habitats are likely to be a priority area for the establishment of ABMTs under the BBNJ Agreement. In this complex scenario, some questions arise: (i) How will existing ABMTs, such as bottom fishing closures implemented by RFMOs, fit with potential ABMTs developed under the BBNJ Agreement, and (ii) Will the BBNJ Agreement interact with existing governance regimes without undermining them? Furthermore, in light of the NAFO case study, an additional question can be asked: How will the issue of multi-sectoral areas be addressed? With regard to EIA, Lothian (2024) also notes that, until the adoption of the BBNJ Agreement, there was no mechanism in place to assess the cumulative impacts of all human activities on deep-sea VMEs. As some sectors already have sectoral impact assessment procedures in place, this raises the question of how the BBNJ Agreement's EIA provisions will interact with and sit alongside the EIA processes established under existing governance regimes, without undermining them. In light of this novel issue, the assessment of cumulative impacts from multiple sectors may become important within RFMOs.

1.3 Aim of this document

The objective of this document is to compile the information from the NEREIDA Task 3, presented to the Scientific Council in June 2024, in particular, that related to *NAFO Commission request #9*, focusing on the interactions between oil and gas activities, deep-sea fisheries and VMEs. It should be noted that this study is not intended to duplicate the work done by the relevant authorities in each sector (e.g., it is not intended to duplicate the work done through existing impact assessment processes).The ultimate goal of the NEREIDA tasks related to activities other than fishing is to understand some of these activities taking place in the NRA, in relation to their potential impact on the fishery resources, the ecosystem and the fishing activity regulated by NAFO. This work will help to develop approaches related to tackling impacts of non-fishing activities on the marine biological resources and fisheries in the NRA.

2. Material and Methods

2.1 Study area: NAFO Regulatory Area, Divs. 3LMNO

The study area (Figure 1) is located in international waters of the Northwest Atlantic Ocean, to the east of the Canadian coastline, in a depth range of about 45-1,500 m. This area corresponds to a part of the Grand Banks of Newfoundland and its slopes, the top and the slopes of the Flemish Cap, and the deep waters of the Flemish Pass. It covers the major international bottom fishing grounds (e.g., Greenland halibut, redfish, cod and skates) within the NRA (NAFO Divisions 3LMNO), i.e., the existing bottom fishing areas (NAFO fishing footprint), as well as important areas for other human activities (e.g., offshore oil and gas). In addition, the area of Flemish Cap hosts cold-water corals, sea pen fields and sponge grounds (Murillo, 2011; 2012) and most of the fishing closures implemented by NAFO to protect VMEs (NAFO, 2024). The NRA is located in the high seas (water column), and partly lies above the seabed within the extended continental shelf of the coastal state (Canada). This implies a complex situation derived from the intersection of the jurisdictional regimes affecting the water column beyond 200 miles (NAFO competence) and the continental shelf (coastal state competence).

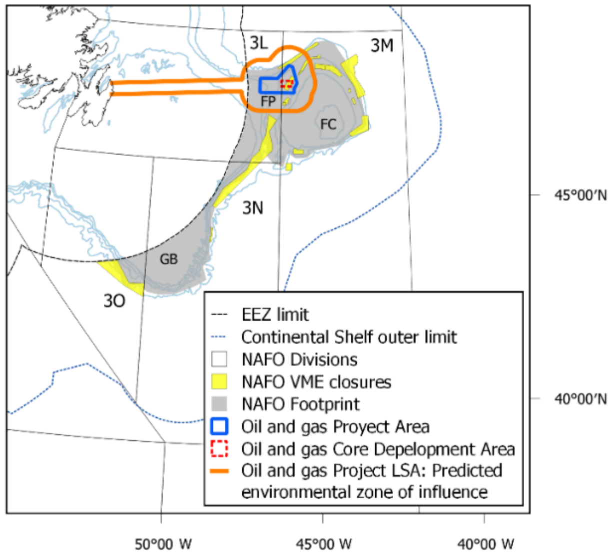

Figure 1. Map of the southern part of the NAFO Regulatory Area showing the location of the study area. The footprint of deep-sea-fisheries (grey area) and the spatial limits of the oil and gas project in the Flemish Pass (outlined in blue, depth range of about 340-1,200 m) is showed. The predicted environmental zone of influence of this project (considering marine fish and fish habitat, including species at risk, marine mammals and sea turtles, and special areas) is outlined in orange (Equinor, 2020)[4]. NAFO VME closures are also indicated (yellow areas). (FC: Flemish Cap; FP: Flemish Pass; GB: Grand Banks of Newfoundland).

2.2 Data collection and analysis

The present study is a desk-based research. Publicly available information on the ecosystem components (natural and socio-economic) of the study area was collated and integrated into a GIS. Spatial data were obtained from various sources (websites, reports, documents, etc.). When spatial data was available, the spatial location of each ecosystem component was mapped. In addition, relevant scientific literature on the environmental impact of offshore oil and gas activities was also reviewed, paying special attention to deep waters.

3. Results and discussion

3.1 Update of maps of main ecosystem components in NAFO Divs. 3LMNO

The baseline for this study was a previous study conducted in Divisions 3LM as part of the ATLAS project (Durán Muñoz *et al.*, 2020a). The main biophysical and natural ecosystem components identified within the study area include geomorphological features, fishery resources, marine species (i.e. marine mammals, seabirds and sea turtles), and VMEs, such as cold-water corals and deep-sea sponges (Kenchington *et al.,* 2019a), including its connectivity pathways (Gary *et al.,* 2020; Combes *et al.,* 2021) (Table 2; Figure 2). The main socio-economic components identified are related to fisheries, shipping, the offshore oil and gas industry, undersea cable routes, and marine research (Durán Muñoz *et al.,* 2012, 2020b) (Table 2; Figure 3). All this information was organized and integrated into a GIS using the open source software QGIS (v3.28).

[4] This zone also includes a smaller area of influence on seabirds.

Table 2. List of the main natural and socio-economic ecosystem components identified in the NRA (*: Potential).

Biophysical/natural components	Bathymetry and geomorphological features (e.g. seamounts, knolls).
	Substrate types (e.g. rock, gravel, sand, silt, clay).
	Vulnerable Marine Ecosystems (VMEs).
	Key species (i.e. marine mammals, sea birds and sea turtles).
	Ecosystem connectivity (i.e. larval dispersal).
	Epibenthic assemblages
	Fisheries resources.
Socio-economic components	Deep sea fisheries (DSF)[5] and bottom fisheries regulated by coastal states (i.e. pots). Pelagic fisheries (seines, gillnets, trawls and longlines).
	Shipping (passenger and items)
	Offshore oil and gas industry
	Offshore renewables* (windfarms, power cables)
	Seabed mining*
	Undersea telecommunication cables
	Military activities
	Pollution (marine litter and long-distance pollution; dumping)
	Bioprospecting*[6]
	Marine research (surveys)
	Deep sea conservation and management (closed areas for VME protection; OECMs; EBSA areas, etc.)

[5] Bottom fisheries operating in the NRA (bottom trawls and bottom longlines).
[6] Biodiversity prospecting or bioprospecting is the systematic search for biochemical and genetic information in nature in order to develop commercially-valuable products for pharmaceutical, agricultural, cosmetic and other applications (https://sdgfinance.undp.org/sdg-tools/bioprospecting)

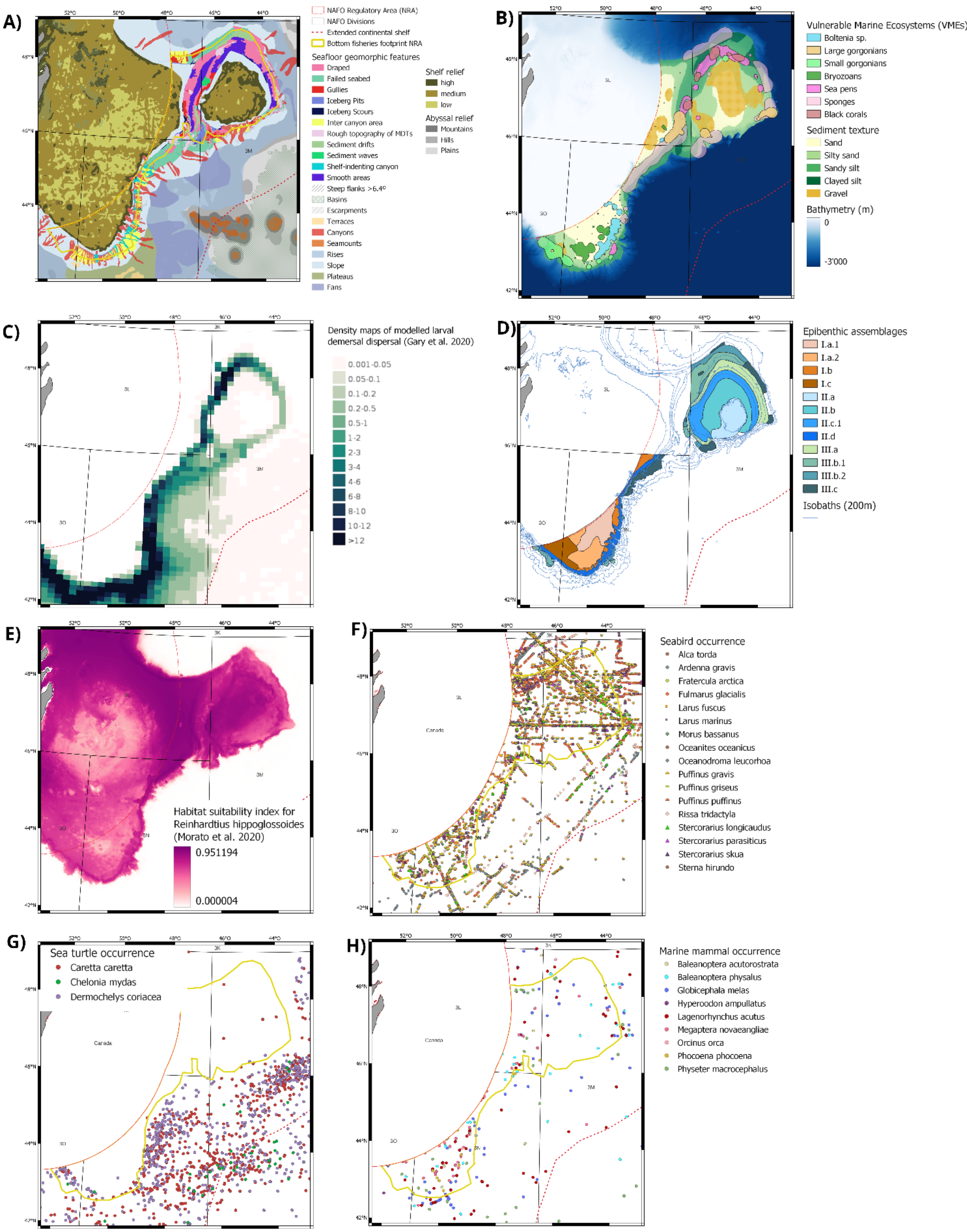
A)
NAFO Regulatory Area (NRA)
NAFO Divisions
Extended continental shelf
Bottom fisheries footprint NRA
Seafloor geomorphic features
Draped
Failed seabed
Gullies
Iceberg Pits
Iceberg Scours
Inter canyon area
Rough topography of MDTs
Sediment drifts
Sediment waves
Shelf-indenting canyon
Smooth areas
Steep flanks >6.4º
Basins
Escarpments
Terraces
Canyons
Seamounts
Rises
Slope
Plateaus
Fans
Shelf relief
high
medium
low
Abyssal relief
Mountains
Hills
Plains
B)
Vulnerable Marine Ecosystems (VMEs)
Boltenia sp.
Large gorgonians
Small gorgonians
Bryozoans
Sea pens
Sponges
Black corals
Sediment texture
Sand
Silty sand
Sandy silt
Clayed silt
Gravel
Bathymetry (m)
0
-3'000
C)
Density maps of modelled larval demersal dispersal (Gary et al. 2020)
0.001-0.05
0.05-0.1
0.1-0.2
0.2-0.5
0.5-1
1-2
2-3
3-4
4-6
6-8
8-10
10-12
>12
D)
Epibenthic assemblages
I.a.1
I.a.2
I.b
I.c
II.a
II.b
II.c.1
II.d
III.a
III.b.1
III.b.2
III.c
Isobaths (200m)
E)
Habitat suitability index for Reinhardtius hippoglossoides (Morato et al. 2020)
0.951194
0.000004
F)
Seabird occurrence
Alca torda
Ardenna gravis
Fratercula arctica
Fulmarus glacialis
Larus fuscus
Larus marinus
Morus bassanus
Oceanites oceanicus
Oceanodroma leucorhoa
Puffinus gravis
Puffinus griseus
Puffinus puffinus
Rissa tridactyla
Stercorarius longicaudus
Stercorarius parasiticus
Stercorarius skua
Sterna hirundo
G)
Sea turtle occurrence
Caretta caretta
Chelonia mydas
Dermochelys coriacea
H)
Marine mammal occurrence
Balaenoptera acutorostrata
Balaenoptera physalus
Globicephala melas
Hyperoodon ampullatus
Lagenorhynchus acutus
Megaptera novaeangliae
Orcinus orca
Phocoena phocoena
Physeter macrocephalus

Figure 2.

Figure 2 (legend). Updated cartographic information on the main biophysical/natural components in the study area. A) Seafloor geomorphic features. Shelf and abyssal areas are classified upon its roughness (high, medium and low) (Harris *et al.,* 2014). Geomorphology on the slopes was obtained from the NEREIDA multibeam echosounder technology (Durán Muñoz *et al.,* 2012, 2020a); B) Bathymetry (blue scale; GEBCO Bathymetric Compilation Group 2023), sediment texture types according Shepard classification (yellow to green; and orange for gravel, Murillo *et al.,* 2016) and polygons of significant concentrations of VME indicator taxa (Kenchington *et al.,* 2019a); C) Density maps (particles per square km) of modelled particles of larvae released from Flemish Cap (Gary *et al.,* 2020); D) Epibenthic megafaunal assemblages in Divisions 3MNO. Assemblages were grouped into three major groups: (i) Continental shelf of the Tail of Grand Bank; (ii) Shallow waters of Flemish Cap and upper slope of the Tail of Grand Bank; and (iii) Lower slope of Flemish Cap and Tail of Grand Bank (see Murillo *et al.,* 2016); E) Fisheries resources: e.g., Habitat suitability index for *R. hippoglossoides* (Morato *et al.,* 2020); F) Spatial distribution of seabirds; G) Spatial distribution of sea turtles; H) Spatial distribution of marine mammals. Limits of the NAFO Regulatory Area (red lines), NAFO Divisions (black lines) and extended continental shelf (dashed red line) are shown in all maps. Occurrence data for seabirds, sea turtles and marine mammals were obtained from OBIS (https://obis.org/).

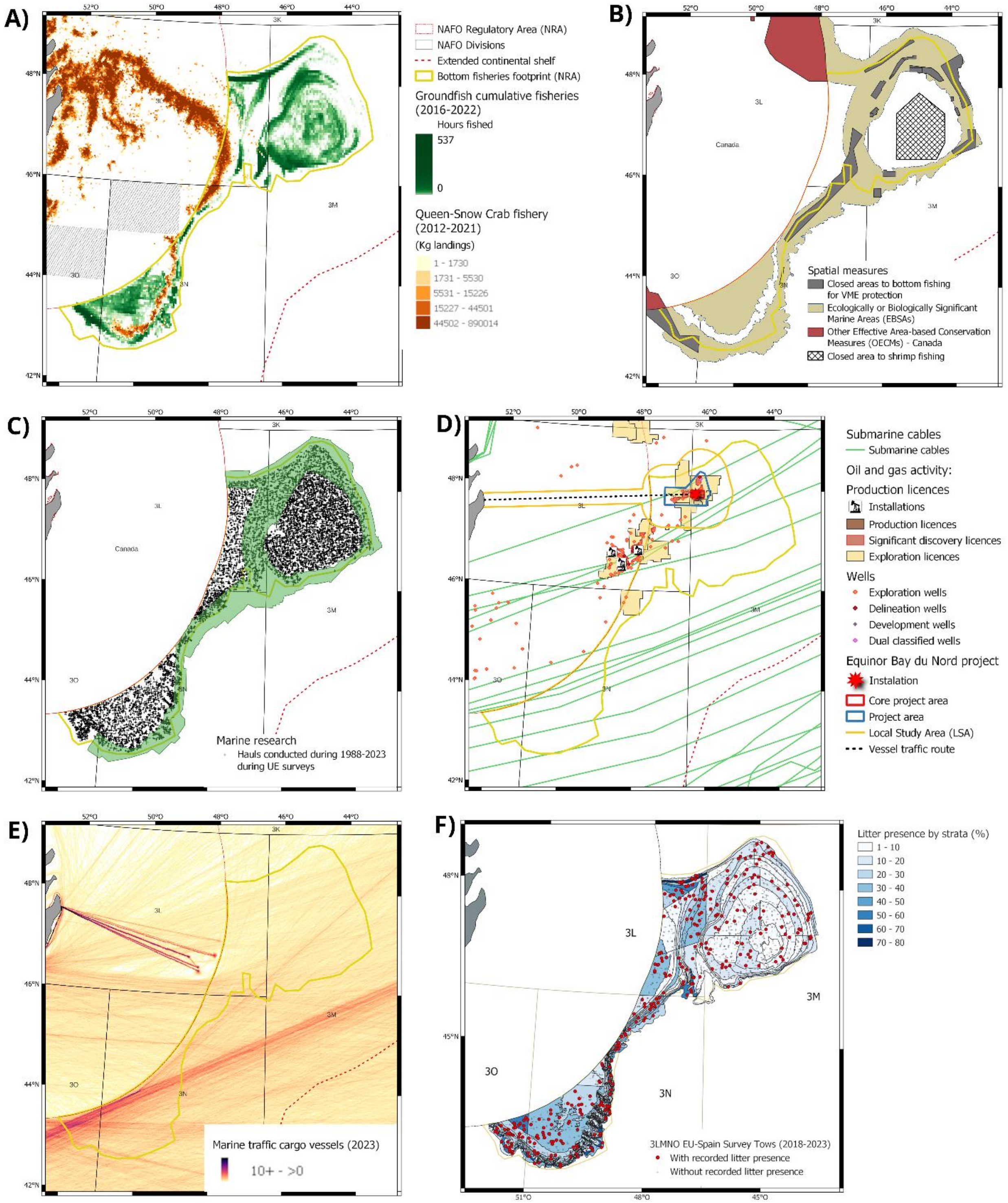
A)
NAFO Regulatory Area (NRA)
NAFO Divisions
Extended continental shelf
Bottom fisheries footprint (NRA)
Groundfish cumulative fisheries (2016-2022)
Hours fished
537
0
Queen-Snow Crab fishery (2012-2021)
(Kg landings)
1 - 1730
1731 - 5530
5531 - 15226
15227 - 44501
44502 - 890014
B)
Spatial measures
Closed areas to bottom fishing for VME protection
Ecologically or Biologically Significant Marine Areas (EBSAs)
Other Effective Area-based Conservation Measures (OECMs) - Canada
Closed area to shrimp fishing
C)
Marine research
Hauls conducted during 1988-2023 during UE surveys
D)
Submarine cables
Submarine cables
Oil and gas activity:
Production licences
Installations
Production licences
Significant discovery licences
Exploration licences
Wells
Exploration wells
Delineation wells
Development wells
Dual classified wells
Equinor Bay du Nord project
Instalation
Core project area
Project area
Local Study Area (LSA)
Vessel traffic route
E)
Marine traffic cargo vessels (2023)
10+ - >0
F)
Litter presence by strata (%)
1 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
3L
3M
3O
3N
3LMNO EU-Spain Survey Tows (2018-2023)
With recorded litter presence
Without recorded litter presence

Figure 3.

Figure 3 (legend). Updated cartographic information on the main socio-economic components identified in the study area. A) Bottom fisheries: NAFO cumulative bottom fisheries in 2016-2022 (hours fished; green scale) (Task 1 NEREIDA contract) and queen-snow crab fishery during 2016-2021 (kg landings; orange scale). Snow crab data obtained from Fisheries and Oceans Canada (DFO) available at: **https://open.canada.ca/data/en/dataset/502da2ef-bffa-4d9b-9e9c-a7425ff3c594;** B) Areas closed for VME protection (grey polygons; NAFO, 2024), areas closed for shrimp fishing during 1 June to 31 September in Division 3M (NAFO, 2024), Ecologically and Biologically Significant Marine Areas (EBSA): Slopes of the Flemish Pass and Grand Bank and Southeast shoal and adjacent areas on the Tail of the Grand Bank (beige polygons) (https://www.cbd.int/ebsa/), and Other-Effective Area-based Conservation Measures (OECMs) established in Canadian waters (red polygons) (UNEP-WCMC and IUCN, 2024); C) Marine research: Hauls conducted during the EU surveys during 1988 to 2023 in the NRA (black crosses; González-Costas *et al.,* 2023; Abalo-Morla *et al.,* 2023) and the study area of NEREIDA cruises: 2009-2010 (in green) (Durán Muñoz *et al.,* 2012); D) Oil and gas activities: installation locations, licences (production licences (PL), significant discovery licences (SDL), exploration licences (EL)), wells (delineation wells, development wells, dual classified wells) and available information about the Equinor Bay du Nord project (installation location, project area, core project area, local study area and vessel traffic route). Data available in May 2024 at **https://www.cnlopb.ca/**. Submarine cables (green lines) obtained from **https://www.submarinecablemap.com/**; E) Marine traffic: Cargo vessel density map during 2023 (Fisheries and Oceans Canada; **https://open.canada.ca/data/en/dataset/5b86e2d2-cec1-4956-a9d5-12d487aca11b**); F) Spatial distribution of seabed litter in the NRA (Abalo-Morla *et al.,* 2024) Limits of the NAFO Regulatory Area (red lines), NAFO Divisions (black lines) and extended continental shelf (dashed red line) are shown in all maps.

3.2. Update of spatial overlap maps

Knowing the spatial and bathymetric location of areas where other human activities overlap with VMEs, VME closures and fisheries, is the starting point to better understand potential interactions and conflicts. This includes: (i) environmental impacts from accidental events or routine activities, (ii) conflicts of use of marine space (loss of fishing opportunities), and (iii) interactions between measures in multiple sectors and the transboundary implications of these measures (Molenaar, 2021). This knowledge help to understand whether non-fishing activities may affect the effectiveness of the conservation and management measures adopted by NAFO (e.g., closed areas). Such information is essential to fill the NAFO Ecosystem Summary Sheets (ESS), particularly the sections on (i) *human activities other than fisheries* and (ii) *pollution*.

Extent of oil and gas activities (licences and wells) and overlap with deep-sea fisheries, VMEs and closed areas

The spatial extent of oil and gas activities (licences and wells) was mapped based on the available information, collected on February 2024, from the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) website. Data on cumulative bottom fisheries (2016-2022 period) was obtained from NEREIDA Project. The map of the Figure 4 reveals that some licences[7] and wells[8] overlap with NAFO-regulated fisheries (fishing grounds), VMEs and areas closed to protect such ecosystems. In summary, the map shows the overlaps between the different users of the marine space, as well as between users and the marine environment. Such overlaps could lead to future conflicts.

[7] A **licence** is the mechanism under the Accord Act by which certain rights are granted in lands in the Canada Newfoundland and Labrador offshore area. According to AMEC (2014), normally, an owner of an **exploration licence** will explore that licence and, upon finding a significant discovery (i.e. accumulation of oil that has potential for sustained production), be issued a **significant discovery licence** to further delineate the discovery in anticipation of finding commercial resources (i.e. discovery that justify the investment and effort to bring the discovery to production) which may lead to the issuance of a **production licence** (for oil production).

[8] According to Kaiser (2021), **exploration** and **development** wells are used to find commercial accumulations of hydrocarbons and develop them. Exploration wells are drilled outside known reservoirs, and therefore, exploratory drilling almost always takes place from a mobile offshore drilling unit. Development drilling is different from exploration drilling, since the objective is to produce, while in exploration the objective is to find hydrocarbons, and in appraisal, to delineate the reservoir and gather the necessary data for planning the development. **Delineation** wells are used to determine the areal and vertical extent of reservoirs and have many similarities to exploration wells. **Dual wells** have dual nature.

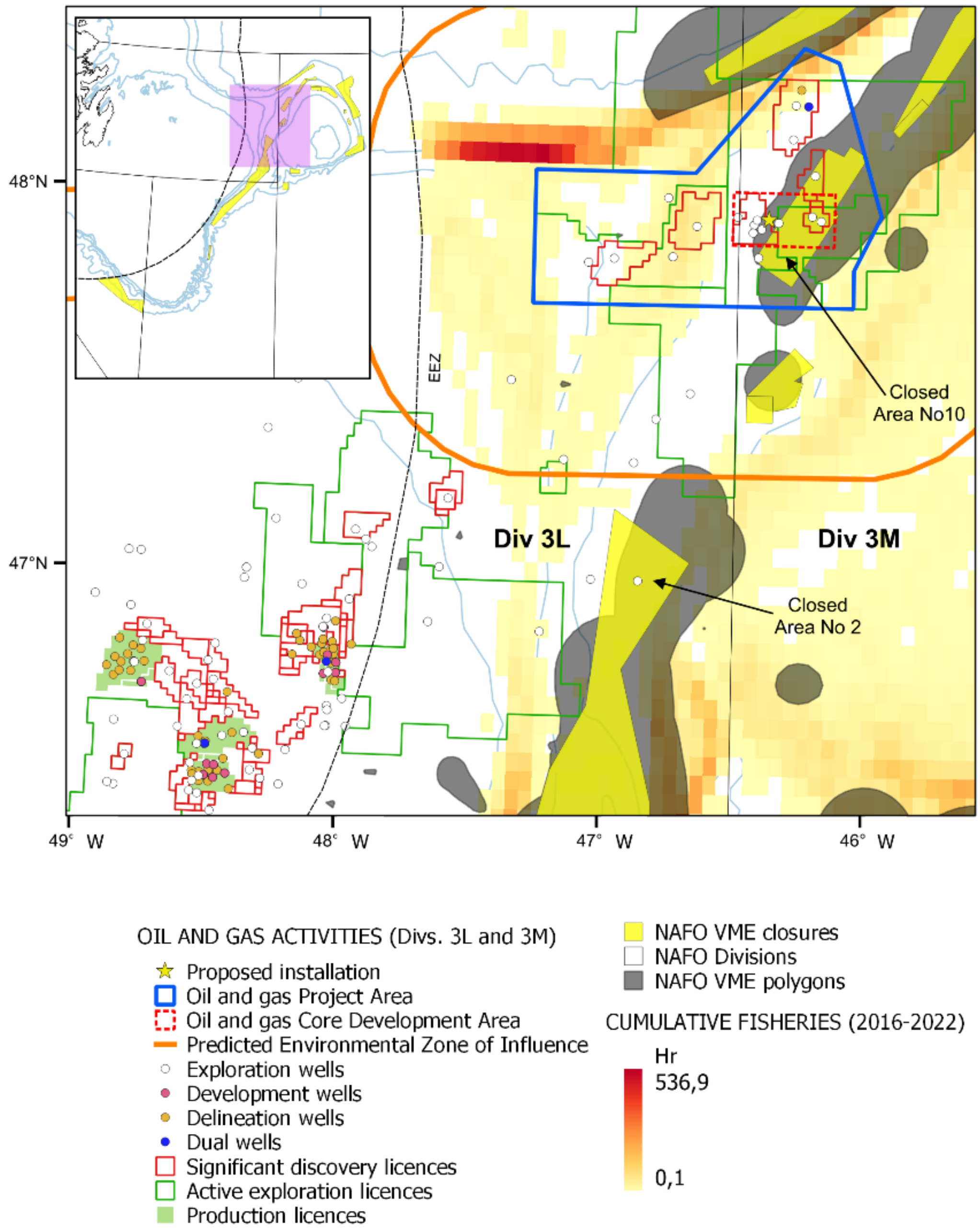

Figure 4. Updated map showing the geographical location of oil and gas activities (licences and wells) in NAFO Divs. 3L and 3M. Data collected in February 2024 (source: C-NLOPB). The yellow star indicates the location of the proposed production installation within the *Bay du Nord Development Project* in the Flemish Pass (outlined in blue). Bottom fishing activity (cumulative fishery 2016-2022) is expressed in hours fished in each cell (from yellow to red). Dark color indicates higher value (source: NEREIDA).

Trends of oil and gas activities (licences and wells) in Divisions 3L and 3M (2018 - 2024 period)

Figure 5 shows the evolution over time of the overlap between oil and gas activities (licences and wells), NAFO-regulated fisheries, VMEs and VME Area Closure No. 10, along the period 2018 - 2024. There has been an increase in overlap due to both the increase in the number of Significant Discovery Licences, the expansion of Area closure No. 10 and the redefinition of NAFO VME polygons occurred in 2019. In addition, the number of Exploration Wells within the project area has also increased during the period analyzed. In this scenario, the potential tension between commitments to protect VMEs and biodiversity, the maintenance of fisheries and the expansion of oil and gas activities is likely to intensify in the near future.

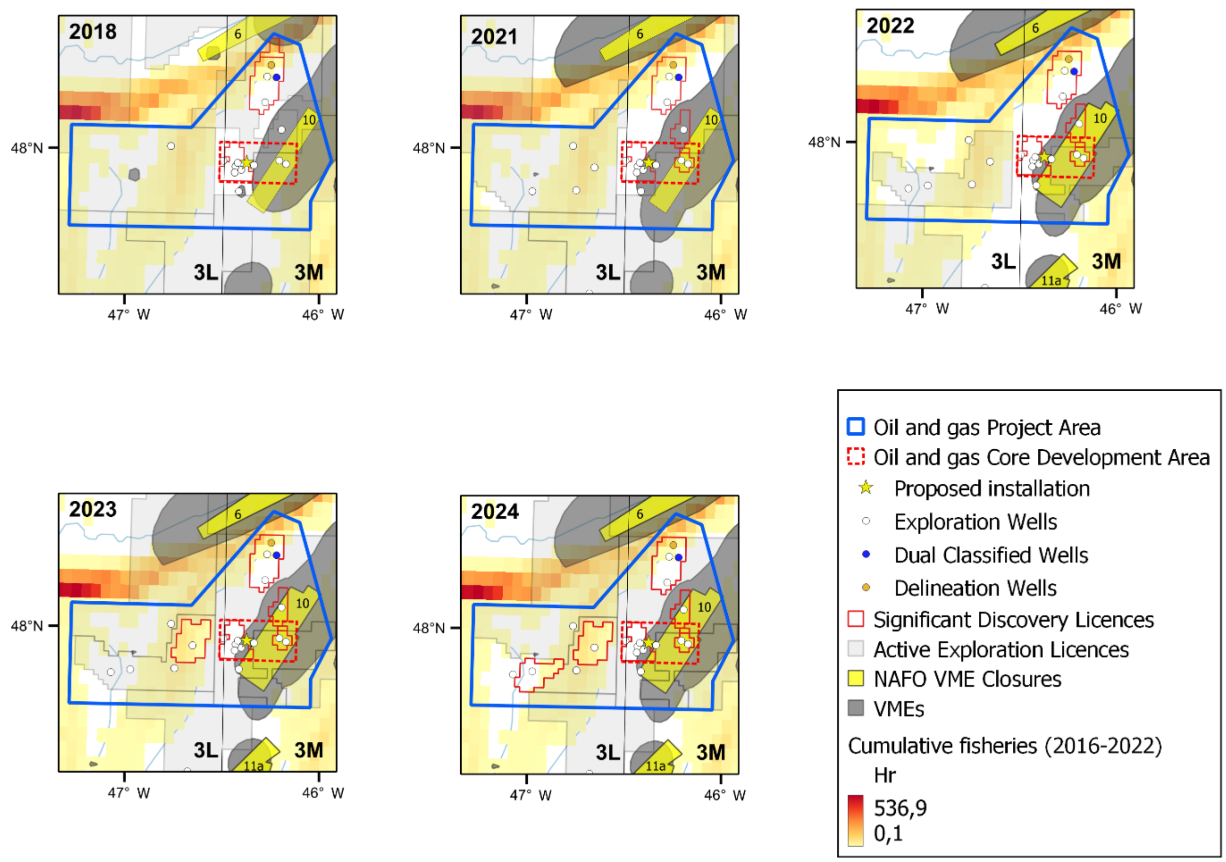

Figure 5. Updated map showing the evolution over time of the degree of overlap between oil and gas activities, VMEs and VME Area closure No. 10 (2018 - 2024 period). Source C-NLOPB. Bottom fishing activity (cumulative fishery 2016-2022) is expressed in hours fished in each cell (from yellow to red). Dark color indicates higher value (source: NEREIDA).

Spatial overlap with the Greenland halibut and redfish bottom fisheries

The international bottom fisheries regulated by NAFO most affected by the overlap with oil and gas activities (wells and licences) is, by far, the Greenland halibut trawl fishery (GHL OTB 3LMNO) and, to a lesser extent, the redfish bottom trawl fisheries (RED OTB 3LNO; RED OTB 3M). Figure 6 shows the overlap of such activities with the mentioned fisheries (2016-2022 period), based on new data from NEREIDA project. The historical footprint of the Greenland halibut trawl fishery is located in the same area where the main oil and gas activities are currently taking place, namely the Flemish Pass area.

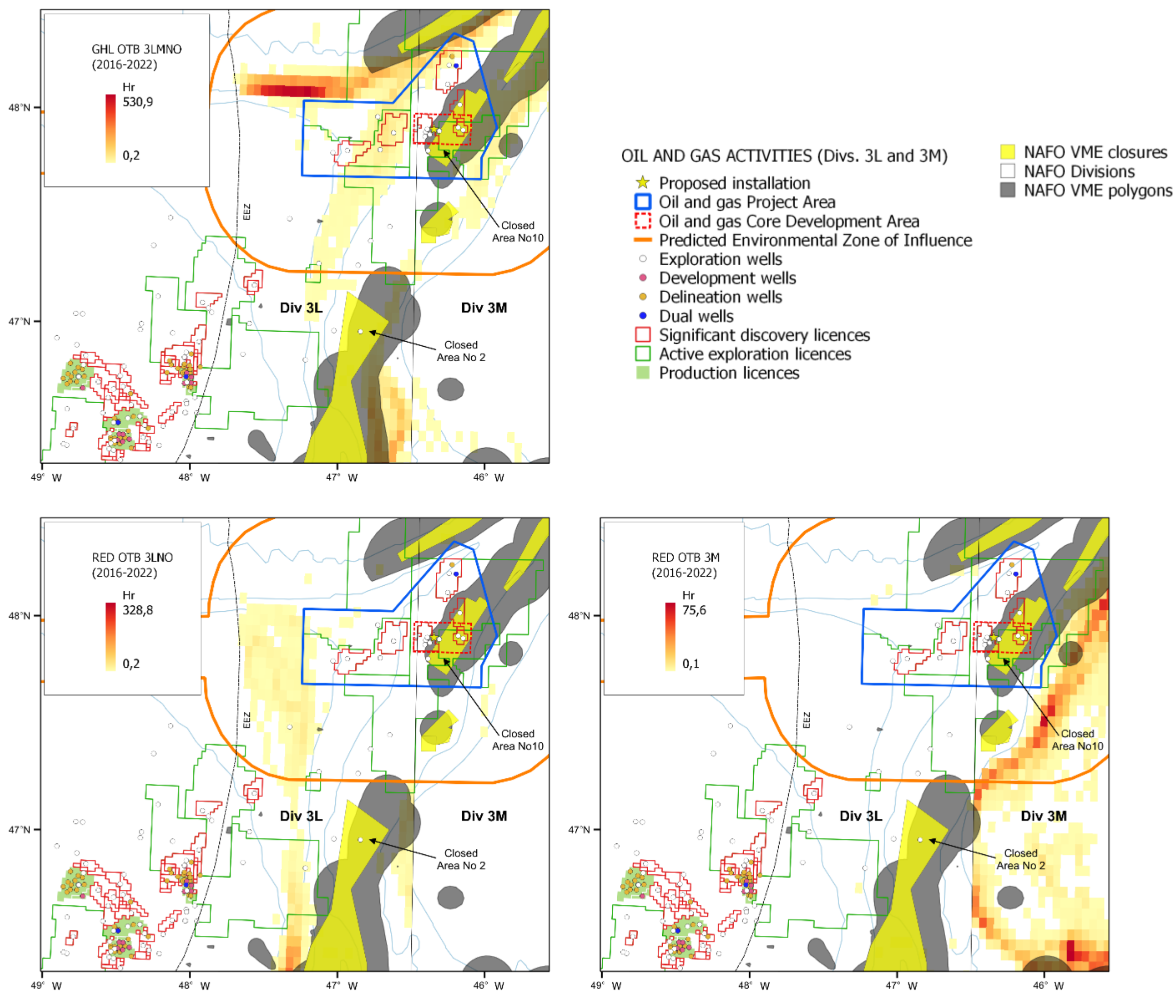

Figure 6. Map showing the spatial overlap between oil and gas activities (wells and licences) and the demersal fisheries for Greenland halibut and redfish (2019). Bottom fishing activity (cumulative fishery 2016-2022) is expressed in hours fished in each cell (from yellow to red). Dark color indicates higher value (source: NEREIDA).

Spatial overlap with VMEs and VME closures: Role in connectivity

Oil and gas activities (wells and licences) in the Flemish Pass, overlap significantly with several patches of VMEs described in Wang *et al.* (2024), specifically those of sponges (S7), sea pens (SP1) and black corals (BC4). VME patches are partially protected from the impact of bottom fishing through fishing closed areas (Table 3; Figures 7 to 9). Based on the available information, the patches of VME are open to oil and gas activities (e.g., drilling, anchoring). It is important to highlight that the fisheries closure No.10, provides protection to three different VMEs (S7, SP1 and BC4). The closed areas 2, 7 to 12 and 14 show physical connectivity and appear to form a network[9] over Flemish Cap (Kenchington *et al.*, 2019b). In addition, the Closed Areas put in place to protect VMEs also contribute to the protection of 3 of the 12 benthic assemblages (NAFO, 2019) identified in the area by Murillo *et al.* (2016).

Table 3. VME patches of sponges, sea pens and black corals, partially protected by NAFO VME Area Closures. Closure Area No. 10 is highlighted in blue.

NAFO VME Closures (NAFO, 2024)	VME patches (Wang *et al.,* 2024)		
	Sponge (S)	Sea pen (SP)	Black coral (BC)
1	S6		
2	S1	SP10	BC3
3	S3		
4	S5		
5	S4, S9		
6	S2		
7		SP1	BC2
8		SP1	
9		SP1	BC1
10	S7	SP1	BC4
11		SP6	
12		SP1	BC1
13	S3		
14		SP5, SP8	BC7

Wang *et al.* (2024) and the literature cited in that paper, suggest that persistence of the sessile benthos over the long term depends on larval supply, and hence on inter-patch connections. Habitat fragmentation has the potential to alter connectivity, affecting population dynamics and ecosystem functioning, and may lead to a loss of biodiversity. According to Wang *et al.* (2024), in the NRA, sea pens had the highest degree of connectivity, while black corals had the least connected network (e.g., BC4 has connections only with 2 black coral patches). Patches serving as source populations to multiple other patches were prevalent in the sea pen network, in which every patch was a source to at least one other, and SP1 had downstream connections to all other patches. In general, the existing networks, including the extant networks of sponge VME, are generally well connected (e.g., S7 has connections with three sponge patches) and, by inference, those connections are likely important to the persistence of VME within the study area. These authors concluded that patches of VMEs within the NRA comprise inter-connected networks, such that maintenance of connectivity should be assumed essential to the persistence of the patches and hence of the VMEs. They also observed that the existing patches in each network differ in their relative importance for connectivity (Figures 7 to 9). On the other hand, connectivity can exacerbate harmful effects caused by anthropogenic activities, such as the spread of pollutants trough a food web or ecosystem (DOSI, 2020; Popova, 2019).

[9] The incremental establishment of the closed areas meant that there was no collective "design" to their placement; however, they could qualify after the fact as a "network" of protected areas (Kenchington *et al.*, 2019b).

VMEs in closure No. 10 (i.e., sea pens, sponges and black corals) are part of an inter-connected network, and hence, impacts on one VME could have cascading effects on other VME areas. In this regard, the effects of non-fishing activities should be further studied in the context of protecting connected VME network, as the development of potentially damaging activities (e.g., oil and gas) may compromises the network (e.g., habitat fragmentation).

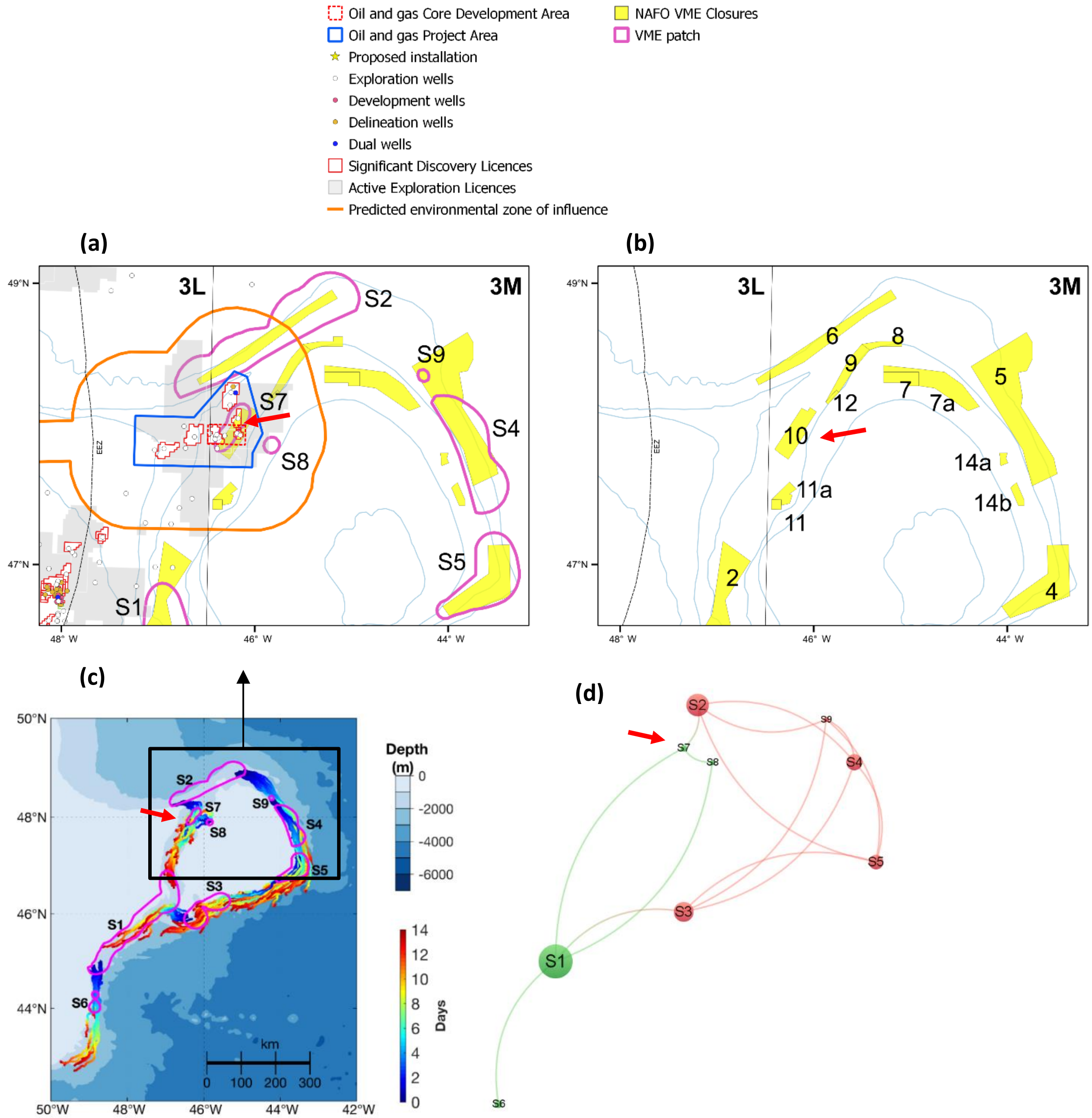

Figure 7. Maps of the NAFO Regulatory area showing the spatial interactions between oil and gas activities (licences and wells), sponge VME and fishing closures, as well as the diagrams of connectivity according to Wang *et al.* 2024. Pannel (a): Spatial overlap between oil and gas activities (licences and wells), sponge VME patches (S) and fishing closures in the Flemish Pass area, in the context of the NAFO network of VME closures shown in Pannel (b). The patches of VME are labeled according to Wang *et al.* 2024. Pannel (c): Minimum particle trajectories connecting the patches of sponges (S). Source: Wang *et al.*, 2024. Pannel (d): Stylized network map created in VOSviewer, using default settings. Nodes are labelled by patch code and their size is proportional to patch area, within the taxon. Node position represents the patch centroid in geographic space. Source: Wang *et al.*, 2024. Oil and gas activities in the Flemish Pass overlap significantly with a sponge patch (S7). The red arrows indicate the location of such patches in all maps.

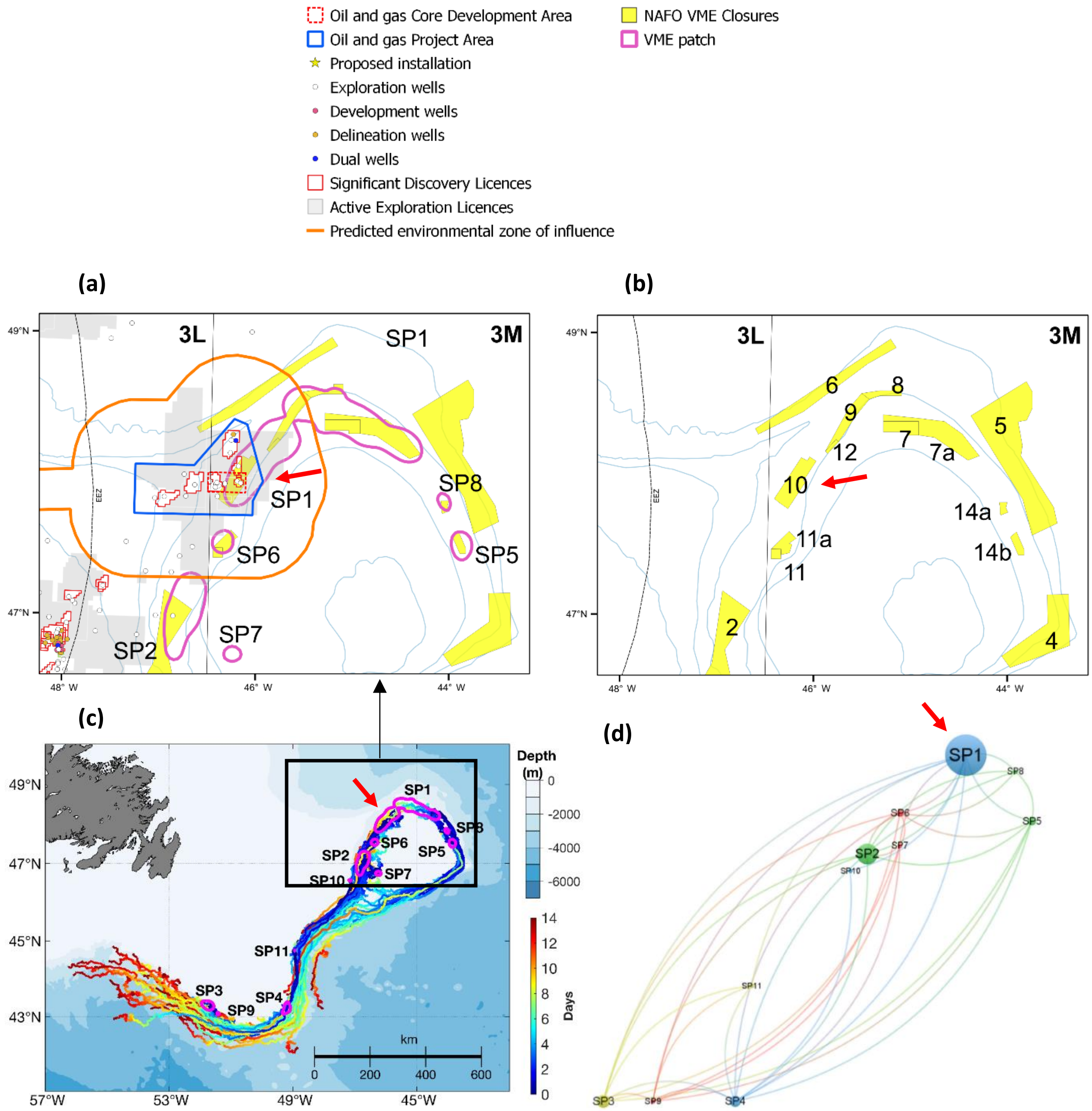

Figure 8. Maps of the NAFO Regulatory area showing the spatial interactions between oil and gas activities (licences and wells), sea pen VME and fishing closures, as well as the diagrams of connectivity according to Wang *et al.* 2024. Pannel (a): Spatial overlap between oil and gas activities (licences and wells), sea pen VME patches (SP) and fishing closures in the Flemish Pass area, in the context of the NAFO network of VME closures shown in Pannel (b). The patches of VME are labeled according to Wang *et al.* 2024. Pannel (c): Minimum particle trajectories connecting the patches of sea pens (SP). Source: Wang *et al.*, 2024. Pannel (d): Stylized network map created in VOSviewer, using default settings. Nodes are labelled by patch code and their size is proportional to patch area, within the taxon. Node position represents the patch centroid in geographic space. Source: Wang *et al.*, 2024. Oil and gas activities in the Flemish Pass overlap significantly with a sea pen patch (SP1). The red arrows indicate the location of such patches in all maps.

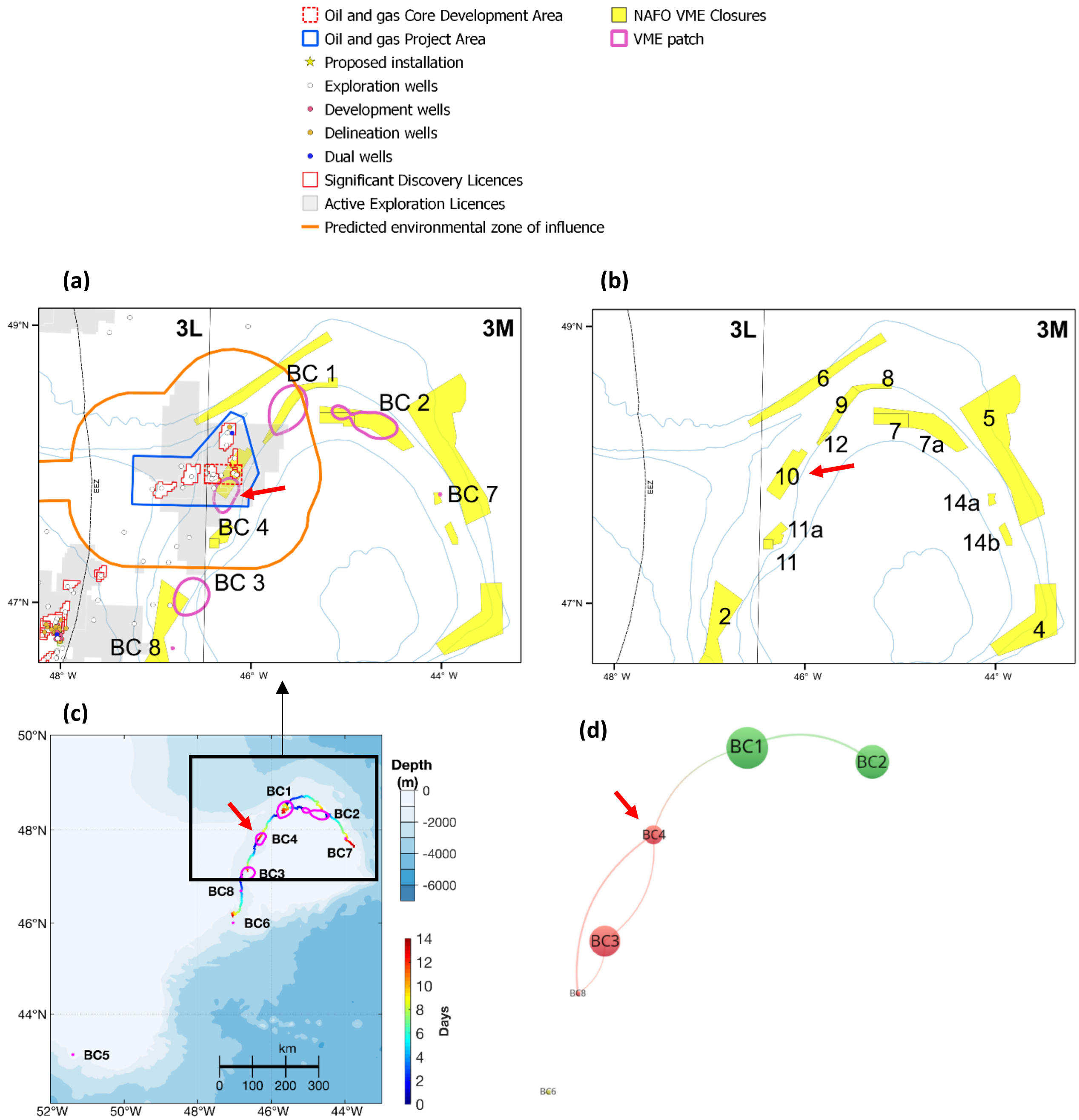

Figure 9. Maps of the NAFO Regulatory area showing the spatial interactions between oil and gas activities (licences and wells black coral VME and fishing closures, as well as the diagrams of connectivity according to Wang *et al.* 2024. Pannel (a): Spatial overlap between oil and gas activities (licences and wells), black coral VME patches (BC) and fishing closures in the Flemish Pass area, in the context of the NAFO network of VME closures shown in Pannel (b). The patches of VME are labeled according to Wang *et al.* 2024. Pannel (c): Minimum particle trajectories connecting the patches of sea pens (SP). Source: Wang *et al.*, 2024. Pannel (d): Stylized network map created in VOSviewer, using default settings. Nodes are labelled by patch code and their size is proportional to patch area, within the taxon. Node position represents the patch centroid in geographic space. Source: Wang *et al.*, 2024. Oil and gas activities in the Flemish Pass overlap significantly with a black coral patch (BC4). The red arrows indicate the location of such patches in all maps.

Implications for the process for nomination and recognizing OECMs

To achieve sustained, long-term biodiversity outcomes, a multi-sectoral, integrated and collaborative process for the identification, assessment and reporting of OECMs is considered best practice in areas with multiple uses and pressures (García *et al.*, 2020; FAO, 2022). In the NAFO context, in absence of such approach, the current process for nomination and recognizing potential OECMs has focused on areas that only support fishing activities. Consequently, Closed Area No.10 was excluded from the process for nomination of the Sponge VME OECM (Figure 10). Sponge VME within closure No. 10 are part of an interconnected network, and they are partially protected from the impacts of bottom fishing. But impacts from activities other than fishing on such a VME could have cascading effects on other areas of VMEs.

Currently, the existence of oil and gas activities within an area closed to bottom fishing to protect VMEs (i.e., Closure Area No.10), hinders its inclusion in the global OECM database. Consideration of Area 10 would bring greater coherence to the OECM proposal (i.e., integrity of the network of closed areas), but this would require a multi-sectoral approach and international collaboration, as recommended by FAO (2022).

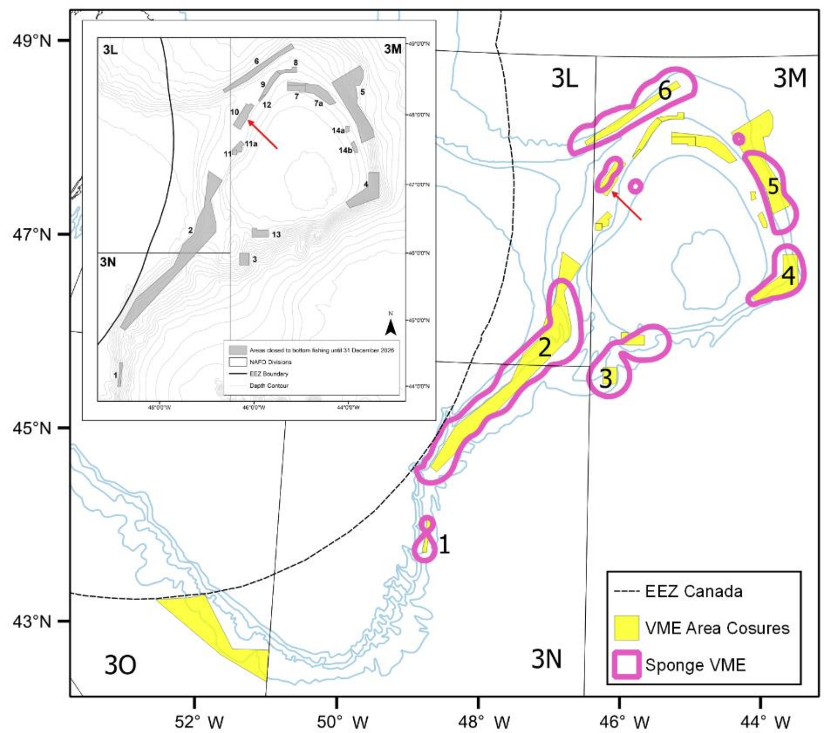

Figure 10. Map showing the six closed areas (1 to 6) comprised in the potential Sponge VME OECM. The box shows the complete NAFO (2024) network of closed areas. The red arrows indicate the location of Closed Area No.10, excluded from the nomination due to risks from oil and gas activities.

3.3. Literature on the impacts of oil and gas: Some key findings

A literature review on relevant research on the impact of offshore oil and gas activities was conducted under the NEREIDA project. A brief selection of key findings, relevant in the NAFO context, are summarized below:

- According to the review from Cordes *et al.* (2016), besides accidental events (e.g. oil spills), routine oil and gas activities can have detrimental environmental effects during each of the main phases of exploration, production, and decommissioning. Environmental impacts can occur throughout the lifecycle of these activities, as OSPAR recognized (Marappan *et al.,* 2022). Moreover, non-fishing activities, including oil and gas, may adversely affect essential fish habitats (Limpisel *et al.,* 2023).

- A study in the Gulf of Mexico revealed that incidents, such as blowouts, injuries, and oil spills, are positively correlated with deeper water (Muehlenbachs *et al.,* 2013). In addition, climate change may affect oil and gas facilities and operations (e.g., damage to pipelines and platforms) both in coastal areas and in the outer continental shelf, due to more intense storms and higher winds and waves (Burkett, 2011). The coexistence of fisheries and oil and gas activities can create competition and conflicts (e.g., limited access to valuable areas, damage of gear and installations, navigational hazards due to installations and increased traffic, operational harms, ecosystem impacts, etc.) as Arbo and Thuy (2016) suggest. The authors concluded that resolving use conflicts is a central issue in the context of ecosystem-based management and is beneficial for the sectors involved and for ecosystem health.

- Marine seismic surveys are a fundamental tool for oil and gas explorations. Noise from seismic surveys may affect a range of species, such as marine mammals (Affati and Camerlenghi, 2023 and references herein) and fish. Van der Knaap *et al.* (2021) observed changes in cod behavior. Cod exhibited disruptions of diurnal feeding activities, unraveling an issue that could potentially lead to consequences at the population level. In addition, McCauley *et al.* (2017) presented evidences suggesting that sound from air gun surveys causes significant mortality to zooplankton populations. This may have implications for ocean health in general (e.g. modifications in plankton community structure).

- According to Ronconi *et al.* (2015), the effects of platforms on birds include both direct and indirect lethal and sub-lethal effects. For seabirds and landbirds (particularly, migrating species), the most frequently observed effect is attraction and sometimes collisions and incinerations associated with lights and flares. Other effects include provision of foraging and roosting opportunities, increased exposure to oil and hazardous environments, increased exposure to predators, or repulsion from feeding sites.

- Environmental effects of oil and gas activities include impacts from routine operational activities such as drilling waste and produced water discharges (Neff *et al.,* 2011; Neff *et al.,* 2014), accidental discharges and spills (Cordes *et al.,* 2016), long-term impacts on deep-sea corals (Fisher *et al.,* 2014; Girard and Fisher, 2018) and deep-sea sponges and the habitats they form (Vad *et al.,* 2018). Studies on the effects of the Deepwater Horizon oil spill, indicate that many years are required for moderately to heavily impacted corals to recover, and that some coral colonies may never recover.

- Operational discharges from offshore oil and gas platforms are a continuous source of contaminants to continental shelf ecosystems (Bakke *et al.,* 2013). Drill cuttings (Tornero and Hanke, 2016) and produced water (Beyer *et al.,* 2020; Hansen, 2019; OSPAR, 2021) are the largest operational source of pollution from the offshore petroleum industry. Effects are generally local (Bakke *et al.*, 2013; OSPAR, 2021) but persistent (Gates *et al.*, 2017). Exposure to produced water can be detected in fish and mussels in laboratory and in field studies, indicating modest impacts (OSPAR, 2021). Haddock and cod larvae subjected to embryonic exposure to produced water extracts were smaller, and displayed signs of cardiotoxicity and body deformations, with more larvae displaying higher severity in haddock compared to cod (Hansen, 2019). Drill cuttings affect *Lophelia* larvae, but there is an age-dependent difference in sensitivity (Järnegren *et al.*, 2017). They also produce local decline of echinoids (Hughes *et al.*, 2010) and meiofauna (Netto *et al.*, 2009). Connectivity can also spread of pollutants trough a food web or ecosystem (DOSI, 2020; Popova, 2019).

- There is evidence for the toxicity of both oil and dispersant on deep-water corals (De Leo, *et al.,* 2016 and references herein) and sponges. Global ocean change can affect the resilience of corals to environmental stressors, and the exposure to dispersants may pose a greater threat than oil itself (Weinnig, 2020). Larvae of sponge survived exposure to high concentrations of petroleum hydrocarbons; however, their ability to settle and metamorphose was adversely affected at environmentally relevant concentrations, and these effects were paralleled by marked changes in sponge gene expression and preceded by disruption of the symbiotic microbiome (Luter *et al.,* 2019). The use of dispersants increases the risk posed by hydrocarbon contamination to sponges and should therefore be limited within areas rich in sponges (Vad *et al.,* 2020) or that contain sponge grounds (Vad *et al.,* 2022).

- Oil and gas exploitation introduce toxic contaminants to the surrounding sediment, resulting in deleterious impacts on marine benthic communities. In the North Sea, contamination from oil and gas platforms caused declines in benthic food web complexity, community abundance, and biodiversity at local level (Chen *et al.,* 2024).

- Effects-oriented studies related to the Deepwater Horizon oil spill (Beyer *et al.,* 2016) demonstrated that the oil was toxic to a wide range of organisms (plankton, invertebrates, fish, birds, and sea mammals), causing a wide array of adverse effects (reduced growth, disease, impaired reproduction, impaired physiological health, and mortality). Both oil exposure and spill response actions caused injuries to a wide range of habitats, species and ecological functions over a vast area.

4. Main outputs and challenges

- Activities other than fishing are a matter of concern for the international community and stakeholders.

- Main natural components and human activities were mapped, based on updated available spatial data.

- Oil and gas licences and wells overlap with NAFO fisheries, VMEs and closed areas, particularly in Divs. 3LM.

- In recent years, an increase in the number of significant discovery licenses has been observed in Divs. 3LM, as well as an increase in overlap with fisheries, VMEs and closed areas.

- VMEs within closure No. 10 (e.g., sea pens, sponges and black corals) are part of an inter-connected network, and hence, impacts on one VME could have cascading effects on other VME areas. They are important for achieving the overall conservation goals.

- Consideration of Area 10 would bring greater coherence to the OECM proposal. This would require a multi-sectoral approach and international collaboration, as recommended by FAO.

- Scientific literature indicates that oil and gas activities can produce impacts during the exploration, production and decommissioning phases. They may also result in conflicts with other users of the marine space.

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