Ocean Use Compatibility Analysis for the Scotian Shelf and Bay of Fundy Planning Area

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Fisheries and Oceans Canada (DFO) is undertaking marine spatial planning (MSP) in several priority areas in Canada, including in the Scotian Shelf and Bay of Fundy planning area. An important consideration in an MSP process is understanding which marine activities can occur together in space. We adapted a tool developed by the COEXIST Project in Europe to score various activities based on spatial scale, temporal scale, vertical scale, and mobility of the activity. Scores were then combined to give a compatibility rating between activities. The resulting compatibility rating provides a high-level overview of which activities may be compatible and which may not, exclusive of possible mitigation or management measures, or the assessment of risks. The results may inform existing decision-making processes and sector-based planning.

RÉSUMÉ

Serdynska, A.R., Nagel, E.J., Kleinknecht, C., Baxter, L.N., and Dykun, L. 2024. Ocean Use Compatibility Analysis for the Scotian Shelf and Bay of Fundy Planning Area. Can. Tech. Rep. Fish. Aquat. Sci. 3613: v + 40 p.

Pêches et Océans Canada (MPO) entreprend des processus de planification spatiale marine dans plusieurs zones prioritaires au Canada, y compris dans la zone de planification du plateau néo écossais et de la baie de Fundy. Dans le cadre de ces processus, il est important de comprendre quelles activités peuvent se dérouler en même temps dans le milieu marin. Nous avons adapté un outil mis au point dans le cadre du projet COEXIST en Europe pour noter diverses activités en fonction de l'échelle spatiale, de l'échelle temporelle, de l'échelle verticale et de la mobilité de l'activité. Nous avons ensuite combiné les notes pour obtenir une cote de compatibilité entre des activités. La cote de compatibilité ainsi obtenue donne une vue d'ensemble des activités qui peuvent être compatibles et de celles qui peuvent ne pas l'être, sans tenir compte des éventuelles mesures d'atténuation ou de gestion. Les résultats peuvent éclairer les processus décisionnels existants et la planification par zone.

1.0 INTRODUCTION

Fisheries and Oceans Canada (DFO) carries out integrated management to support sustainable development of Canada's oceans using tools such as marine spatial planning (MSP). MSP is a process that strives to ensure that marine spaces are collaboratively managed and used to support social, economic, and conservation goals. The world's oceans are under increasing pressure from current uses, expanding industrial activities, and climate change. MSP aims to reduce conflict, support more informed decision making, and support integrated management of human activities and their impacts on the oceans. DFO Maritimes Region is developing a first-generation marine spatial plan for the Scotian Shelf and Bay of Fundy planning area as well as a range of decision-support tools that will be widely available to support government decision making with the best available information.

Government departments exercise their authority in part through a range of decision-making processes linked to their legislation and policies. Decisions occur and take information into account at various spatial and temporal scales. These decisions may have direct or indirect impacts on individuals, projects or entire industries and have consequences for ecosystems and species present. Decision-support tools (DSTs) are tools (e.g., software, processes, or other instruments) used to support decision-making activities. These tools may be used to analyze data, generate reports or products, or assess multiple options. The use of these DSTs can support increased consistency and transparency of management decisions.

The characterization of various ocean uses and the compatibility between them is a key question for MSP, and as such, is the focus of this analysis. Previous analyses by DFO have examined the compatibility between human activities and ecosystem components (DFO 2006; DFO 2010a; DFO 2010b; DFO 2015), but few have assessed the compatibility between human activities. Ecosystem components are not considered in this analysis, but will be the focus of other DSTs. Baseline characterization of human uses and assessment of their compatibility is a key step for effective MSP (Ehler and Douvere 2009, UNESCO-IOC/ European Commission 2021). Another objective of this analysis was to characterize human uses in a standardized way to allow for greater comparability between activities, which can increase the harmonization and usability of data for decision making (UNESCO-IOC/ European Commission 2021).

Many MSP processes and DSTs have been developed in Europe (Pınarbaşı et al. 2017), including the ADRIPLAN (ADRiatic Ionian maritime spatial PLANning) project (ADRIPLAN 2023). The aim of ADRIPLAN was to provide a common approach for MSP across four countries in the Adriatic-Ionian Macroregion of the Mediterranean Sea. Several DSTs were developed under that project, including a method to assess compatibility between marine uses through the COEXIST project (Barbanti et al. 2015a; CORDIS 2019, Stelzenmüller et al. 2013).

The COEXIST project examined how to reduce conflict and balance competing activities and interactions in marine space (CORDIS 2019, Stelzenmüller et al. 2013). Multiple case studies were included across additional regions in Europe, including regions within ADRIPLAN (Barbanti et al. 2015a). The Maritime Use Conflict (MUC) Analysis tool was developed for

ADRIPLAN based on the COEXIST project, and allows for quantitative assessment of conflicts between marine uses to support MSP (European MSP Platform 2023; CNS-ISMAR 2019). This tool scores the potential compatibility between human uses based on the mobility of the activity, as well as the spatial, vertical, and temporal extent (Barbanti et al. 2015b; CNS-ISMAR 2019; Stelzenmüller et al. 2013).

The MUC conflict scoring tool was chosen to be adapted for use in the Scotian Shelf and Bay of Fundy planning area, as it specifically focuses on compatibility between human uses (i.e., use-use compatibility). The MUC tool provides an objective method to score compatibility by calculating spatial and temporal conflict scores across uses, which is both transparent and reproducible (Stelzenmüller et al. 2013). In addition, its use has been demonstrated successfully under a cross-border MSP process in the Mediterranean Sea (Barbanti et al. 2015b; ADRIPLAN 2023). This tool can be used in MSP at various stages, for example to analyze existing uses and their interactions, and to support planning and decision making for potential future scenarios with different distributions of ocean uses (CNS-ISMAR 2019).

This analysis adapted the MUC tool and used it to characterize human activities that occur in the Scotian Shelf and Bay of Fundy planning area, and to analyze potential compatibility between them. This modified tool is named the Ocean Use Compatibility Analysis (OUCA). This DST characterizes existing and anticipated future ocean activities, and supports the assessment of potential compatibility between human uses of marine spaces (e.g., fishing, aquaculture, and energy, among others) to inform sector-based planning. For each activity pairing, conflict scores were calculated based on spatial and temporal activity characteristics. Baseline characterization of ocean uses and analysis of compatibility potential between sectors will be key to integrated, transparent decision making for the use of ocean spaces.

It is important to note that this analysis only examined potential compatibilities between activities using expert opinion on scoring. It was based on general descriptions of activities and real-world examples where available, and did not consider any mitigation or management measures or assessment of risks that could be used to make activities more compatible. These measures were not considered at this stage, as they would depend on the specific activities involved, whereas this tool is meant to provide a high level characterization. This tool is meant for decision support only and does not replace existing decision-making processes.

2.0 METHODS

The original MUC analysis (Barbanti et al. 2015b; CNS-ISMAR 2019) scored the compatibility of activities based on their size, time, location in the water column, and mobility. The scores were then combined to calculate overall conflict scores between each activity pairing, which were used to determine general compatibility of activities. These methods have been adapted for use in the Scotian Shelf and Bay of Fundy planning area to examine the potential compatibility between activities that occur and are expected to occur in the near future. The list of activities considered in the OUCA is included in section 3.0.

Each human activity in the OUCA was scored based on the following scoring rubric (Table 1-Table 4) adapted from Barbanti et al. (2015b) and CNS-ISMAR (2019). Scoring considered average or typical scales for individual activities within the specified industry (e.g., individual vessels or development projects). Coastal activities that occur on shore or in the intertidal zone were not included in this analysis. For example, recreational fishing for invertebrates (e.g., clams, oysters, scallops, and marine worms) via hand or handheld tools such as tongs and rakes on the shoreline was not assessed as part of this analysis.

Some activities are more accurately represented by length (such as the length of vessels) and others by area (such as the area occupied by aquaculture or an oil and gas installation), therefore both measurements are provided in Table 1. Spatial scale scores are based on the greater value of length or area for each activity.

Table 1. Scores for spatial scale

Size	Score	Description
Small	1	< 50 m in length, or < 0.0025 km^2 in area (0.05 km x 0.05 km)
Medium	2	50 m to < 1 km in length, or 0.0025 km^2 to < 1 km^2 in area (1 km x 1 km)
Large	3	≥ 1 km in length, or ≥ 1 km^2 in area

The temporal scale was divided into three scores based on the duration of the activity (Table 2). The short-term time scale was for activities occurring for less than a day, medium-term for activities with durations between 1 day and 1 year, and long-term for activities occurring for more than a year or permanent structures.

Table 2. Scores for time scale

Size	Score	Description
Short-term	1	< 1 day (24 hours)
Medium-term	2	≥ 1 day (24 hours) and < 365 days (1 year)
Long-term	3	≥ 365 days (1 year) or permanent

The vertical scale was based on where the activity occurred in the water column, and whether it occupied the surface, water column, or seafloor (Table 3).

Table 3. Scores for vertical scale

Location	Score	Description
Surface/pelagic	1	Activity occurs at the surface and in the water column, but not at the seafloor
Benthic/seafloor	2	Activity occurs on the seafloor, but does not extend up into the water column
Entire water column	3	Activity extends from the surface throughout the water column to the seafloor.

Mobility scores were applied based on whether the activity and associated gear or equipment were stationary or mobile (i.e., changed locations over time) (Table 4). The definition of mobile activities differs from the DFO definitions of mobile fishing gears, as the focus of this DST in on a broader range of human activities beyond fishing. For example, groundfish license conditions consider baited hook and line to be a type of fixed gear (DFO 2018a), but in OUCA the 'Hook and Line' activity was scored as mobile as it covers a broader range of activities and can occurs from a mobile vessel.

Table 4. Description of mobility

Mobility	Description
Mobile	Activity is mobile
Stationary	Activity is stationary[1]

These scores were combined to develop conflict scores based on the following rules (modified from Barbanti et al. 2015b and CNS-ISMAR 2019). Lower conflict scores indicate higher compatibility between activities. The decision tree for implementing these rules is shown in Figure 1.

1) If the activities do not occur on the same vertical scale (e.g., surface vs. seafloor), and neither of the activities occupies the entire water column, the conflict score is zero, and the activities are theoretically compatible as they do not occur in the same vertical space.[2]
2) If both activities are mobile and there is more flexibility on location, the lower of the scores of the spatial scale and time scale for each activity are summed (conflict score of 2 – 6).
3) If rules 1 or 2 do not apply (i.e., one or both activities are fixed or they overlap spatially) the higher of the scores of the spatial scale and time scale of activities are summed (conflict score of 2 – 6).

[1] Short-term fixed gear fishing was considered a stationary activity on a short time scale, which differs from the Maritime Use Conflict Analysis (Barbanti et al. 2015b; CNS-ISMAR 2019).
[2] Note that the vertical scale score is only used to assess whether the activities are fully compatible (score of 0) or not. It is not combined with the spatial and time scale scores.

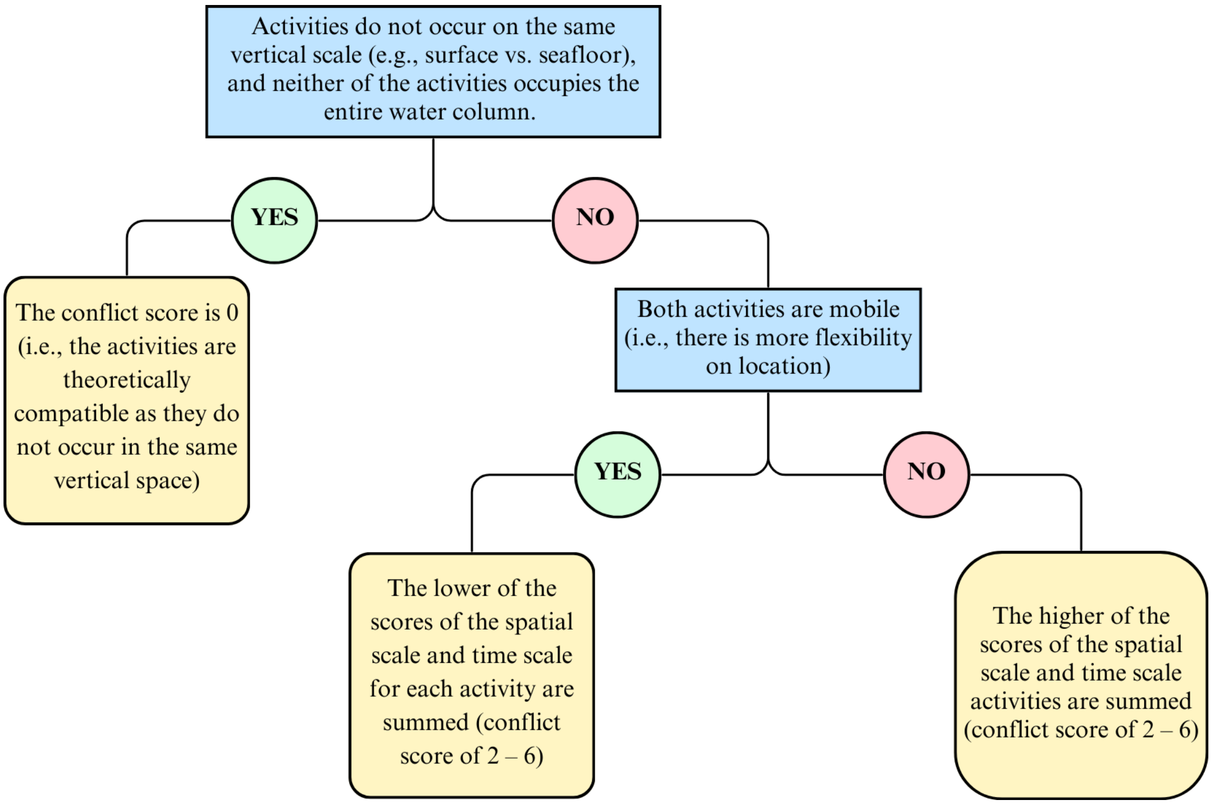

Figure 1. Decision tree for calculating conflict scores between activity pairings.

Based on these scoring rules, possible conflict scores for two activities can range from 0 (most compatible) to 6 (least compatible). Some of the activities assessed in this report have a range of sizes and timescales, so where applicable the largest score was used to provide conservative estimates of compatibility.

Note that the scores are based on the equipment, gear, or infrastructure involved, not any effect they may have on the surrounding environment. This scoring only assesses the activities themselves and not any secondary impacts.

3.0 DESCRIPTION OF ACTIVITIES AND SCORING

The activities considered for this analysis were those that occur or could occur in the future in the Scotian Shelf and Bay of Fundy planning area. Each section describes an activity, as well as the temporal and spatial scores and rationale assigned to that activity.

3.1 Marine Transportation

3.1.1 Vessel traffic routes

A significant amount of international and domestic commercial shipping traffic occurs over the Scotian Shelf and Bay of Fundy. Upon their approach to port, vessel traffic service zones are designated to direct and regulate traffic flow (CCG 2022, CHS 2020). Scoring includes shipping lanes, corridors, and any areas with high frequency of vessel traffic (Table 5).

Table 5. Compatibility scores for shipping lanes

	Score	Rationale
Spatial scale	3	Vessel traffic routes are > 1 km^2
Time scale	3	Vessel traffic routes are typically permanent (> 356 days)
Vertical scale	1	Occurs at the surface
Mobility	stationary	Vessel traffic routes are stationary

3.1.2 Other vessel transit areas

Other vessel transit areas are areas of vessel traffic outside designated vessel traffic routes. These areas are transited by a range of fishing vessels, cruise ships and various government vessels, but for scoring the largest vessels were considered (Table 6). Commercial shipping in the planning area is generally in the form of tankers and general, bulk and containerized cargo carriers. The primary commodities being moved in the region include crude oil and gas, minerals and chemicals, paper and forest products, coal and coke, and various containerized goods (Breeze and Horsman 2005). These transit areas could not be defined spatially, thus, the scoring is based on the length of the vessels.

Table 6. Compatibility scores for other vessel transit areas

	Score	Rationale
Spatial scale	2	Other vessel transit areas are > 50 m and < 1 km
Time scale	2	Other vessel transit areas operate > 1 day and < 365 days
Vertical scale	1	Occurs at the surface
Mobility	mobile	Vessels transit is mobile

3.1.3 Anchorages

Anchorages are considered areas where vessels frequently anchor, due to suitability of the environment and/or permission to do so in designated anchorage areas (Table 7). This activity does not include fixed infrastructure, such as a marina or wharf. Therefore, scoring was based upon the anchorage, the length of the anchor line, and the boat length. Anchored vessels are recommended to set a bow line that is equal to 5 – 10 times the depth of the water (National Boating Safety School 2021). Further, the maximum designated anchorages in Canada are 1 nautical mile in maximal diameter or 2 km^2 (CHS 2020, Transport Canada 2020). Duration of anchoring can vary from a few hours to multiple weeks depending on the reason for anchorage (Transport Canada 2020).

Table 7. Compatibility scores for anchorages

	Score	Rationale
Spatial scale	3	Anchorages are > 1 km^2
Time scale	2	Anchorages operate > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor.
Mobility	stationary	Anchorages are stationary

3.1.4 Marinas, wharves and berths

Marinas, wharves, and berths, etc., were considered to be any fixed infrastructure or facilities where vessels are docked on a regular basis (Table 8). These include structures such as buildings, wharves, and ramps. They differ from a port as they are smaller and do not handle larger cargo and passenger vessels.

Table 8. Compatibility scores for marinas, wharves and berths

	Score	Rationale
Spatial scale	2	Marinas, wharves and berths are > 0.0025 km^2 and < 1 km^2
Time scale	3	Marinas, wharves and berths typically operate year-round (> 365 days)
Vertical scale	3	The infrastructure of marinas, wharves and berths extends from the surface throughout the water column to the seafloor
Mobility	stationary	Marinas, wharves and berths are stationary structures

3.1.5 Ports

Ports generally refer to near-shore locations where ships can load/unload cargo and/or passengers (Table 9). Often these operations serve on a larger, more commercial scale than smaller harbours or marinas. Major ports for the Maritimes Region are located in: Saint John (NB), Port Hawkesbury (NS), Sydney (NS), and Halifax (NS). The Port of Halifax is the largest in the region, comprising various port facilities that span 265 acres and in 2020, directly contributed $2.3 billion to the Province of Nova Scotia (Port of Halifax n.d.).

Table 9. Compatibility scores for ports

	Score	Rationale
Spatial scale	3	Ports are > 1 km^2
Time scale	3	Ports typically operate year-round (> 365 days)
Vertical scale	3	The infrastructure of ports extends from the surface throughout the water column to the seafloor
Mobility	stationary	Ports are stationary

3.2 Fishing

3.2.1 Bottom contacting gear

3.2.1.1 Bottom otter trawl

Bottom otter trawl fishing involves dragging nets along the ocean floor to catch groundfish, invertebrates, and other organisms (Table 10). This gear is comprised of a cone-shaped net, which is attached to the vessel by a line (FAO 2024a). The net is closed at one end with a narrow bag, known as a cod-end, where the catch is collected. The other end of the net is held open horizontally by two otter boards, which can be made of metal or wood (DFO 2020a), and is held open vertically by a float line at the top and a weighted groundline at the bottom of the net (FAO 2024b). The typical otter trawl has a door spread of about 91 m and a wingspread of 20 m (DFO 2004). In this region, bottom otter trawls are used to catch groundfish, including Haddock (*Melanogrammus aeglefinus*), Pollock (*Pollachius virens*), Silver Hake (*Merluccius bilinearis*), and Redfish (*Sebastes sp.*; DFO 2018a). For the purpose of this analysis, only one trawl vessel was considered rather than a fleet of vessels.

Table 10. Compatibility scores for bottom otter trawl

	Score	Rationale
Spatial scale	3	The vessel, warps, and bottom otter trawl are > 1 km
Time scale	1	Bottom otter trawling is a short-term activity (< 1 day)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	Bottom otter trawls are mobile

3.2.1.2 Danish/Scottish seine

Danish or Scottish seines are similar to trawl nets (FAO 2024c) and are comprised of a cone-shaped net, with a bag at one end, and two wings at the other end (Table 11). The wings are attached to long warps, which are in turn connected to the vessel. The net is dragged along the bottom to stir up mud and herd fish into the net, while the warps are used to close it (Donaldson et al. 2010). Warps can be up to 3 km long (Donaldson et al. 2010). In Danish seining the vessel is anchored while the seine net is closed, while in Scottish seining, the vessel is kept in one location using its propeller (FAO 2024c).

Table 11. Compatibility scores for Danish/Scottish seine

	Score	Rationale
Spatial scale	3	The vessel, warps, and seine are > 1 km
Time scale	1	Danish/Scottish seine fishing is a short-term activity (< 1 day)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	Danish/Scottish seines are mobile

3.2.1.3 Dredge

Dredge gear consists of a metal frame that is dragged along the ocean floor to catch shellfish (Table 12). A bag composed of metal rings is attached to the frame to collect the catch, and the entire gear is attached to the vessel via a line/cable (FAO 2024d). Specific gear configurations vary by fishery. In the Scotian Shelf and Bay of Fundy planning area, dredge gear is used in the inshore and offshore scallop (*Placopecten magellanicus*), and surf clam (*Mactromeris polynyma*) fisheries. The offshore scallop fishery uses one bag attached to the frame as described above (Knapman et al. 2020), while the inshore scallop fishery uses a frame with up to twelve smaller bags or baskets attached (Dignan et al. 2018). The surf clam fishery uses hydraulic dredges. A hose is attached to the front of the dredge to shoot water jets into the sediment to uncover the clams and scoop them into the dredge (Knapman et al. 2020).

Table 12. Compatibility scores for dredge

	Score	Rationale
Spatial scale	3	The vessel, warps, and dredge are >1 km
Time scale	1	Dredging is a short-term activity (< 1 day)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	Dredge gear is mobile

3.2.1.4 Bottom longline

Bottom (demersal) longline fishing involves a series of hooks anchored to the bottom to passively catch fish (Table 13). This gear includes a mainline that is anchored to the seafloor with baited hooks, attached via shorter lines called gangions (DFO 2010a). Hooks are set along the mainline at one to six metre intervals; Hook size and spacing varies depending on the species targeted. Each end of the mainline is moored to the bottom and marked with a buoy on the surface. Mainlines can be kilometres long, with hundreds or thousands of baited hooks attached (DFO 2010a). Generally, longlines are set for 24 hrs or less (Butler et al. 2019). In the Scotian Shelf and Bay of Fundy planning area, this gear typically targets Halibut (*Hippoglossus hippoglossus*) and other groundfish. While longlines are set with mobile vessels, this activity was categorized as stationary as gear are stationary when set.

Table 13. Compatibility scores for bottom longline

	Score	Rationale
Spatial scale	3	Bottom longlines are > 1 km
Time scale	2	Bottom longlines are set for < 1 day
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Bottom longlines are stationary when set.

3.2.1.5 Set/fixed gillnet

Set or fixed gillnets are stationary nets set in the water column or along the seafloor (Table 14). Gillnets capture fish as they swim through the mesh of the net, becoming trapped at the gill cover or the largest part of their body (He 2006). Benthic gillnets have a weighted rope or lead line at the bottom of the panel and are anchored in place by weights at either end. The top of the net is kept buoyant with a float line (DFO 2010a). Benthic gillnets are typically 91 m (50 fathoms) long (He 2006), but are commonly attached together in fleets or strings of 5 – 7 nets (DFO 2010a). Pelagic gillnets are comprised of the same materials, but are set in the water column as individual nets at lengths of 30 fathom (55 m), or in strings of up to 200 fathom (366 m; T. Hayman (DFO), pers. comm. 2024). Setting and hauling gear can vary by licencing conditions, but harvesters generally set all set/fixed gillnets for less than 24 hours due to risks of gear loss, gear conflicts, and seal predation on captured fish (DFO 2018a; T. Hayman (DFO), pers. comm. 2024). In the Scotian Shelf and Bay of Fundy planning area, benthic gillnets target groundfish and pelagic gillnets catch herring and mackerel (DFO 2010a). While set/fixed gillnets are set with mobile vessels, this activity was categorized as stationary as gear are stationary when set.

Table 14. Compatibility scores for set/fixed gillnet

	Score	Rationale
Spatial scale	2	Individual set/fixed gillnets are > 50 m and < 1 km
Time scale	1	Set/fixed gillnets are set for < 1 day
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Set/fixed gillnets are stationary when set

3.2.1.6 Traps and pots (single)

Traps and pots (used interchangeably here) are baited cages or barrels that are set on the seafloor to catch a variety of species, including invertebrates and groundfish (Table 15). They are designed so that once the animal enters the trap, they are unable to escape (FAO 2024e). The shape and composition of the trap varies depending on the species targeted (Donaldson et al. 2010). Traps can be fished one at a time or in a group, or “string.” Single traps are attached to a rope with a buoy at the surface. Soak times for traps and pots vary by fishery but are usually at least one day (DFO 2010a, DFO 2018b). In the Scotian Shelf and Bay of Fundy planning area, this gear type is mainly used to target Lobster (*Homarus americanus*), Snow crab (*Chionoecetes opilio*) and Hagfish (*Myxine glutinosa*). While traps and pots are set with mobile vessels, this activity was categorized as stationary as gear are stationary when set.

A caveat to the compatibility analysis is on-demand gear used during whale closures. On demand gear does not extend throughout the water column until it is released by the harvester (Alkire 2022). As on-demand gear is limited to specific circumstances, it was not included in the analysis.

Table 15. Compatibility scores for traps and pots (single)

	Score	Rationale
Spatial scale	1	Single traps and pots are < 50 m
Time scale	2	Traps and pots are set for > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Traps/pots are stationary when set

3.2.1.7 Traps and pots (multiple)

Traps and pots can be fished in groups known as "strings" or "trawls" (DFO 2010a; Table 16). In this case, multiple traps are connected together with a groundline, with one or more lines connecting the string of traps to a buoy at the surface (DFO 2010a). In the Scotian Shelf and Bay of Fundy planning area, trawls are used in the offshore American Lobster (*Homarus americanus*) fishery. Groups of 120 to 150 individual traps are placed approximately 25 metres apart and are attached together via a ground line. The vessel will set approximately 30 strings at a time spanning approximately 2 kilometres, with a 4 to 5-day soak time (Bannister et al. 2010). While traps and pots are set with mobile vessels, this activity was categorized as stationary as gear are stationary when set.

Table 16. Compatibility scores for traps and pots (multiple)

	Score	Rationale
Spatial scale	3	Trap/pot trawls are > 1 km
Time scale	2	Soaking traps and pots are set for > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Trap/pot trawls are stationary when set

3.2.1.8 Trap net

Trap nets are any type of large, stationary net designed so that once an animal enters the net they are unable to escape (FAO 2024f; Table 17). There are numerous types of trap nets, including box nets, bag nets, fyke nets, square nets, Newfoundland cod traps, and Japanese cod traps (Donaldson et al. 2010). These traps can vary in size, but were grouped for this analysis as they all fall within the same scoring parameters below. Newfoundland cod traps are the most commonly used trap nets in Atlantic Canada (Donaldson et al. 2010). These traps consist of four walls of netting, a netted floor, and a doorway in one of the walls. Traps range from 11–22 m around (Armour et al. 1991 in Donaldson et al. 2010). They are held in place by anchored ropes, lead weights along the bottom of the walls, and floats along the top of the walls. A leader net extends from the doorway to guide fish into the trap.

Table 17. Compatibility scores for trap net

	Score	Rationale
Spatial scale	1	Trap nets are < 0.0025 km^2
Time scale	2	Trap nets are set for > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Trap nets are stationary when set

3.2.1.9 Weir

A weir is a stationary structure set up in the water to catch and enclose fish on a permanent or semi-permanent basis (Donaldson et al. 2010; Table 18). Weirs can be set up as barriers, fences, or corrals, with a narrow opening, and can be composed of stakes, branches, and netting, etc. (FAO 2024g). In the Scotian Shelf and Bay of Fundy planning area, weirs can vary in size ranging from 3 – 4 m in height and lengths of 100 – 700 m (Baker et al. 2014). Commercial catches from weirs include Atlantic Herring (*Clupea harengus*), Gaspereau (*Alosa pseudoharengus*), and multiple species of flounder (Dadswell et al. 2020; Donaldson et al. 2010).

Table 18. Compatibility scores for weir

	Score	Rationale
Spatial scale	2	Weirs are > 50 m and < 1 km
Time scale	3	Weirs typically operate year-round (> 365 days)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Weirs are stationary

3.2.2 <u>Non-bottom contacting gear</u>

3.2.2.1 Midwater trawl

Midwater trawls function similarly to bottom trawls (see section 3.2.1.1), but are designed to operate above the seafloor (Donaldson et al. 2010; Table 19). The mobile gear fleet varies in vessel size (<65' fleet, 65' – 100' fleet, and >100' fleet), with all permitted to fish using midwater trawls (DFO 2018a). The size of nets may vary, but are approximately 700 m in length with an average door spread of 120 m (Cheng et al. 2020). Target species for the midwater trawl fishery include Silver Hake (*Urophycis sp.*), Pollock (*Pollachius virens*), Haddock (*Melanogrammus aeglefinus*), Herring (*Clupea harengus*) and Mackerel (*Scomber scombrus*). Additionally, this gear has historically been used to target Redfish (*Sebastes spp.*), and is anticipated to be used more widely in the future (Aker et al. 2014). Although the midwater trawl is not designed to contact the seafloor, benthic interactions can occur during operation via the trawl doors, auxiliary weights, the cod-end and footropes (Kenchington et al. 2009; DFO 2010a; Donaldson et al. 2010; Boutlier et al. 2013; DFO 2018c; Chosid and Pol 2020).

Table 19. Compatibility scores for midwater trawl

	Score	Rationale
Spatial scale	3	The vessel, warps, and midwater trawls are > 1 km
Time scale	1	Midwater trawling is a short-term activity (< 1 day)
Vertical scale	1	Extends from the surface through the water column, but does not touch seafloor
Mobility	mobile	Midwater trawls are mobile

3.2.2.2 Drift gillnet

Drift gillnets are similar to Set/fixed gillnets (see section 3.2.1.5), however they float in the midwater or near the surface (Table 20). Gillnets can vary in size and can be set individually or attached together in fleets or strings (DFO 2010a). Setting and hauling gear can vary, but harvesters generally set gillnets for less than 24 hours due to risks of gear conflicts, gear loss, and seal predation on captured fish (T. Hayman (DFO), pers. comm. 2024). In the Scotian Shelf and Bay of Fundy planning area, they are used to catch small pelagic species such as Herring and Mackerel (DFO 2010a).

Table 20. Compatibility scores for drift gillnet

	Score	Rationale
Spatial scale	2	Drift gillnets are > 50 m and < 1 km
Time scale	1	Drift gillnets are set for < 1 day
Vertical scale	1	Extends from the surface through the water column, but does not touch seafloor.
Mobility	stationary	Gillnets are stationary when set

3.2.2.3 Purse seine

Seines are large nets that can be used to enclose groups of fishes (Table 21). Purse seines are comprised of a large wall of netting, with a float line at the top, and a lead line at the bottom (Donaldson et al. 2010). The bottom of the gear also has rings (known as purse rings) hanging from it. A wire or rope known as the purse line is run through the purse rings to allow the net to close. It is usually operated mechanically from the vessel. Purse seines can be up to 2,000 m long and 200 m deep, depending on the species targeted (NOAA 2022). In the Scotian Shelf and Bay of Fundy planning area, purse seines are used to target schooling fish such as Mackerel (*Scomber scombrus*), Herring (*Clupea harengus*), and Capelin (*Mallotus villosus*; Donaldson et al. 2010).

Table 21. Compatibility scores for purse seine

	Score	Rationale
Spatial scale	3	The vessel, ropes, and purse seine are > 1 km
Time scale	1	Purse seine fishing is a short-term activity (< 1 day)
Vertical scale	1	Extends from the surface through the water column, but does not touch seafloor
Mobility	mobile	Purse seines are mobile

3.2.2.4 Pelagic longline

Pelagic longline gear is similar to Bottom longline (see section 3.2.1.4; Table 22). Baited hooks are attached to a mainline via shorter lines called gangions (DFO 2010a). Hooks are set along the mainline at one to six metre intervals; hook size and spacing varies depending on the species targeted. Buoys are attached to both ends of the mainline to mark the gear. Pelagic longlines can be many kilometers long, but unlike bottom longlines, are not anchored to the seafloor (DFO 2010a). Generally, longlines are set for 24 hours or less and drift with tethered high-flyer radio beacons (Butler et al. 2019). In the Scotian Shelf and Bay of Fundy region, this fishery targets Swordfish (*Xiphias gladius*) and various tuna species, including Albacore (*Thunnus alalunga*), Bigeye (*Thunnus obesus*), and Yellowfin (*Thunnus albacares*; Hanke et al. 2012).

Table 22. Compatibility scores for pelagic longline

	Score	Rationale
Spatial scale	3	Pelagic longlines are > 1 km
Time scale	2	Pelagic longline fishing are set for > 1 day and < 365 days
Vertical scale	1	Extends from the surface through the water column, but does not touch seafloor
Mobility	mobile	Pelagic longlines are mobile

3.2.2.5 Hook and line

For the purposes of this analysis, hook and line was considered any fishing gear (other than longline) involving lines with hooks attached to catch fish, including handline, rod and reel, jigging, and trolling, etc. (Table 23). The design of this gear type can vary, but all involve one or more lines with baited hooks deployed in the water targeting groundfish and pelagic species (Donaldson et al. 2010). Handline involves one line with one or more baited hooks; it may or may not be done using a pole (Donaldson et al. 2010). Rod and reel fishing falls under this gear type. Jigging involves a lure attached to a line that is raised and lowered to imitate prey. Finally, trolling involves one or more lines with baited hooks that are towed behind a vessel. Each line can have one or multiple baited hooks (Donaldson et al. 2010). Deployment and retrieval of hook and line gear may be done by hand or mechanized. While some hook and line methods require the vessel to be in motion, DFO classifies this gear type as fixed specifically when referring to fisheries management (DFO 2018a).

Table 23. Compatibility scores for hook and line

	Score	Rationale
Spatial scale	1	Hook and line is < 50 m
Time scale	1	Hook and line fishing is a short-term activity (< 1 day)
Vertical scale	1	Extends from the surface through the water column, but does not touch seafloor
Mobility	mobile	Hook and line gear is mobile

3.2.2.6 Spear/harpoon

Fishing with spears or harpoons involves throwing or launching a sharp rod from a vessel to kill or wound fishes and marine mammals (Donaldson et al. 2010; Table 24). Harpoons are used in deeper waters than spears and may be attached to the vessel with a line. Spears and harpoons are used to catch animals one at a time. In the Scotian Shelf and Bay of Fundy planning area, harpoons are used to catch Swordfish (*Xiphias gladius*).

Table 24. Compatibility scores for spear/harpoon

	Score	Rationale
Spatial scale	2	Spears/harpoons are > 50 m and < 1 km
Time scale	1	Spear/harpoon fishing is a short-term activity (< 1 day)
Vertical scale	1	Occurs at the surface
Mobility	mobile	Spears/harpoons are mobile

3.2.3 Other fishing

3.2.3.1 Hand collection

The sea urchin fishery in Nova Scotia uses divers to harvest green sea urchins (*Strongylocentrotus droebachiensis*) (Miller 2008). See Diving (section 3.6.3).

3.2.3.2 Recreational fishing

Recreational fishing is done for pleasure or personal use (*Maritime Provinces Fishery Regulations* 1993). Recreational fishing for finfish is commonly done via angling, which involves a fishing rod with one or more hooks attached to the line, or handlines (DFO 2023). See Hook and line (section 3.2.2.5).

Additionally, recreational hand harvest of sea scallop (*Placopecten magellanicus*) can occur through diving (Sameoto et al. 2022). See Diving (section 3.6.3).

3.2.3.3 Lobster cars

Lobster cars are wood and wire cages which can be used to store live lobsters on a temporary basis during fishing seasons (Barnett and Eakin 2015; Table 25). These cars consist of floating structures containing lobster crates, which are moored close to shore and are flushed regularly by tides.

Table 25. Compatibility scores for lobster cars

	Score	Rationale
Spatial scale	1	Lobster cars are < 50 m
Time scale	2	Lobster cars are in use > 1 day and < 365 days
Vertical scale	1	Extends from the surface through the water column, but does not touch the seafloor
Mobility	stationary	Lobster cars are typically stationary

3.3 Aquaculture

3.3.1 Finfish aquaculture

Marine-based finfish aquaculture consists of rearing fish in large pens placed in the marine environment (Table 26). Fish are grown to the appropriate harvesting size within net pens and monitored by aquaculture operators (Senate of Canada 2016).The cages consist of elements above and below the surface, which may include floating containment structures anchored to the sea bottom and walkways above the cages (Senate of Canada 2016). In Nova Scotia, Atlantic Salmon (*Salmo salar*), accounts for the majority of aquaculture exports (Province of Nova Scotia 2021). Lease areas for finfish aquaculture licensed in 2021 in the province of Nova Scotia did not individually exceed 0.5 km^2 (Province of Nova Scotia 2024).

Table 26. Compatibility scores for finfish aquaculture

	Score	Rationale
Spatial scale	2	Sites are < 1 km^2
Time scale	3	Sites are typically semi-permanent (> 365 days)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Finfish aquaculture sites are stationary

3.3.2 Shellfish aquaculture

Shellfish aquaculture employs a wide range of husbandry practices generally classified into off-bottom and bottom culture methods (Table 27). Off-bottom methods encompass cage culture, tray culture, surface/floating culture, and suspended culture which can employ longlines, rafts and/or floating bags (O'Beirn et al. 2013). On-bottom methods grow shellfish in contact with the ocean floor. The top harvested species in Nova Scotia in 2019 included Bay Quahog (*Arctica islandica*), Blue Mussel (*Mytilus edulis*), American Oyster (*Crassostrea virginica*), and giant Sea Scallop (*Placopecten magellanicus*) (NSDFA 2019). The largest shellfish aquaculture site licensed in 2021 in Nova Scotia exceeded 15 km^2 (Province of Nova Scotia 2024).

Table 27. Compatibility scores for shellfish aquaculture

	Score	Rationale
Spatial scale	3	Sites are > 1 km^2
Time scale	3	Sites are typically semi-permanent (> 365 days)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Shellfish aquaculture sites are stationary

3.3.3 Marine plant aquaculture

Marine plant cultivation consists of four phases: the collection and settlement of zoospores on seed strings, the production of seedlings, transplantation and outgrowing of seedlings, and harvesting (Sahoo and Yarish 2004; Table 28). While there are numerous marine plant cultivation methods, the longline method is popular in Atlantic Canada (Tamigneaux 2017).

Longlines are anchored to the ocean floor and employ buoys to maintain the longline at the desired depth with the marine plants hanging vertically (De San 2012). This method is typically practiced in water from 4 to 10 m deep (De San 2012).

In Nova Scotia, six marine shellfish and plant leases are in effect for the cultivation of the following species: Kelp (*Laminaria longicruris*), Sugar Kelp (*Saccharina latissima*), Finger Kelp (*Laminaria digitata*), Dulse (*Palmaria palmata*) and Sea Lettuce (*Ulva lactuca*) (Province of Nova Scotia 2024). These leases ranged in size, with one exceeding 1 km^2.

Table 28. Compatibility scores for marine plant aquaculture

	Score	Rationale
Spatial scale	3	Sites are > 1 km^2
Time scale	3	Sites are typically semi-permanent (> 365 days)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Marine plant aquaculture sites are stationary

3.4 Energy

3.4.1 Tidal barrage

Tidal barrages have similar operation to reservoir hydro dams, however, barrages are built across tidal estuaries or inlets with water flowing cyclically on flood and ebb tides (Breeze 2014; Table 29). Sluice gates are opened as the tide rises and are closed at high tide to capture water. As the tide ebbs, the captured water is released through a turbine generator to produce power using the height differential (Frid et al. 2012; Canada Energy Regulator 2017). Turbines may be installed into existing structures such as causeways or dams, or may be constructed with materials such as concrete (Breeze 2014).

The only tidal barrage power plant in North America is located in Nova Scotia. The Annapolis Tidal Station was installed in Nova Scotia in 1984 and ceased operation in 2019 (Canada Energy Regulator 2023).

Table 29. Compatibility scores for tidal barrage

	Score	Rationale
Spatial scale	2	Tidal barrages are > 50 m and < 1 km
Time scale	3	Tidal barrages are typically semi-permanent > 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Tidal barrages are stationary structures

3.4.2 In-water turbines (tidal and wave)

Tidal energy generation involves deploying turbines and other devices into the water column to directly extract energy from changing tides (Table 30). Tidal stream generators use underwater turbines to extract kinetic energy from water movement generated from tidal patterns, and are situated on either a vertical or horizontal axis (Canada Energy Regulator 2017). The Fundy Ocean Research Centre for Energy (FORCE) is the leading innovation and research hub for tidal energy innovation in Canada, and is located in Parrsboro, NS (FORCE n.d; DFO 2024). . FORCE partners with industry, government, and research partners to test in-stream tidal energy technologies in the Bay of Fundy in a Crown Lease Area of Minas Passage, which is a high energy environment connecting the Minas Basin to the rest of the Bay of Fundy (FORCE n.d.). Grand Passage between Brier Island and Long Island and Petite Passage near Digby, NS, are also focus areas for tidal energy developers.

Within the FORCE lease site, a single bottom-mounted gravity-based turbine has been tested to date (FORCE n.d). Recently in Grand Passage, a horizontal axis floating turbine was deployed and tested (Chandler 2020) and within Petite Passage, a bottom-mounted turbine may be deployed in the near-future (Nova 2023). The approximate dimensions of the devices deployed to date were 16 m in width and 20 m in height, and 27 m in width by 32 m in length, 8 m bellow the surface (Macdonald and Fraser 2018). Tidal turbines can vary in physical size and generating capacity. Additionally, the number of turbines, style of blade, swept area of each turbine and rotational speed vary considerably across designs. For the purposes of this analysis, the spatial scale is based on a single device and not arrays of multiple devices.

Wave energy devices capture energy found near the surface through the horizontal and/or vertical movement of waves and convert this into useable energy. In general, devices operate at or just below the water surface and are anchored to the ocean floor (EIA 2020). A variety of technologies exist to harness this energy source including surface buoys, surface following structures, oscillating water column devices, terminators, and overtopping structures (Clean Energy BC 2022).

Tidal and wave turbine technologies also require cables to transmit power to shore, which would affect the overall footprint of the project. For further details on these activities, see Installation of pipelines and cables (section 3.5.1) and Pipelines and cables (section 3.5.2)

Table 30. Compatibility scores for in-water turbines (tidal and wave)

	Score	Rationale
Spatial scale	1	Tidal and wave turbines are < 50 m
Time scale	3	Tidal and wave turbines are typically semi-permanent > 365 days
Vertical scale	3	Occurs at the seafloor and extends up into the water column, or extends from the surface throughout the water column to the seafloor
Mobility	stationary	Tidal and wave turbines are stationary devices

3.4.3 Offshore wind farms

Currently, no offshore wind farms exist in Canada but this technology may be developed in the future in the Scotian Shelf and Bay of Fundy planning area. Offshore wind turbines can be separated into fixed-base and floating structures. The majority of offshore wind turbine technologies use three-bladed turbines with variations on foundation designs (Table 31). The installation process for offshore turbines varies between projects due to the complexity of variables involved (Jiang 2021). Vessels are also employed to transit turbine segments and support installation (see sections 3.1.1 Vessel traffic routes and 3.1.2 Other vessel transit areas). Floating wind turbines are moored or anchored to the seabed (Jiang 2021). The three common types of fixed-base turbine technologies include monopile foundations, gravity-based foundations, and jacket foundations, each with various depth restrictions and seabed composition requirements (Jiang 2021).

The first demonstration offshore wind project in the United States was the Block Island Wind Farm, which consisted of five 6 MW turbines each spaced 830 metres apart (Carey et al. 2020). Individual turbines range in height, and offshore wind farms with multiple turbines extend over multiple square kilometres. Federal legislation for offshore wind does not currently exist in Canada, however, regulations are in development that may include safety zones around turbines (NRCan 2022).

Offshore wind farms require power cables to transmit power to shore, which would affect the overall footprint of the project. For further details on these activities, see Installation of pipelines and cables (section 3.5.1) and Pipelines and cables (section 3.5.2).

Table 31. Compatibility scores for offshore wind farms

	Score	Rationale
Spatial scale	3	Offshore wind farms are > 1 km^2
Time scale	3	Offshore wind farms are typically semi-permanent (> 365 days)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Offshore wind is a stationary activity

3.4.4 Oil and gas exploratory drilling

Oil and natural gas operations involve four stages – exploration, development, production, and decommissioning (CAPP 2021). In the exploration stage, oil and gas resources are located through seismic surveys (see section 3.4.6 Seismic surveys) and exploratory drilling (CAPP 2021). The maximum term for an exploratory license from the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) is nine years (CNSOPB 2024).

Currently, no exploration activity is underway in the province of Nova Scotia, and all offshore exploration licenses expired in 2022 (CNSOPB 2022). The most recent exploration project in the Scotian-Shelf Bay of Fundy planning area was Scotian Basin Exploration Drilling Project. Exploratory wells drilled for this project were expected to take ~120 days (CEAA 2018). The footprint of exploratory drilling can be significantly smaller than development operations, with single wellheads having a benthic footprint of 1 m^2 (DFO 2019). A safety zone of 500 m from the outer edge of an installation is required, which excludes other marine activities (*Canada Oil and Gas Drilling and Production Regulations* 2009). For the purposes of this analysis, both the wellhead and the safety zone were considered for scoring (Table 32).

Table 32. Compatibility scores for oil/gas exploratory drilling

	Score	Rationale
Spatial scale	2	Exploratory drilling and safety zone are > 0.0025 km^2 and < 1 km^2
Time scale	2	Exploratory drilling operates > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Oil and gas drilling is a stationary activity

3.4.5 Oil and gas drilling (production)

Offshore drilling rigs are large steel or concrete structures used for extraction of oil or gas (Sadeghi 2007; Table 33). Three types of production facilities had been common in Atlantic Canada: gravity-based structures, floating vessels connected to wells, and anchored structures with legs (CAPP 2021).

Offshore structures are generally built at fabrication yards and then transported to the assembly site via vessels. The installation process depends on the type of platform used. Fixed platforms are physically attached to the seafloor via piles that are driven into the seabed (Sadeghi 2008). Impact pile driving creates high sound levels in surrounding marine environments and is likely to impact marine mammals up to many kilometres from the construction site (Tougaard et al. 2009; Brandt et al. 2011; Dahl et al. 2014).

Two natural gas projects in Nova Scotia finished production in 2018 and have been decommissioned: the Sable Offshore Energy Project and Deep Panuke. As with exploratory drilling, 500 m safety zones extend from the outer edge of installations which excludes other marine activities (*Canada Oil and Gas Drilling and Production Regulations* 2009). CNSOPB production licenses are valid for 25 years (CNSOPB 2024).

There are numerous support vessels associated with oil and gas production, but they are considered under ‘Other vessel transit areas’ (section 3.1.2).

Table 33. Compatibility scores for oil/gas drilling (production)

	Score	Rationale
Spatial scale	2	Oil/gas drilling rigs and safety zone are > 0.0025 km^2 and < 1 km^2
Time scale	3	Rigs are typically semi-permanent (> 365 days)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Oil and gas drilling is a stationary activity

3.4.6 Seismic surveys

Seismic surveys are used to collect information on subsurface geological structures, for both research purposes and to locate formations which may contain hydrocarbons (DFO 2016). Marine surveys are conducted by vessels towing one or more air source arrays, which focus sound energy pulses composed of compressed air towards the seafloor (Table 34). Streamers containing instruments to record reflected acoustic energy pulses are also towed behind the vessel. Surveys can be classified as either 2D or 3D; in 2D surveys a single air source array and streamer are used, and in 3D surveys multiple sets or arrays and streamers may be used (DFO 2016). Streamers can be several kilometers in length (IAGC 2002), and seismic surveys typically have durations of several weeks to several months (Stantec Consulting Ltd. 2020; Aker et al. 2014).

Table 34. Compatibility scores for seismic surveys

	Score	Rationale
Spatial scale	3	Length of vessels and arrays are > 1 km
Time scale	2	Seismic surveys operate > 1 day and < 365 days
Vertical scale	1	Occurs at the surface
Mobility	mobile	Seismic surveys are mobile

3.5 Infrastructure/Construction

3.5.1 Installation of pipelines and cables

The installation of cables and pipelines requires the use of specialized vessels, which have restricted maneuverability and mobility during laying operations (Table 35). If cables are buried, this is done using a cable ship which uses a plough to cut a furrow into the seafloor (UN 2016a). This plough rests on skids, and the total disturbed area is typically between 2-8 m although the furrow itself is typically 30 cm in width for fibre-optic cable and larger for power cables. Fibre-optic cables are expected to have a lifespan of 20-25 years before decommissioning. Replacing cables involves using a grapnel or remotely operated vehicle to bring the surface laid cable to the surface and reburying the cable following repair. Decommissioned buried cables are not removed from the seabed (UN 2016a).

Pipeline sites are first surveyed using acoustic seabed mapping technology and underwater cameras to identify geological features, obstacles and suitable sites (UN 2016b). Pipelines are either built onshore and then towed by ship to their final location, or laid along the pipeline route by a pipe-laying vessel (UN 2016b).

During the construction of cables and pipelines, mariners are required to maintain a distance of one nautical mile from ships laying cable and pipelines (Burnett and Carter 2017; Rule 18, *Collision Regulations* 2008)

Table 35. Compatibility scores for installation of pipelines and cables

	Score	Rationale
Spatial scale	3	Installation of pipelines and cables and safety zones are > 1 km^2
Time scale	2	Pipeline and cable installation occurs for > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	The installation of pipelines and cables is mobile

3.5.2 Pipelines and cables

Submarine cables transmit the vast majority of intercontinental and international internet traffic (UN 2016a). Submarine fibre-optic cables in the abyssal plain are about 17-20 mm in diameter and are larger in the continental shelf regions (28-50 mm) due to armouring to protect against impacts or abrasions from other marine activities (Carter et al. 2009; UN 2016a). These cables are normally buried in the seabed if the total depth is less than 1,500 m, if burial is possible due to the existing substrate. At greater depths, cables may be left unburied (Carter et al. 2009; UN 2016a). Submarine power cables are larger in diameter than fibre-optic cables and provide linkages between power stations or between different countries (UN 2016a).

Submarine pipelines can be used to transport gas, oil, and water (UN 2016a). Intra-field pipelines transport oil or gas from a well-head to an operating field, for the purpose of collection, processing, and transport (Table 36). Export pipelines transport oil or gas to land (UN 2016a).

Table 36. Compatibility scores for pipelines and cables

	Score	Rationale
Spatial scale	3	Pipelines and cables are > 1 km
Time scale	3	Pipelines and cables are typically permanent (>365 days)
Vertical scale	2	Pipelines and cables occur on the seafloor
Mobility	stationary	Pipelines and cables are stationary

3.5.3 Disposal at sea

Disposal of substances at sea (Table 37) is regulated through the *Canadian Environmental Protection Act* (CEPA; 1999) and is prohibited in Canadian waters unless a permit is issued by the Environment and Climate Change Canada (ECCC) Disposal at Sea Program (ECCC 2017). Only products listed under schedule 5 of CEPA are eligible for disposal at sea, such as dredged material, fish waste, or ships purposefully sunken at sea, with the majority (90%) of material composed of dredged sediment (ECCC 2017). Vessels used for disposal at sea could include side or pipe rock-dumping vessels or dredging vessels.

Table 37. Compatibility scores for disposal at sea

	Score	Rationale
Spatial scale	2	Lengths of disposal vessels are > 50 m and < 1 km
Time scale	2	Disposal at sea occurs > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	Disposal at sea is mobile

3.5.4 Disposal sites and shipwrecks

ECCC tracks active and inactive dump sites and sites that may be available for additional use (ECCC 2020; Table 38). Disposal site sizes are variable and can exceed 1km in length (ECCC 2020). Further, sites may vary by the inclusion of deleterious and non-deleterious substances, effecting the sites safety. The Scotian Shelf and Bay of Fundy planning area contains many shipwrecks, including 350 wrecks off the coast of Sable Island (Landry and Turner 2015).

Table 38. Compatibility scores for disposal sites and shipwrecks

	Score	Rationale
Spatial scale	3	Disposal sites and shipwrecks are > 1 km^2
Time scale	3	Disposal sites and shipwrecks are typically permanent (> 365 days)
Vertical scale	2	Disposal sites and shipwrecks occur on the seafloor
Mobility	stationary	Disposal sites are stationary

3.5.5 Dredging

Dredging is the physical removal of materials, such as silt, bottom sediment, plants, and debris from the bottom of a water body, generally with the purpose of deepening or maintaining navigation channels, anchorages, or berthing areas (DFO 2020b; NOAA 2024.). Removal of accumulated sediment can be accomplished via clamshell buckets, draglines, backhoes, or suction dredges (DFO 2020b). Routine maintenance dredging generally occurs at least once every 10 years (DFO 2020b).

Dredging equipment generally falls into two categories: mechanical and hydraulic. They use different technology and occur at varying temporal and spatial scales; therefore dredging methods were scored separately for this analysis.

3.5.5.1 Mechanical dredging

Mechanical dredging is the removal of benthic sediments using methods such as clamshell dredgers, backhoe dredgers or bucket ladder dredgers, etc. (IADC 2020; Table 39). Sediments are excavated by dredging vessels and transferred to supporting barges for handling and disposal of material (Government of Canada 2016). Support and dredging vessels can vary in size, exceeding 70 meters in length (IADC 2014a). Mechanical dredging is best suited for the removal of coarse sediments in shallow waters (Government of Canada 2016; IADC 2020).

Table 39. Compatibility scores for mechanical dredging

	Score	Rationale
Spatial scale	2	Mechanical dredging is > 0.0025 km^2 and < 1 km^2
Time scale	2	Mechanical dredging operates > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	Mechanical dredging is a mobile activity

3.5.5.2 Hydraulic dredging

Hydraulic dredging is the removal of sediments through methods that use a hydraulic centrifugal pump which creates a liquid slurry of benthic material for transport (Government of Canada 2016; IADC 2020). Common hydraulic dredgers include the plain suction dredgers, trailing suction hopper dredges, and the dustpan dredgers which can exceed 200 m in length (IADC 2014b). Hydraulic dredging is optimal for the removal of fine sediments from depths up to 20 m, and can transport sediment through pipes several kilometres from the source (Government of Canada 2016). Scoring was based on the vessel and gear, including pipes for sediment transport. Hydraulic dredging operations can occur over several months and a single dredge cycle can take up to 12 hours (CBCL Limited 2012).

Table 40. Compatibility scores for hydraulic dredging

	Score	Rationale
Spatial scale	3	Hydraulic dredging is >1 km^2
Time scale	2	Hydraulic dredging operates > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	Hydraulic dredging is a mobile activity

3.5.6 Moorings

A mooring is a fixed location where vessels, platforms or scientific instruments are anchored or fixed to the seafloor (Table 41). Block and chain swing moorings include a surface float attached to a chain, which is fixed to an anchor such as a concrete block (Morrisey et al. 2018). Other mooring systems such as those for floating tidal energy platforms can involve anchors secured to the seabed using specialized equipment (Nova Scotia Department of Energy and Mines 2019). Instrumented moorings allow for multiple configurations of instruments or sensors to float at the surface or within the water column, attached to anchored buoys (Bailey et al. 2019). These instruments can record physical oceanographic information such as temperature or salinity, meteorological information, wave data, and ecological information including water quality (Bailey et al. 2019).

Table 41. Compatibility scores for moorings

	Score	Rationale
Spatial scale	1	Moorings are < $0.0025km^2$
Time scale	3	Moorings are typically permanent (> 365 days)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	stationary	Moorings are stationary

3.6 Tourism & Recreation

3.6.1 Recreational boating

Recreational boating includes any boat activity that does not fall into other listed activities (Table 42). Transport Canada defines vessels used for pleasure, recreation or daily living as pleasure craft, and vessels used for any other purpose as non-pleasure vessels (Transport Canada 2018). Pleasure craft include small human-powered boats such as canoes, kayaks, sailboats, and rowboats (Transport Canada 2019).

Table 42. Compatibility scores for recreational boating

	Score	Rationale
Spatial scale	1	Recreational boats are < 50 m
Time scale	1	Recreational boating is a short-term activity (< 1 day)
Vertical scale	1	Occurs at the surface
Mobility	mobile	Recreational boating is a mobile activity

3.6.2 Marine wildlife observation

Marine wildlife observation involves the use of tourism or research vessels to view cetaceans, other marine mammals, and seabirds. Whale-watching vessels have been used in the Scotian Shelf and Bay of Fundy planning area to conduct cetacean research, which can include data collection methods such as acoustic recordings and photo identification (Augusto et al. 2016; Zwamborn and Whitehead 2016). Data collected from vessels can be used to monitor behaviour and spatiotemporal distributions of both cetaceans (McComb-Turbitt et al. 2021) and seabirds (Williams et al. 2009). See Recreational boating (section 3.6.1) for scoring.

3.6.3 Diving

Diving includes freediving, Scuba diving, and the use of vessels to support diving operations (Table 43). Scuba diving is popular in the Scotian Shelf and Bay of Fundy planning area and may include divers visiting one of many shipwrecks on the seafloor (Heinerth 2020). Scuba diving can also be used to conduct research activities including surveying and sampling (Feehan et al. 2012).

Table 43. Compatibility scores for diving

	Score	Rationale
Spatial scale	1	Diving is < 50 m
Time scale	1	Diving is a short-term activity (< 1 day)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	Diving is a mobile activity

3.7 Research Activities

3.7.1 Water sampling

Water sampling is the process of taking a portion of water for analysis or other testing (Table 44). For example, ocean water may be taken back to a lab onshore or on a research vessel to check for pollutants, determine its chemical or biological composition, etc. A variety of equipment can be used for water sampling, ranging from simple buckets to sophisticated equipment. DFO's Atlantic Zone Monitoring Program (AZMP) uses manually deployed Niskin-type bottles on a hydrowire, and rosette-mounted sampling bottles (Mitchell et al. 2002).

Table 44. Compatibility scores for water sampling

	Score	Rationale
Spatial scale	1	Water sampling equipment and vessel are < 50 m
Time scale	1	Water sampling is a short-term activity (< 1 day)
Vertical scale	1	Extends from the surface through the water column, but does not touch seafloor
Mobility	mobile	Water sampling is a mobile activity

3.7.2 Sediment sampling

Sediment sampling may be carried out for chemical, physical, toxicological and biological analysis (Table 45). Different sampling methods include cores, dredges, and grab samples. Grab samplers have a set of jaws that close around sediments on the seafloor or a bucket that rotates into the sediment. A sediment core is a cylindrical section taken from sediments underneath a water body using coring equipment like a pressure core barrel (He et al. 2020). Dredge samplers are similar to but usually smaller than dredges used in the dredging of harbours and shipping channels (Neill and Hashemi 2018; see section 3.2.1.3 Dredge).

Table 45. Compatibility scores for sediment sampling

	Score	Rationale
Spatial scale	1	Sediment sampling equipment and vessel are < 50 m
Time scale	1	Sediment sampling is a short-term activity (< 1 day)
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	Sediment sampling is a mobile activity

3.7.3 Remotely Operated Vehicles

Remotely Operated Vehicles (ROVs) are unmanned submersibles that are operated from the surface. They can be used to observe and sample the marine environment (Table 46). The Remotely Operated Platform for Ocean Sciences (ROPOS) is an ROV that is often used in the Scotian Shelf and Bay of Fundy planning area. ROPOS can be equipped with a variety of cameras, manipulators, and tools (e.g., chainsaws, pumps, etc.) to carry out scientific missions (Canadian Scientific Submersible Facility 2020). ROPOS can dive to depths of 5,000 m and is able to remain underwater for > 99 hours (NOAA 2020).

Table 46. Compatibility scores for Remotely Operated Vehicles

	Score	Rationale
Spatial scale	3	ROVs are > 1 km
Time scale	2	ROVs operate > 1 day and < 365 days
Vertical scale	3	Extends from the surface throughout the water column to the seafloor
Mobility	mobile	ROVs are mobile

3.7.4 Multibeam surveys

Multibeam surveys use sonar to construct detailed images of the seafloor (Table 47). Multibeam systems (echosounders) work by ensonifying (filling with sound) part of the seafloor below the survey ship and then detecting the echoes that return from the bottom (Pickrill and Todd 2003). The returned echo is resolved into multiple beams, hence "multibeam" (Parrott et al. 2008). Multibeam systems can also provide backscatter data (a measure of the peak or average backscattered intensity), which can be used to estimate the type of sediment on the seafloor. Multibeam systems can be mounted on various-sized vessels and launches.

Table 47. Compatibility scores for multibeam surveys

	Score	Rationale
Spatial scale	2	Vessels for multibeam surveys are > 50 m and < 1 km
Time scale	2	Multibeam surveys operate > 1 day and < 365 days
Vertical scale	1	Occurs on the surface
Mobility	mobile	Multibeam surveys are mobile

4.0 RESULTS

The results of the conflict scoring exercise, where the rules from section 2.0 were applied for each activity pairing, are shown in Figure 2. Low scores (0–2) indicate that activities are likely compatible, whereas high scores (5–6) indicate that the activities may not be compatible and there may be a potential spatial or temporal conflict. These scores do not take into account any mitigation or management measures in place or the assessment of risks. Caveats associated with these results are discussed below.

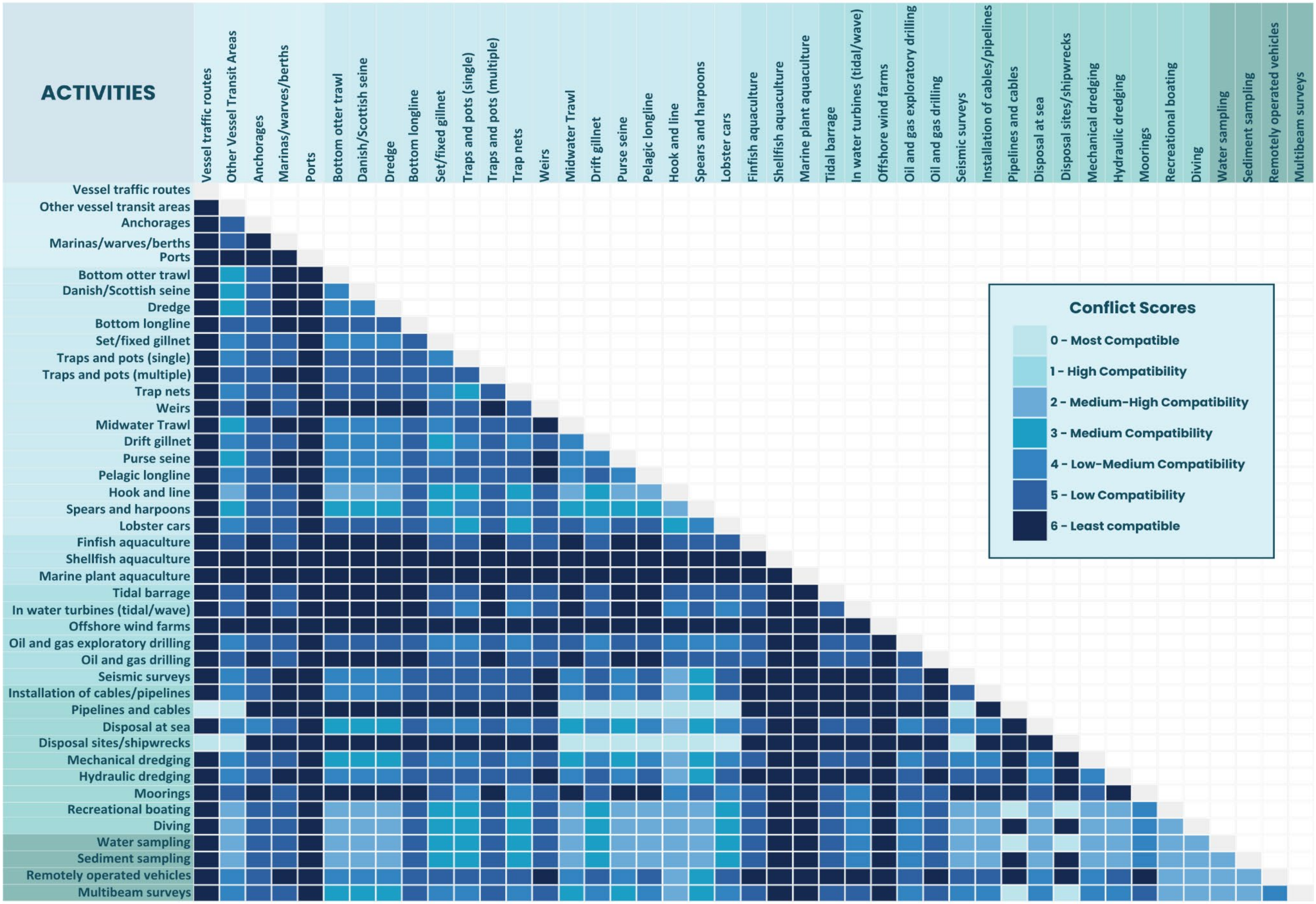

Figure 2. Matrix of conflict scores between activity pairings.

Stationary activities and structures (e.g., wharves, oil and gas drilling, offshore wind farms, etc.) tended to have higher conflict scores with other activities (i.e., lower compatibility), as there was less potential for activities to take place within the same area. In addition, activities that occurred through the whole water column (such as bottom trawl fisheries, finfish aquaculture, dredging, etc.) had higher conflict scores with other activities. Short-term mobile activities that tended to be more compatible were those that occurred only at the surface or the bottom (such as pelagic fisheries, vessel transits, and water sampling, etc.), as well as activities with small spatial footprints (e.g., recreational boating, diving, etc.).

5.0 DISCUSSION

Marine spatial planning aims to reduce conflict using proactive planning and decision-support tools to inform decision making. Results from the OUCA could be used to identify potential compatibility issues across ocean activities. This analysis could inform sector-based planning by highlighting where potential conflicts may occur with existing or future activities, and where mitigation measures may be needed. Further, if spatial zoning is considered in the Scotian Shelf and Bay of Fundy planning area in the future, the first step in that process would be to determine which human activities are more likely able to occur together in the same space and time, and which are less likely. A potential next step for this analysis could be to combine the results with spatial data from the Scotian Shelf and Bay of Fundy planning area to create maps of potential conflicts between uses, as demonstrated by ADRIPLAN (Stelzenmüller et al. 2013; Barbanti et al. 2015a).

There are several caveats associated with this analysis. Scores were assigned based on published information available for each activity. These values reflect general knowledge of activities rather than specific projects, which may vary in spatial and temporal scale and may have different spatial and/ or temporal scores than listed in OUCA. Where variation was found in the size of activities, the largest size was used to generate the score to provide a conservative estimate of spatial extent.

The results of this analysis do not consider any management or mitigation measures that could be used to increase compatibility between ocean activities. In reality, mitigation or management measures are likely to be considered on a case-by-case basis. Activities scored here as incompatible may be compatible with appropriate measures. For example, diving and shipwrecks are scored as higher conflict as they overlap spatially, but are often compatible within the planning area with appropriate safety precautions (East Coast Scuba 2017). Additionally although some activities were scored by phase, it is possible that certain stages of an activity may alter compatibility with other uses. For example, in the United States some activities may not be allowed in close proximity to offshore wind farms during the construction phase due to safety zones, but may be allowed during the operations phase (United States Government 2023). Mitigation measures could also be explored further in future research, but would require details about specific activities as mitigation is typically assessed on a case by case basis.

The OUCA provides baseline information to characterize ocean activities in a standardized way, to allow for comparability between activities. Compatibility and coexistence between these activities could be assessed in future research based on the activity descriptions and scores developed. The results of this analysis do not replace existing decision-making processes or sector based management. The OUCA is a decision-support tool and is meant to supplement existing processes, rather than replace them. This DST demonstrates how MSP can be used to develop tools and data products which are transparent and reproducible, to support integrated management and sustainable use of ocean spaces.

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