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**Maritimes Region**

# Maritimes Regional Application of the National Framework for Assessing the Vulnerability of Biological Components to Ship-Source Oil Spills in the Marine Environment

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Canada

**Foreword**

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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# 1. ABSTRACT

An important contribution to fulfilling Fisheries and Oceans Canada (DFO) commitment in oil–spill response planning was the development of a framework for the rapid assessment of vulnerability of marine biological components to ship-source oil spills that fall under the DFO mandate, contributing to the ecological aspects of the ‘Resources at Risk’ component of oil spill planning and response. A National framework, developed in 2017 (Thornborough et al. 2017) – uses a structured approach for assessing and screening biological components expected to be most affected by a ship-source oil spill, utilizing a suite of criteria to assess vulnerability.

The framework identified two key phases for assessing vulnerabilities of marine components:

1. Grouping of biological components (sub-groups) based upon shared characteristics related to oil vulnerability; and
2. Scoring of biological sub-groups against ecological vulnerability criteria (Exposure, Sensitivity, and Recovery) to identify those most vulnerable to oil using a binary scoring system.

For validation purposes, the National framework stressed the need to apply and test the framework in a variety of marine aquatic environments across Canada. This research document describes how the National framework was used in the Maritimes Region, to:

1. Adapt the National framework to create appropriate sub-groups for Maritimes Region biota;
2. Apply the National scoring criteria to Maritimes Region sub-groups, adapting scoring criteria where necessary; and
3. Develop a rank list of sub-groups most vulnerable to a ship-source oil spill in the Maritimes Region.

The vulnerability results from the application of the National framework in the Maritimes Region will help identify marine sub-groups that are most vulnerable to oil and will be used to inform oil spill response strategies in an effort to manage and limit the impacts of oil spills in the Region.

# 2. INTRODUCTION

## 2.1. OIL FATE AND BEHAVIOUR IN THE MARINE ENVIRONMENT

Oil is composed of organic hydrocarbons and inorganic molecules that arise from the anaerobic breakdown of biological material. While all petroleum products have related chemical compositions, they vary according to the molecular weight of the hydrocarbons they contain. Light refined products (e.g., gasoline) contain a larger proportion of low molecular weight hydrocarbons in comparison to heavy oils, such as crude, which are primarily made up of high molecular weight hydrocarbons. Molecular weight differences influence the particular properties and characteristics of the petroleum product (e.g., density, viscosity, and flash point), as well as the fate and behaviour of the product when released into the aquatic environment (Wang and Fingas 2003). In general, lighter hydrocarbons are more volatile, have higher solubility in water and vaporize faster than their heavier counterparts.

Oil spills can be disastrous to the marine environment. The severity of impacts of oil spills depend on a number of factors: the chemical properties of the oil product spilled, environmental parameters of the spill area, spill size and time of year, mitigation measures used, among others (Fingas 2011).

In the event of a spill, light oils will evaporated more quickly than heavy oils. In fact, up to 75% of light oil mass can be lost to the evaporative process compared to only 10% for heavier oils (Fingas 1999). However, evaporation of the lighter oils will result in an increased proportion of heavier oils in the slick, which can persist in the marine environment.

Once an oil product is spilled at sea, a complex series of factors such as oil weathering rate, spill location, hydrodynamic conditions, spill site geography, substrate type, dispersion, and dilution rate will determine the nature and complexity of the spill and its effects on the marine biota living in the intertidal and subtidal marine environments.

## 2.2. OIL TOXICITY AND EFFECTS ON MARINE FLORA AND FAUNA

Toxicity has been defined as negative effects (lethal and/or sub lethal) on organisms caused by exposure (acute or chronic) to a chemical or substance. The toxicity and effects of petroleum products on marine species is a complex issue, given the sheer number of petroleum products, changing environmental conditions impacting the bioavailability of oil, the differences in life history strategies between species, and more.

Impacts to marine species from exposure to oil products in the environment can be broadly categorized into physical/mechanical and chemical toxicological impacts.

Physical/mechanical impacts can generally occur when an organism, exposed to a petroleum product, exhibits a physical impairment such as a reduction in feeding caused by the obstruction of feeding structures (baleen, gill rakers, etc.), reduction in photosynthesis through physical coating of plants, or the loss of thermoregulation capacity resulting from coating of fur in oil.

Chemical toxicological impacts to marine species can be further categorized into lethal and sub-lethal impacts from either acute or chronic exposure. Common approaches for measure acute lethal toxicity in laboratory settings include the determination of an LC50 (concentration at which 50% of the test population exhibits mortality). When considering sub-lethal impacts, there are a variety of endpoints that can be examined including behavioral changes, embryo toxicity and early stage developmental abnormalities, individual effects (deformities, heart-related impacts), endocrine disruption effects on reproductive physiology, growth rate depression, metabolic function, genotoxicity and more (Dupuis and Ucan-Marin 2015).

When considering marine organisms in a broad sense, laboratory studies and field observations have generally shown that lethal and sub-lethal impacts can occur following exposure to petroleum products, whether by physical or chemical sensitivity. However, it should be noted that the Environment and Climate Change Canada (ECCC) Crude Oil and Petroleum Product Database (ECCC 2021) lists 351 different crude and refined petroleum products. With the sheer number of oil products, their associated weathering patterns in a dynamic environment, the number marine species in the region, work on biological effects of petroleum product exposure is far from conclusive, requiring additional consideration.

While a great deal of research and a number of comprehensive literature reviews (e.g., O'Brien and Dixon 1976, Dupuis and Ucan-Marin 2015) have been conducted on the impacts of oil spills on marine biota, studies are not equal across taxa. Furthermore, within taxa research results are often not comparable due to differences in oil type tested, dose administered, exposure length and endpoints used in the studies. A lack of pre-spill baseline data, sampling method differences and the fact that impacts of oil may take years to be fully realized in organisms, further complicate definitive conclusions.

For this application, it is assumed that all organisms will experience some degree of impairment or toxic effect when exposed to an oil spill. The framework was used to determine the 'degree' to which inherent ecological and biological traits predispose some groups to be more vulnerable to oil than others.

## 2.3. MARITIMES REGION AND OIL

The DFO Maritimes Region (Figure 1) is home to a shoreline that is approximately 10,000 km long. The shoreline contains a variety of sediment types, from consolidated (e.g., bedrock, boulder, cobble beaches) to unconsolidated substrates such as sand beaches and muddy tidal flats (ECCC 2015). The region is also home to several major shipping ports and oil handling facilities, and experiences high-levels of marine vessel traffic.

### 2.3.1. Oil Transport and Handling in the Maritimes

The Maritimes Region features two of the main petroleum shipping ports in Eastern Canada – Saint John, New Brunswick in the Bay of Fundy, and Port Hawkesbury–Canso Strait, Nova Scotia (Figure 1).

Tankers of 200,000 deadweight tonnage and larger transit the lower Bay of Fundy bringing crude oil from various foreign sources into the Port of Saint John, New Brunswick (Figure 1), one of the busiest Canadian ports for oil tanker traffic. The Saint John Port Authority has noted that 12,382,874 metric tons (MT) of crude oil, 11,770,564 MT of petroleum, 656,556 MT of refined petroleum products, and 239,640 MT of natural gas passed through the port in 2016 (Somerville 2017 as cited in Ryan et al. 2019). With respect to the volume of oil products being transported through the Port of Saint John, it is considered to have the highest risk of an oil spill of any port in Canada (SL Ross Environmental Research 1999). Port Hawkesbury and Point Tupper are the main petroleum shipping centres for the Strait of Canso (Prouse 1994) (Figure 1).

In the Strait of Canso, the refinery at Point Tupper, NS became a terminal for supertankers in 1993, with facilities to store, blend, and transfer crude and refined oils to smaller vessels. With depths greater than 60 m, the Strait of Canso can accommodate vessels of up to 500,000 deadweight tonnes (DWT) and provides the deepest harbour on the North American east coast (Gardner Pinfold 2010). In addition to the two public harbours, Port Hawkesbury and Mulgrave, there are also five private terminals in the Strait (Invest Cape Breton 2018 as cited in Ryan et al. 2019). The whole area is known as the Strait of Canso Superport, and has handled over

30 million tonnes of cargo annually from 2005 to 2010 (Strait of Canso Superport 2018). Of the 31.6 million metric tonnes of cargo in 2006, 21.6 million tonnes were crude petroleum (Statistics Canada 2011). In 2009, two-thirds of all cargo in Nova Scotia was handled by Port Hawkesbury, although in 2010 tonnage decreased 10.5% to 26.3 million tonnes, largely as a result of a 12.1% decline in the tonnage of crude petroleum (Government of Nova Scotia 2010).

Port Hawkesbury handles both crude oil and refined products (Gardner Pinfold 2010). Increasing amounts of foreign oil are being trans-shipped to the northeastern United States, bringing in crude oil from Europe in tankers of 250,000 DWT (20 shipments from Norway in 1998) and transferring it to smaller tankers in the 80,000 DWT range, because many foreign tankers are too large to be accommodated by the U.S. ports (SL Ross Environmental Research 1999).

This trans-shipment activity has more than doubled since 1994, amounting to about 11 million tonnes in 1998, which is 14% of all oil moved by ocean vessel in Canada, representing a large spill risk (SL Ross Environmental Research 1999).

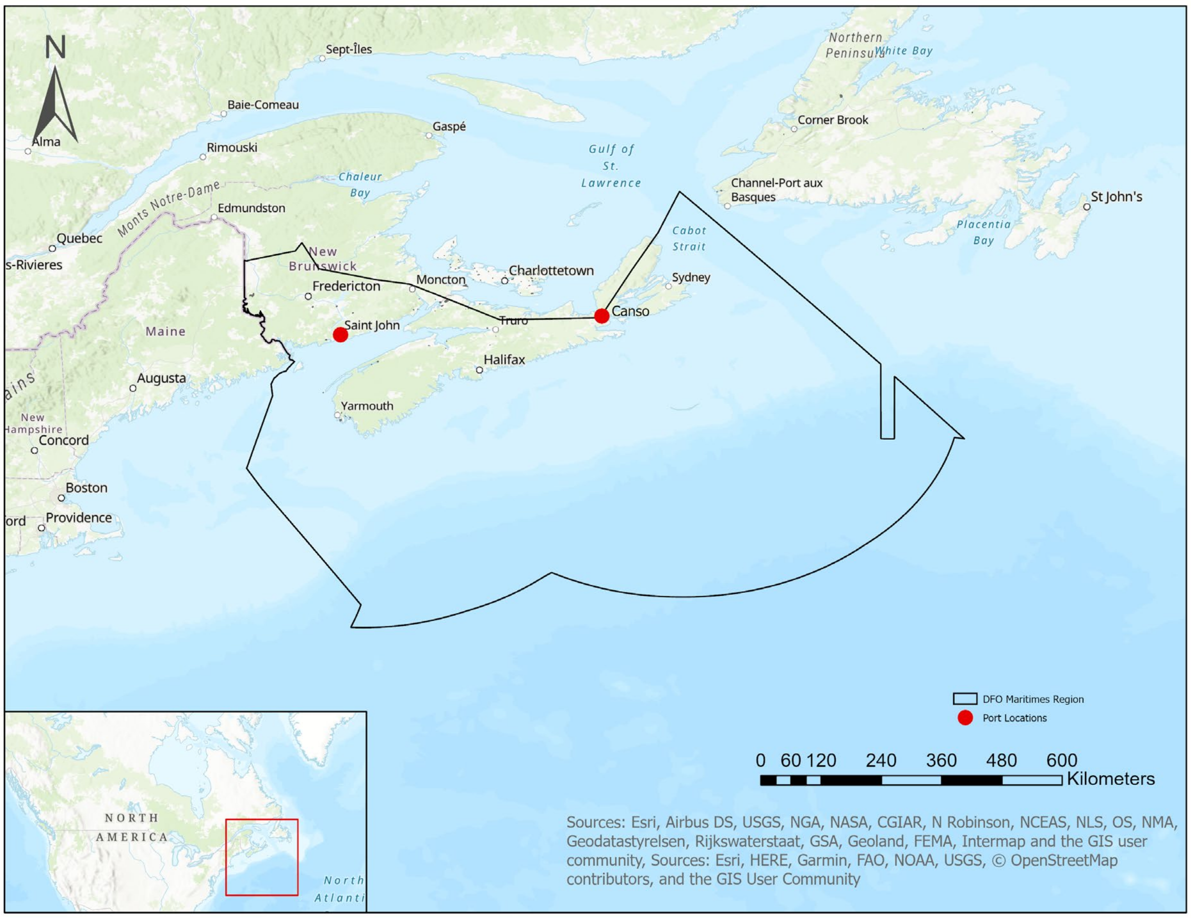


*Figure 1. DFO Maritimes Region administrative boundary. Port Saint John and the Strait of Canso Superport locations are shown in red.*

## 2.3.2. Past Oil Spills in the Maritimes Region

The largest oil spill in Canada occurred off the East Coast in 1970. The tanker *M/T Arrow* spilled over 10,000 tonnes of oil off Nova Scotia. This is about one quarter the amount spilled in US waters by the *Exxon Valdez* in 1989. About 2000 m$^3$ of Bunker C was spilled, covering 300 km of shoreline. Rakes, peat moss, and shovels were used on the shorelines, but despite efforts, less than 50 km were cleaned up and oil persisted for several years on the shores of Chedabucto Bay. Remaining oil in the tanker was transferred to the Irving Whale Barge (Ryan et al. 2019).

Thirty years after the spill, sediments and interstitial waters were collected from a sheltered lagoon in Black Duck Cove, an area that had been heavily oiled and left to recover naturally. Chemical analysis of the sediments confirmed that the remaining oil had undergone significant weathering, including photo-oxidation, abrasion by ice scour, dissolution, dispersion with mineral fines, evaporation of volatile components, and biodegradation. In the fall of 2015, 33,000 litres of oil and oily water were suctioned from the *Arrow* wreck by divers contracted by Canadian Coast Guard (Ryan et al. 2019).

Marine pollution incidents are generally reported to the Canadian Coast Guard and/or the Environment and Climate Change Canada (ECCC) National Environmental Emergencies Centre (NEEC) for assessment. While the Maritimes Region has not experienced a spill as large as the *M/T Arrow* since 1970, other marine incidents occur in the region every year. Many such incidents are small, with amounts ranging from 0.0001 L to 2 L, sometimes occurring via fueling mishaps (over-fueling a vessel, a small leak from a fueling hose, etc.). Some incident reports can be considered 'potential' pollution for a variety of reasons (e.g., vessel loses then regains steerage; vessel aground with no visible pollution), while others can range from grounding incidents to sunken vessels – involving a range of vessel types, from small pleasure crafts, fishing vessels, tanker and transports.

Data on past spills in the Maritimes Region is scarce, as a coordinated effort to digitize past pollution reports has only recently begun. The ECCC National Environmental Emergencies Operation Center (NEEOC) has been actively registering all spill data from across the country since mid-2018, and is in the process of engaging the environmental response community to further developing a consistent reporting method. Currently, the ECCC NEEOC data is organized at a provincial level and is not yet suited to querying by DFO administrative boundary.

Using previous pollution reports summarized by the Canadian Coast Guard, an average of 463 incidents have been reported annually between 2017 and 2020 in the Maritimes Region. Many of these incidents represent potential pollution, but a number of them are actual pollution events, highlighting the need for continued efforts in marine spill response in the region.

## 2.4. CANADIAN OIL SPILL RESPONSE REGIME

Since 1995, Canada's Ship-Source Oil Spill Preparedness and Response Regime has provided the framework for readiness to respond to ship-source oils spills in the Canadian marine environment. Since its implementation, there have been few major ship-source oil spills in Canadian waters. While the Regime has been effective in minimizing marine oil spills, there has been a steady increase in the volume of oil transported within Canadian waters, as well as the number and size of vessels transporting oil products (Ryan et al. 2019). As tanker traffic increases so does the risk of accidental oil spills. In 2013, recognizing the risks and increasing public concern around oil transport safety, as well as the growing awareness and progressive developments in oil spill preparedness and response internationally, the Government of Canada announced the creation of a Tanker Safety Expert Panel (TSEP) and a World-class Tanker Safety System (WCTSS) program.

Established with a goal to analyze and strengthen Canada's oil tanker safety and oil spill response preparedness, the TSEP released its initial report in November 2013, *A Review of Canada's Ship-Source Oil Spill Preparedness and Response Regime – Setting the Course for the Future* (Houston et al. 2013), which offers a comprehensive analysis of Canada's existing oil spill response systems south of 60°N latitude. The panel indicated that, in general, the foundational principals of the 1995 regime have stood the test of time, but also made several recommendations to improve preparedness and response to ship-source oil spills in Canada, to reflect a more modern and comprehensive response approach.

One of the recommendations from the TSEP was that, in lieu of a single overarching National response program, regional response plans should be developed based on addressing specific regional risks, taking into account distinct geographic and climate variables. Furthermore, the respective regional response plans should be indicative of differences in industrialization and environmental parameters, the most probable types of oil spills, and worst case impacts (Houston et al. 2013).

### 2.4.1. Area and Regional Response Planning

Following TSEP recommendations, in 2014, the Government of Canada stood-up the Area Response Planning (ARP) initiative, co-led by Transport Canada (TC) and the Canadian Coast Guard (CCG), in partnership with other Federal Departments, with the goal of furthering the development of specific oil-spill response plans in the following pilot areas:

- Saint John and the Bay of Fundy, New Brunswick (Maritimes Region)
- Port Hawkesbury–Canso Strait, Nova Scotia (Maritimes Region)
- St. Lawrence Seaway, Montreal to Anticosti, Québec (Quebec Region)
- Strait of Georgia and the Juan de Fuca Strait, British Columbia (Pacific Region)

In 2017 the ARP initiative expanded to become the Regional Response Planning initiative (RRP), which included greater collaboration with indigenous and coastal communities, and increased integration with existing planning processes in the existing ARP areas. In 2019, Planning for Integrated Environmental Response (PIER) began, expanding the scope in the Maritimes beyond the existing ARP/RRP areas to the whole of the Department of Fisheries and Oceans (DFO) Maritimes Region (Figure 1).

Under these initiatives, one of the directives of the Department of Fisheries and Oceans (DFO) Science Branch was to provide science based information to better understand the impacts of ship-sourced oil spills on marine biological components.

### 2.4.2. National Vulnerability Framework

An important contribution to fulfilling DFO’s commitment in oil-spill response planning was the development of a framework for the rapid assessment of vulnerability of marine biological components to ship-source oil spills that fall under the DFO mandate, and which contributes to the ecological aspects of the ‘Resources at Risk’ component of oil spill planning and response (Figure 2).

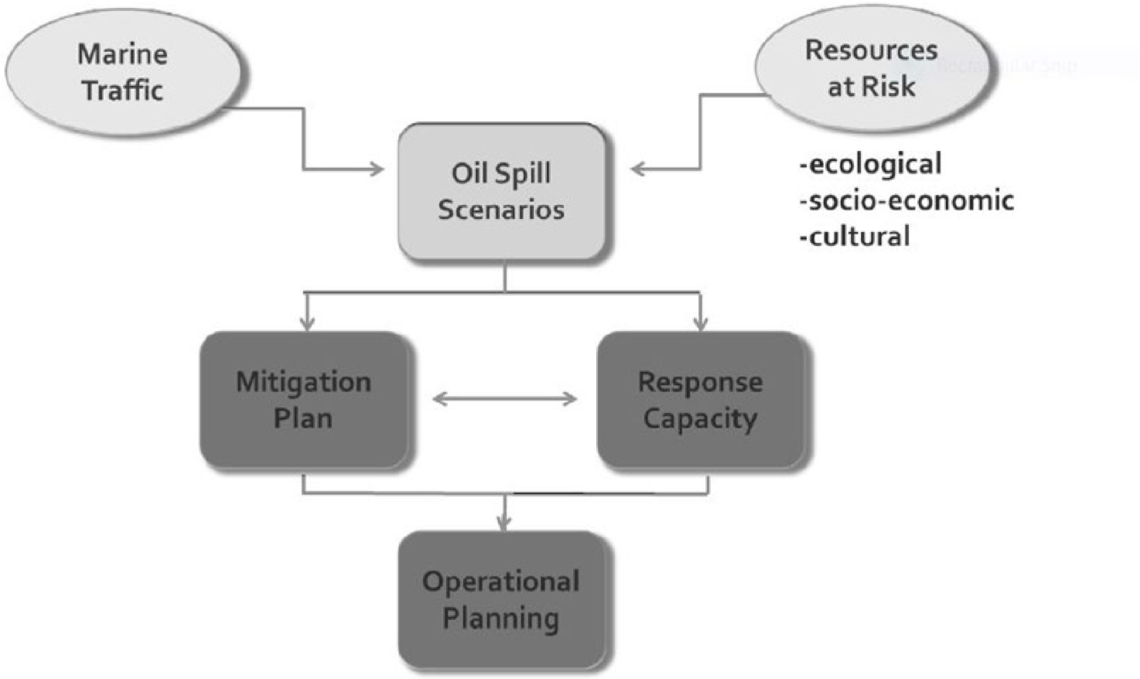


*Figure 2. Overview of how the vulnerability framework fits in with the overall model for oil spill planning and response ("ecological" Resources at Risk).*

The National framework, developed in 2017 – *A Framework to Assess Vulnerability of Biological Components to Ship-source Oil Spills in the Marine Environment* (Thornborough et al. 2017) – uses a structured approach for assessing and screening biological components expected to be most affected by a ship-source oil spill, utilizing a suite of criteria to assess vulnerability. While often used interchangeably with sensitivity, vulnerability is generally defined as the degree to which a system is susceptible to, and unable to cope with, injury, damage, or harm (De Lange et al. 2010). As such, sensitivity is a nested factor of vulnerability, where vulnerability is a function of: exposure to a stressor, sensitivity, and recovery potential.

Building on this approach, the National framework divided vulnerability into three categories: Exposure, Sensitivity and Recovery, each encompassing a number of criteria which were envisaged to be consistent yet broad enough to be applicable in a variety of aquatic environments (Thornborough et al. 2017). The authors intended that the framework should not be limited by data availability or heavily influenced by, or dependent on, expert opinion and be adaptable for application in any aquatic environment in Canada. Vulnerabilities, once determined, should be used by stakeholders when selecting appropriate response strategies to manage and limit the impact of oil spills.

For validation purposes, the National framework stressed the need to apply and test the framework in a variety of marine aquatic environments across Canada.

## 2.5. OBJECTIVES

This research document describes how the National framework was adapted, modified and applied in the Maritimes Region. The specific objectives of the Maritimes application are:

1. Adaptation of the National framework to create appropriate sub-groups for Maritimes Region biota;

2. Application of the National scoring criteria to Maritimes Region sub-groups, adapting scoring criteria where necessary; and
3. Development of a rank list of sub-groups most vulnerable to a ship-source oil spill in the Maritimes Region.

# 3. FRAMEWORK

## 3.1. SCOPE

The National framework (as outlined in Thornborough et al. 2017):

- Assesses vulnerability on acute effects from direct contact with oil and does not consider the effects of chronic exposure to spilled oil;
- Does not consider secondary impacts (higher level trophic dynamics), (e.g., the ingestion of contaminated food sources); or cumulative effects from multiple stressors;
- Focuses on generalized impacts from the initial stages of a ship-source oils spill and does not differentiate between oil types;
- Does not consider mitigation measures such as the use of chemical dispersants;
- Is focused on marine biological components that fall within DFO’s mandate; those at and below means high water springs, including plants, invertebrates, fish, mammals, and reptiles;
- Does not assess species based on socio-economic or cultural value; species with conservation status (i.e., listed under Species at Risk Act (SARA)) are captured within the assessment;
- Does not assess habitat directly. Habitat is included when associated with vulnerable biological components such as areas supporting high concentrations or aggregations of vulnerable species groups/sub-groups, and are assumed to be an underlying reason for aggregations or for seasonal movements;
- Assesses biogenic habitats (e.g., eelgrass beds, glass sponge reefs) on a species sub-group level (e.g., eelgrass, Porifera), rather than as separate habitats;
- Does not consider shoreline type due to the pre-existing shoreline classification system that ranks shoreline types by sensitivity to spilled oil (Howes et al.1994);
- Does not assess Ecologically and Biologically Significant Areas (EBSAs), Marine Protected Areas (MPAs), or other planning areas. These are considered as sources of supplementary information for oil spill planning and response purposes;
- Was developed for marine environments.

## 3.2. OVERVIEW

A flowchart developed for the National framework working process (as published in Thornborough et al. 2017), can be seen in Figure 3. The framework identified two key phases for assessing vulnerabilities of marine components:

1. Grouping of biological components (sub-groups) based upon shared characteristics related to oil vulnerability; and

2. Scoring of biological sub-groups against ecological vulnerability criteria (Exposure, Sensitivity, and Recovery) to identify those most vulnerable to oil using a binary scoring system.

The framework was developed to be:

1. Nationally consistent;
2. Regionally flexible;
3. Grounded in science;
4. Rapid and simple to implement;
5. Able to provide a concise list of biological components most vulnerable to oil.

The framework is considered rapid and easy to use based on the use of sub-groups and not individual species for scoring, as well as the use of a binary scoring system to score the sub-groups against three categories of vulnerability criteria; to generate a rank list of the vulnerability of biological components to oil in any region. The framework is meant to be grounded in science as scientific justification would be used to rationalize all scores given to sub-groups in each scoring category.

For validation purposes (and to test the regional flexibility of the National model), the National framework stressed the need to apply and test the framework in a variety of marine aquatic environments across Canada. This research document describes how the National framework was adapted, modified and applied to the Maritimes Region.

## 3.3. GROUPING BIOLOGICAL COMPONENTS

Determining vulnerabilities using the National framework is considered to be simple to implement and quick to use based on the premise that the use of species sub-groups eliminates the need to assemble lists of all available species for a geographic area at the study outset. In the National framework, sub-groupings were developed for five high-level biological groups: Marine Plants and Algae; Marine Invertebrates; Marine Fish; Marine Reptiles, and Marine Mammals. Sub-groups were organized using characteristics and shared biological and ecological traits among its members pertaining to their vulnerability to oil. Within these five broader groups, the framework proposed seventy-five sub-groups, and only the sub-groups identified as most vulnerable would be populated with species (i.e., after scoring).

### 3.3.1. General Modifications to the National Framework

The National vulnerability framework application is built on a top-down in approach, whereby all species groupings are assumed to be present in the application area regardless of data availability, with groupings populated with appropriate species only at the end of the process. In the National framework (Figure 3), only sub-groups identified as most vulnerable to oil are populated with species. However, the framework allows flexibility in the development of sub-groupings that account for regional differences.

In contrast, sub-group development was completed using a bottom up approach in the Maritimes Region, with the initial development of lists of verified regional species at the high-level biological groups (Marine Plants and Algae, Marine Invertebrates, Marine Fishes, Marine Mammals, and Marine Reptiles) (Figure 4).

In order for a species to be considered a “verified input” for sub-group consideration, its existence in the Maritimes Region was confirmed by a minimum of two sources (primary literature, DFO survey data, databases, museum holdings, field guides, textbooks and trusted web sources (e.g., Smithsonian collections; World Register of Marine Species, 'WoRMs'; Canadian Register of Marine Species, 'CaRMs')). This first verification step, while time consuming was considered necessary as a foundational building block to build the Maritimes sub-groups, increasing the confidence around sub-group inclusiveness and subsequent sub-group scoring and vulnerability rankings. Species lists, while not exhaustive, are considered to be inclusive of a high proportion of Maritimes species in each group, and highly representative of the differences in ecological and biological traits used in the development of sub-groups (species lists for each higher-level group can be seen in Appendix 6, Tables A16 to A20).

Information on the biological and ecological traits for each species was collected concurrently with species verification, and was used to develop regional sub-groups. Sub-group levels were structured with increasing levels of specificity and finer detail with regard to shared biological and ecological characteristics related to vulnerability to oil, enabling them to be distinguished from one another and to be effectively assessed by the scoring criteria.

Upon sub-group completion, all scoring and ranking was applied at the sub-group level, using the scoring criteria broadly outlined in the National framework. There were no screened out sub-groups during scoring Maritimes sub-groups against the Exposure and Sensitivity vulnerability criteria so the 'screened out sub-groups' component was dropped from the Maritimes application. A flowchart developed for the Maritimes Region application, illustrating modifications from the National model is detailed in Figure 4.

### 3.3.2. General Sub-grouping Modifications

- The base nomenclature for organizing the sub-groups within the high-level biological groups was changed from 'sub-group 1, 2, 3…' (e.g., Table 1) as presented in the National framework, to 'sub-group level 1,2,3…', (e.g., Table 2) to simplify the process and to avoid confusion, as scoring is done for only the last sub-groups created from the culmination of applying all previous levels (i.e., highest order distinction).
- In some cases, reorganization of sub-groups where deemed necessary to allow for clearer differentiation in scoring (e.g., Marine Fishes group).
- In some cases, additional levels added to further break down sub-groups. For example, location and habitat descriptors was included where needed to further differentiate sub-groups in the Marine Plants and Algae group.
- In a few instances, sub-groups were added to account for species that were not captured in the groupings outlined in the National model (e.g., lophophorates in Marine Invertebrates group).

The following sections illustrate the modifications made to the National framework for all 5 high-level biological groups. A total of 116 sub-groups were developed for the Maritimes Region application at the highest level of detail and distinction (i.e., final sub-groupings at level 3, 4 or 5 – depending on group).

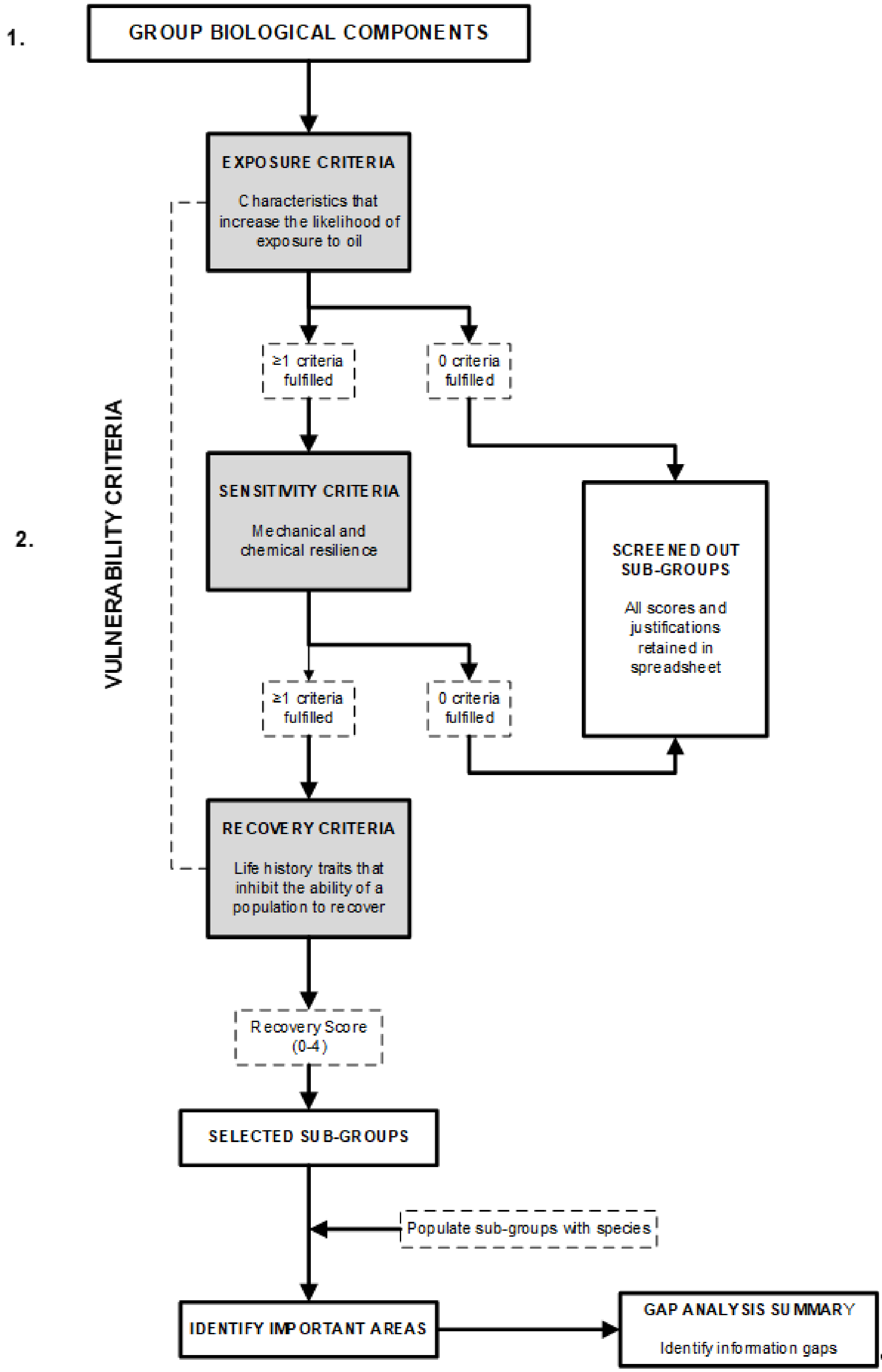


*Figure 3. Overview of National vulnerability framework process (Thornborough et al. 2017).*

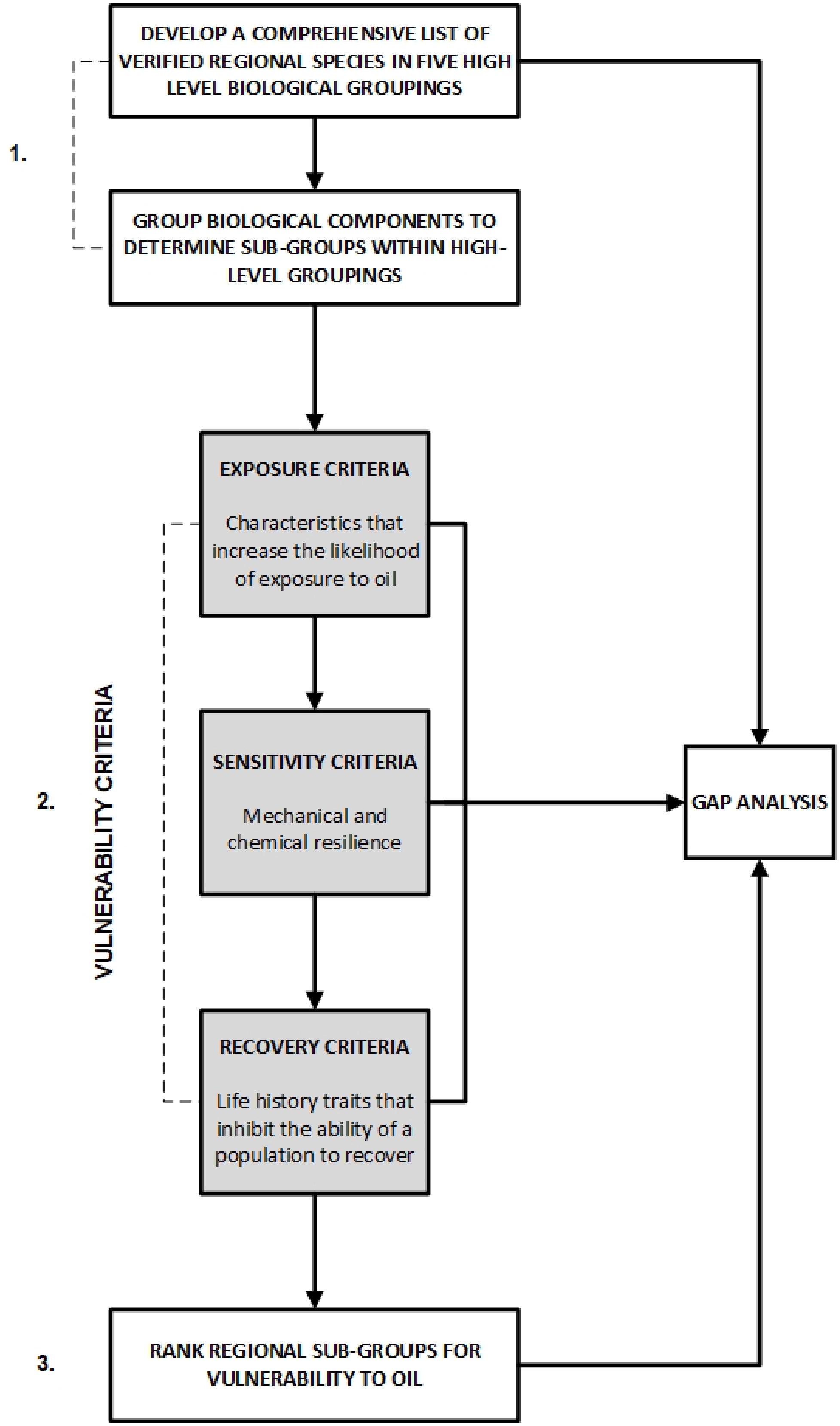


*Figure 4. Maritimes Region modification to the National framework process.*

### 3.3.2.1. Marine Plants and Algae Grouping

The National framework proposed 8 sub-groups in the marine plants and algae group (Table 1). Substantial changes were made to the sub-group levels within the marine plants and algae group for the Maritimes Region application.

*Table 1. Proposed National sub-group breakdown for marine plants and algae (N/A = not applicable).*

<table>
<tr><th colspan="3">Sub-group breakdown</th></tr>
<tr><th>Sub-group 1</th><th>Sub-group 2</th><th>Sub-group 3</th></tr>
<tr><td>Pelagic</td><td>N/A</td><td>Phytoplankton</td></tr>
<tr><td rowspan="7">Benthic</td><td rowspan="3">Vascular</td><td>Eelgrasses</td></tr>
<tr><td>Surf grasses</td></tr>
<tr><td>Saltmarsh grasses</td></tr>
<tr><td rowspan="4">Non-vascular</td><td>Canopy forming kelps</td></tr>
<tr><td>Understory</td></tr>
<tr><td>Turf</td></tr>
<tr><td>Encrusting</td></tr>
</table>

With modifications, an extra 6 sub-groups were added in the Maritimes application, creating a total of 14 sub-groups (Table 2).

The changes made were as follows:

**Sub-group level 1**: was modified from ‘pelagic’ and ‘benthic’ to ‘intertidal’, ‘subtidal’ and ‘epipelagic’ to address the difference between intertidal and subtidal plant and algae species with regard to tidal exposure and zonation. Epipelagic was used to distinguish phytoplankton from the other sub-group levels.

**Sub-group level 2**: maintained ‘vascular’ and ‘non-vascular’ and applied them to both the intertidal and subtidal in sub-group level 1. Both vascular and non-vascular plants are present in the intertidal sub-group level, with only non-vascular being present in the subtidal sub-group level. This breakdown helps tease out those species which have broad ranges across both the intertidal and subtidal zones and whether there are scoring differences in the same species due to location.

**Sub-group level 3**: further breaks down the non-vascular component into more specific algal growth forms: ‘canopy’, ‘understory and turf’, and ‘encrusting’. These components, not present in the National framework, provide more separation of the non-vascular plant types and allows the examination of morphological impacts on scoring with regard to vulnerability to oil.

**Sub-group level 4**: added a combined habitat feature based on substrate and wave exposure.

**Sub-group level 5**: delves into more detail in the vascular plants, considering more specific plant types (seagrasses, saltmarsh grass, salt-marsh-non-grass, and saltmarsh succulent). This allows the examination of morphological, zonation, and tidal flux impacts on scoring with regard to vulnerability to oil, and allows clearer separation of high marsh and low marsh plant species.

**Additional changes:** Phytoplankton is presented as a single epipelagic sub-group, representative of all regional species. Breaking phytoplankton into further sub-groups would be unmanageable in the current application, and likely would render few to no difference in scoring with regard to vulnerability to oil.

*Table 2. Maritimes Region sub-group breakdown for marine plants and algae with example species (N/A = not applicable).*

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | Examples of Maritime species within the sub-group |
|---|---|---|---|---|---|
| Intertidal | Vascular | N/A | High energy unconsolidated habitat | None found | |
| | | | Moderate to low energy unconsolidated habitat | Seagrasses | *Ruppia maritima, Zostera marina* |
| | | | | Saltmarsh grass | *Carex paleacea, Juncus gerardii, Juncus caesariensis, Puccinellia maritima, Spartina alterniflora* |
| | | | | Saltmarsh non-grass | *Achillea millefolium, Plantago maritima, Limonium carolinianum, Triglochin maritimum* |
| | | | | Saltmarsh succulent | *Crassula aquatica, Honckenya peploides, Salicornia europae/ S. depressa* |
| | Non-vascular | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* |
| | | Understory and turf | High energy consolidated habitat | N/A | *Chondrus crispus, Fucus endentatus, Fucus spiralis, Porphyra purpurea, Corallina officinalis* |
| | | | Moderate to low energy consolidated habitat | N/A | *Chorda tomentosa, Polysiphonia stricta, Ptilota elegans, Ulva intestinalis, Ulva lactuca, Corallina officinalis* |
| | | Encrusting | Consolidated habitat | N/A | Coralline encrusting algae, e.g., *Lithothamnion glaciale* |
| Subtidal | Non-vascular | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* |
| | | | Moderate to low energy consolidated habitat | N/A | *Agarum clathratum, Halosiphon tomentosus, Laminaria digitata, Saccharina latissima* |
| Subtidal | Non-vascular | Understory and turf | High energy consolidated habitat | N/A | *Chondrus crispus, Chorda tomentosa, Desmarestia viridis, Euthora cristata, Furcellaria lumbricalis* |

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | Examples of Maritime species within the sub-group |
|---|---|---|---|---|---|
| Subtidal Epipelagic | Non-vascular | Understory and turf Encrusting | Moderate to low energy consolidated habitat | N/A | *Desmarestia aculeata, Desmarestia viridis, Euthora cristata, Petalonia fascia, Ulva intestinalis, Spongomorpha arcta (Acrosiphonia arcta)* |
| | | | Consolidated habitat | N/A | Coralline encrusting algae, e.g., *Lithothamnion glaciale* |
| | | PHYTOPLANKTON | N/A | N/A | N/A |

### 3.3.2.2. Marine Invertebrates Grouping

The National framework proposed 37 sub-groups in the marine invertebrates group (Table 3). Only a few changes were made to the marine invertebrates sub-groups (Table 4) for the Maritimes Region application.

*Table 3. Proposed National sub-group breakdown for marine invertebrates (N/A = not applicable).*

| Sub-group breakdown | | | |
|---|---|---|---|
| **Sub-group 1** | **Sub-group 2** | **Sub-group 3** | **Sub-group 4** |
| Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | Crustacea (*e.g., barnacles*) |
| | | | Mollusca (*e.g., oysters*) |
| | | | Cnidaria (*e.g., sea anemones*) |
| | | | Porifera (*e.g., demosponges*) |
| | | | Worms (*e.g., tube worms*) |
| | | | Ascidia (*e.g., sea squirts*) |
| | | Low mobility | Worms (*e.g., annelids*) |
| | | | Echinoderms (*e.g., sea urchins*) |
| | | | Mollusca (*e.g., gastropods*) |
| | | High mobility | Crustacea (*e.g., crabs*) |
| | | | Mollusca (*e.g., octopus*) |
| | Sediment infauna | Low mobility | Mollusca (*e.g., clams*) |
| | | | Worms (*e.g., annelids*) |
| | Sediment epifauna | Low mobility | Mollusca (*e.g., gastropods*) |
| | | | Cnidaria (*e.g., sea pens*) |
| | | | Echinoderms (*e.g., sea stars*) |
| | | High mobility | Crustacea (*e.g., crabs*) |
| Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | Crustacea (*e.g., barnacles*) |
| | | | Mollusca (*e.g., mussels*) |
| | | | Cnidaria (*e.g., coral*) |
| | | | Porifera (*e.g., glass sponges*) |
| | | | Worms (*e.g., tube worms*) |
| | | | Ascidia (*e.g., sea squirts*) |

| Sub-group breakdown | | | |
|---|---|---|---|
| **Sub-group 1** | **Sub-group 2** | **Sub-group 3** | **Sub-group 4** |
| | | Low mobility | Worms (*e.g., annelids*) |
| | | | Echinoderms (*e.g., sea urchins*) |
| | | | Mollusca (*e.g., gastropods*) |
| | | High mobility | Crustacea (*e.g., crabs*) |
| | | | Mollusca (*e.g., octopus*) |
| | Sediment infauna | Low mobility | Mollusca (*e.g., clams*) |
| | | | Worms (*e.g., annelids*) |
| | Sediment epifauna | Low mobility | Mollusca (*e.g., gastropods*) |
| | | | Cnidaria (e.g., *sea pens*) |
| | | | Echinoderms (*e.g., sea stars*) |
| | | High mobility | Crustacea (*e.g., crabs*) |
| Pelagic | N/A | Low mobility | Zooplankton |
| | | | Cnidaria (*e.g., jellyfish*) |
| | | High mobility | Mollusca (*e.g., squid*) |

With modifications, an extra 21 sub-groups were added in the Maritimes application, creating a total of 58 invertebrate sub-groups (Table 4).

The changes made were as follows:

**Sub-group level 1**: separates marine invertebrates by location (intertidal/subtidal/pelagic) to address differences in exposure. No changes made to this level for the Maritimes application.

**Sub-group level 2**: uses a substrate habitat factor (rock and rubble dwellers/sediment infauna/sediment epifauna) to differentiate habitat role in exposure and recovery. In the Maritimes application, sub-groups for pelagic larval forms were added at this level.

**Sub-group level 3**: addresses mobility (sessile/low mobility/high mobility) to identify sub-groups with the ability/inability to move in the event of an oil-spill. No changes made to this level for the Maritimes application.

**Sub-group level 4**: is based on taxonomic divisions, mostly at the phyla level. Several changes were made at this level for consistency.

A reorganization of this sub-group level was performed to ensure consistency at the phylum level. The National framework includes a mixture of phyla and classes in sub-group 4. In the Maritimes application, only phyla (or an amalgamation of phyla) are used in sub-group level 4, with classes being used only as examples within phyla (e.g., sea squirts and others members of Class Ascidacea, were used as an example class for the new Phylum - 'hemichordates').

There were two sub-groups created in sub-group level 4 via an amalgamation of phyla:

1. 'Worms' include the Phyla Acanthocephala, Annelida, Chaetognatha, Gastrotricha, Gnathostomulida, Nemadoda, Nematomorpha, Nemertea, Onychophora, Platyhelminthes, Priapulida, Sipuncula and Xenacoelomorpha.
2. Lophophorates include the Phyla Entoprocta, Ectoprocta, Brachiopoda and Phoronida.

**Additional changes:** Non-larval zooplankton, was presented as a single sub-group, representative of all regional species. As with phytoplankton, breaking non-larval zooplankton into further sub-groups would be unmanageable in the current application, and likely would render few to no difference in scoring with regard to vulnerability to oil.

*Table 4. Maritimes Region sub-group breakdown for marine invertebrates with example species (CL = class, N/A = not applicable).*

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Examples of Maritime species within the sub-group |
|---|---|---|---|---|
| Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | Porifera | Sponges [CL. Demospongiae, Calcarea] |
| | | | Cnidaria | Colonial hydroids [Hydrozoa]; Stalked jellyfish [Staurozoa] |
| | | | Worms | Tube worms [Polychaeta] |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] |
| | | | Mollusca | Oysters, Mussels [Bivalvia]; Snails [Gastropoda] |
| | | | Hemichordata | Sea peaches, Sea squirts [Ascidiacea] |
| | | | Arthropoda | Barnacles [CL. Hexanauplia] |
| | | Low mobility | Cnidaria | Anemones [Anthozoa] |
| | | | Worms | Bloodworms [Polychaeta]; Flatworms [Platyhelminthes]; Nemertean worms |
| | | | Mollusca | Chitons [Polyplacophora]; Whelks, Limpets, Snails [Gastropoda] |
| | | | Echinodermata | Sea stars [Asteroidea]; Sea urchins [Echinoidea]; Sea cucumbers [Holothuroidea] |
| | | | Arthropoda | Amphipods [Amphipoda]; Isopods [Isopoda] |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] |
| | Sediment infauna | Low mobility | Worms | Sandworms, Lugworms, other burrowers [Polychaeta]; Nemertean worms [Paleonemertea]; Sipuncula worms [Sipunculidea]; Flatworms [Platyhelminthes] |
| Intertidal | Sediment infauna | Low mobility | Mollusca | Clams, Astartes [Bivalvia]; Moonsnails [Gastropoda] |
| | | | Arthropoda | Mud crab [Decapoda, Panopeidae]; Tube-building gammarid amphipods [Amphipoda] |
| | Sediment epifauna | | Cnidaria | Starlet anemones, Sand anemones [Anthozoa] |
| | | | Mollusca | Nudibranchs [Gastropoda, Nudibranchia]; Snails [Gastropoda], Scallops [Bivalvia] |
| | | | Echinodermata | Brittle stars [Ophiuroidea]; Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea] |
| | | | Arthropoda | Hermit crabs [Decapoda]; Sand fleas and other Amphipods [Amphipoda]; Sea spiders [Pycnogonida]; Isopods [Isopoda] |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] |

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Examples of Maritime species within the sub-group |
|---|---|---|---|---|
| Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | Porifera | Boring sponges, breadcrumb sponges, encrusting sponges [CL. Demospongiae, Calcarea] |
| | | | Cnidaria | Colonial hydroids [Hydrozoa], Soft corals [Anthozoa] Stalked jellyfish [Staurozoa] |
| | | | Worms | Tube worms [Polychaeta] |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] |
| | | | Mollusca | Slipper limpets [Gastropoda]; Mussels, Oysters, Comb bathyarks [Bivalvia] |
| | | | Hemichordata | Ascidians (Tunicates, Sea squirts, Sea grapes) [Ascidiacea] |
| | | | Arthropoda | Barnacles [CL. Hexanauplia] |
| | | Low mobility | Cnidaria | Anemones [Anthozoa]; Colonial hydroids [Hydrozoa] |
| | | | Worms | Ribbon worms [Hoplonemertea]; Polychaete worms [Polychaeta]; Flatworms [Platyhelminthes] |
| | | | Mollusca | Nudibranchs, Whelks, Periwinkles [Gastropoda]; Scallops [Bivalvia] |
| | | | Echinodermata | Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea]; Basket stars, Brittle stars [Ophiuroidea], Sea urchins [Echinoidea] |
| | | High mobility | Mollusca | North Atlantic octopus [Cephalopoda] |
| | | | Arthropoda | Crabs, Lobsters [Decapoda] |
| Subtidal benthic | Sediment infauna | Low mobility | Cnidaria | Burrowing anemones [Anthozoa] |
| | | | Worms | Polychaete worms [Polychaeta]; Flatworms [Platyhelmintes]; Nemertean worms [Pilidiophora]; Peanut worms [Sipunculidea] |
| | | | Mollusca | Clams [Bivalvia] |
| | | | Echinodermata | Sea cucumbers (e.g., *Caudina arenata*), [Holothuroidea] |
| | | | Arthropoda | Amphipods [Amphipoda, Cumacea] |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] |
| | Sediment epifauna | | Cnidaria | Anemones [Anthozoa] |
| | | | Worms | Sea mouse [Polychaeta] |
| | | | Mollusca | Nudibranchs, Whelks, Moonsnails [Gastropoda], Quahogs, Scallops [Bivalvia] |

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Examples of Maritime species within the sub-group |
|---|---|---|---|---|
| | | | Echinodermata | Sand dollars [Echinoidea]; Cushion stars, Mud stars [Asteroidea]; Sea cucumbers [Holothuroidea] |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] |
| Pelagic | N/A | Low mobility | Cnidaria | Moon jellies [Scyphozoa]; Hydromesusae [Hydrozoa]; Jellyfish [Scyphozoa] |
| | | | Ctenophora | Comb jellies [CL. Nuda, Tentaculata] |
| | | | Zooplankton | Copepods, Mysids |
| | | High mobility | Mollusca | Squid [Cephalopoda] |
| | LARVAE | Porifera | | |
| | | Ctenophora | | |
| | | Cnidaria | | |
| | | Worms | | |
| | | Lophophorates | | |
| | | Mollusca | | |
| | | Echinodermata | | |
| | | Hemichordata | | |
| | | Arthropoda | | |

### 3.3.2.3. Marine Fishes Grouping

The National framework proposed 30 sub-groups in the marine fishes group (Table 5). Substantial changes were made to the marine fishes sub-groups for the Maritimes Region application (Table 6).

*Table 5. Proposed National sub-group breakdown for marine fishes.*

| Sub-group breakdown | | | |
|---|---|---|---|
| | **Sub-group 1** | **Sub-group 2** | **Sub-group 3** |
| **Marine Fish** | Diadromous | Anadromous | Lampreys |
| | | | Acipenseridae |
| | | | Clupeidae |
| | | | Osmeridae |
| | | | Salmonidae |
| | | Catadromous | Anguillidae |
| | Estuarine (*excluding migrating groups*) | Demersal/ Semi-demersal | Roundfish |
| | | | Rockfish/Redfish |
| | | | Flatfish |
| | | | Elasmobranchs |
| | Intertidal | Demersal/ Semi-demersal | Roundfish |
| | | | Rockfish/Redfish |
| | | | Flatfish |
| | | | Elasmobranchs |
| | On shelf | Demersal/ Semi-demersal | Roundfish |
| | | | Rockfish/Redfish |
| | | | Flatfish |
| | | | Elasmobranchs |
| | | Small pelagics/ Forage fish | Ammodytidae (*e.g., sandlance*) |
| | | | Embiotocidae (*e.g., perch*) |
| | | | Clupeidae (*e.g., herring*) |
| | | | Osmeridae (*e.g., smelt, eulachon*) |
| | | Large pelagics | Elasmobranchs |
| | | | Scombrids |
| | Off shelf | Demersal/ Semi-demersal | Roundfish |
| | | | Rockfish/Redfish |
| | | | Flatfish |
| | | | Elasmobranchs |
| | | Small pelagics/ Forage fish | Clupeidae (*e.g., sardines*) |
| | | Large pelagics | Elasmobranchs |

With modifications, an extra 6 sub-groups were added in the Maritimes application, creating a total of 36 marine fishes sub-groups (Table 6).

The changes made were as follows:

Overall, the National framework sub-group 1 was significantly reorganized for the Maritimes application, with several components removed and others distributed across 3 further sub-group levels based on exposure, vertical location and benthic association.

**Sub-group level 1**: separates fishes into marine and estuarine divisions. Diadromous and off shelf fish groupings were not used. On-shelf fish groups are represented in the 'subtidal' division in sub-group level 2.

**Sub-group level 2**: further development of sub-group level 1 separates marine fish into intertidal and subtidal components to examine differences in exposure potentials. The estuarine group was further subdivided into estuarine resident and estuarine transient.

Estuarine transient species will encompass all diadromous species (both anadromous and catadromous) that have a freshwater and marine life stage, and are assumed to spend only short durations in estuaries. All estuarine anadromous and catadromous species represented in estuarine transient are subsequently represented in the marine sub-group to reflect their dual life history stages, and the effect that habitat changes might have on their vulnerability to oil (e.g., an anadromous species passing from freshwater to the marine environment is expected to interact with the sea surface in an estuary, but not in the marine environment).

**Sub-group level 3**: separates marine and estuarine fish species into 'benthic' and 'non-benthic' (pelagic and demersal) to consider vertical distribution.

**Sub-group level 4**: was added to address habitat characteristics for the benthic sub-groups and their associations with consolidated and unconsolidated substrates. Non-benthic groups were not included in this sub-group level.

**Sub-group level 5:** based on high-level fish taxonomic divisions, usually at the family level of differentiation. Some families are repeated in sub-group level 5 due to their habitat range (e.g., species that are present in both intertidal and subtidal habitats), or dual life history stage (i.e., diadromous species).

*Table 6. Maritimes Region sub-group breakdown for marine fishes with example species (N/A = not applicable).*

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | Examples of Maritime Species within the sub-group |
|---|---|---|---|---|---|
| Marine | Intertidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Snailfishes (Liparidae) | Atlantic Snailfish |
| Marine | Intertidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Pout (Zoarcidae) | Ocean Pout |
| Marine | Intertidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Cryptacanthodidae | Wrymouth |
| Marine | Intertidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Snailfishes (Liparidae) | Atlantic Snailfish |
| Marine | Intertidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Pout (Zoarcidae) | Ocean Pout |
| Marine | Intertidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Pholidae | Rock Gunnel |
| Marine | Intertidal | Non-benthic (pelagic and demersal) | N/A | Sticklebacks (Gasterosteidae) | Blackspotted Stickleback, Fourspine Stickleback, Threespine Stickleback |

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | Examples of Maritime Species within the sub-group |
|---|---|---|---|---|---|
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Skates (Rajidae) | Little Skate, Thorny Skate, Smooth Skate |
| | | | | Flatfishes (Pleuronectidae) | Winter Flounder, Yellowtail Flounder, Atlantic Halibut, Windowpane, American Plaice |
| | | | | Sculpins (Cottidae) | Shorthorn Sculpin, Longhorn Sculpin, Moustache Sculpin |
| | | | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Pout (Zoarcidae) | Ocean Pout |
| | | | | Redfish (Sebastidae) | Acadian Redfish |
| | | | | Lophiidae | Monkfish |
| | | | | Myxinidae | Atlantic Hagfish |
| | | | | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon |
| | | | Associated with consolidated substrates (cobble/boulder/bedrock) | Sculpins (Cottidae) | Snowflake Hookear Sculpin, Longhorn Sculpin, Shorthorn Sculpin |
| | | | | Lumpfishes (Cyclopteridae) | Atlantic Spiny Lumpsucker, Lumpfish |
| | | | | Wolffishes (Anarhichadidae) | Atlantic Wolffish, Spotted Wolffish, Northern Wolffish |
| | | | | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon |

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | Examples of Maritime Species within the sub-group |
|---|---|---|---|---|---|
| | Subtidal | Non-benthic (pelagic and demersal) | N/A | Cod (Gadidae) | Atlantic Cod, Arctic Cod, Tomcod, Pollock |
| | | | | Elasmobranchs | Shortfin Mako, Porbeagle, Blue Shark |
| Marine | | | | Osmeridae | Rainbow Smelt, Capelin |
| | | | | Salmon (Salmonidae) | Atlantic Salmon |
| | | | | Scombridae | Atlantic Mackerel, Atlantic Bluefin Tuna |
| | | | | Clupeidae | Atlantic Herring, American Shad, Blueback Herring, Alewife |
| | | | | Eels (Anguillidae) | American Eel |
| Estuarine | Estuarine transient | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon |
| | | | | Eels (Anguillidae) | American Eel |
| | | | Associated with consolidated substrates (cobble/boulder/bedrock) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon |
| | | Non-benthic (pelagic and demersal | N/A | Clupeidae | American Shad, Blueback Herring, Alewife |
| | | | | Salmon (Salmonidae) | Atlantic Salmon |
| | | | | Silversides (Atherinopsidae) | Atlantic Silverside |
| | | | | Sticklebacks (Gasterosteidae) | Threespine Stickleback |
| | | | | Petromyzontidae | Sea Lamprey |
| | Estuarine resident | | | Fundulidae | Mummichog |
| | | | | Syngnathidae | Northern Pipefish |

### 3.3.2.4. Marine Mammals Grouping

The National framework proposed 9 sub-groups in the marine mammals group (Table 7). Minor changes were made to the marine mammal sub-groups for the Maritimes Region application.

*Table 7. Proposed National sub-group breakdown for marine mammals (– = not applicable).*

| Sub-group breakdown | | |
|---|---|---|
| **Sub-group 1** | **Sub-group 2** | **Sub-group 3** |
| Cetaceans | Toothed | Discrete |
| | | Dispersed |
| | Baleen | Discrete |
| | | Dispersed |
| Pinnipeds | Thermoregulate with fur | Discrete |
| | | Dispersed |
| | Other pinnipeds | Discrete |
| | | Dispersed |
| Mustelids | – | – |

With modifications, 2 sub-groups were removed in the Maritimes application, creating a total of 7 marine mammal sub-groups (Table 8).

The changes made were as follows:

**Sub-group level 1:** separates marine mammals into cetaceans (whales and dolphins), pinnipeds (seals and sea lions). Mustelids were not evaluated in the Maritimes application and were removed from the tables.

**Sub-group level 2:** separates out physical characteristics of species related to an increased vulnerability to oil (e.g., baleen for whales, fur for pinnipeds that rely on fur for thermoregulation There are no pinniped species in the Maritimes Region that rely solely on their fur for thermoregulation.

Sub-group level 3: separates out species/populations with regard to whether they are discrete or dispersed in the Maritimes Region. Sub-groups considered to be 'dispersed' do not tend to aggregate, whereas 'discrete' sub-groups are considered to occur in concentrations due to behavior or for a certain purpose (e.g., feeding, reproduction).

*Table 8. Maritimes Region sub-group level breakdown for marine mammals with example species (N/A = not applicable).*

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Examples of Maritime species within the sub-group |
|---|---|---|---|
| Cetaceans | Toothed | Discrete | Killer Whale, Long-finned Pilot Whale, Northern Bottlenose Whale, Atlantic White-sided Dolphin |
| | | Dispersed | Harbour Porpoise, Sperm Whale, Cuvier's Beaked Whale, Sowerby's Whale, True's Beaked Whale, Blainville's Beaked Whale |
| Cetaceans | Baleen | Discrete | Fin Whale, Humpback Whale, North Atlantic Right Whale |
| | | Dispersed | Minke Whale, Blue Whale, Sei Whale |

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Examples of Maritime species within the sub-group |
|---|---|---|---|
| Pinnipeds | Thermoregulate with fur | None | N/A |
| | Other pinnipeds | Discrete | Harbour Seal, Harp Seal |
| | | Dispersed | Grey Seal, Ringed Seal, Bearded Seal, Hooded Seal |

### 3.3.2.5. Marine Reptiles Grouping

Sea turtles such as the migratory loggerhead and leatherback sea turtles, which use Canada's Atlantic and Pacific waters for foraging (Gregr et al. 2015), are the only representatives in this group in Canada. All sea turtles are expected to be impacted in similar ways when exposed to oil and hence, this is the only sub-group identified by the National framework, and is carried over for the Maritimes application. Table 9 shows the Maritimes Region sub-group breakdown for marine reptiles.

*Table 9. Maritimes Region sub-group breakdown for marine reptiles with example species (N/A = not applicable).*

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Examples of Maritime Species within the sub-group |
|---|---|---|---|
| Sea turtles | N/A | N/A | Leatherback Sea Turtle, Loggerhead Sea Turtle, Kemp's Ridley |

## 3.4. ECOLOGICAL VULNERABILITY CRITERIA

While all marine biological components are assumed to be vulnerable to oil to some extent, a vulnerability framework, can provide guidance to response coordinators on the 'degree' of vulnerability, allowing for rapid assessment decisions pertaining to the prioritizing of marine biological components, via a comprehensive regional list of sub-groups that are ranked according to their vulnerability to oil.

The use of a standard set of vulnerability selection criteria, when applied to regional sub-groups, makes scoring consistent and renders results that are comparable across regions. Sub-groups are comparable to one another as well, as they are scored against identical criteria in a relative manner.

The National framework lays out a detailed approach to scoring vulnerability based on three overarching categories:

1. potential **Exposure** to spilled oil;
2. **Sensitivity** to oil; and,
3. **Recovery** potential.

In some cases criteria may appear to be biased toward certain groups, but those groups have characteristics that make them more vulnerable to oil than other groups (e.g., mammals lost the ability to thermoregulate when their fur becomes oiled; sessile invertebrates that cannot move to avoid spilled oil) (Thornborough et al. 2017). The framework attempts to capture those characteristics.

Criteria were developed to be applicable to sub-group levels and relevant to any region in Canada. The criteria identify vulnerable sub-groups based on direct contact with spilled oil;

secondary (food web) impacts resulting from contact with oil is not addressed in the framework (Thornborough et al. 2017).

While the National framework recommended that vulnerability criteria not be changed (in order to make direct comparisons across regions straightforward), during this application there were a number of general, and sub-group specific modifications, expounding on the vulnerability criteria as they were specifically applied. These small changes were necessary to improve understanding of the Maritimes application in general and did not affect the National criteria as proposed.

### 3.4.1. Exposure Category Criteria

Marine biological components that are more likely to encounter spilled oil are assumed to be more vulnerable (Reich et al. 2014). Exposure criteria developed by the National framework identify characteristics that increase the likelihood of exposure to oil, including: concentration/aggregation and/or site fidelity; sessile/low mobility; surface interaction; and sediment interaction criteria.

The following general modifications were made to the Exposure criteria:

- **Concentration (aggregation) and/or site fidelity:** ‘site fidelity’ was moved to the ‘mobility’ criterion.
- **Mobility:** mobility criteria changed to ‘mobility and/or site fidelity’, as site fidelity is used to score organisms that may have the ability to move, yet they may not move due to a limited home range.
- **Sea surface interacting:** quantification was deemed necessary for this criteria. Surface layer was defined as 0 to −1m to better capture the ‘sea surface interacting’ criteria.
- **Sediment interacting:** was changed to ‘seafloor or vegetation interacting’ to include interactions with all sediment types and vegetation. Oil may persist on rocks and vegetation, as well as those subsurface sediment types more commonly known to retain oil (e.g., silt and sand). This change was used to score all benthic substrate habitats equally.

#### 3.4.1.1. Scoring Guidance

Scoring was performed using both general guidance from the National framework (Table 10) and specific guidance developed for the Maritimes application (Table 11) to ensure consistency.

*Table 10. National framework proposed Exposure criteria and guidance for scoring.*

| **Exposure criteria and scoring guidance** | |
|---|---|
| **Concentration (aggregation) and/or site fidelity** | |
| Question | Does the sub-group contain species that concentrate or aggregate in areas linked to fixed/transient habitat within the study area and/or exhibit site fidelity? |
| Justification | Organisms that live in high concentrations or aggregate in large numbers in fixed/transient locations have an increased likelihood of exposure to oil. Organisms exhibiting site fidelity may try to remain in, or return to a specific area, even if they were to become exposed to oil. |

| Exposure criteria and scoring guidance | |
|---|---|
| Scoring guidance | Sub-groups containing species that concentrate in fixed/transient locations for habitat, feeding, or breeding; Sub-groups containing species that exhibit site fidelity. |
| **Mobility** | |
| Question | Does the sub-group contain species with low or no mobility? |
| Justification | Organisms that are unable to, or have limited ability to move away from spilled oil, or are known to be attracted to spilled oil are likely to have higher exposure to spilled oil. |
| Scoring guidance | Sub-groups containing species with sessile life-stages (e.g., sponges, corals, kelp, sea grass, etc.); sub-groups containing species with low mobility (e.g., echinoderms); sub- groups containing species with evidence of attraction to spilled oil. |
| **Sea surface interacting** | |
| Question | Does the sub-group contain species that are reliant on or have regular interaction with the air/near sea surface, including intertidal areas? |
| Justification | The sea surface is the first point of contact in a ship-sourced spill. Therefore, organisms reliant on or with regular interaction with the sea surface have an increased likelihood of exposure to spilled oil. The intertidal zone is likely to experience significant exposure from floating oil spills as tidal movements bring species in direct contact with oil (Chang et al. 2014). |
| Scoring guidance | Sub-groups containing species that are reliant on or have regular interaction with the near- surface of the ocean (e.g., marine mammals, basking sharks). This includes intertidal species as intertidal areas regularly interact with the surface. The depth of the surface layer (e.g., sea-air interface or −10 m) should be defined by regional conditions (i.e., localized hydrodynamics). |
| **Sediment interacting** | |
| Question | Does the sub-group contain species closely associated with types of sediment that can retain oil for long periods? |
| Justification | Reoccurring direct exposure due to persistence of oil in sediments. Contaminated sediments can expose individuals in a population repeatedly. This is still considered an acute impact since it is not due to chronic (or multiple exposures) to a single individual. Rather this type of reoccurring exposure impacts a greater proportion of the population through direct contact. |
| Scoring guidance | Sub-groups containing species that inhabit sediment such as eelgrass and other sediment dwellers such as clams; Sub-groups containing species which spend a significant proportion of time in close association with sediment (e.g., grey whales feeding within sediments). |

The following table (Table 11) outlines the detailed scoring guidance applied to the Exposure criteria in the Maritimes Region.

*Table 11. Detailed guidance used for scoring criteria within the Exposure category for each biological group in the Maritimes Region application (CL = class).*

| Criterion | Group | Scoring Guidance |
|---|---|---|
| Concentration (aggregation) | Marine Plants and Algae | Vascular plants were considered aggregated if they formed concentrated monospecific beds or were the dominant plant type in dense mixed species stands.<br>Non-vascular plants were considered aggregated if they form dense beds (e.g., canopy kelp bed); thick mats (e.g., turf algae) or were considered abundant across the intertidal and/or subtidal zones.<br>Epipelagic phytoplankton are ubiquitous throughout the Maritimes Region, occurring in mixed species populations and discrete single species blooms. |
| | Marine Invertebrates | Marine invertebrates were considered aggregated if they were colony, bed, or reef forming (e.g., colonial hydroids, tube worms); if they exhibit gregarious settlement (e.g., oysters, mussels, barnacles); or if they aggregate for distinct purposes, such as feeding or reproduction (e.g., gastropods form breeding aggregations). |
| | Marine Fishes | Fish were considered aggregated if they were a schooling species (e.g., Silversides [Atherinopsidae]); a shoaling species (e.g., Cod [Gadidae]); formed feeding aggregations (e.g., Hagfish [Myxinidae]); exhibited mass spawning (e.g., Capelin [Osmeridae]; or congregate for seasonal spawning migrations (e.g., American Eel [Anguillidae]). |
| | Marine Mammals | Marine mammals were considered aggregated if concentrated for social, feeding, reproduction or migration purposes. |
| | Marine Reptiles | Marine reptiles were considered aggregated if concentrated for social, feeding, reproduction or other purposes. |
| Mobility and/or Site Fidelity | Marine Plants and Algae | Vascular plants were considered immobile.<br>Non-vascular plants were considered immobile.<br>Epipelagic phytoplankton were considered immobile and subject to oceanographic currents. |
| | Marine Invertebrates | The mobility criterion was a relative measure within the marine invertebrates group.<br>Low mobility and sessile invertebrates were considered to exhibit limited (e.g., anemones [Anthozoa]); or no ability to move (e.g., barnacles [CL. Hexanauplia]); while high mobility invertebrates (e.g., North Atlantic Octopus [Cephalopoda]), were considered highly mobile in relation to low mobility sub-groups. |

| Criterion | Group | Scoring Guidance |
| --- | --- | --- |
| | | Highly mobile invertebrates (i.e., lobsters [Decapoda]) were considered to exhibit site fidelity if they demonstrated annual migrations for mating and spawning. |
| | Marine Fishes | Fish were considered to fulfill the mobility criterion if they: were a small-bodied species (< 15 cm); exhibited short migrations (i.e., from shallow water to intertidal areas, and reverse); exhibited slow swimming behaviour (e.g., sculpins [Cottidae]); or were considered deep water sedentary (e.g., Redfish [Sebastidae]).<br>Fish were considered not fulfill the mobility criterion if they: undertook long migrations (e.g., inshore to offshore, and reverse); travelled long distances (e.g., Cod [Gadidae]); or were proven to be "fast" swimmers (e.g., Elasmobranchs).<br>Fish were considered to fulfill the site fidelity criterion if they: demonstrated homing behaviours; or have specific breeding or feeding grounds. |
| | Marine Mammals | All marine mammals were considered highly mobile. |
| | Marine Reptiles | All marine reptiles were considered highly mobile. |
| Sea Surface Interacting | Marine Plants and Algae | Intertidal marine plant and algae sub-groups were expected to interact with the sea surface.<br>Subtidal algal species were not expected to interact with the sea surface unless exhibiting morphological characteristics enabling them to do so. |
| | Marine Invertebrates | Intertidal marine invertebrate sub-groups were expected to interact with the sea surface.<br>Subtidal benthic marine invertebrate sub-groups were not expected to interact with the sea surface<br>Pelagic marine invertebrate sub-groups (including larvae) were expected to interact with the sea surface. |
| Sea Surface Interacting | Marine Fishes | Marine fish sub-groups that live in the intertidal zone, or pass through intertidal or estuarine zones enroute to spawning grounds, were expected to have interaction with the sea surface, compared to strictly marine subtidal fish sub-groups. |
| | Marine Mammals | Marine mammals regularly interact with the sea surface to breathe. |
| | Marine Reptiles | Marine reptiles regularly interact with the sea surface to breathe. |
| Seafloor or Vegetation Interacting | Marine Plants and Algae | Vascular plants have root or rhizome systems that are anchored in the sediment.<br>Non-vascular plants are attached to the seafloor via holdfasts or grow directly on substrate (e.g., encrusting algal species).<br>Phytoplankton would not be expected to have any interaction with the seafloor. |
| | Marine Invertebrates | All intertidal and subtidal marine invertebrate sub-groups were expected to have interaction with the seafloor. |

| Criterion | Group | Scoring Guidance |
|---|---|---|
| | | Pelagic invertebrate sub-groups will generally not interact with the seafloor. |
| | Marine Fishes | All benthic fish sub-groups would be expected to maintain constant contact with the seafloor.<br>Some non-benthic fish sub-groups were expected to interact with the seafloor for feeding or reproduction purposes (e.g., Capelin, Cod), or use aquatic vegetation for cover (e.g., Northern Pipefish [Syngnathidae]). |
| | Marine Mammals | Marine mammals are generally expected to interact with the seafloor via feeding behaviour. |
| | Marine Reptiles | Marine reptiles are generally expected to interact with the seafloor via feeding behaviour. |

### 3.4.2. Sensitivity Category Criteria

The criteria in this category examine both mechanical and chemical sensitivities, based on physiological characteristics that may increase the degree of impairment experienced by an organism from exposure to oil (Thornborough et al. 2017).

As described in the National framework, the mechanical sensitivity criterion outlines three physiological characteristics that make an organism mechanically vulnerable to oil: reduction in feeding (i.e., blocking of filter feeding structures); reduction in photosynthesis; and reduction of insulation due to oiled fur (in some marine mammals).

Chemical sensitivity is identified as the physiological characteristics that make organisms more vulnerable to oil (e.g., pathologies developed as a result of contact with oil), where the pathways of exposure to oil are considered as adhesion, ingestion, absorption and/or inhalation (Thornborough et al. 2017).

The following general modifications were made to the sensitivity criteria:

- **Mechanical sensitivity**: ‘reduction of feeding/photosynthesis/thermoregulation’ wording was added to this criterion for clarity and to indicate that the definition of mechanical sensitivity differs among high-level biological groups.
- **Chemical sensitivity:** ‘impairment due to toxicity’ wording was added to this criterion for clarity and to indicate that a broad range of impairments and toxic effects can occur across high-level biological groups.

#### 3.4.2.1. Scoring Guidance

Scoring was performed using both general guidance from the National framework (Table 12) and specific guidance developed for the Maritimes application (Table 13) to ensure consistency.

*Table 12. National framework proposed Sensitivity criteria and guidance for scoring.*

| Sensitivity criteria and scoring guidance | |
|---|---|
| **MECHANICAL SENSITIVITY** | |
| **Loss of insulation** | |
| Question | Does contact with oil result in a loss of insulation/ability to thermoregulate for species in the sub-group? |
| Justification | Oil causes a substantial decrease in the insulative value of fur, inhibiting the ability of affected organisms to thermoregulate (Reich et al. 2014). |
| Scoring guidance | Sub-groups containing species reliant on fur as their primary means of thermoregulation. |
| **Reduction of feeding/photosynthesis** | |
| Question | Does direct contact with oil result in the mechanical impairment of feeding structures for species in the sub-group? |
| Justification | Fouling of feeding structures by oil may reduce the ability of organisms to feed, reducing their condition and reproductive capacity and increasing time spent feeding (Reich et al. 2014). |
| Scoring guidance | Sub-groups that contain species that feed by filtering water through their systems and removing particles (filter-feeders); sub-groups containing species that photosynthesize (smothering effects reducing photosynthesis). |
| **CHEMICAL SENSITIVITY** | |
| **Impairment due to toxicity** | |
| Question | Does direct contact with oil result in severe, irreversible effects or death for species in the sub-group? |
| Justification | Organisms that are more sensitive to toxic effects of oil are more likely to experience irreversible effects or death. |
| Scoring guidance | Sub-groups containing species that display severe, irreversible effects or death due to oil toxicity. Acute effects from direct contact include: the inability of animals to digest and absorb foods; reproductive failure; respiratory failure; lesions; hemorrhaging; neurological impairment; and mortality. |

The following table (Table 13) outlines the detailed scoring guidance applied to the sensitivity criteria in the Maritimes Region.

*Table 13. Detailed guidance used for scoring criteria within the Sensitivity category for each biological group in the Maritimes Region application.*

| Criterion | Group | Rationale |
|---|---|---|
| Mechanical Sensitivity (reduction in feeding/photosy | Marine Plants and Algae | All marine plants and algae were considered to have a reduction in photosynthesis due smothering by oil. |
| | Marine Invertebrates | Marine invertebrate sub-groups that have feeding structures that can become clogged with oil (e.g., filter or suspension feeders) fulfill this criterion. |

| Criterion | Group | Rationale |
|---|---|---|
| | Marine Fishes | Marine fish sub-groups that have filter feeding structures (e.g., gill rakers) that can become clogged with oil fulfill this criterion (e.g., American Shad [Clupeidae], Atlantic Mackerel [Scombridae]). |
| | Marine Mammals | Marine mammal sub-groups that have filter feeding structures (e.g., baleen), or thermoregulate with fur fulfill this criterion. |
| | Marine Reptiles | Marine reptiles are not expected to fulfill this criterion. |
| Chemical Sensitivity (impairment due to toxicity) | Marine Plants and Algae | All sub-groups that exhibit impairment due to toxic impacts of oil on physiological characteristics specific to the high-level group, as demonstrated in the literature, will fulfill this criterion. |
| | Marine Invertebrates | |
| | Marine Fishes | |
| | Marine Mammals | |
| | Marine Reptiles | |

### 3.4.3. Recovery Category Criteria

The recovery criteria (often referred to as adaptive capacity), identifies the life history traits that impact the ability of a population to recover after an oil spill. Recovery criteria address the long-term recovery from a single spill event only and do not account for repeated exposures. The National framework lists four criteria: 'population status'; 'reproductive capacity'; 'endemism or isolation'; and 'close association with sediments', to be scored in the Recovery category.

Within the framework, 'population' is defined as a Designatable Unit (DU) by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as a species, sub-species, variety, or geographically or genetically distinct population that is both discrete and evolutionarily significant.

The following general modifications were made to the Recovery criteria:

- Population status: no changes
- Reproductive capacity: was expanded to include life history traits that can affect reproductive potential; as well as low reproductive capacity.
- Endemism or isolation: no changes
- Close association to sediments: was changed to 'close association with unconsolidated substrates'. Although oil can be retained on rocks/boulders, unconsolidated substrates (such as sand, clay, silt) typically retain oil for longer periods of time. This change allows the criterion to capture the influence of sediment type on vulnerability.

### 3.4.3.1. Scoring Guidance

Scoring was performed using both general guidance from the National framework (Table 14) and specific guidance developed for the Maritimes application (Table 15) to ensure consistency.

*Table 14. National framework proposed Recovery criteria and guidance for scoring.*

| Recovery criteria and scoring guidance | |
|---|---|
| **Population Status** | |
| Question | Does the sub-group contain species with reduced or declining population levels? |
| Justification | Sub-groups containing species with greatly reduced or declining population numbers (in particular breeding population numbers) are compromised in their ability to recover from an impact, in contrast to those with healthy population levels which are most capable of recovering (Reich et al. 2014). Conservation status can be used as a proxy for reduced or declining population levels. |
| Scoring guidance | Sub-groups containing species with: low population levels relative to historic levels (incorporates groups underrepresented/not assessed in conservation indices) (e.g., stock assessment zones – healthy/cautious/critical); greatly reduced breeding population numbers relative to historic levels; special conservation status (a proxy for a low population status), e.g., Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended, Species at Risk Act (SARA) listed, International Union for Conservation of Nature (IUCN) listed; Provincially listed. |
| **Reproductive capacity** | |
| Question | Does the sub-group contain species with low reproductive capacity? |
| Justification | Reproductive capacity of a species is a key contributor to population recovery. Sub-groups containing species with low reproductive capacity can be slow to recover from impact even with high population levels, whereas species with relatively high reproductive capacity are inherently more capable of population recovery from oil spill impacts (Reich et al. 2014). |
| Scoring guidance | Sub-groups that contain K-strategist species (i.e., have a longer life expectancy, grow and mature more slowly, and have fewer progeny with higher reproductive investment); Sub-groups that contain species with sporadic, infrequent, or density dependent recruitment success. |
| **Endemism or isolation** | |
| Question | Does the sub-group contain endemic species or isolated populations that have limited distribution within the region? |
| Justification | Sub-groups that contain species or populations endemic or isolated in the area are more likely to have a greater proportion of the population impacted by an oil spill, as well as decreased ability of the population to recolonize an area (Reich et al. 2014). |

| Recovery criteria and scoring guidance | |
|---|---|
| Scoring guidance | Sub-groups containing endemic or isolated populations with limited distribution within the region. Assessed only for the period the species was present in the area of interest (e.g., seasonal abundances of species at certain times of the year). |
| **Close association with sediments** | |
| Question | Does the sub-group contain species that are closely associated with sediments types that can retain oil for long periods of time? |
| Justification | Sediments retaining oil can expose associated organisms for decades after a spill hindering their recovery. Aliphatic and polycyclic aromatic hydrocarbon fractions of dissolved petroleum accumulate in sediments and can affect benthic organisms long after spill events (Gunster et al. 1993, Kennish 1996). |
| Scoring guidance | Sub-groups containing species that inhabit sediment such as eelgrass and other sediment dwellers such as clams, worms; sub-groups containing species which spend a significant proportion of time in close association with sediment (e.g., grey whales feeding within sediments). |

The following table outlines the detailed scoring guidance applied to the Recovery criteria in the Maritimes Region.

*Table 15. Detailed guidance used for scoring criteria within the Recovery category for each biological group in the Maritimes Region application.*

| Group | | Rationale |
|---|---|---|
| Population Status | Marine Plants and Algae | Marine plants and algae sub-groups that have a conservation status listed by: Species at Risk Act (SARA); the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); on the International Union for Conservation of Nature (IUCN) Red List; or the Endangered Species Act (ESA) Threatened and Endangered lists.<br>An added post CSAS population status state of literature analysis was conducted for this group to ascertain whether there were recent (2015 to present), population status declines (e.g., abundance and/or distribution shifts in response to anthropogenic stressors), which would be significant but not yet included on the above lists. Where literature supported a population status change, the scoring for this group was updated to reflect these changes. |
| | Marine Invertebrates | Marine invertebrate sub-groups that have a conservation status listed by: Species at Risk Act (SARA); the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); or on the International Union for Conservation of Nature (IUCN) Red List.<br>An added post CSAS population status state of literature analysis was conducted for this group to ascertain whether there were recent (2015 to present), population status declines (e.g., abundance and/or distribution shifts in response to anthropogenic stressors), which would be significant but not yet included on the above lists. Where |

| Group | | Rationale |
|---|---|---|
| | | literature supported a population status change, the scoring for this group was updated to reflect these changes. |
| | Marine Fishes | Marine fish sub-groups that have a conservation status listed by: Species at Risk Act (SARA); the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); or on the International Union for Conservation of Nature (IUCN) Red List.<br>An added post CSAS population status state of literature analysis was conducted for this group to ascertain whether there were recent (2015 to present), population status declines (e.g., abundance and/or distribution shifts in response to anthropogenic stressors), which would be significant but not yet included on the above lists. Where literature supported a population status change, the scoring for this group was updated to reflect these changes. |
| | Marine Mammals | Marine mammal sub-groups that have a conservation status listed by: Species at Risk Act (SARA); the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); or on the International Union for Conservation of Nature (IUCN) Red List.<br>An added post CSAS population status state of literature analysis was conducted for this group to ascertain whether there were recent (2015 to present), population status declines (e.g., abundance and/or distribution shifts in response to anthropogenic stressors), which would be significant but not yet included on the above lists. Where literature supported a population status change, the scoring for this group was updated to reflect these changes. |
| | Marine Reptiles | Marine reptiles that have a conservation status listed by: Species at Risk Act (SARA); the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); or on the International Union for Conservation of Nature (IUCN) Red List.<br>An added post CSAS population status state of literature analysis was conducted for this group to ascertain whether there were recent (2015 to present), population status declines (e.g., abundance and/or distribution shifts in response to anthropogenic stressors), which would be significant but not yet included on the above lists. Where literature supported a population status change, the scoring for this group was updated to reflect these changes. |
| Reproductive Capacity | Marine Plants and Algae | Vascular plants were considered to have low reproductive capacity if they: rely heavily on vegetative (asexual) propagation as opposed to sexual reproduction; or are considered long lived perennial species.<br>Non-vascular plants sub-groups were generally considered to have high reproductive capacity, unless reproduction was easy disturbed.<br>Epipelagic phytoplankton were considered to have a rapid reproduction rate. |
| | Marine Invertebrates | Marine invertebrate sub-groups that exhibit lower reproductive capacity due to: asexual or clonal reproduction; higher parental |

| Group | | Rationale |
|---|---|---|
| | | investment relative to other invertebrate sub-groups fulfill this criterion. |
| | Marine Fishes | Marine fishes sub-groups that exhibit lower reproductive capacity due to: low fecundity; delayed maturity; long gestation period; brooding species; irregular spawning patterns. |
| | Marine Mammals | All marine mammals are K-strategists with high parental investment and long gestation times. |
| | Marine Reptiles | Marine reptiles were considered to have low reproductive capacity. |
| Endemism or Isolation | Marine Plants and Algae | Marine plants sub-groups that contain species or Designatable Units (DU) whose distribution does not extend beyond the Maritimes Regional boundary, or have isolated populations in the region, fulfill this criterion. |
| | Marine Invertebrates | Marine invertebrate sub-groups that contain species or Designatable Units (DU) whose distribution does not extend beyond the Maritimes Regional boundary, or have isolated populations in the region, fulfill this criterion. |
| | Marine Fishes | Marine fish sub-groups that contain species or Designatable Units (DU) whose distribution does not extend beyond the Maritimes Regional boundary, or have isolated populations in the region, fulfill this criterion. |
| | Marine Mammals | Marine mammal sub-groups that contain species or Designatable Units (DU) whose distribution does not extend beyond the Maritimes Regional boundary, or have isolated populations in the region, fulfill this criterion. |
| | Marine Reptiles | Marine reptile sub-groups that contain species or Designatable Units (DU) whose distribution does not extend beyond the Maritimes Regional boundary, or have isolated populations in the region, fulfill this criterion. |
| Close association with unconsolidated substrates | Marine Plants and Algae | Vascular plant sub-groups have root or rhizome systems that are anchored in unconsolidated substrates.<br>Some intertidal non-vascular plant sub-groups can interact with unconsolidated substrates when exposed at low tide. |
| | Marine Invertebrates | Marine invertebrate infaunal and epifaunal sub-groups fulfill this criterion as they spend the majority of their lives in close association with unconsolidated substrates. |
| | Marine Fishes | Marine fish sub-groups that have a close association with unconsolidated substrates as a function of: reproductive behaviour, feeding, burrowing or resting. |
| | Marine Mammals | Marine mammal sub-groups that interact with unconsolidated substrates via feeding behaviour. |

| Group | | Rationale |
|---|---|---|
| | Marine Reptiles | Marine reptiles that interact with unconsolidated substrates via feeding behaviour. |

# 4. SCORING AND RANKING

A binary system was used to score 116 Maritimes Region sub-groups against 10 criteria that comprise the Exposure, Sensitivity, and Recovery vulnerability categories. A score of one (1) indicated that the criterion was fulfilled for that sub-group, while a score of zero (0) denoted a sub-group that did not fulfill the criterion. Each criterion was scored against the final sub-group level for each of the high-level biological groups (i.e., sub-group level 5 for Marine Plants and Algae; sub-group level 5 for Marine Invertebrates; sub-group level 5 for Marine Fishes; sub-group level 3 for Marine Mammals; and sub-group level 1 for Marine Reptiles). Scoring decisions were made based on the general guidance tables provided by the National framework for each group (Tables 10, 12, and 14) as well as the more specific guidance developed in the Maritimes Region (Tables 11, 13, and 15).

A referenced justification for each score was included to support decisions that were not intuitive (i.e., based on general biological knowledge; e.g., 'all vascular plants are rooted in substrate'), to ensure scientific integrity of decision making, and to maintain confidence in scoring consistency across the application. The number of supporting references needed varied across categories and sub-groups, and differed in accordance with the availability of definitive conclusions in the scientific literature (e.g., there are few conclusive and comparable studies on chemical toxicity for most sub-groups).

A precautionary approach was taken with regard to scoring sub-groups in the following ways:

1. If at least one species within a sub-group was known to fulfill the criterion the entire sub-group fulfilled the criterion.
2. Sub-groups were scored based on the life stages most vulnerable to oil (e.g., juveniles compared to adult) where information was available.
3. Where literature was lacking to support a definitive score (0 or 1), a precautionary score of "1P" was assigned for the criterion.

The scoring process as outlined in the National framework can be seen in Figure 3. The modified scoring process for the Maritimes Region is shown in Figure 4.

Exposure criteria were scored first. There were no screened out sub-groups during scoring for Maritimes Region, as all sub-groups received a score of 1–4 in the exposure category.

Sensitivity criteria were scored next. The 'impairment due to toxicity' criterion proved the most difficult to score. For many sub-groups, there was limited peer-reviewed research on oil toxicity. While for others, conflicting results made it challenging to make a definitive decision. The lack of standardization in experimental methods confounded this problem further. Therefore, the approach taken was to score all sub-groups in this criterion using precautionary scoring (1P), citing as many available sources as possible to illustrate the state of knowledge.

There were no screened out sub-groups during the sensitivity scoring for Maritimes Region, as all sub-groups received a score of 1–2 in the Sensitivity category.

Four criteria in the Recovery category were then assessed, providing an additional score of 0–4 for each sub-group. Exposure, Sensitivity, and Recovery scores for each sub-group were tallied

(/10) and then ranked to produce a list of sub-groups most vulnerable to ship-sourced oil spills in the Maritimes Region (Table 16).

# 5. RESULTS

The following sections provide a summary of Maritimes Region application vulnerability scoring results. Detailed vulnerability category criteria scoring results, including in-depth justifications and precautionary scoring rational for all sub-groups in each high-level biological group can be found in the Appendices to this document. Note that an attempt was made to follow a similar format for each justification, providing general information related to the assigned score for the sub-group, followed by more in depth supporting information where available.

- Marine Plants and Algae – APPENDIX 1
- Marine Invertebrates – APPENDIX 2
- Marine Fishes – APPENDIX 3
- Marine Mammals – APPENDIX 4
- Marine Reptiles – APPENDIX 5

The Final Rank Table (Table 16) shown below lists sub-groups in order from highest to lowest vulnerability regardless of high-level biological group. For each sub-group, criteria that received a precautionary score (1P) were considered fulfilled for the purposes of ranking by total vulnerability score.

Tables 17–20 and Figures 5–9 were developed using the final rank tables to further explain overall vulnerability results: across and within groups (Figure 6); the relative influences of Exposure, Sensitivity and Recovery categories (Figure 6 and 7); some sub-group level differences within the groups (Figure 8); as well as an overview of how the precautionary approach was used across groups (Figure 9).

## 5.1. FINAL RANK TABLES

*Table 16. Final ranked list of sub-groups for the Maritimes Region application of the National vulnerability framework produced by scoring sub-groups against EXPOSURE, SENSITIVITY, and RECOVERY criteria (N/A = not applicable).*

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE PLANTS AND ALGAE | Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Saltmarsh grass | *Carex paleacea, Juncus gerardii, Juncus caesariensis, Puccinellia maritima, Spartina alterniflora* | 4 | 2 | 3 | **9** |
| MARINE PLANTS AND ALGAE | Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Seagrasses | *Ruppia maritima, Zostera marina* | 4 | 2 | 3 | **9** |
| MARINE PLANTS AND ALGAE | Intertidal | Non-vascular | Understory and turf | High energy consolidated habitat | N/A | *Chondrus crispus, Fucus endentatus, Fucus spiralis, Porphyra purpurea, Corallina officinalis* | 4 | 2 | 3 | **9** |
| MARINE PLANTS AND ALGAE | Intertidal | Non-vascular | Understory and turf | Moderate to low energy consolidated habitat | N/A | *Chorda tomentosa, Polysiphonia stricta, Ptilota elegans, Ulva intestinalis, Ulva lactuca, Corallina officinalis* | 4 | 2 | 3 | **9** |
| MARINE INVERTEBRATES | Intertidal | Sediment infauna | Low mobility | N/A | Mollusca | Clams, Astartes [Bivalvia]; Moonsnails [Gastropoda] | 4 | 2 | 3 | **9** |
| MARINE INVERTEBRATES | Pelagic | LARVAE | | Mollusca | | | 4 | 2 | 3 | **9** |
| MARINE FISHES | Estuarine | Estuarine transient | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 4 | 1 | 4 | **9** |
| MARINE FISHES | Estuarine | Estuarine transient | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 4 | 1 | 4 | **9** |
| MARINE MAMMALS | Pinnipeds | Other pinnipeds | Dispersed | N/A | N/A | Grey Seal, Ringed Seal, Bearded Seal, Hooded Seal | 4 | 2 | 3 | **9** |
| MARINE PLANTS AND ALGAE | Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Saltmarsh non-grass | *Achillea millefolium, Plantago maritima, Limonium carolinianum, Triglochin maritimum* | 4 | 2 | 2 | **8** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE PLANTS AND ALGAE | Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Saltmarsh succulent | *Crassula aquatic, Honckenya peploides, Salicornia europae/S. depressa* | 4 | 2 | 2 | **8** |
| MARINE PLANTS AND ALGAE | Intertidal | Non-vascular | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* | 3 | 2 | 3 | **8** |
| MARINE PLANTS AND ALGAE | Subtidal | Non-vascular | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* | 4 | 2 | 2 | **8** |
| MARINE PLANTS AND ALGAE | Subtidal | Non-vascular | Canopy | Moderate to low energy consolidated habitat | N/A | *Agarum clathratum, Halosiphon tomentosus, Laminaria digitata, Saccharina latissima* | 4 | 2 | 2 | **8** |
| MARINE PLANTS AND ALGAE | Subtidal | Non-vascular | Understory and turf | High energy consolidated habitat | N/A | *Chondrus crispus, Chorda tomentosa, Desmarestia viridis, Euthora cristata, Furcellaria lumbricalis* | 4 | 2 | 2 | **8** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 3 | 1 | 4 | **8** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 3 | 1 | 4 | **8** |
| MARINE FISHES | Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Eels (Anguillidae) | American Eel | 4 | 1 | 3 | **8** |
| MARINE FISHES | Estuarine | Estuarine transient | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Eels (Anguillidae) | American Eel | 4 | 1 | 3 | **8** |
| MARINE FISHES | Estuarine | Estuarine transient | Non-benthic (pelagic and demersal | N/A | Salmon (Salmonidae) | Atlantic Salmon | 4 | 1 | 3 | **8** |
| MARINE FISHES | Estuarine | Estuarine transient | Non-benthic (pelagic and demersal | N/A | Clupeidae | American Shad, Blueback Herring, Alewife | 4 | 2 | 2 | **8** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE MAMMALS | Cetaceans | Toothed | Discrete | N/A | N/A | Killer Whale, Long-finned Pilot Whale, Northern Bottlenose Whale, Atlantic White-sided Dolphin | 3 | 1 | 4 | **8** |
| MARINE MAMMALS | Cetaceans | Baleen | Discrete | N/A | N/A | Fin Whale, Humpback Whale, North Atlantic Right Whale | 3 | 2 | 3 | **8** |
| MARINE MAMMALS | Cetaceans | Baleen | Dispersed | N/A | N/A | Minke Whale, Blue Whale, Sei Whale | 3 | 2 | 3 | **8** |
| MARINE REPTILES | Sea turtles | N/A | N/A | N/A | N/A | Leatherback Sea Turtle, Loggerhead Sea Turtle, Kemp's Ridley | 4 | 1 | 3 | **8** |
| MARINE FISHES | Marine | Intertidal | Non-benthic (pelagic and demersal) | N/A | Sticklebacks (Gasterosteidae) | Blackspotted Stickleback, Fourspine Stickleback, Threespine Stickleback | 4 | 2 | 2 | **8** |
| MARINE INVERTEBRATES | Intertidal | Sediment epifauna | Low mobility | N/A | Echinodermata | Brittle stars [Ophiuroidea]; Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea] | 4 | 2 | 2 | **8** |
| MARINE PLANTS AND ALGAE | Intertidal | Non-vascular | Encrusting | Consolidated habitat | N/A | Coralline encrusting algae, e.g., *Lithothamnion glaciale* | 3 | 2 | 2 | **7** |
| MARINE PLANTS AND ALGAE | Subtidal | Non-vascular | Understory and turf | Moderate to low energy consolidated habitat | N/A | *Desmarestia aculeata, Desmarestia viridis, Euthora cristata, Petalonia fascia, Ulva intestinalis, Spongomorpha arcta (Acrosiphonia arcta)* | 3 | 2 | 2 | **7** |
| MARINE PLANTS AND ALGAE | Subtidal | Non-vascular | Encrusting | Consolidated habitat | N/A | Coralline encrusting algae, e.g., *Lithothamnion glaciale* | 3 | 2 | 2 | **7** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Porifera | Sponges [CL. Demospongiae, Calcarea] | 4 | 2 | 1 | **7** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Cnidaria | Colonial hydroids [Hydrozoa]; Stalked jellyfish [Staurozoa] | 4 | 2 | 1 | **7** |
| MARINE INVERTEBRATES | Intertidal | Sediment infauna | Low mobility | N/A | Arthropoda | Mud crab [Decapoda, Panopeidae]; Tube-building gammarid amphipods [Amphipoda] | 4 | 2 | 1 | **7** |
| MARINE INVERTEBRATES | Intertidal | Sediment epifauna | High mobility | N/A | Arthropoda | Crabs, Lobsters [Decapoda] | 4 | 1 | 2 | **7** |
| MARINE INVERTEBRATES | Intertidal | Sediment epifauna | Low mobility | N/A | Cnidaria | Starlet anemones, Sand anemones [Anthozoa] | 4 | 2 | 1 | **7** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment epifauna | Low mobility | N/A | Echinodermata | Sand dollars [Echinoidea]; Cushion stars, Mud stars [Asteroidea]; Sea cucumbers [Holothuroidea] | 3 | 2 | 2 | **7** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment infauna | Low mobility | N/A | Echinodermata | Sea cucumbers (e.g., *Caudina arenata*) [Holothuroidea] | 3 | 2 | 2 | **7** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Low mobility | N/A | Echinodermata | Sea stars [Asteroidea]; Sea urchins [Echinoidea]; Sea cucumbers [Holothuroidea] | 4 | 2 | 1 | **7** |
| MARINE INVERTEBRATES | Intertidal | Sediment epifauna | Low mobility | N/A | Mollusca | Nudibranchs [Gastropoda, Nudibranchia]; Snails [Gastropoda]; Scallops [Bivalvia] | 4 | 2 | 1 | **7** |
| MARINE INVERTEBRATES | Pelagic | LARVAE | | Cnidaria | | | 4 | 2 | 1 | **7** |
| MARINE INVERTEBRATES | Pelagic | LARVAE | | Worms | | | 4 | 2 | 1 | **7** |
| MARINE INVERTEBRATES | Pelagic | LARVAE | | Lophophorates | | | 4 | 2 | 1 | **7** |
| MARINE INVERTEBRATES | Pelagic | LARVAE | | Echinodermata | | | 4 | 2 | 1 | **7** |
| MARINE INVERTEBRATES | Pelagic | LARVAE | | Hemichordata | | | 4 | 2 | 1 | **7** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE INVERTEBRATES | Pelagic | LARVAE | | Arthropoda | | | 4 | 2 | 1 | **7** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Redfish (Sebastidae) | Acadian Redfish | 3 | 1 | 3 | **7** |
| MARINE FISHES | Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Clupeidae | Atlantic Herring, American Shad, Blueback Herring, Alewife | 3 | 2 | 2 | **7** |
| MARINE FISHES | Estuarine | Estuarine transient | Non-benthic (pelagic and demersal | N/A | Sticklebacks (Gasterosteidae) | Threespine Stickleback | 4 | 1 | 2 | **7** |
| MARINE MAMMALS | Cetaceans | Toothed | Dispersed | N/A | N/A | Harbour Porpoise, Sperm Whale, Cuvier's Beaked Whale, Sowerby's Whale, True's Beaked Whale, Blainville's Beaked Whale | 3 | 1 | 3 | **7** |
| MARINE PLANTS AND ALGAE | Epipelagic | Non-vascular | PHYTOPLANKTON | | | | 3 | 2 | 1 | **6** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Wolffishes (Anarhichadidae) | Atlantic Wolffish, Spotted Wolffish, Northern Wolffish | 2 | 1 | 3 | **6** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Worms | Tube worms [Polychaeta] | 4 | 2 | 0 | **6** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 4 | 2 | 0 | **6** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Mollusca | Oysters, Mussels [Bivalvia]; Snails [Gastropoda] | 4 | 2 | 0 | **6** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Hemichordata | Sea peaches, Sea squirts [Ascidiacea] | 4 | 2 | 0 | **6** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Arthropoda | Barnacles [CL. Hexanauplia] | 4 | 2 | 0 | **6** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Low mobility | N/A | Cnidaria | Anemones [Anthozoa] | 4 | 2 | 0 | **6** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | High mobility | N/A | Arthropoda | Crabs, Lobsters [Decapoda] | 4 | 1 | 1 | **6** |
| MARINE INVERTEBRATES | Intertidal | Sediment infauna | Low mobility | N/A | Worms | Sandworms, Lugworms, other burrowers [Polychaeta]; Nemertean worms [Paleonemertea]; Sipuncula worms [Sipunculidea]; Flatworms [Platyhelminthes] | 4 | 1 | 1 | **6** |
| MARINE INVERTEBRATES | Intertidal | Sediment epifauna | Low mobility | N/A | Arthropoda | Hermit crabs [Decapoda]; Sand fleas and other amphipods [Amphipoda]; Sea spiders [Pycnogonida]; Isopods [Isopoda] | 4 | 1 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Porifera | Boring sponges, Breadcrumb sponges, Encrusting sponges [CL. Demospongiae, Calcarea] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Cnidaria | Colonial hydroids [Hydrozoa]; Soft corals [Anthozoa]; Stalked jellyfish [Staurozoa] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Low mobility | N/A | Echinodermata | Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea]; Basket stars, Brittle stars [Ophiuroidea]; Sea urchins [Echinoidea] | 3 | 2 | 1 | **6** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Low mobility | N/A | Cnidaria | Anemones [Anthozoa]; Colonial hydroids [Hydrozoa] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment infauna | Low mobility | N/A | Cnidaria | Burrowing anemones [Anthozoa] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment infauna | Low mobility | N/A | Worms | Polychaete worms [Polychaeta]; Flatworms [Platyhelmintes]; Nemertean worms [Pilidiophora]; Peanut worms [Sipunculidea] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment infauna | Low mobility | N/A | Mollusca | Clams [Bivalvia] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment infauna | Low mobility | N/A | Arthropoda | Amphipods [Amphipoda, Cumacea] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment infauna | Low mobility | N/A | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment epifauna | Low mobility | N/A | Cnidaria | Anemones [Anthozoa] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment epifauna | Low mobility | N/A | Mollusca | Nudibranchs, Whelks, Moonsnails [Gastropoda]; Quahogs, Scallops [Bivalvia] | 3 | 2 | 1 | **6** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment epifauna | High mobility | N/A | Arthropoda | Crabs, Lobsters [Decapoda] | 3 | 1 | 2 | **6** |
| MARINE INVERTEBRATES | Pelagic | N/A | High mobility | N/A | Mollusca | Squid [Cephalopoda] | 4 | 1 | 1 | **6** |
| MARINE INVERTEBRATES | Pelagic | LARVAE | | Porifera | | | 4 | 1 | 1 | **6** |
| MARINE FISHES | Marine | Intertidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Snailfishes (Liparidae) | Atlantic Snailfish | 3 | 1 | 2 | **6** |
| MARINE FISHES | Marine | Intertidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Cryptacanthodidae | Wrymouth | 3 | 1 | 2 | **6** |
| MARINE FISHES | Marine | Intertidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Snailfishes (Liparidae) | Atlantic Snailfish | 3 | 1 | 2 | **6** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE FISHES | Marine | Intertidal | Non-benthic (pelagic and demersal) | N/A | Silversides (Atherinopsidae) | Atlantic Silverside | 4 | 1 | 1 | **6** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Flatfishes (Pleuronectidae) | Winter Flounder, Yellowtail Flounder, Atlantic Halibut, Windopane, American Plaice | 1 | 1 | 4 | **6** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Myxinidae | Atlantic Hagfish | 3 | 1 | 2 | **6** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Lophiidae | Monkfish | 2 | 1 | 3 | **6** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Lumpfishes (Cyclopteridae) | Atlantic Spiny Lumpsucker, Lumpfish | 3 | 1 | 2 | **6** |
| MARINE FISHES | Estuarine | Estuarine transient | Non-benthic (pelagic and demersal | N/A | Silversides (Atherinopsidae) | Atlantic Silverside | 4 | 1 | 1 | **6** |
| MARINE FISHES | Estuarine | Estuarine resident | Non-benthic (pelagic and demersal | N/A | Fundulidae | Mummichog | 3 | 1 | 2 | **6** |
| MARINE FISHES | Estuarine | Estuarine resident | Non-benthic (pelagic and demersal | N/A | Syngnathidae | Northern Pipefish | 3 | 1 | 2 | **6** |
| MARINE MAMMALS | Pinnipeds | Other pinnipeds | Discrete | N/A | N/A | Harbour Seal, Harp Seal | 3 | 1 | 2 | **6** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Low mobility | N/A | Worms | Bloodworms [Polychaeta]; Flatworms [Platyhelminthes]; Nemertean worms | 4 | 1 | 0 | **5** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Low mobility | N/A | Mollusca | Chitons [Polyplacophora]; Whelks, Limpets, Snails [Gastropoda] | 4 | 1 | 0 | **5** |
| MARINE INVERTEBRATES | Intertidal | Rock and rubble dwellers | Low mobility | N/A | Arthropoda | Amphipods [Amphipoda]; Isopods [Isopoda] | 4 | 1 | 0 | **5** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Worms | Tube worms [Polychaeta] | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Mollusca | Slipper limpets [Gastropoda]; Mussels, Oysters, Comb bathyarks [Bivalvia] | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Hemichordata | Ascidians (Tunicates, Sea squirts, Sea grapes) [Ascidiacea] | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | N/A | Arthropoda | Barnacles [CL. Hexanauplia] | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Low mobility | N/A | Worms | Ribbon worms [Hoplonemertea]; Polychaete worms [Polychaeta]; Flatworms [Platyhelminthes] | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | Low mobility | N/A | Mollusca | Nudibranchs, Whelks, Periwinkles [Gastropoda]; Scallops [Bivalvia] | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | High mobility | N/A | Arthropoda | Crabs, Lobsters [Decapoda] | 3 | 1 | 1 | **5** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE INVERTEBRATES | Pelagic | N/A | Low mobility | N/A | Cnidaria | Moon jellies [Scyphozoa]; Hydromesusae [Hydrozoa]; Jelly fish [Scyphozoa] | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Pelagic | N/A | Low mobility | N/A | Ctenophora | Comb jellies [CL. Nuda, Tentaculata] | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Pelagic | N/A | Low mobility | N/A | Zooplankton | Copepods, Mysids | 3 | 2 | 0 | **5** |
| MARINE INVERTEBRATES | Pelagic | LARVAE | | Ctenophora | | | 3 | 2 | 0 | **5** |
| MARINE FISHES | Marine | Intertidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Pout (Zoarcidae) | Ocean Pout | 2 | 1 | 2 | **5** |
| MARINE FISHES | Marine | Intertidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Pout (Zoarcidae) | Ocean Pout | 2 | 1 | 2 | **5** |
| MARINE FISHES | Marine | Intertidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Pholidae | Rock Gunnel | 2 | 1 | 2 | **5** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Skates (Rajidae) | Little Skate, Thorny Skate, Smooth Skate | 1 | 1 | 3 | **5** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Sculpins (Cottidae) | Shorthorn Sculpin, Longhorn Sculpin, Moustache Sculpin | 2 | 1 | 2 | **5** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Sculpins (Cottidae) | Snowflake Hookear Sculpin, Longhorn Sculpin, Shorthorn Sculpin | 2 | 1 | 2 | **5** |
| MARINE FISHES | Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Cod (Gadidae) | Atlantic Cod, Arctic Cod, Tomcod, Pollock | 2 | 1 | 2 | **5** |
| MARINE FISHES | Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Elasmobranchs | Shortfin Mako, Porbeagle, Blue Shark | 2 | 1 | 2 | **5** |

| Biological Group | FRAMEWORK SUB-GROUPS | | | | | Maritime example species | Exposure Score (/4) | Sensitivity Score (/2) | Recovery Score (/4) | Total Vulnerability Score (/10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | | | | | |
| MARINE FISHES | Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Salmon (Salmonidae) | Atlantic Salmon | 1 | 1 | 3 | **5** |
| MARINE FISHES | Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Scombridae | Atlantic Mackerel, Atlantic Bluefin Tuna | 2 | 2 | 1 | **5** |
| MARINE FISHES | Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Osmeridae | Rainbow Smelt, Capelin | 3 | 1 | 1 | **5** |
| MARINE INVERTEBRATES | Subtidal benthic | Rock and rubble dwellers | High mobility | N/A | Mollusca | North Atlantic Octopus [Cephalopoda] | 2 | 1 | 1 | **4** |
| MARINE INVERTEBRATES | Subtidal benthic | Sediment epifauna | Low mobility | N/A | Worms | Sea Mouse [Polychaeta] | 2 | 1 | 1 | **4** |
| MARINE FISHES | Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Pout (Zoarcidae) | Ocean Pout | 1 | 1 | 2 | **4** |
| MARINE FISHES | Estuarine | Estuarine transient | Non-benthic (pelagic and demersal | N/A | Petromyzontidae | Sea Lamprey | 3 | 1 | 0 | **4** |

## 5.2. VULNERABILITY TRENDS

Shown in Figure 5A, total vulnerability scores across all sub-groups ranged from 3 (1 sub-group) to 9 (9 sub-groups), with a mode vulnerability score of 6 (37 sub-groups). In all, 54.3% of sub-groups received a total vulnerability score of 5 or 6.

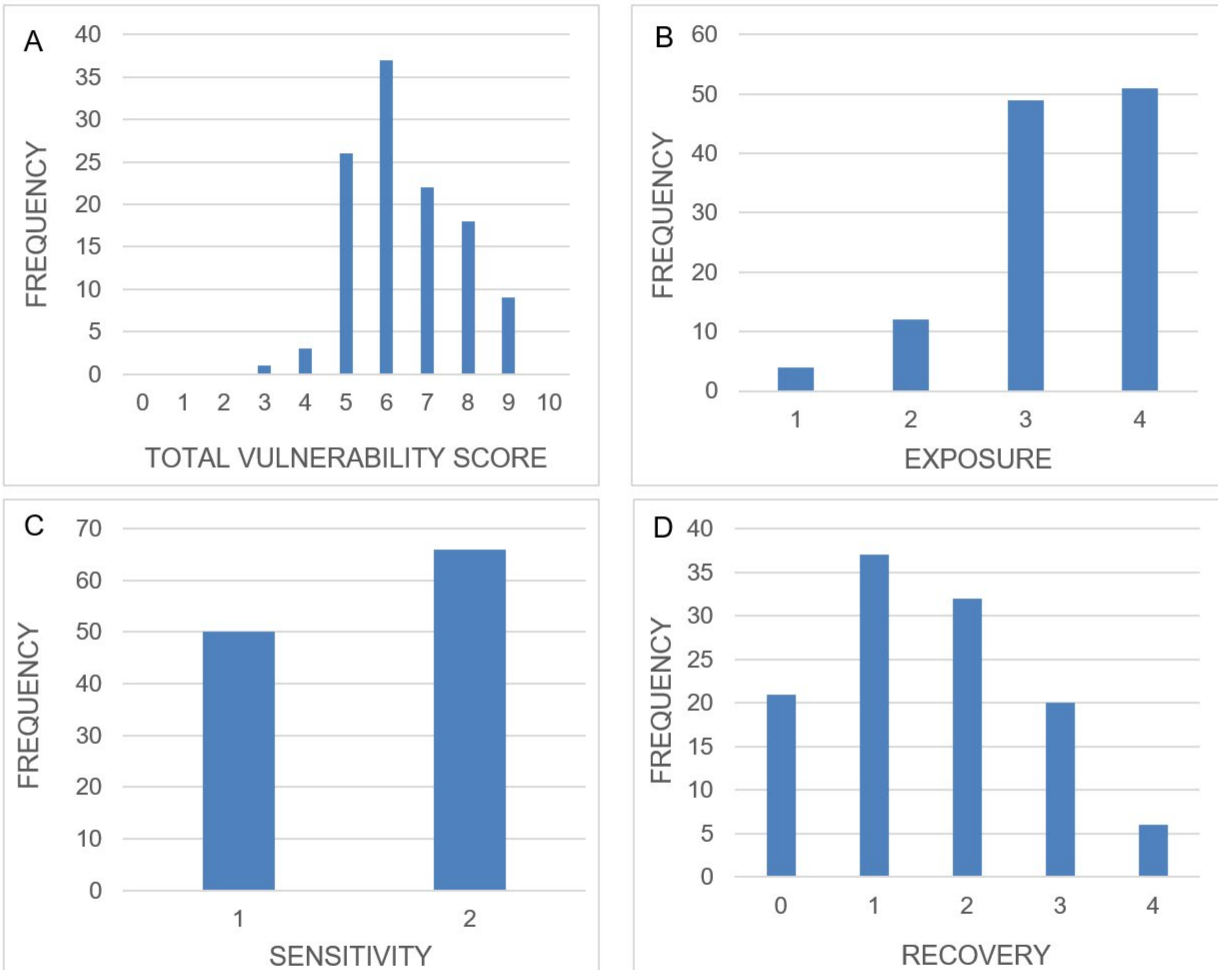


*Figure 5. Summary vulnerability scoring results showing; A) total vulnerability score frequency; B) Exposure category score frequency; C) Sensitivity category score frequency; and D) Recovery score frequency across all sub-groups.*

When considering the Exposure category and the distribution of Exposure scores across all sub-groups (Figure 5B), 86% sub-groups scored 3 or 4 in this category (100/116), with four sub-groups scoring a 1. Note that no sub-groups received a 0 in this category, hence there were no screened out sub-groups.

The distribution of Sensitivity category scores across all sub-groups (Figure 5C) shows that 50 sub-groups (43%) scored a 1 in this criterion, while 66 (57%) scored a 2, where a 2 indicates that both the mechanical and chemical toxicity criterion were fulfilled in this category. Note that no sub-groups received a 0 in this category, meaning that no sub-groups were screened out at this level.

The distribution of Recovery category scores across all sub-groups (Figure 5D) illustrates that of 116 sub-groups; 21 (18.1%) scored a 0; 37 (31.9%) scored a 1; 32 (27.6%) scored a 2; 20 (17.2%) scored a 3; and 6 (5.2%) scored a 4.

### 5.2.1. High-level Group Vulnerability

Of the high-level biological groups, Marine Plants and Algae shows the highest (7.9) mean vulnerability score, followed by Marine Mammals (7.67), Marine Fishes (6.19), and Marine Invertebrates (6.07) (Figure 6). Note that Marine Reptiles, which contained only a one sub-group (received an 8), is not comparable to the mean of others, and is not shown in Figure 6.

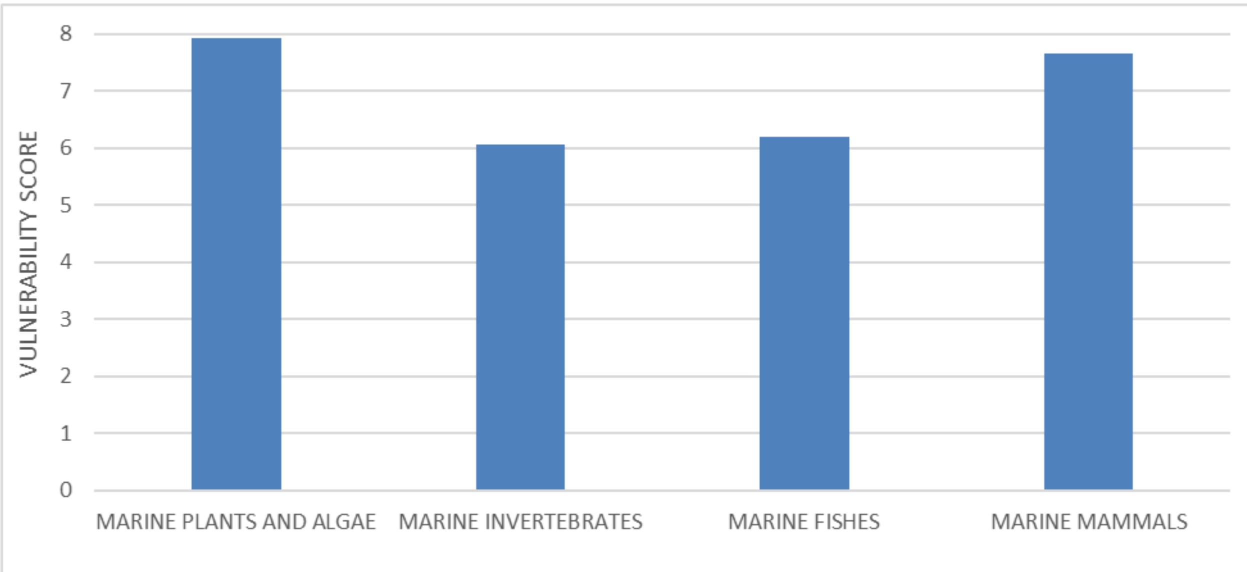


*Figure 6. Mean total Vulnerability Score across all categories for each high-level biological group. Note that Marine Reptiles are not represented here.*

### 5.2.2. Marine Plants and Algae Group

The Marine Plants and Algae grouping received a mean total vulnerability score of 7.9 (Figure 6). When individual vulnerability criteria scores were averaged across all sub-groups, Marine Plants and Algae received a mean score of 3.64 (of 4), 2.0 (of 2.0), and 2.28 (of 4) in Exposure, Sensitivity, and Recovery categories, respectively (Figure 7).

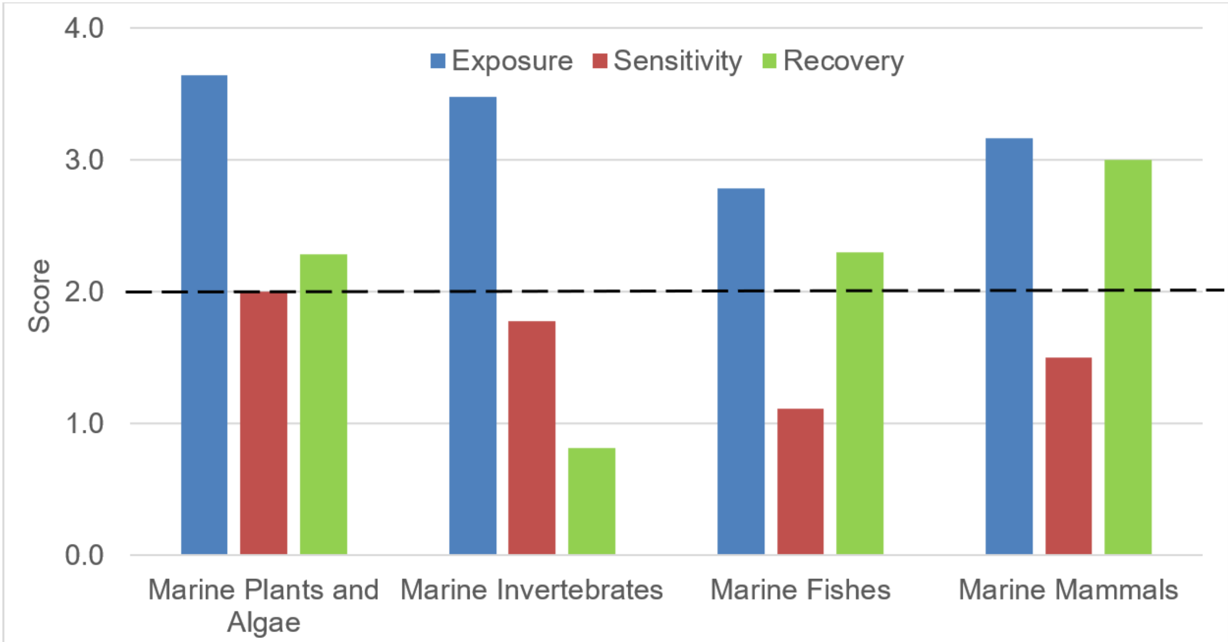


*Figure 7. Mean score for each Vulnerability Category (Exposure, Sensitivity, Recovery) across sub-groups by high level biological group. Dashed line represents the maximum vulnerability score for Sensitivity.*

When examining the mean vulnerability score by category at sub-group level 1, the Exposure category contributes the most to the total vulnerability score in each Epipelagic (Phytoplankton) (3), Intertidal (3.75), and Subtidal (3.6) sub-groups (Figure 8A). All sub-groups in the Marine Plants and Algae high level group received a 2 in the Sensitivity category. In the Recovery category, the Epipelagic sub-group (Phytoplankton) received a 1, the Intertidal sub-group received a 2.63, and the Subtidal sub-group received a 2.

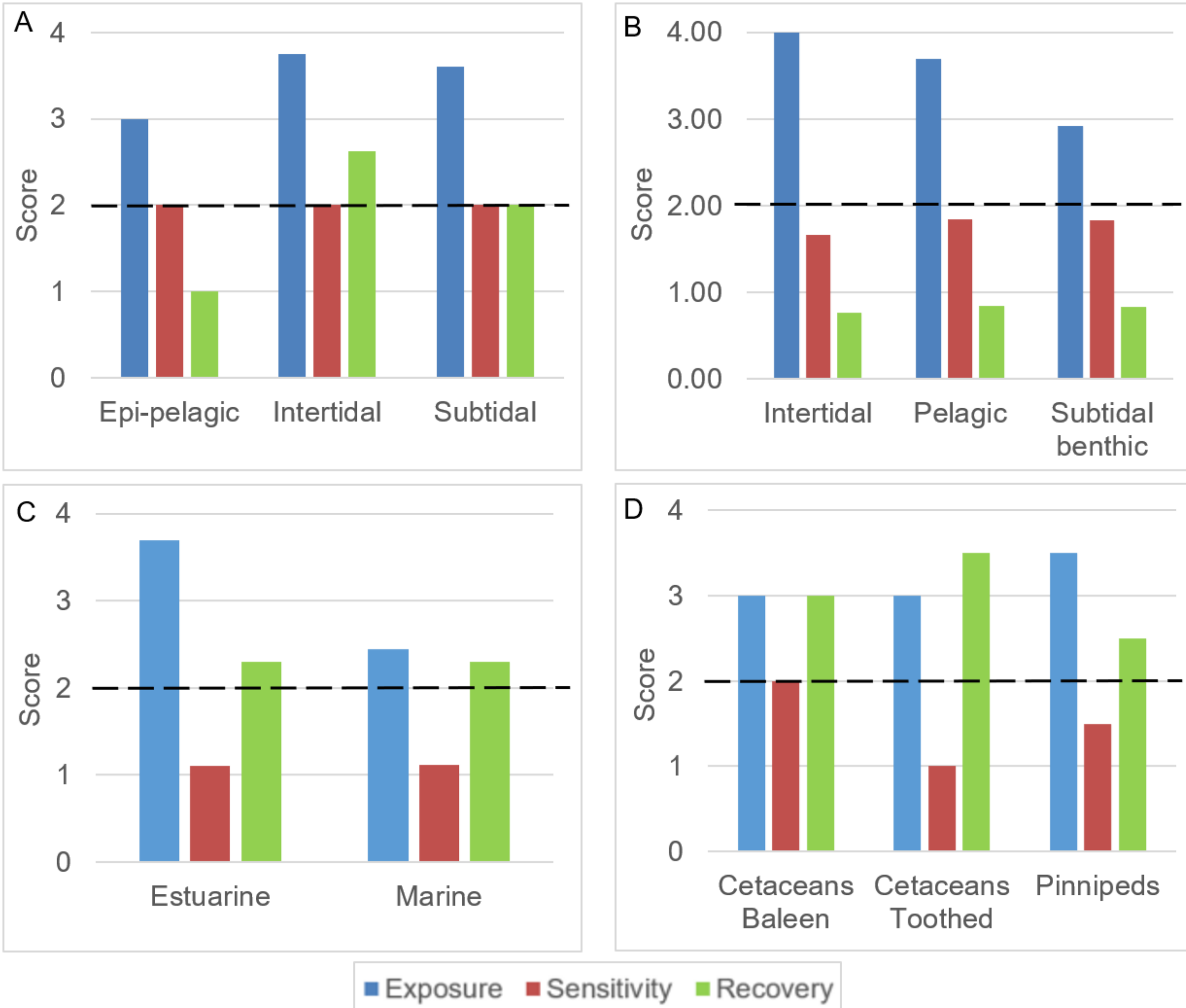


*Figure 8. Mean Exposure, Sensitivity and Recovery category score for A) Marine Plants and Algae sub-group level 1; B) Marine Invertebrate sub-group level 1; C) Marine Fishes sub-group level 1; and C) Marine Mammals sub-group level 2. Dashed line represents the maximum vulnerability score for Sensitivity.*

### 5.2.3. Marine Invertebrates Group

The Marine Invertebrates grouping received a mean total vulnerability score of 6.07 (Figure 6). When individual vulnerability criteria scores were averaged across all sub-groups, Marine Invertebrates received a mean score of 3.5 (of 4), 1.8 (of 2.0), and 0.81 (of 4) in Exposure, Sensitivity, and Recovery categories, respectively (Figure 7).

When examining the mean vulnerability score by category at sub-group level 1, the Exposure category contributes the most to the total vulnerability score in each Intertidal (4), Pelagic (3.7), and Subtidal benthic (2.9) sub-groups (Figure 8B). The Marine Invertebrates sub-groups (Level 1), received a 1.6 (Intertidal), 1.8 (Pelagic) and 1.8 (Subtidal benthic) in the Sensitivity category. In the Recovery category, the Intertidal sub-group received a 0.76, the pelagic sub-group received a 0.85, and the Subtidal benthic sub-group received a 0.83.

### 5.2.4. Marine Fishes Group

The Marine Fishes grouping received a mean total vulnerability score of 6.19 (Figure 6). When individual vulnerability criteria scores were averaged across all sub-groups, Marine Fishes received a mean score of 2.8 (of 4), 1.1 (of 2.0), and 2.3 (of 4) in Exposure, Sensitivity, and Recovery categories, respectively (Figure 7).

When examining the mean vulnerability score by category at sub-group level 1, the Exposure category contributes the most to the total vulnerability score in each Estuarine (3.7) and Marine (2.4) sub-groups (Figure 8C). The Marine Fishes sub-groups (Level 1), received a 1.1 (Estuarine) and 1.1 (Marine) in the Sensitivity category. In the Recovery category, the estuarine sub-group received a 2.3 and the Marine sub-group received a 2.3.

### 5.2.5. Marine Mammals Group

The Marine Mammals grouping received a mean total vulnerability score of 7.67 (Figure 6). When individual vulnerability criteria scores were averaged across all sub-groups, Marine Mammals received a mean score of 3.2 (of 4), 1.5 (of 2.0), and 3 (of 4) in Exposure, Sensitivity, and Recovery categories, respectively (Figure 7).

In the Marine Mammals, the mean vulnerability score by category was examined at sub-group level 2 (Figure 8D). The Marine Mammals sub-groups (Level 2), received a mean Exposure score of 3 (‘Cetaceans – Baleen’), 3 (‘Cetaceans – Toothed’), and 3.5 (‘Pinnipeds’).The Marine Mammals sub-groups (Level 2), received a mean Sensitivity score of 2 (‘Cetaceans – Baleen’), 1 (‘Cetaceans – Toothed’), and 1.5 (‘Pinnipeds’). In the Recovery category, the ‘Cetaceans – Baleen’ sub-group received a 3, the ‘Cetaceans – Toothed’ sub-group received a 3.5, and the ‘Pinnipeds’ sub-group received a 2.5.

## 5.3. PRECAUTIONARY SCORING OVERVIEW

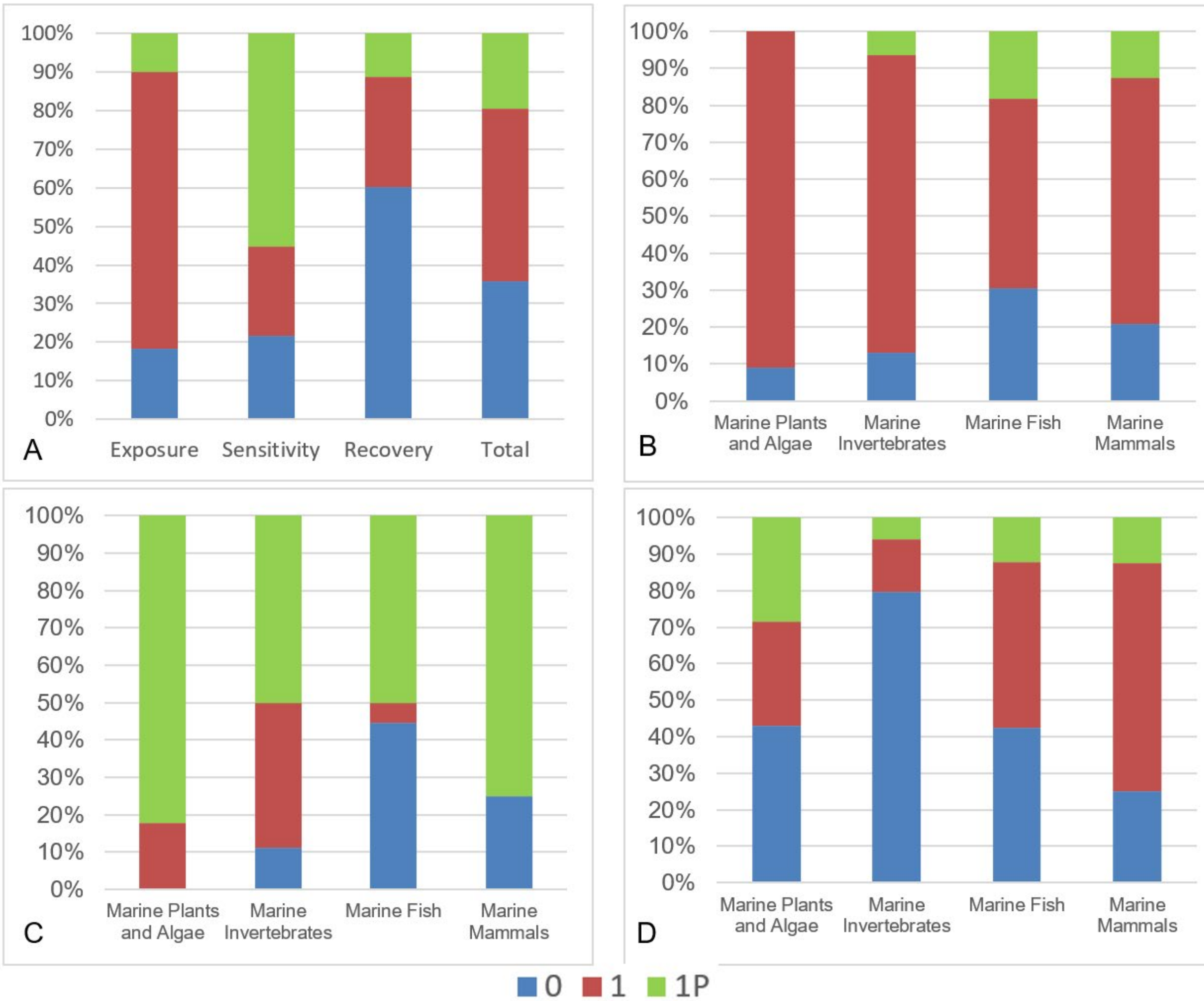


*Figure 9. Proportion of assigned scores (0 = not fulfilled, 1 = fulfilled, 1P = fulfilled (precautionary)) A) by vulnerability category across all sub-groups; and by high-level biological grouping for B) Exposure; C) Sensitivity; and D) Recovery.*

An overview of the use of precautionary scoring (1P) as applied in the Maritimes application can be seen in Figure 9. A precautionary approach was used when there was an increased level of uncertainty, or limited or conflicting information to support a binary score (1 or 0) for the sub-group. Overall, across the entire application, a precautionary score was used 19% of the time, with 81% of the scoring being supported by definitive justifications and grounded in science (Figure 9A 'Total'). Degree of use of precautionary scoring differed among scoring criteria and between high-level groups. While there was limited use of the 1P score in the Exposure and Recovery categories (10% and 11%, respectively), the proportion of use in the Sensitivity category was 55% (Figure 9A). A precautionary score in the Sensitivity category was used between 50% (Marine Invertebrates, Marine Fish), and 82% of the time (Marine Plants and Algae, Figure 9C); while the Exposure and Recovery between 0% (Marine Plants and Algae: Exposure category, Figure 9B), and 29% (Marine Plants and Algae: Recovery category, Figure 9D).

## 5.4. DUPLICATE SPECIES AND VULNERABILITY

In some cases, sub-groups exhibited physiological characteristics enabling them to span differing habitats. It was important to determine the vulnerability score for the same sub-group in **all** habitats to ascertain the effect of a large habitat range on overall scoring. Some may consider this a "duplication", though it provides some interesting nuance to the vulnerability of a species.

The following tables illustrate examples of how a change in habitat can change vulnerability score for the same sub-group in Marine Plants and Algae Group (Table 17), while having no effect on other sub-groups (Table 18). The same is illustrated for the Marine Fishes Group in Table 19 and Table 20.

*Table 17. Showing that plant species that span different sub-groups may receive different vulnerability scores.*

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Maritime example species | EXPOSURE | SENSITIVITY | RECOVERY | Total Vulnerability Score |
|---|---|---|---|---|---|---|---|---|
| Intertidal | Non-vascular | Canopy | High energy consolidated habitat | *Alaria esculenta, Laminaria digitata, Saccharina latissima* | 3 | 2 | 3 | 8 |
| Subtidal | Non-vascular | Canopy | High energy consolidated habitat | | 4 | 2 | 2 | 8 |
| Subtidal | Non-vascular | Understory and turf | High energy consolidated habitat | *Chondrus crispus, Chorda tomentosa, Desmarestia viridis, Euthora cristata, Furcellaria lumbricalis* | 4 | 2 | 2 | 8 |
| Intertidal | Non-vascular | Understory and turf | High energy consolidated habitat | | 4 | 2 | 3 | 9 |

*Table 18. Showing that plant species spanning different sub-groups many not always receive different scores.*

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Maritime example species | EXPOSURE | SENSITIVITY | RECOVERY | Total Vulnerability Score |
|---|---|---|---|---|---|---|---|---|
| Intertidal | Non-vascular | Encrusting | Consolidated habitat | Coralline encrusting algae, e.g., *Lithothamnion glaciale* | 3 | 2 | 2 | 7 |
| Subtidal | Non-vascular | Encrusting | Consolidated habitat | | 3 | 2 | 2 | 7 |

*Table 19. Showing that fish species that span different sub-groups (Estuarine and Marine) may receive different vulnerability scores (N/A = not applicable).*

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | Maritime example species | EXPOSURE | SENSITIVITY | RECOVERY | Total Vulnerability Score |
|---|---|---|---|---|---|---|---|---|---|
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal | N/A | Salmon (Salmonidae) | Atlantic Salmon | 4 | 1 | 3 | 8 |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Salmon (Salmonidae) | Atlantic Salmon | 1 | 1 | 3 | 5 |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Clupeidae | Atlantic Herring, American Shad, Blueback Herring, Alewife | 3 | 2 | 2 | 7 |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal | N/A | Clupeidae | American Shad, Blueback Herring, Alewife | 4 | 2 | 2 | 8 |
| Estuarine | Estuarine transient | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 4 | 1 | 4 | 9 |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 3 | 1 | 4 | 8 |

*Table 20. Showing that fish species spanning different sub-groups many not always receive different total scores (N/A = not applicable).*

| Sub-group Level 1 | Sub-group Level 2 | Sub-group Level 3 | Sub-group Level 4 | Sub-group Level 5 | Maritime example species | EXPOSURE | SENSITIVITY | RECOVERY | Total Vulnerability Score |
|---|---|---|---|---|---|---|---|---|---|
| Marine | Intertidal | Non-benthic (pelagic and demersal) | N/A | Silversides (Atherinopsidae) | Atlantic Silverside | 4 | 1 | 1 | 6 |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal | N/A | Silversides (Atherinopsidae) | Atlantic Silverside | 4 | 1 | 1 | 6 |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Eels (Anguillidae) | American Eel | 4 | 1 | 3 | 8 |
| Estuarine | Estuarine transient | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/gravel) | Eels (Anguillidae) | American Eel | 4 | 1 | 4 | 9 |

# 6. DISCUSSION

A National framework to assess the vulnerability of marine biological components to ship-source oil spills in Canada, was developed in 2017. For validation purposes, the National model required testing in a variety of marine aquatic environments across Canada. Applications of the National model were previously completed for the Pacific Region (Hannah, et al. 2017), as well as in the Quebec Region (Desjardins, et al. 2018). This research document describes how the National framework was applied to marine biological components in the Maritimes Region.

The framework identified two key phases for assessing vulnerabilities of marine biological components: 1) grouping the biological components into related sub-groups based on shared characteristics; and 2) subsequently scoring the sub-groups against ecological vulnerability criteria. While the architecture of the main framework was generally used in the Maritimes application, some modifications were made to enhance sub-group differentiation and criteria application as previously discussed.

## 6.1. VULNERABLE SUB-GROUPS

### 6.1.1. Marine Plants and Algae

Marine plants an algae had a mean vulnerability score of 7.93 in the Maritimes application.

Results indicate that within the Marine Plants and Algae group, the most vulnerable sub-groups to oil are the intertidal vascular plants that comprise saltmarshes. All non-vascular plant sub-groups ranked in the top 10 of all sub-groups (116) in overall vulnerability rankings, with saltmarsh grasses ranking the highest at a 9 (Table 16). Seagrasses, saltmarsh-non grasses and saltmarsh succulents scored 8.

These findings are consistent with other studies examining the effect of oil-spills on saltmarsh plant communities. The *Deepwater Horizon* oil spill in 2010, induced nearly 100% plant mortality in heavily oiled coastal marshes dominated by saltmarsh grasses, including *Spartina alterniflora,* with plants dying as a direct result of smothering, the alteration of the soil, and toxic effects (Fleeger et al. 2018). Saltmarshes can also be slow to recover after a spill, as destruction of salt marsh communities by oil can result in increased erosion, which can impede the recolonization and recovery of the saltmarsh plants in general (Hester et al. 2016). Additionally, *Spartina alterniflora* mortality has been shown to have negative effects on the recovery of other species (such as macroalgae and meiofauna) after an oil spill (Fleeger et al. 2015). This is not surprising considering the ecological services provided by saltmarshes for other species including the provision of habitat and nutrients.

While many short-term studies on the effects of oil have been conducted, the overall and long-term impacts to vascular plants likely depend on a number of factors including the severity of fouling and the extent of damage to underground structures (roots and rhizomes).

The physiological characteristics that enable them to span different habitats can drive differences in vulnerability scores for non-vascular plant sub-groups. In this application, intertidal sub-groups located on rocky consolidated habitats scored higher than subtidal components in overall vulnerability. Understory and turf species in the intertidal zone (e.g., *Chondrus crispus)*, were the most vulnerable sub-groups therein. This score is driven by the fact that these species can be aggregated in the intertidal zone, and have regular interaction with both the sea surface and seafloor as the tide changes, while subtidal species would not be expected to have such interactions.

Relatedly, *Alaria esculenta* can be found in both the intertidal and subtidal zones (Table 17). In the intertidal, *Alaria esculenta* receives a vulnerability score of 3, rather than a 4 in the Exposure category, because when found in the intertidal, it is not generally found in aggregations, as it is in the subtidal. Additionally, *Alaria esculenta* can be found in close association with unconsolidated substrate in the intertidal, as it may come into frequent contact with sand/mud/silt/gravel when the tide goes out whereas in the subtidal zone, this is not the case. Studies on the effects of oil spills on subtidal algae, have found some instances of rapid recovery or lessened effects of oil on some subtidal macroalgae species (e.g., kelps) (Pecko et al. 1990).

Phytoplankton is presented as a single epipelagic sub-group, representative of all regional species. While acknowledging that phytoplankton are taxonomically diverse and the limitations of this approach, breaking phytoplankton into further sub-groups would be unmanageable in the current application. All phytoplankton subsequently have a total vulnerability score of 6. This moderate vulnerability score was primarily driven by the higher reproductive capacity exhibited by this sub-group as a whole. Perhaps further iterations of the framework could be expanded to include phytoplankton taxonomic breakdowns.

For detailed justifications on scoring decisions for this high-level biological group, see Appendix 1, Tables A1, A2, and A3.

### 6.1.2. Marine Invertebrates

Marine invertebrates had a mean vulnerability score of 6.07 in the Maritimes application.

A relatively high overall vulnerability score for invertebrate groups in general is aligned with other work examining the post oil-spill impacts on marine invertebrate biota. Dupuis and Ucan-Marin (2015) state that bivalves and other filter feeders are very sensitive to crude oil as they ingest oil droplets as they feed. Clam and mussel communities were found to be still recovering 20 years after the *Exxon Valdez* oil spill, and intertidal invertebrate meiofauna are one of the slowest groups to recover after a spill (Fleeger et al. 2015).

For marine invertebrates, sediment infaunal Mollusca with low mobility (e.g., clams and other bivalves, gastropods) had a total vulnerability score of 9 in this application. Mollusca larvae were also considered more vulnerable than other larval types (also at a 9) (Table 16). Both scores were likely elevated because the Marine Invertebrates group contained a species at risk that is isolated in the Maritimes Region (Mud piddock).

Intertidal, sessile and low mobility groups (including Mollusca, Echinodermata and Cnidaria) all scored a 7 for vulnerability. This aligns with scientific evidence that intertidal invertebrate communities are highly affected by, and are slow to recover from the impacts of oil spills (Duval et al. 1989).

Most subtidal benthic invertebrates scored a 6, which was likely related to the decrease in exposure compared to intertidal species in the same group. Highly mobile and pelagic invertebrates (e.g., squid, octopus, lobsters) had lower vulnerability scores of between 4 and 6, due to the fact they are assumed to be more mobile, and hence can escape an oil spill.

Besides Mollusca previously described, most invertebrate larvae scored a 7, higher than its adult life stage, revealing that the larval forms represent a more vulnerable life stage in those groups (Ctenophore and Porifera larvae scored the same as their adult stages).

For detailed justifications on scoring decisions for this high-level biological group, see Appendix 2, Tables A4, A5, and A6.

### 6.1.3. Marine Fishes

The Marine Fishes group had a mean vulnerability score of 6.19 in the Maritimes application.

In the Maritimes Regional application of the framework, estuarine sub-groups were more vulnerable on average than marine sub-groups, receiving an average total vulnerability score of 7.1 and 5.85 respectively. This difference was primarily driven by differences in the Exposure category, with estuarine sub-groups receiving a mean score of 3.7, and marine sub-groups receiving a mean score of 2.4. Estuarine sub groups were generally considered to interact more with the sea surface than marine sub-groups, and were more likely (on average) to concentrate or aggregate for a purpose (e.g., spawning).

Eleven sub-groups in the Marine Fishes scored between a 7 and 9 for overall vulnerability to oil (Table 6). Six of these sub-groups were estuarine while 5 were Marine. The two sub-groups with the highest vulnerability to oil (9) were the estuarine life stage of Sturgeon (Acipenseridae), associated with both consolidated and unconsolidated substrates.

All but four sub-groups in the Marine Fishes scored a 1 in sensitivity. This low number of sub-groups receiving a 2 in sensitivity was expected as the mechanical sensitivity criterion only measures mechanical impairment or fouling of feeding structures, and few marine fish species have structures that may be easily fouled. The sub-groups receiving a 2 in sensitivity were 'Sticklebacks (Gasterosteidae) (Marine-Intertidal)', 'Clupeidae (Marine and Estuarine)' and 'Scombridae (Marine)', all of which contain species that feed using gill-rakers.

The Marine Fishes biological grouping illustrates the importance of considering different life stages of diadromous fish and their associated sub-groups, as many received a higher score for the estuarine life-stage than the marine (Table 19). For example, the estuarine transient sub-group 'Salmon (Salmonidae)' received a total vulnerability score of 8, while the marine sub-group 'Salmon (Salmonidae)' received a 5. This particular instance was driven by differences in the Exposure category, as the marine life-stage of Atlantic Salmon are not expected to aggregate for a specific reason, are expected to have higher mobility and are not expected to interact with the seafloor.

However, life-stage and habitat factors may not be driving vulnerability differences in all diadromous fishes, as other diadromous sub-groups can have the same total score (and same category score), such as the 'Silversides (Atherinopsidae)' in marine and estuarine sub-groups (total vulnerability score of 6) (Table 20).

For detailed justifications on scoring decisions for this high-level biological group, see Appendix 3, Tables A7, A8, and A9.

### 6.1.4. Marine Mammals

The Marine Mammals group had a mean vulnerability score of 7.67 in the Maritimes application (the highest mean score for any group).

While the habits and life histories of marine mammals make them vulnerable to the effects of ship-source oil spills, specific research is lacking for this group overall.

Mammals can be impaired by oil in different ways. Contact with oils can lead to long-term coating of the body surface, which may interfere with swimming ability in seals, with filtering capabilities by baleen whales, and with thermoregulation in the furred marine mammals. Pathways to exposure in seals can include absorption of oil through their skin and gastrointestinal tract and inhalation (Englehardt 1983).

Five of six Marine Mammal sub-groups scored between 7 and 9 for overall vulnerability to oil in this application (Table 16). Ranking the highest was the dispersed pinnipeds (Grey seal, Ringed seal, Bearded seal, Hooded seal) sub-group, with cetaceans (toothed and baleen) scoring just below them, at 7–8.

Dispersed pinnipeds were considered more vulnerable in this application because they have an on-land component to their behaviour (e.g., haul out areas for resting and reproduction); are known bottom feeders who will interact with benthic sediments; and have a species listed as "special Concern' by COSEWIC (Ringed seal). Discrete pinnipeds, while sharing the on-land component, are primarily pelagic feeders, and do not have any COSEWIC listing in the Maritimes Region and hence scored lower.

Some toothed whales scored higher than baleen counterparts for vulnerability. This was unexpected and was driven by both the fact that there are endangered/special concern species (e.g., Northern bottlenose whale, Sowerby's beaked whale) and endemic/isolated populations (e.g., Northern bottlenose whale) in this group.

All cetaceans were considered highly mobile and therefore scored a 0 in the mobility criterion. However, this criterion may be slightly simplified in the current framework. In Marine Mammals, vulnerability to oil can be complicated by the assumption that they may not have the ability to avoid or detect oil on water or in food, despite being highly mobile. Seals have not been shown to consistently avoid oil (Englehardt 1983); and Goodale et al., (1982) indicated that a broad range of cetacean species (humpback whales, fin whales, white-sided dolphins) did not actively avoid a slick of Bunker C and No. 2 fuel oil from the *Regal Sword* spill. Marine mammals were therefore likely underscored in the Exposure category in this application.

For detailed justifications on scoring decisions for this high-level biological group, see Appendix 4, Tables A10, A11, and A12.

### 6.1.5. Marine Reptiles

Three sea turtle species comprise the Marine Reptiles group in the Maritimes Region. Marine Reptiles scored high in the Exposure and Recovery categories, producing an overall vulnerability score of 8 (Table 16).

Although Sea turtles are migratory visitors to offshore waters in the Atlantic, Dodge et al. (2014) determined that Leatherbacks were highly aggregated in temperate shelf and slope waters during summer, early fall, and late spring in the Northwest Atlantic. Also, this sub-group will have regular surface and sediment interactions for breathing and feeding. Combined with a COSEWIC endangered status for both the Loggerhead and Leatherback sea turtles, and low reproductive capacity, the sea turtle sub-group was defined by the framework as being very vulnerable to oil spills in the Maritimes Region.

For detailed justifications on scoring decisions for this high-level biological group, see Appendix 5, Tables A13, A14, and A15.

## 6.2. BOTTOM UP APPROACH

The National vulnerability framework recommended that sub-groups be populated with species after scoring was completed. However, inherent in this approach is uncertainty around the assumption that the species assigned to a sub-group in a rapid application are truly representative of the defined sub-group. This uncertainty is further compounded by assuming that the assigned score is applicable to all species in the sub-group.

From the outset, the Maritimes Region application utilized a bottom up approach to populating sub-groups. This approach lessened uncertainty while increasing confidence that the sub-groups contained appropriate species; and that species biological and ecological traits were used to develop the sub-group levels used.

Sub-groups were pre-populated with as many species as could be verified using a wide variety of sources. This approach increased confidence that the species scored had characteristics that were representative of the majority of other species within their sub-group, and decreased the likelihood that a score was based on a species that was the exception to the rule.

## 6.3. UNCERTAINTY, PRECAUTIONARY SCORING AND KNOWLEDGE GAPS

A key result of the Maritimes application of the National vulnerability framework, was the identification of sources of scoring uncertainty that created knowledge gaps.

Lack of knowledge or conflicting information arose during the two main stages of the application process:

1. Creation of sub-groups
2. Scoring sub-groups against vulnerability criteria

One of the goals of the Maritimes Region application was to minimize sources of uncertainty. This was accomplished by using a bottom up approach to sub-group creation (previously discussed), and by performing in-depth literature searches for justifications to lessen the reliance on precautionary scoring. By employing these principles, the Maritimes Region assigned a precautionary score only 19% of the time (across all 116 sub-groups).

Where the literature did not support a binary score (0, 1) directly, a deeper review into difficult to score sub-groups was undertaken with a synthesized ‘state of knowledge’, provided as a justification to explain why a precautionary score was warranted.

While this approach took time to develop, the Maritimes Regional application of the National framework to assess the vulnerability of biological components to ship source oil spills provides responders with an objective list of vulnerable sub-groups, allowing them to make rapid and accurate decisions that are grounded in science.

Despite the comprehensive approach to sub-group creation and scoring that was used in the Maritimes Region application, some knowledge gaps were uncovered during its development.

Major gaps included:

- Lacking or conflicting information on chemical toxicity across all sub-groups limited the ability to adequately score this criterion. Since oil is believed to be toxic to all organisms at some level, all sub-groups were scored a 1P for this criterion, meaning that chemical toxicity cannot be used to distinguish between sub-group vulnerabilities as the criterion is defined.
- There was a dearth of specific biological information (e.g., life history, habitat types) for some groups. This was especially evident for some invertebrate and fishes sub-groups.
- Some scoring criteria were too narrow to score sub-groups adequately. This was evident in the mechanical sensitivity scoring. While the approach was needed to differentiate between sub-groups, its definition may be too limited in scope and likely caused some groups to be underscored (e.g., fish without gill rakers for feeding were scored a 1 but have other structures that could become clogged with oil (e.g., gills)).

- There is limited information on the effect of developmental life stage on vulnerability to oil. In this application, results were reported on the most vulnerable life stage where possible, but an overall lack of information was evident.

## 7. CONCLUSIONS AND RECOMMENDATIONS

- In the Maritimes application, sub-groups were created in a bottom-up manner using verified species lists prior to scoring (unlike the National framework where sub-groups would be populated after scoring).
- Some sub-groups required significant changes in the Maritimes application (e.g., Marine Plants and Algae and Marine Fishes) while other groups were changed very little from the National framework (e.g., Marine Invertebrates).
- Sub-groups created in the Maritimes application were sufficient to represent the suite of Maritimes Region biota and provided the necessary delineation for effective scoring against vulnerability criteria in most cases.
- While the National framework recommended that vulnerability criteria not be changed (in order to make direct comparisons across regions straightforward), during this application there were a number of general, and sub-group specific modifications, expounding on the vulnerability criteria as they were specifically applied. These small changes were necessary to improve understanding of the Maritimes application in general and did not affect the National criteria as proposed.
- At present the sensitivity criterion ‘impairment due to toxicity’ is not effective to differentiate between sub-groups; and while the mechanical sensitivity criterion allows for further breakdown, the three conditions it presents may be too narrow, increasing the potential for underscoring. Further development of the Sensitivity category is needed.
- The binary screening method described in the National application was retained in the Maritimes application, but scores were based on a total across all criteria and not just their recovery score as was presented in the National model.
- The Maritimes application did not screen out any sub-groups.
- Phytoplankton, zooplankton and most vulnerable life stages were not adequately assessed in sufficient resolution in this application and need further development.
- The application provided a valid list for all Maritimes Region sub-groups ranked by total vulnerability to ship-source oil spills, which will be use to inform response efforts.

# 8. REFERENCES


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# APPENDIX 1. DETAILED SCORING TABLES WITH JUSTIFICATIONS FOR MARINE PLANTS AND ALGAE

*Table A1. Marine plants and algae sub-group scores for EXPOSURE scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps).*

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Seagrasses | *Ruppia maritima, Zostera marina* | 1 | Seagrasses can form extensive beds which support high-levels of biodiversity (Short et al. 2007). *Zostera marina* will frequently grow in concentrated single species stands as well as in large beds with *Ruppia maritima* (Green and Short 2003). | 1 | All plants are immobile. | 1 | By definition, intertidal species will interact with the sea surface. Primary habitat for *Zostera marina* is mid-low intertidal and shallow subtidal, down to depths of 1–2 meters (Green and Short 2003), and would be expected to interact with the sea surface. | 1 | Seagrasses have underground root and rhizome systems that are rooted in unconsolidated substrates (Hemminga 1998). |
| | | | | Saltmarsh grass | *Carex paleacea, Juncus gerardii, Juncus caesariensis, Puccinellia maritima, Spartina alterniflora* | 1 | Members of this sub-group form dense mixed colonies along shoreline salt marshes and brackish meadows (Hinds 2000). *Spartina alterniflora* (Long and Mason 1983) and *Puccinellia maritima* (Roman 2001) often dominate the lower salt marsh zone, while *Carex paleacea*, is commonly the dominant species in the high marsh (Roberts and Robertson 1986, Hatcher and Patriquin 1981). | 1 | All plants are immobile. | 1 | By definition, intertidal species will interact with the sea surface. | 1 | Vascular plants are rooted in unconsolidated substrates. |
| | | | | Saltmarsh non-grass | *Achillea millefolium, Plantago maritima, Limonium carolinianum, Triglochin maritimum* | 1 | Members of this sub-group contain genera very common in saltmarshes as well as saline or brackish areas in the Maritimes Region, often forming dense hummocks (*Achillea millefolium* – Warwick and Black 1982, *Plantago maritima* – Hinds 2000, *Limonium carolinianum* – Long and Mason 1983). | 1 | All plants are immobile. | 1 | By definition, intertidal species will interact with the sea surface. | 1 | Vascular plants are rooted in unconsolidated substrates. |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Saltmarsh succulent | *Crassula aquatica, Honckenya peploides, Salicornia europae/ S.depressa* | 1 | Members of this sub-group can grow in dense mats. *Salicornia europaea* dominated communities occur near low tide level in Bay of Fundy (Roberts and Robertson 1986). | 1 | All plants are immobile. | 1 | By definition, intertidal species will interact with the sea surface. Species in this group are present in the high marsh and are reached by very high tides (Roberts and Robertson 1986). | 1 | Vascular plants are rooted in unconsolidated substrates. |
| Intertidal | Non-vascular | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* | 0 | Members of this sub-group are common to abundant in localized tide pools (Wilson 1978) but not considered abundant across the intertidal range. | 1 | All algae are immobile. | 1 | By definition, intertidal species will interact with the sea surface. | 1 | Species in this sub-group attach to consolidated substrates via holdfasts so will always interact with the seafloor. Blades will likely also interact with the seafloor during the low tide periods. |
| Intertidal | Non-vascular | Understory and turf | High energy consolidated habitat | N/A | *Chondrus crispus, Fucus endentatus, Fucus spiralis, Porphyra purpurea, Corallina officinalis* | 1 | *Chondrus crispus* forms a thick dense mat over rocks and ledges (Rayment and Pizzola 2008). *Fucus* sp. grow in abundance and cover rocks throughout the intertidal zone (Lee 1986). *Porphyra purpurea* often forms dense colonies in the intertidal and shallow sublittoral zones (Lee 1986). | 1 | All algae are immobile. | 1 | By definition, intertidal species will interact with the sea surface. *Chondrus crispus* occurs both in the lower intertidal and shallow subtidal ranges (Rayment and Pizzola 2008). *Fucus* sp. and *Porphyra purpurea* occur extensively in the intertidal zone (Lee 1986); *Corallina officinalis* occurs in intertidal areas that are not exposed to extensive drying (Lee 1989). | 1 | Species in this sub-group attach to consolidated substrates via holdfasts so will always interact with the seafloor. Blades will likely also interact with the seafloor during the low tide periods. |
| Intertidal | Non-vascular | Understory and turf | Moderate to low energy consolidated habitat | N/A | *Chorda tomentosa, Polysiphonia stricta, Ptilota elegans, Ulva intestinalis, Ulva lactuca, Corallina officinalis* | 1 | *Ulva intestinalis* is often found in high densities (Budd and Pizzola 2008). *Polysiphonia and Ptilota* species often form dense epiphytic layers on larger intertidal algal species (Lee 1986). | 1 | All algae are immobile. | 1 | By definition, intertidal species will interact with the sea surface. *Ulva intestinalis* is found in the intertidal zone, and may become detached from the substratum, and buoyed up by gas, rises to the surface, where it continues to grow in floating masses (Budd and Pizzola 2008). | 1 | Species in this sub-group attach to consolidated substrates via holdfasts so will always interact with the seafloor. Blades will likely also interact with the seafloor during the low tide periods. |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Non-vascular | Encrusting | Consolidated habitat | N/A | Coralline encrusting algae e.g., *Lithothamnion glaciale* | 0 | Abundant in small low littoral tidal pools on rocky surfaces (Wilson 1978), but not considered abundant across the intertidal range. | 1 | All algae are immobile. | 1 | By definition, intertidal species will interact with the sea surface. | 1 | Encrusting algae species grow directly on rocks, therefore interacting with the seafloor. |
| Subtidal | | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* | 1 | Members of this sub-group form dense kelp beds and are the dominant algae of the sublittoral zone starting at ~10 ft. depth (Lee 1986). *Alaria esculenta* generally grows on rocky substrate in high energy locations, often forming a dense band at low water (Lee 1986). | 1 | All algae are immobile. | 1 | Tall species of canopy algae grow attached to rocky substrates and may be tall enough to interact with the sea surface. (e.g., *Alaria esculenta* interacts with the sea surface in the subtidal to approximately 8 m depth on exposed rocky shores) (Hurd et al. 2014). | 1 | Species in this sub-group attach to consolidated substrates via holdfasts so will always be in contact with the sea floor. |
| | | | Moderate to low energy consolidated habitat | N/A | *Agarum clathratum, Halosiphon tomentosus, Laminaria digitata, Saccharina latissima* | 1 | Members of this sub-group grow in high densities forming kelp beds. *Agarum clathratum* grows in small, single species stands (1–10 $m^2$) in the sublittoral zone (Gagnon et al. 2005). | 1 | All algae are immobile. | 1 | Tall species of canopy algae grow attached to rocky substrates and may be tall enough to interact with the sea surface. | 1 | Species in this sub-group attach to consolidated substrates via holdfasts so will always be in contact with the sea floor. |
| | | Understory and turf | High energy consolidated habitat | N/A | *Chondrus crispus, Chorda tomentosa, Desmarestia viridis, Euthora cristata, Furcellaria lumbricalis* | 1 | Members of this sub-group grow in concentrations. *Chondrus crispus* forms a thick dense mat over rocks and ledges (Rayment and Pizzola 2008). *Desmarestia viridis* can form extensive beds on stones down to depths of 50 feet (Lee 1986). | 1 | All algae are immobile. | 1 | Understory and turf species are generally not expected to interact with the sea surface when living in the subtidal zone. However, some species in this sub-group (e.g., *Chondrus crispus*) can straddle the lower intertidal and shallow subtidal ranges (Rayment and Pizzola 2008), and would be expected to interact with the sea surface at low tide. | 1 | Species in this sub-group attach to consolidated substrates via holdfasts so will always be in contact with the sea floor. |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor interacting | |
| **1** | **2** | **3** | **4** | **5** | | **S** | **Justification** | **S** | **Justification** | **S** | **Justification** | **S** | **Justification** |
| Subtidal | Non-vascular | Understory and turf | Moderate to low energy consolidated habitat | N/A | *Desmarestia aculeata, Desmarestia viridis, Euthora cristata, Petalonia fascia, Ulva intestinalis, Spongomorpha arcta (Acrosiphonia arcta)* | **1** | Although some members of this sub-group are considered solitary (e.g., *Desmarestia viridis* grows solitary up to 2 m long); other members are found in high concentrations (e.g., *Ulva intestinalis* and *Spongomorpha arcta* can be found in high densities in quiet bays and salt marshes) (Lee 1986). | **1** | All algae are immobile. | **0** | Understory and turf species are generally not expected to interact with the sea surface when living in the subtidal zone. | **1** | Species in this sub–group attach to consolidated substrates via holdfasts so will always be in contact with the sea floor. |
| | | Encrusting | Consolidated habitat | N/A | Coralline encrusting algae, e.g., *Lithothamnion glaciale* | **1** | Encrusting algal species are abundant in the shallow to deep sublittoral zone throughout the region. *Lithothamnion glaciale* is a very abundant species of crustose coralline algae in Atlantic Canada (South 1984). | **1** | All algae are immobile. | **0** | Encrusting algae in the subtidal zone will not interact with the sea surface. | **1** | Encrusting algae species grow directly on rocks, therefore interacting with the seafloor. |
| Epipelagic | | PHYTOPLANKTON | | | | **1** | Phytoplankton are ubiquitous throughout the Maritimes Region, occurring in mixed species populations and discrete single species blooms. | **1** | Phytoplankton are immobile and subject to oceanographic currents. | **1** | Phytoplankton are found throughout the water column and would interact with the sea surface. | **0** | This is a pelagic sub-group that is not expected to interact with the seafloor. |

*Table A2. Marine plants and algae sub-group scores for SENSITIVITY scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps).*

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical sensitivity (reduction in feeding/photosynthesis/thermoregulation) | | Chemical sensitivity (impairment due to toxicity) | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Seagrasses | *Ruppia maritima, Zostera marina* | 1 | Impairment of photosynthesis can be caused by direct coating by oil of marine plant and soil surfaces (Pezeshki and DeLaune 2015).<br>Studies suggest the seagrasses experience blade and shoot mortality when covered with oil (Jackson et al. 1989, Marshall 1990). Some eelgrass beds recover quickly after losing blades due to oiling (Dean et al. 1998), yet recovery is slower if rhizomes are damaged by oil (Zieman et al. 1984). | 1P | Precautionary scoring for vascular plants.<br>In addition to direct coating and suffocation, oils can cause a variety of sub-lethal effects on enzyme systems, photosynthesis, respiration, transpiration and protein and nucleic acid synthesis leading to impairment and death (Lewis and Pryor 2013).<br>There are few oil-specific standardized phytotoxicity tests designed to determine toxic effect (acute and chronic) concentration thresholds for the above parameters. (Lewis and Pryor 2013). There are very few multiple dose toxicity tests and first effect, $EC_{50}$ and $LC_{50}$ concentrations for wetland plants.<br>Studies involving chemical sensitivities of seagrasses to oil have used differing response parameters (1–15) and Exposure periods (12 h to 20 mo.), and $LC_{50}$/$EC_{50}$'s are very uncommon (Lewis and Pryor 2013).<br>Scarlett et al. (2005) found the 96 h $LC_{50}$ for *Zostera marina* to be 202.4 mg/L for crude oil. Dispersed oils have been reported to be less toxic on *Zostera* sp. (Thorhaug et al. 1986, Macinnis-Ny and Ralph 2003, Wilson and Ralph 2008). |
| | | | | Saltmarsh grass | *Carex paleacea, Juncus gerardii, Juncus caesariensis, Puccinellia maritima, Spartina alterniflora* | 1 | Impairment of photosynthesis in marsh plants can be caused by coating of marine plant and soil surfaces by oil (Pezeshki and DeLaune 2015).<br>*Spartina alterniflora* subjected to oiling with Bunker C oil did not produce any new leaves and the plants died due to impaired photosynthesis (Pezeshki et al. 1995). | 1P | Precautionary scoring for vascular plants.<br>In addition to direct coating and suffocation, oils can cause a variety of sub-lethal effects on enzyme systems, photosynthesis, respiration, transpiration and protein and nucleic acid synthesis leading to impairment and death (Lewis and Pryor 2013).<br>There are few oil-specific standardized phytotoxicity tests designed to determine toxic effect (acute and chronic) concentration thresholds for the above parameters. (Lewis and Pryor 2013). There are very few multiple dose toxicity tests and first effect, $EC_{50}$ and $LC_{50}$ concentrations for wetland plants. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical sensitivity (reduction in feeding/photosynthesis/thermoregulation) | | Chemical sensitivity (impairment due to toxicity) | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Saltmarsh non-grass | *Achillea millefolium, Plantago maritima, Limonium carolinianum, Triglochin maritimum* | 1 | Impairment of photosynthesis can be caused by coating of marine plant and soil surfaces by oil (Pezeshki and DeLaune 2015).<br>*Triglochin maritima* demonstrates more resistance to smothering due to underground storage organs, however, they are still vulnerable to heavy oil types (Baker 1971). | 1P | Precautionary scoring for vascular plants.<br>In addition to direct coating and suffocation, oils can cause a variety of sub-lethal effects on enzyme systems, photosynthesis, respiration, transpiration and protein and nucleic acid synthesis leading to impairment and death (Lewis and Pryor 2013).<br>There are no oil-specific standardized phytotoxicity tests designed to determine toxic effect (acute and chronic) concentration thresholds for the above parameters. (Lewis and Pryor 2013). There are very few multiple dose toxicity tests and first effect, $EC_{50}$ and $LC_{50}$ concentrations for wetland plants.<br>Oiling can cause a decrease in flowering if *Plantago maritima*<br>plants are oiled during budding; developed flowers will rarely produce seeds if oiled; and a reduction in germination in the spring can be caused by oiling of seeds over winter (Baker 1971). |
| | | | | Saltmarsh succulent | *Crassula aquatica, Honckenya peploides, Salicornia europae/S. depressa* | 1 | Impairment of photosynthesis can be caused by coating of marine plant and soil surfaces by oil (Pezeshki and DeLaune 2015).<br>Members of this sub-group are considered very susceptible to oil and can be quickly killed by a single oil spill due to lack of underground storage organs and shallow root systems (Baker 1979).<br>*Salicornia* sp. are typically killed with one oiling (Baker 1979). | 1P | Precautionary scoring for vascular plants.<br>In addition to direct coating and suffocation, oils can cause a variety of sub-lethal effects on enzyme systems, photosynthesis, respiration, transpiration and protein and nucleic acid synthesis leading to impairment and death (Lewis and Pryor 2013).<br>There are few oil-specific standardized phytotoxicity tests designed to determine toxic effect (acute and chronic) concentration thresholds for the above parameters. (Lewis and Pryor 2013). There are very few multiple dose toxicity tests and first effect, $EC_{50}$ and $LC_{50}$ concentrations for wetland plants. |
| | Non-vascular | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* | 1P | Impairment of photosynthesis in non-vascular plants can result from both the mechanical covering (smothering) of the plant and soil surfaces with oil, as well as the chemical disruption of photosynthetic pathways due to oil toxicity (Hurd et al. 2014).<br>The mechanisms of photosynthetic inhibition are rarely investigated and results in difficulty differentiating between mechanical smothering and toxicity effects. | 1P | In general, the mucilaginous coating on brown algae is thought to protect members of this sub-group from damage by oil (Hurd et al. 2014).<br>However, precautionary scoring applied as *Laminaria digitata* has exhibited a 50% reduction in growth over 2 years when exposed to diesel oil at 130 µg/L, while no growth reduction was noted at 30 µg/L, and plants completely recovered in oil-free conditions (Steele and Hanisak 1979). |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Mechanical sensitivity (reduction in feeding/photosynthesis/thermoregulation)** | | **Chemical sensitivity (impairment due to toxicity)** | |
| **1** | **2** | **3** | **4** | **5** | | **S** | **Justification** | **S** | **Justification** |
| Intertidal | Non-vascular | Understory and turf | High energy consolidated habitat | N/A | *Chondrus crispus, Fucus endentatus, Fucus spiralis, Porphyra purpurea, Corallina officinalis* | **1P** | Impairment of photosynthesis in non-vascular plants can result from both the mechanical covering (smothering) of the plant and soil surfaces with oil, as well as the chemical disruption of photosynthetic pathways due to oil toxicity (Hurd et al. 2014).<br>The mechanisms of photosynthetic inhibition are rarely investigated and results in difficulty differentiating between mechanical smothering and toxicity effects.<br>Mechanical damage can occur when emulsified oil in sufficient thickness coats the thalli of algae, causing breakage (Hurd et al. 2014). The loss of too many photosynthetic blades to oiling during growing season, when metabolic products are stored, can impact a seaweeds regenerative ability (O'Brien and Dixon 1976).<br>Many high intertidal brown and red algal species in this sub-group become oleophilic as they dry out when exposed by tides. This increased capacity for oil adsorption can increase the species susceptibility to thallic breakage, especially those species that grow between neap and spring high tide marks (Hurd et al. 2014).<br>However, increased wave energy in a high energy consolidated habitat might cause rapid dissipation of oil (Peckol et al. 1990).<br>*Porphyra* sp. experienced decreased photosynthesis when coated with oil (O'Brien and Dixon 1976). | **1P** | Toxic effect concentrations for algae vary greatly.<br>Reproductive response parameters are more sensitive to oil in some species. *Chondrus crispus* plants reproduced normally after the Amoco Cadiz oil spill. However, young stages developed slower than expected, and a reduction in biomass for 2 years post-Exposure (Hurd et al. 2014).<br>*Fucus endentatus* reproductive stage is particularly sensitive to oil, especially during gamete or spore release, at concentrations of crude or fuel oil as low as 2 µg/L (Steele and Hanisak 1979).<br>After the *Exxon Valdez* oil spill in 1989, mature *Fucus* sp. were covered with oil but did not die (Driskell et al. 2001).<br>Bleaching is commonly seen among red algae (e.g., *Porphyra purpurea*, *Corallina officinalis*), and is caused by the breakdown of phycoerythrin by kerosene-related compounds (Hurd et al. 2014).<br>*Porphyra* sp. experienced bleaching and decrease in physiological activity after being in contact with oil from spills (O'Brien and Dixon 1976). |
| | | | Moderate to low energy consolidated habitat | N/A | *Chorda tomentosa, Polysiphonia stricta, Ptilota elegans, Ulva intestinalis, Ulva lactuca, Corallina officinalis* | **1P** | Impairment of photosynthesis in non-vascular plants can result from both the mechanical covering (smothering) of the plant and soil surfaces with oil, as well as the chemical disruption of photosynthetic pathways due to oil toxicity (Hurd et al. 2014).<br>The mechanisms of photosynthetic inhibition are rarely investigated and results in difficulty differentiating between mechanical smothering and toxicity effects. | **1P** | Budd and Pizzola (2008) found that hydrocarbon contamination leads to bleaching and interference with reproduction in the green alga *Ulva intestinalis*.<br>Bleaching is also commonly seen among red algae (e.g., *Polysiphonia stricta*, *Ptilota elegans* and *Corallina officianalis*), and is caused by the breakdown of phycoerythrin by kerosene-related compounds (Hurd et al. 2014).<br>Additionally, lipid soluble pigments such as chlorophylls may be leached from cells by oil (O'Brien and Dixon 1976).<br>Aromatics and other toxic hydrocarbons appear to exert their toxic effects by entering the lipophilic layer of the cell membrane. As a result, the membrane ceases to properly control the transport of ions into and out of cells (O'Brien and Dixon 1976). |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical sensitivity (reduction in feeding/photosynthesis/thermoregulation) | | Chemical sensitivity (impairment due to toxicity) | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Intertidal | Non-vascular | Encrusting | Consolidated habitat | N/A | Coralline encrusting algae e.g., *Lithothamnion glaciale* | 1P | Impairment of photosynthesis in non-vascular plants can result from both the mechanical covering (smothering) of the plant and soil surfaces with oil, as well as the chemical disruption of photosynthetic pathways due to oil toxicity (Hurd et al. 2014).<br>The mechanisms of photosynthetic inhibition are rarely investigated and results in difficulty differentiating between mechanical smothering and toxicity effects. | 1P | Precautionary scoring due to lack of research on chemical impairment due to toxicity of oil in this sub-group.<br>The response of coralline algae to oil pollution is not well documented although bleaching of these forms as a result of oiling has been reported (O'Brien and Dixon 1976). |
| Subtidal | Non-vascular | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* | 1P | Impairment of photosynthesis in non-vascular plants can result from both the mechanical covering (smothering) of the plant and soil surfaces with oil, as well as the chemical disruption of photosynthetic pathways due to oil toxicity (Hurd et al. 2014).<br>The mechanisms of photosynthetic inhibition are rarely investigated and results in difficulty differentiating between mechanical smothering and toxicity effects.<br>Holt et al. (1995) concluded that because of dispersion in the water column and high-levels of dilution, *Saccharina latissima* did not show any discernible effects from oil spills. | 1P | In general, the mucilaginous coating on brown algae is thought to protect members of this sub-group from damage by oil (Hurd et al. 2014).<br>However, precautionary scoring applied as *Laminaria digitata* has exhibited a 50% reduction in growth over 2 years when exposed to diesel oil at 130 µg/L, while no growth reduction was noted at 30 µg/L, and plants completely recovered in oil-free conditions (Steele and Hanisak 1979). |
| Subtidal | Non-vascular | Canopy | Moderate to low energy consolidated habitat | N/A | *Agarum clathratum, Halosiphon tomentosus, Laminaria digitata, Saccharina latissima* | 1P | Impairment of photosynthesis can be caused by coating of the marine plant with oil (Pezeshki and DeLaune 2015).<br>However, due to its preference for exposed locations where wave action dissipates oil more quickly, *Laminaria digitata* was less likely to become coated that other plant species (Hill 2008). All brown algae have some resistance to oil coating as their blades are partially protected initially due to their mucilaginous coating. Their thalli are still susceptible to coating, and adsorption there can result in breakage as well (Hurd et al. 2014). | 1P | Precautionary scoring due to lack of research on chemical impairment due to toxicity of oil in this sub-group.<br>Chronic low level pollution of diesel oil (25 µg/L) caused reduced growth rates of *Laminaria digitata* in the second and third years of growth (Bokn 1987). |
| Subtidal | Non-vascular | Understory and turf | High energy consolidated habitat | N/A | *Chondrus crispus, Chorda tomentosa, Desmarestia viridis, Euthora cristata, Furcellaria lumbricalis* | 1P | Impairment of photosynthesis can be caused by coating of the marine plant with oil (Pezeshki and DeLaune 2015).<br>However, high wave energy in this habitat might cause rapid dissipation (Peckol et al. 1990). Plants found growing underneath a taller species may benefit from reduced smothering (O'Brien and Dixon 1976). | 1P | According to Kaas (1980), as cited in Rayment and Pizzola (2008), adult *Chondrus crispus* plants reproduced normally after the *Amoco Cadiz* oil spill. However, young stages developed slower than expected, and there was a related reduction in algal biomass for 2 years post-exposure. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical sensitivity (reduction in feeding/photosynthesis/thermoregulation) | | Chemical sensitivity (impairment due to toxicity) | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Subtidal | Non-vascular | Understory and turf | Moderate to low energy consolidated habitat | N/A | *Desmarestia aculeata, Desmarestia viridis, Euthora cristata, Petalonia fascia, Ulva intestinalis, Spongomorpha arcta (Acrosiphonia arcta)* | **1P** | Impairment of photosynthesis can be caused by coating of the marine plant with oil (Pezeshki and DeLaune 2015).<br><br>Plants found growing underneath a taller species may benefit from reduced smothering (O'Brien and Dixon 1976). | **1P** | Precautionary scoring due to lack of research on chemical impairment due to toxicity of oil in this group.<br><br>Budd and Pizzola (2008) found that hydrocarbon contamination led to bleaching and interference with reproduction in *Ulva intestinalis.* |
| | | Encrusting | Consolidated habitat | N/A | Coralline encrusting algae, e.g., *Lithothamnion glaciale* | **1P** | Impairment of photosynthesis can be caused by coating of marine algae with oil (Pezeshki and DeLaune 2015). | **1P** | Precautionary scoring due to lack of research on chemical impairment due to toxicity of oil in this group.<br><br>The response of coralline algae to oil pollution is not well documented although bleaching of these forms as a result of oiling has been reported (O'Brien and Dixon 1976). |
| | | Phytoplankton | N/A | | N/A | **1P** | Phytoplankton are assumed to be a low risk from oil contamination (O'Brien and Dixon 1976, Hyland and Schneider 1979), based on rapid reproduction rates that can compensate temporarily for population declines (Lewis and Pryor 2013).<br><br>However, precautionary scoring was applied as there are few experimental studies conducted with phytoplankton communities exposed to oil. | **1P** | Marine phytoplankton was found to be suppressed by petroleum hydrocarbons exceeding 1.5 mg/L (Yu et al. 1987).<br><br>Fuel oil was found to increase marine phytoplankton abundance post Exposure, although this may have been an effect of lessened zooplankton (Vargo et al. 1982). |

*Table A3. Marine plants and algae sub-group scores for RECOVERY scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to lack of knowledge).*

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Seagrasses | *Ruppia maritima, Zostera marina* | 1P | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br><br>Precautionary scoring applied for this sub-group as eelgrass (*Zostera marina*) population estimates show a decreasing trend worldwide in the second half of the twentieth century (Lopez-Calderon et al. 2016). | 1P | Seagrasses reproduce sexually via seeds (e.g., *Zostera marina* can produce large quantities of seeds, at times numbering several thousand seeds per square meter); or via asexual clonal growth – sending out rhizome roots to sprout new growth (Phillips et al. 1983).<br><br>However, damaged rhizomes affect reproduction and slow recovery after an oil Exposure (Zieman et al. 1984). | 0 | No evidence of endemic/isolated populations in this sub-group.<br><br>*Zostera marina* and *Ruppia maritima* are widely distributed in the Maritimes Region (Hinds 2000). | 1 | Seagrasses have underground root and rhizome systems that are rooted in unconsolidated substrates (Hemminga 1998). |
| | | | | Saltmarsh grass | *Carex paleacea, Juncus gerardii, Juncus caesariensis, Puccinellia maritima, Spartina alterniflora* | 1 | *Juncus caesariensis* listed by SARA as Special Concern in Nova Scotia. (assessed May 2004). *Juncus caesariensis* listed as Special Concern (COSEWIC 2004). | 1P | Saltmarsh plant communities are often dominated by long-lived perennial species that rely heavily on vegetative reproduction compared to sexual reproduction, especially in aquatic or stressful habitats (Grace 1993, Silvertown 2008).<br><br>For example, *Spartina alterniflora* saltmarsh communities do not have a viable seed bank (Hartman 1988) as seeds are only viable for a single year and rely heavily on vegetative reproduction for survival (Mooring et al. 1971). | 0 | No evidence of endemic/isolated populations in this sub-group.<br><br>*Spartina alterniflora* and *Juncus gerardii* are widely distributed in the Maritimes Region (Hinds 2000). | 1 | Vascular plants are rooted in unconsolidated substrates. |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Vascular | N/A | Moderate to low energy unconsolidated habitat | Saltmarsh non-grass | *Achillea millefolium, Plantago maritima, Limonium carolinianum, Triglochin maritimum, Symphyotrichum subulatum* | 0 | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists for the Maritimes Region.<br>The sub-population of the Saltmarsh Aster, the Bathurst Aster (*Symphyotrichum subulatum*), was Designated Special Concern in April 1992 Status re-examined and designated Not at Risk in April 2017 (COSEWIC 2017). | 1P | Saltmarsh plant communities are often dominated by long-lived perennial species that rely heavily on vegetative reproduction compared to sexual reproduction, especially in aquatic or stressful habitats (Grace 1993, Silvertown 2008). | 0 | No evidence of endemic/isolated populations in this sub-group<br>Species in this sub-group *(Achillea millefolium, Plantago maritima, Limonium carolinianum,* and *Triglochin maritima)* are widely distributed in the Maritimes Region (Hinds 2000). | 1 | Vascular plants are rooted in unconsolidated substrates. |
| | | | | Saltmarsh succulent | *Crassula aquatica, Honckenya peploides, Salicornia europae/ S.depressa* | 0 | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists for the Maritimes Region.<br>*Crassula aquatica* listed as vulnerable by the Province of Newfoundland (Maunder 2008), not in the Maritimes Region. | 1P | Saltmarsh plant communities are often dominated by long-lived perennial species that rely heavily on vegetative reproduction compared to sexual reproduction, especially in aquatic or stressful habitats (Grace 1993, Silvertown 2008). | 0 | No evidence of endemic/isolated populations in this sub-group.<br>*Crassula aquatica* is uncommon but often overlooked in salt marshes. *Honckenya peploides, Salicornia europae and Salicornia europae/S.depressa* are commonly distributed in the Maritimes Region (Hinds 2000). | 1 | Vascular plants are rooted in unconsolidated substrates. |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Non-vascular | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* | 1 | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br>In the Northeast Atlantic, some cold-adapted canopy forming seaweeds have been decreasing in abundance in recent years as a function of ocean warming (Piñeiro-Corbeira et al. 2018). | 1P | All algae use the same basic pattern of alteration of sporophyte and gametophyte generations, with many variations on this reproductive strategy being employed. Overall most algae are characterized as having high reproductive capacity (Hurd et al. 2014).<br>However, precautionary scoring was used for this criteria given that in some algal species reproduction is easily disrupted by disturbance<br>(e.g., *Fucus* sp. communities can recover 5–7 years post oil spill but oscillations in reproduction and population are common [Driskell et al. 2001]). | 0 | In the Maritimes Region there is no evidence of endemic/isolated populations in this sub-group. | 1P | All algae are non-vascular and have no root systems. Therefore, not expected to have close association with unconsolidated substrates.<br>However, species in the intertidal zone could interact with the unconsolidated substrate when they are exposed during low tides. |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | Understory and turf | | N/A | *Chondrus crispus, Fucus endentatus, Fucus spiralis, Porphyra purpurea, Corallina officinalis* | 1P | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br><br>Precautionary scoring was applied for this criteria as current data suggests macroalgae species including Irish Moss (*Chondrus crispus*) are particularly susceptible to substantial abundance and distribution in Atlantic Canada, as a function of anthropogenic stressors (Wilson et al. 2018). | 1P | All algae use the same basic pattern of alteration of sporophyte and gametophyte generations, with many variations on this reproductive strategy being employed. Overall most algae are characterized as having high reproductive capacity (Hurd et al. 2014).<br><br>However, precautionary scoring was used for this criteria given that in some algal species reproduction is easily disrupted by disturbance (e.g., *Fucus* sp. communities can recover 5–7 years post oil spill but oscillations in reproduction and population are common (Driskell et al. 2001). | 0 | No evidence of endemic/isolated populations in this sub-group.<br><br>Members of this sub-group are common to abundantly distributed throughout the Maritimes Region: *Chondrus crispus* (Wilson 1978), *Fucus* sp. (White 2008), *Corallina officinalis*, *Porphyra purpurea* (Wilson 1978). | 1P | All algae are non-vascular and have no root systems. Therefore, not expected to have close association with unconsolidated substrates.<br><br>However, species in the intertidal zone could interact with the unconsolidated substrate when they are exposed during low tides. |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Non-vascular | Understory and turf | Moderate to low energy consolidated habitat | N/A | *Chorda tomentosa, Polysiphonia stricta, Ptilota elegans, Ulva intestinalis, Ulva lactuca, Corallina officinalis* | 1P | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br>Precautionary scoring was applied for this criteria as current data suggests macroalgae species are particularly susceptible to substantial abundance and distribution shifts in Atlantic Canada, as a function of anthropogenic stressors (Wilson et al. 2018). | 1P | All algae use the same basic pattern of alteration of sporophyte and gametophyte generations, with many variations on this reproductive strategy being employed. Overall most algae are characterized as having high reproductive capacity (Hurd et al. 2014).<br>However, precautionary scoring was used for this criteria given that in some algal species reproduction is easily disrupted by disturbance<br>(e.g., *Fucus* sp. communities can recover 5–7 years post oil spill but oscillations in reproduction and population are common [Driskell et al. 2001]). | 0 | No evidence of endemic/isolated populations in this sub-group. | 1P | All algae are non-vascular and have no root systems. Therefore, not expected to have close association with unconsolidated substrates.<br>However, species in the intertidal zone could interact with the unconsolidated substrate when they are exposed during low tides. |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | Encrusting | Consolidated habitat | N/A | Coralline encrusting algae e.g., *Lithothamnion glaciale* | 1P | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br>Precautionary scoring was applied for this criteria as current data suggests macroalgae species are particularly susceptible to substantial abundance and distribution shifts in Atlantic Canada, as a function of anthropogenic stressors (Wilson et al. 2018). | 1P | All algae use the same basic pattern of alteration of sporophyte and gametophyte generations, with many variations on this reproductive strategy being employed. Overall most algae are characterized as having high reproductive capacity (Hurd et al. 2014).<br>However, precautionary scoring was used for this criteria given that in some algal species reproduction is easily disrupted by disturbance (e.g., *Fucus* sp. communities can recover 5–7 years post oil spill but oscillations in reproduction and population are common (Driskell et al. 2001). | 0 | No evidence of endemic/isolated populations in this sub-group. | 0 | Encrusting on consolidated substrates. |
| Subtidal | Non-vascular | Canopy | High energy consolidated habitat | N/A | *Alaria esculenta, Laminaria digitata, Saccharina latissima* | 1 | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br>In the Northeast Atlantic, some cold-adapted canopy forming seaweeds have been decreasing in abundance in recent years as a function of ocean warming (Piñeiro-Corbeira et al. 2018) | 1P | All algae use the same basic pattern of alteration of sporophyte and gametophyte generations, with many variations on this reproductive strategy being employed. Overall most algae are characterized as having high reproductive capacity (Hurd et al. 2014).<br>However, precautionary scoring was used for this criteria given that in some algal species reproduction is easily disrupted by disturbance (e.g., *Fucus* sp. communities can recover 5–7 years post oil spill but oscillations in reproduction and population are common (Driskell et al. 2001). | 0 | No evidence of endemic/isolated populations in this sub-group. | 0 | All algae are non-vascular and have no root systems. Therefore, not expected to have close association with unconsolidated substrates. |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Moderate to low energy consolidated habitat | N/A | *Agarum clathratum, Halosiphon tomentosus, Laminaria digitata, Saccharina latissima* | 1 | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br>In the Northeast Atlantic, some cold-adapted canopy forming seaweeds have been decreasing in abundance in recent years as a function of ocean warming (Piñeiro-Corbeira et al. 2018). | 1P | All algae use the same basic pattern of alteration of sporophyte and gametophyte generations, with many variations on this reproductive strategy being employed. Overall most algae are characterized as having high reproductive capacity (Hurd et al. 2014).<br>However, precautionary scoring was used for this criteria given that in some algal species reproduction is easily disrupted by disturbance (e.g., *Fucus* sp. communities can recover 5–7 years post oil spill but oscillations in reproduction and population are common (Driskell et al. 2001). | 0 | No evidence of endemic/isolated populations in this sub-group. | 0 | All algae are non-vascular and have no root systems. Therefore, not expected to have close association with unconsolidated substrates. |
| Subtidal | Non-vascular | Understory and turf | High energy consolidated habitat | N/A | *Chondrus crispus, Chorda tomentosa, Desmarestia viridis, Euthora cristata, Furcellaria lumbricalis* | 1P | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br>Precautionary scoring was applied for this criteria as current data suggests macroalgae species including Irish moss (*Chondrus crispus*) are particularly susceptible to substantial abundance and distribution shifts in Atlantic Canada, as a function of anthropogenic stressors (Wilson et al. 2018). | 1P | All algae use the same basic pattern of alteration of sporophyte and gametophyte generations, with many variations on this reproductive strategy being employed. Overall most algae are characterized as having high reproductive capacity (Hurd et al. 2014).<br>However, precautionary scoring was used for this criteria given that in some algal species reproduction is easily disrupted by disturbance (e.g., *Fucus* sp. communities can recover 5–7 years post oil spill but oscillations in reproduction and population are common (Driskell et al. 2001). | 0 | No evidence of endemic/isolated populations in this sub-group. | 0 | All algae are non-vascular and have no root systems. Therefore, not expected to have close association with unconsolidated substrates. |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Moderate to low energy consolidated habitat | N/A | *Desmarestia aculeata, Desmarestia viridis, Euthora cristata, Petalonia fascia, Ulva intestinalis, Spongomorpha arcta (Acrosiphonia arcta)* | 1P | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br>Precautionary scoring was applied for this criteria as current data suggests macroalgae species are particularly susceptible to substantial abundance and distribution shifts in Atlantic Canada, as a function of anthropogenic stressors (Wilson et al. 2018). | 1P | All algae use the same basic pattern of alteration of sporophyte and gametophyte generations, with many variations on this reproductive strategy being employed. Overall most algae are characterized as having high reproductive capacity (Hurd et al. 2014).<br>However, precautionary scoring was used for this criteria given that in some algal species reproduction is easily disrupted by disturbance (e.g., *Fucus* sp. communities can recover 5–7 years post oil spill but oscillations in reproduction and population are common (Driskell et al. 2001). | 0 | No evidence of endemic/isolated populations in this sub-group. | 0 | All algae are non-vascular and have no root systems. Therefore, not expected to have close association with unconsolidated substrates. |
| Subtidal | Non-vascular | Encrusting | Consolidated habitat | N/A | Coralline encrusting algae, e.g., *Lithothamnion glaciale* | 1P | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br>Precautionary scoring was applied for this criteria as current data suggests macroalgae species are particularly susceptible to substantial abundance and distribution shifts in Atlantic Canada, as a function of anthropogenic stressors (Wilson et al. 2018). | 1P | All algae use the same basic pattern of alteration of sporophyte and gametophyte generations, with many variations on this reproductive strategy being employed. Overall most algae are characterized as having high reproductive capacity (Hurd et al. 2014).<br>However, precautionary scoring was used for this criteria given that in some algal species reproduction is easily disrupted by disturbance (e.g., *Fucus* sp. communities can recover 5–7 years post oil spill but oscillations in reproduction and population are common (Driskell et al. 2001). | 0 | No evidence of endemic/isolated populations in this sub-group. | 0 | All algae are non-vascular and have no root systems. Therefore, not expected to have close association with unconsolidated substrates.<br>Encrusting algae species grow directly on consolidated substrate (e.g., rocks) only. |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Epipelagic | | PHYTOPLANTON | | | | 1P | Not listed on SARA, COSEWIC or ESA Threatened and Endangered lists.<br>However, precautionary scoring was used for this criteria given that phytoplankton populations are particularly sensitive to anthropogenic stressors on both local and global scales (Salmaso and Tolotti 2021). | 0 | Phytoplankton have rapid reproduction rates that can compensate temporarily for population declines (Lewis and Pryor 2013) | 0 | No evidence of endemic/isolated populations in this sub-group. | 0 | Phytoplankton are pelagic and do not have close association with unconsolidated substrates. |

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## APPENDIX 2. DETAILED SCORING TABLES WITH JUSTIFICATIONS FOR MARINE INVERTEBRATES

*Table A4. Marine invertebrates sub-group scores for EXPOSURE scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps).*

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | Porifera | Sponges [CL. Demospongiae, Calcarea] | 1 | Sponges form aggregations (Brusca and Brusca 1990). | 1 | By definition, sessile sub-groups are immobile. | 1 | Intertidal sessile organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Cnidaria | Colonial hydroids [Hydrozoa]; Stalked jellyfish [Staurozoa] | 1 | Initial settled polyps may undergo a period of asexual reproduction which forms colonies (Gosner 1971). Hydroids form clumps (Hughes 1977). | 1 | By definition, sessile sub-groups are immobile. | 1 | Intertidal sessile organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Worms | Tube worms [Polychaeta] | 1 | Some are gregarious (e.g., Eunicidae) and others form extensive shelves and reefs (e.g., Sabellariidae) (Brusca and Brusca 1990). | 1 | By definition, sessile sub-groups are immobile. | 1 | Intertidal sessile organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 1 | Bryozoans are colonial (Gosner 1971). Branchiopods tend to aggregate (Gosner 1971). | 1 | By definition, sessile sub-groups are immobile. | 1 | Intertidal sessile organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Mollusca | Oysters, Mussels [Bivalvia] | 1 | Oysters and mussels form beds (Brusca and Brusca 1990). | 1 | By definition, sessile sub-groups are immobile. | 1 | Intertidal sessile organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | Hemichordata | Sea peaches, Sea squirts [Ascidiacea] | 1 | Ascidians may be solitary or colonial.<br>In the order Aplousobranchia all species are colonial (e.g., *Didemnum vexillum*). The order Stolidobranchia includes solitary (e.g., *Molgula manhattensis)* and colonial species (e.g., *Botryllus schlosseri*) (Shenkar and Swalla 2011). | 1 | By definition, sessile sub-groups are immobile. | 1 | Intertidal sessile organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Arthropoda | Barnacles [CL. Hexanauplia] | 1 | Encrusts in aggregations on hard substrates (Gosner 1971). Gregarious recruitment (Burke 1986). | 1 | By definition, sessile sub-groups are immobile. | 1 | Intertidal sessile organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | Low mobility | Cnidaria | Anemones [Anthozoa] | 1 | Solitary or colonial (Brusca and Brusca 1990). | 1 | Species in this sub-group exhibit low mobility.<br>Anemones move at a slow pace (Gosner 1971). Adults move very little, juveniles move more often to find suitable habitat. Anemones often persist even while habitat conditions change and once situated near a prey source, have the potential to occupy the site for many years (Sebens 1983). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out.<br>Anemones may live in the littoral zone so will have interaction with the sea surface as the tide moves in and out (Gosner 1971). | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Rock and rubble dwellers | Low mobility | Worms | Bloodworms [Polychaeta]; Flatworms [Platyhelminthes]; Nemertean worms | 1 | Bloodworms can occur in high densities. Polychaetes form breeding aggregations (Heip 1975). Turbellarian flatworms aggregate (Boaden 1995). Nemerteans are gregarious, which may be related to reproduction events, or the focus on a suitable microhabitat (Gonzalez-Cueto et al. 2014). | 1 | Species in this sub-group exhibit low mobility. Polychaetes tend to show fidelity to the same habitat types rather than geographic fidelity (Kupriyanova and Badyaev 1998). Some turbellarian flatworms migrate vertically with the seasons and the tide (Boaden 1995). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| Intertidal | Rock and rubble dwellers | Low mobility | Mollusca | Chitons [Polyplacophora]; Whelks, Limpets, Snails [Gastropoda] | 1 | Dog Whelks (*Nucella lapillus*) form aggregations on open rocks. They also form breeding aggregations (Feare 1971). *Leptochiton* sp. are solitary. Limpets have gregarious settlement (Brusca et al. 2003). Gastropods can be highly aggregated particularly during breeding (Spight 1974, Heip 1975). | 1 | Species in this sub-group exhibit low mobility. Some chitons exhibit site fidelity, however site fidelity decreases as food availability decreases (Montecinos et al. 2020). Some gastropods return to the same breeding site and a juvenile breeding for the first time is likely to return to near where it hatched (Spight 1974). Some limpets travel as much as 5 feet at night or at high tide and return to their original position (Brusca et al. 2003). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| Intertidal | Rock and rubble dwellers | Low mobility | Echinodermata | Sea stars, [Asteroidea]; Sea urchins [Echinoidea]; Sea cucumbers [Holothuroidea] | 1 | Sea urchins aggregate for feeding and defense (Vadas 1986). Sea stars form feeding aggregations (Scheibling and Lauzon-Guay 2007). Sea cucumbers form beds to improve reproductive success (Fisheries and Oceans Canada 2019). | 1 | Species in this sub-group exhibit low mobility. Sea urchins form migrating feeding aggregations, grazing on macrophytes and sea stars will follow them, feeding on mussels exposed from the grazed kelp (Scheibling and Lauzon-Guay 2007). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. All echinoderms will be in constant interaction with the sea floor (Brusca and Brusca 1990). |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Arthropoda | Amphipods [Amphipoda]; Isopods [Isopoda] | 1 | Most amphipods and isopods are gregarious (Brusca and Brusca 1990). | 1 | Some amphipod species are highly mobile relative to others, when searching for food and mates, but overall species in this sub-group exhibit low mobility.<br><br>Scavenging amphipods constantly search for food, and herbivorous amphipods move between living macrophytes and plant detritus (Beermann et al. 2015). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation.<br><br>Amphipods and isopods interact regularly with the sea floor and vegetation (Brusca and Brusca 1990). |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] | 1 | Most decapods live singly, but aggregate during mating season (Brusca and Brusca 1990).<br><br>Berried Lobsters off the coast of Grand Manan, NB have been observed aggregating in the warmer, shallower waters (Campbell 1990). | 1P | Despite being a highly mobile species, in some areas, female Lobsters exhibit site fidelity by migrating seasonally for mating and spawning (Campbell 1990). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| Intertidal | Sediment infauna | Low mobility | Worms | Sandworms, Lugworms, other burrowers [Polychaeta]; Nemertean worms [Paleonemertea]; Sipuncula worms [Sipunculidea]; Flatworms [Platyhelminthes] | 1 | Juvenile lugworms tend to aggregate away from adults, and have a higher survival rate in areas not dominated by adults (Hardege et al. 1998).<br><br>Nemertean worms often aggregate before fertilization occurs (Thiel and Junoy 2006).<br><br>Sipunculidea are usually reclusive (Brusca and Brusca 1990).<br><br>Turbellarian flatworms form aggregations (Boaden 1995). | 1 | Species in this sub-group exhibit low mobility.<br><br>Polychaetes tend to show fidelity to the same habitat types rather than geographic fidelity (Kupriyanova and Badyaev 1998). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out.<br><br>Sediment infauna can maintain burrows at the sediment-water interface for respiration, feeding, and to ventilate/flush out their burrows (Hull 2019). | 1 | By definition, sediment infauna will interact with the seafloor/vegetation.<br><br>Sipunculeans burrow into the sediments or beneath stones or in algal holdfasts so will have constant contact with the seafloor/vegetation (Brusca and Brusca 1990). |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Mollusca | Clams, Astartes [Bivalvia]; Moonsnails [Gastropoda] | 1 | Gastropods can be highly aggregated particularly during breeding (Spight 1974).<br>Clams aggregate in dense beds (Bowen and Hunt 2009). | 1 | Species in this sub-group exhibit low mobility.<br>Some gastropods return to the same breeding site and a juvenile breeding for the first time is likely to return to near where it hatched (Spight 1974).<br>Infaunal clams move up and down vertically in the sediment related to seasonal and tidal cues. Horizontal movement does occur for some species (*Mercenaria mercenaria),* but triggers for this movement aren't fully known (Tettelbach et al. 2017). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out.<br>Sediment infauna can maintain burrows at the sediment-water interface for respiration, feeding, and to ventilate/flush out their burrows (Hull 2019). | 1 | By definition, sediment infauna will interact with the seafloor/vegetation. |
| Intertidal | Sediment infauna | Low mobility | Arthropoda | Mud Crab [Decapoda, Panopeidae]; Tube-building gammarid amphipods [Amphipoda] | 1 | Tube building amphipods usually only co-habitate with mate or offspring in their tube, but in favourable feeding locations, there may be high densities of tubes resulting in frequent intraspecific interactions (Beermann et al. 2015). Most decapods live singly, except during mating season (Brusca and Brusca 1990). | 1 | Species in this sub-group exhibit low mobility.<br>Tube-building amphipods are semi-sessile, and usually have distinct feeding territories around their tube openings (Beermann et al. 2015).<br>Mud Crabs exhibit habitat selectivity for muddy substrates (Gehrels et al. 2016) and exhibit limited (< 2 km) alongshore movement (Bonine et al. 2008). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out.<br>Sediment infauna can maintain burrows at the sediment-water interface for respiration, feeding, and to ventilate/flush out their burrows (Hull 2019). | 1 | By definition, sediment infauna will interact with the seafloor/vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | Sediment epifauna | | Cnidaria | Starlet Anemones, Sand Anemones [Anthozoa] | 1 | Solitary or colonial (Brusca and Brusca 1990). | 1 | Species in this sub-group exhibit low mobility. Anemones move at a slow pace (Gosner 1971). Adults move very little; juveniles move more often to find suitable habitat (Gosner 1971). Anemones often persist even while habitat conditions change and once situated near a prey source, have the potential to occupy the site for many years (Sebens 1983). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. Anemones may live in the littoral zone so will have interaction with the sea surface as the tide moves in and out (Gosner 1971). | 1 | By definition, sediment epifauna will interact with the seafloor/vegetation. |
| Intertidal | Sediment epifauna | Low mobility | Mollusca | Nudibranchs [Gastropoda, Nudibranchia]; Snails [Gastropoda]; Scallops [Bivalvia] | 1 | Gastropods can be highly aggregated particularly during breeding (Spight 1974). Scallops form aggregations and have gregarious recruitment (Carey and Stokesbury 2011). Nudibranchs form breeding aggregations (Claverie and Kamenos 2008). | 1 | Species in this sub–group exhibit low mobility. Some gastropods return to the same breeding site and a juvenile breeding for the first time is likely to return to near where it hatched (Spight 1974). There is limited evidence that nudibranchs may form spawning migrations (Claverie and Kamenos 2008). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | By definition, sediment epifauna will interact with the seafloor/vegetation. |
| | | | Echinodermata | Brittle stars [Ophiuroidea]; Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea] | 1 | Sea cucumbers gather in beds for improved reproductive success (Fisheries and Oceans Canada 2019). Ophiuroidea and Asteroidea form feeding aggregations (Scheibling and Lauzon-Guay 2007). | 1 | Species in this sub-group exhibit low mobility. Some sea stars are opportunistic predators and will detect prey at a distance via chemoreception and move to those locations (Scheibling and Lauzon-Guay 2007). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | By definition, sediment epifauna will interact with the seafloor/vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Arthropoda | Hermit crabs [Decapoda]; Sand fleas and other amphipods [Amphipoda]; Sea spiders [Pycnogonida]; Isopods [Isopoda] | 1 | Most decapods live singly, except during mating season (Brusca and Brusca 1990).<br>Most amphipods and isopods are gregarious (Brusca and Brusca 1990).<br>Pycnogonida can be abundant in small patches and may form masses of several hundred where they are crawling over each other (Brescia and Tunnicliffe 1998). | 1 | Some amphipod species are highly mobile relative to others, when searching for food and mates, but overall species in this sub-group exhibit low mobility.<br>Scavenging amphipods constantly search for food, and herbivorous amphipods move between living macrophytes and plant detritus (Beermann et al. 2015). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | By definition, sediment epifauna will interact with the seafloor/vegetation. |
| Intertidal | Sediment epifauna | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] | 1 | Most decapods live singly, except during mating season (Brusca and Brusca 1990).<br>Berried, female Lobsters off the coast of Grand Manan, NB have been observed aggregating in the warmer, shallower waters (Campbell 1990). | 1P | Despite being a highly mobile species, in some areas, female Lobsters exhibit site fidelity by migrating seasonally for mating and spawning (Campbell 1990). | 1 | Intertidal organisms will have regular contact with the sea surface as the tide moves in and out. | 1 | By definition, sediment epifauna will interact with the seafloor/vegetation. |
| Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | Porifera | Boring sponges, Breadcrumb sponges, Encrusting sponges [CL. Demospongiae, Calcarea] | 1 | Sponges form aggregations (Brusca and Brusca 1990). | 1 | By definition, sessile sub–groups are immobile. | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Cnidaria | Colonial hydroids [Hydrozoa]; Soft corals [Anthozoa]; Stalked jellyfish [Staurozoa] | 1 | Initial settled polyps may undergo a period of asexual reproduction which forms colonies (Gosner 1971). Hydroids form clumps (Hughes 1977). | 1 | By definition, sessile sub-groups are immobile. | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Worms | Tube worms [Polychaeta] | 1 | Some are gregarious (e.g., Eunicidae) and others form extensive shelves and reefs (e.g., Sabellariidae) (Brusca and Brusca 1990). | 1 | By definition, sessile sub-groups are immobile. | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 1 | Bryozoans are colonial (Gosner 1971).<br>Branchiopods tend to aggregate (Gosner 1971). | 1 | By definition, sessile sub-groups are immobile. | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | Mollusca | Slipper Limpets [Gastropoda]; Mussels, Oysters, Comb bathyarks [Bivalvia] | 1 | Many bivalve species form beds that create areas of high biodiversity (Craeymeersch and Jansen 2019).<br>Oysters and mussels form beds (Brusca and Brusca 1990).<br>Slipper Limpets (*Crepidula* sp.) have gregarious settlement (McGee and Targett 1989). | 1 | By definition, sessile sub-groups are immobile. | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Hemichordata | Ascidians (Tunicates, Sea squirts, Sea grapes) [Ascidiacea] | 1 | Ascidians may be solitary or colonial.<br>In the order Aplousobranchia all species are colonial (e.g., *Didemnum vexillum*).<br>The order Stolidobranchia includes solitary (e.g., *Molgula manhattensis)* and colonial species (e.g., *Botryllus schlosseri*) (Shenkar and Swalla 2011). | 1 | By definition, sessile sub-groups are immobile. | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Arthropoda | Barnacles [CL. Hexanauplia] | 1 | Encrusts hard substrates (Gosner 1971). Gregarious recruitment (Burke 1986). | 1 | By definition, sessile sub-groups are immobile. | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| Subtidal benthic | Rock and rubble dwellers | Low mobility | Cnidaria | Anemones [Anthozoa]; Colonial hydroids [Hydrozoa] | 1 | Species in this sub-group are solitary or colonial (Brusca and Brusca 1990). Hydroids form clumps (Hughes 1977). | 1 | Species in this sub-group exhibit low mobility.<br><br>Anemones move at a slow pace (Gosner 1971). Adults move very little, juveniles move more often to find suitable habitat. Anemones often persist even while habitat conditions change and once situated near a prey source, have the potential to occupy the site for many years (Sebens 1983). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Worms | Ribbon worms [Hoplonemertea]; Polychaete worms [Polychaeta]; Flatworms [Platyhelminthes] | 1 | Worms exhibit gregarious recruitment (Burke 1986).<br><br>Turbellarian flatworms form aggregations (Boaden 1995). | 1 | Species in this sub-group exhibit low mobility.<br><br>Polychaetes tend to show fidelity to the same habitat types rather than geographic fidelity (Kupriyanova and Badyaev 1998). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | | Mollusca | Nudibranchs, Whelks, Periwinkles [Gastropoda]; Scallops [Bivalvia] | 1 | Gastropods can be highly aggregated particularly during breeding (Spight 1974).<br><br>Scallops form aggregations and have gregarious recruitment (Carey and Stokesbury 2011).<br><br>Nudibranchs form breeding aggregations (Claverie and Kamenos 2008). | 1 | Species in this sub-group exhibit low mobility.<br><br>Some gastropods return to the same breeding site and a juvenile breeding for the first time is likely to return to near where it hatched (Spight 1974).<br><br>There is limited evidence that nudibranchs may form spawning migrations (Claverie and Kamenos 2008). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Subtidal benthic | Rock and rubble dwellers | Low mobility | Echinodermata | Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea]; Basket stars, Brittle stars [Ophiuroidea]; Sea urchins [Echinoidea] | 1 | Sea cucumbers gather in beds for improved reproductive success (Fisheries and Oceans Canada 2019).<br>Ophiuroidea and Asteroidea form feeding aggregations (Scheibling and Lauzon-Guay 2007). | 1 | Species in this sub-group exhibit low mobility.<br>Sea urchins form migrating feeding aggregations, grazing on macrophytes and sea stars will follow them, feeding on mussels exposed from the grazed kelp (Scheibling and Lauzon-Guay 2007).<br>Sea stars are opportunistic predators and will detect prey at a distance via chemoreception (Scheibling and Lauzon-Guay 2007). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | | High mobility | Mollusca | North Atlantic Octopus [Cephalopoda] | 1P | Octopuses are typically solitary (Gosner 1971). Octopuses do not aggregate in response to conspecifics unless mating but may aggregate around resources (Hofmeister and Voss 2017). | 0 | High mobility sub-group.<br>No site fidelity information found for the specific octopuses in this framework.<br>Octopuses may occupy the same shelter for a long period. Movement may be related to food scarcity and females may move to find better shelters (Mereu et al. 2015).<br>Another study on a different species of octopus says that home range is difficult to determine because of their highly mobile nature and it is difficult to discern if moving to another shelter is part of a larger home range (Hofmeister and Voss 2017). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion.<br>Atlantic Octopus is a benthic deep water species, and adults of this species will not interact with the sea surface (Gosner 1971). | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation.<br>Adult octopuses are benthic deep water species, interacting with the seafloor (Gosner 1971). |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Subtidal benthic | Rock and rubble dwellers | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] | 1 | Most decapods live singly, except during mating season (Brusca and Brusca 1990).<br>Berried Lobsters off the coast of Grand Manan, NB have been observed aggregating in the warmer, shallower waters (Campbell 1990). | 1P | Despite being a highly mobile species, in some areas, female Lobsters exhibit site fidelity by migrating seasonally for mating and spawning (Campbell 1990). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | Rock and rubble dwellers live in close association with the seafloor and/or vegetation. |
| | Sediment infauna | Low mobility | Cnidaria | Burrowing anemones [Anthozoa] | 1 | Solitary or colonial (Brusca and Brusca 1990). | 1 | Species in this sub-group exhibit low mobility.<br>Anemones move at a slow pace (Gosner 1971). Adults move very little, juveniles move more often to find suitable habitat. Anemones often persist even while habitat conditions change and once situated near a prey source, have the potential to occupy the site for many years (Sebens 1983). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | By definition, sediment infauna will interact with the seafloor/vegetation. |
| | | | Worms | Polychaete worms [Polychaeta]; Flatworms [Platyhelminthes]; Nemertean worms [Pilidiophora]; Peanut worms [Sipunculidea] | 1 | Worms exhibit gregarious recruitment (Burke 1986).<br>Nemertean worms often aggregate before fertilization occurs (Thiel and Junoy 2006).<br>Sipunculidea are usually reclusive (Brusca and Brusca 1990).<br>Turbellarian flatworms form aggregations (Boaden 1995). | 1 | Species in this sub-group exhibit low mobility.<br>Polychaetes tend to show fidelity to the same habitat types rather than geographic fidelity (Kupriyanova and Badyaev 1998). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | By definition, sediment infauna will interact with the seafloor/vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Subtidal benthic | Sediment infauna | Low mobility | Mollusca | Clams [Bivalvia] | 1 | Clams aggregate in dense beds (Bowen and Hunt 2009). | 1 | Species in this sub-group exhibit low mobility.<br>Infaunal clams move up and down in the sediment related to seasonal and tidal cues. Horizontal movement does occur for some species (*Mercenaria mercenaria),* but triggers for this movement aren't fully known (Tettelbach et al. 2017). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | By definition, sediment infauna will interact with the seafloor/vegetation. |
| | | | Echinodermata | Sea cucumbers (e.g., *Caudina arenata*), [Holothuroidea] | 1 | Echinoderms commonly form aggregations (Warner 1979). | 1 | Species in this sub-group exhibit low mobility.<br>Holothurians move through the use of tube feet (locomotor podia) (Brusca and Brusca 1990, Hyman et al. 1955). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | By definition, sediment infauna will interact with the seafloor/vegetation. |
| | | | Arthropoda | Amphipods [Amphipoda, Cumacea] | 1 | Most amphipods are gregarious (Brusca and Brusca 1990). | 1 | Some amphipod species are highly mobile relative to others, when searching for food and mates, but overall species in this sub-group exhibit low mobility.<br>Scavenging amphipods constantly search for food, and herbivorous amphipods move between living macrophytes and plant detritus (Beermann et al. 2015). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | By definition, sediment infauna will interact with the seafloor/vegetation. |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 1 | Bryozoans are colonial (Gosner 1971).<br>Branchiopods tend to aggregate (Gosner 1971). | 1 | Species in this sub-group exhibit low mobility. | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | By definition, sediment infauna will interact with the seafloor/vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Subtidal benthic | Sediment epifauna | Low mobility | Cnidaria | Anemones (Anthozoa] | 1 | Solitary or colonial (Brusca and Brusca 1990). | 1 | Species in this sub-group exhibit low mobility.<br>Anemones move at a slow pace (Gosner 1971). Adults move very little, juveniles move more often to find suitable habitat. Anemones often persist even while habitat conditions change and once situated near a prey source, have the potential to occupy the site for many years (Sebens 1983). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | By definition, sediment epifauna will interact with the seafloor/vegetation. |
| | | | Worms | Sea mouse [Polychaeta] | 0 | Solitary (Tyler-Walters and Hughes 2007). | 1P | Species in this sub-group exhibit low mobility.<br>Polychaetes tend to show site fidelity to the same habitat types rather than geographic fidelity (Kupriyanova and Badyaev 1998).<br>Sea mouse are scavengers and predators, so expected to move in relation to food (Brusca and Brusca 1990). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | By definition, sediment epifauna will interact with the seafloor/vegetation. |
| | | | Mollusca | Nudibranchs, Whelks, Moonsnails [Gastropoda]; Quahogs, Scallops [Bivalvia] | 1 | Nudibranchs form breeding aggregations (Claverie and Kamenos 2008).<br>Gastropods can be highly aggregated particularly during breeding (Spight 1974).<br>Scallops form aggregations and have gregarious recruitment (Carey and Stokesbury 2011). | 1 | Species in this sub-group exhibit low mobility.<br>Some gastropods return to the same breeding site and a juvenile breeding for the first time is likely to return to near where it hatched (Spight 1974).<br>There is limited evidence that nudibranchs may form spawning migrations (Claverie and Kamenos 2008). | 0 | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | 1 | By definition, sediment epifauna will interact with the seafloor/vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Subtidal benthic | Sediment epifauna | Low mobility | Echinodermata | Sand Dollars [Echinoidea]; Cushion stars, Mud stars [Asteroidea]; Sea cucumbers [Holothuroidea] | **1** | Sea cucumbers gather in beds for improved reproductive success (Fisheries and Oceans Canada 2019).<br>Asteroidea form feeding aggregations (Scheibling and Lauzon-Guay 2007). | **1** | Species in this sub-group exhibit low mobility. | **0** | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | **1** | By definition, sediment epifauna will interact with the seafloor/vegetation. |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] | **1** | Most decapods live singly, except during mating season (Brusca and Brusca 1990).<br>Berried, female Lobsters off the coast of Grand Manan, NB have been observed aggregating in the warmer, shallower waters (Campbell 1990). | **1P** | Despite being a highly mobile species, in some areas, female Lobsters exhibit site fidelity by migrating seasonally for mating and spawning (Campbell 1990). | **0** | Subtidal benthic species are not expected to interact with the sea surface; only intertidal or pelagic species will fulfill this criterion. | **1** | By definition, sediment epifauna will interact with the seafloor/vegetation. |
| Pelagic | N/A | Low mobility | Cnidaria | Moon jellies [Scyphozoa]; Hydromedusae [Hydrozoa]; Jellyfish [Scyphozoa] | **1** | Some Scyphozoa do form swarms e.g., *Cyanea* and *Chrysaora* (Gosner 1971). Jellyfish form spawning aggregations (Hamner et al. 1994). | **1** | Species in this sub-group exhibit low mobility.<br>Jellyfish (e.g., *Aurelia aurita*) drift on current (Hamner et al. 1994). Since jellyfish drift passively, they are not expected to exhibit site fidelity. | **1** | Pelagic species can interact with the sea surface.<br>Medusoid stages of Cnidarians are pelagic, and can interact with the sea surface (Brusca and Brusca 1990). | **0** | Pelagic species will not interact with the seafloor/vegetation. |
| | | | Ctenophora | Comb jellies [CL. Nuda, Tentaculata] | **1** | Often occur in dense swarms (Gosner 1971). | **1** | Species in this sub-group exhibit low mobility.<br>Comb jellies drift with ocean currents, though ctenes provide modest locomotion up and down the water column and to locate richer feeding grounds (Brusca and Brusca 1990). | **1** | Pelagic species can interact with the sea surface;<br>Ctenophores are found at the ocean surface to depths of 3,000 m (Brusca and Brusca 1990). | **0** | Pelagic species will generally not interact with the seafloor/vegetation.<br>Ctenophores have no attached, sessile stage (Brusca and Brusca 1990). |

<table>
<tr><th colspan="4">SUB-GROUP LEVEL</th><th rowspan="2">Maritime example species</th><th colspan="8">EXPOSURE Criteria</th></tr>
<tr><th colspan="4"></th><th colspan="2">Concentration (aggregation)</th><th colspan="2">Mobility and/or site fidelity</th><th colspan="2">Sea surface interacting</th><th colspan="2">Seafloor or vegetation interacting</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th></th><th>S</th><th>Justification</th><th>S</th><th>Justification</th><th>S</th><th>Justification</th><th>S</th><th>Justification</th></tr>
<tr><td>Pelagic</td><td>N/A</td><td>Low mobility</td><td>Zooplankton</td><td>Copepods, Mysids</td><td>1</td><td>Zooplankton can be patchy and have aggregations (Folt and Burns 1999).</td><td>1P</td><td>Species in this sub-group exhibit low mobility.<br>Some studies have shown that copepods may be able to sense oil and actively avoid it (Dupuis and Ucan-Marin 2015).</td><td>1</td><td>Pelagic species can interact with the sea surface.</td><td>0</td><td>Species in the pelagic sub-group will generally not interact with the seafloor.</td></tr>
<tr><td rowspan="3">Pelagic</td><td>N/A</td><td>High mobility</td><td>Mollusca</td><td>Squid [Cephalopoda]</td><td>1</td><td>Squid are gregarious (Arnold 1962).</td><td>1P</td><td>Considered a highly mobile species. However, squid migrate to inshore areas to spawn in the spring and winter in deeper, more temperature-stable waters (Brusca and Brusca 1990).<br>Research isn't clear if some populations demonstrate homing behavior when returning to spawn or if it due to sub-population recognition (Buresch et al. 2006).</td><td>1</td><td>Pelagic species can interact with the sea surface.<br>Squid move up and down in the water column for feeding and spawning (Brusca and Brusca 1990).</td><td>1</td><td>Fertilized eggs are deposited on the substratum (Brusca and Brusca 1990).</td></tr>
<tr><td colspan="2" rowspan="2">LARVAE</td><td colspan="2">Porifera</td><td>1</td><td>Most invertebrates have pelagic larvae that could form aggregations.</td><td>1</td><td>Limited ability to swim. Some pelagic larvae can control diel movements up and down in the water column (Miliekovsky 1973).</td><td>1</td><td>Larvae in the pelagic sub-group can be found interacting with the sea surface.</td><td>1P</td><td>Precautionary scoring applied to this sub-group. While early pelagic larval stages are not expected to interact with the seafloor, late larval settlement stages will interact with the seafloor/vegetation.</td></tr>
<tr><td colspan="2">Ctenophora</td><td>1</td><td>Most invertebrates have pelagic larvae that could form aggregations.</td><td>1</td><td>Limited ability to swim. Some pelagic larvae can control diel movements up and down in the water column (Miliekovsky 1973).</td><td>1</td><td>Larvae in the pelagic sub-group can be found interacting with the sea surface.</td><td>0</td><td>Most members of this sub-group have an entirely pelagic life cycle and larvae are not expected to interact with the seafloor/vegetation.</td></tr>
</table>

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Pelagic | LARVAE | | Cnidaria | | 1 | Most invertebrates have pelagic larvae that could form aggregations. | 1 | Limited ability to swim. Some pelagic larvae can control diel movements up and down in the water column (Miliekovsky 1973). | 1 | Larvae in the pelagic sub-group can be found interacting with the sea surface. | 1P | Precautionary scoring applied to this sub-group. While early pelagic larval stages are not expected to interact with the seafloor, late larval settlement stages will interact with the seafloor/vegetation. |
| | | | Worms | | 1 | Most invertebrates have pelagic larvae that could form aggregations. | 1 | Limited ability to swim. Some pelagic larvae can control diel movements up and down in the water column (Miliekovsky 1973). | 1 | Larvae in the pelagic sub-group can be found interacting with the sea surface. | 1P | Precautionary scoring applied to this sub-group. While early pelagic larval stages are not expected to interact with the seafloor, late larval settlement stages will interact with the seafloor/vegetation. |
| | | | Lophophorates | | 1 | Most invertebrates have pelagic larvae that could form aggregations. | 1 | Limited ability to swim. Some pelagic larvae can control diel movements up and down in the water column (Miliekovsky 1973). | 1 | Larvae in the pelagic sub-group can be found interacting with the sea surface. | 1P | Precautionary scoring applied to this sub-group. While early pelagic larval stages are not expected to interact with the seafloor, late larval settlement stages will interact with the seafloor/vegetation. |
| | | | Mollusca | | 1 | Most invertebrates have pelagic larvae that could form aggregations. | 1 | Limited ability to swim. Some pelagic larvae can control diel movements up and down in the water column (Miliekovsky 1973). | 1 | Larvae in the pelagic sub-group can be found interacting with the sea surface. | 1P | Precautionary scoring applied to this sub-group. While early pelagic larval stages are not expected to interact with the seafloor, late larval settlement stages will interact with the seafloor/vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Pelagic | LARVAE | | Echinodermata | | 1 | Most invertebrates have pelagic larvae that could form aggregations. | 1 | Limited ability to swim. Some pelagic larvae can control diel movements up and down in the water column (Miliekovsky 1973). | 1 | Larvae in the pelagic sub-group can be found interacting with the sea surface. | 1P | Precautionary scoring applied to this sub-group. While early pelagic larval stages are not expected to interact with the seafloor, late larval settlement stages will interact with the seafloor/vegetation. |
| | | | Hemichordata | | 1 | Most invertebrates have pelagic larvae that could form aggregations. | 1 | Limited ability to swim. Some pelagic larvae can control diel movements up and down in the water column (Miliekovsky 1973). | 1 | Larvae in the pelagic sub-group can be found interacting with the sea surface. | 1P | Precautionary scoring applied to this sub-group. While early pelagic larval stages are not expected to interact with the seafloor, late larval settlement stages will interact with the seafloor/vegetation. |
| | | | Arthropoda | | 1 | Most invertebrates have pelagic larvae that could form aggregations. | 1 | Limited ability to swim. Some pelagic larvae can control diel movements up and down in the water column (Miliekovsky 1973). | 1 | Larvae in the pelagic sub-group can be found interacting with the sea surface. | 1P | Precautionary scoring applied to this sub-group. While early pelagic larval stages are not expected to interact with the seafloor, late larval settlement stages will interact with the seafloor/vegetation. |

*Table A5. Marine invertebrates sub-group scores for SENSITIVITY scoring criteria, the column labelled “S” indicates the score assigned (note: species lists are not exhaustive; scores with a “P” indicate a precautionary score due to knowledge gaps).*

| **SUB-GROUP LEVEL** | | | | **Maritime example species** | **SENSITIVITY Criteria** | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | **Mechanical Sensitivity**<br>**Reduction of feeding/photosynthesis/thermoregulation** | | **Chemical Sensitivity**<br>**Impairment due to toxicity** | |
| **1** | **2** | **3** | **4** | | **S** | **Justification** | **S** | **Justification** |
| Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | Porifera | Sponges [CL. Demospongiae, Calcarea] | **1** | Filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Sponges can accumulate hydrocarbons which may affect growth and overall health (Vad et al. 2018). |
| | | | Cnidaria | Colonial hydroids [Hydrozoa]; Stalked jellyfish [Staurozoa] | **1** | Filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil.<br>Dahlia anemone may be susceptible to smothering effects and, in the case of thick oil, mortality seems likely (Jackson and Hiscock 2008). | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>The water soluble fractions of Monterey crude oil and drilling muds were reported to cause polyp shedding and other sub-lethal effects in the athecate hydrozoan *Tubularia crocea* in laboratory tests (Michel and Case 1984, Michel et al. 1986). The athecate hydrozoan *Cordylophora caspia* may show similar sublethal effects assuming similar physiology. |
| | | | Worms | Tube worms [Polychaeta] | **1** | Some species of polychaete tube worms are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | **1P** | Precautionary scoring applied as there is little research on this sub-group as a whole.<br>Figuerola et al. (2019) found no significant difference in the ability of marine calcifiers (*Spirobis* sp.) to build their exoskeleton/shell when comparing a control group to a group growing in sediment contaminated with polycyclic aromatic hydrocarbons (PAHs) and heavy metals.<br>Dorgan et al. (2020) found no significant impact to the feeding behaviour of *Owenia fusiformis* when exposed to sub-lethal concentrations of the water accommodated fraction (WAF) of oil. |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | **1** | Filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Although they may tolerate some hydrocarbon pollution, it is likely that *Bugula* species (Bryozoa) will be adversely affected by oil spills (Tyler-Walters 2005). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | Mollusca | Oysters, Mussels [Bivalvia]; Snails [Gastropoda] | 1 | Bivalves are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. Bivalves reduced feeding rates and/or food detection probably as a result of direct ciliary inhibition (Suchanek 1993).<br><br>Gastropods overweighted with oil may be washed from the substratum where there is increased likelihood of predation or if washed into the supratidal zone, desiccation. Reduced speed and movement may affect ability to elicit an effective predatory response (Suchanek 1993). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Bayne et al. (1982) reported that sublethal concentrations of petroleum hydrocarbons depressed the rate of feeding in gastropods and bivalves and increased the rates of oxygen consumption.<br><br>An 11-month monitoring study with mussels from two beaches impacted by the T/V Prestige oil spill found significantly higher DNA damage in mussel gills compared to reference animals. The damage was positively correlated with PAH concentrations in the seawater (Laffon et al. 2006 as cited in Bejarano and Michel 2016). |
| | | | Hemichordata | Sea peaches, Sea squirts [Ascidiacea] | 1 | Most ascidians are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>*Styela plicata,* a sea squirt, exposed to an acute, low dose (5% and 10%) of marine water-soluble fraction of diesel oil (WFDO) showed slower siphon closure and an inflammatory response (Barbosa et al. 2018). |
| | | | Arthropoda | Barnacles [CL. Hexanauplia] | 1 | Barnacles are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Unless directly covered and die from smothering, this sub group appears tolerant to oil (Suchanek 1993).<br><br>Goose-neck barnacles often seen attached to tar balls (Suchanek 1993). However, Johnson (1977), found that *Balanus balanoides* had reduced cirral sweeping rates after 6 hours of oil exposure, by 30 hours cirral activity stopped with the valves open and the cirri partially extended, and by 70 hours were dead. |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Intertidal | Rock and rubble dwellers | Low mobility | Cnidaria | Anemones [Anthozoa] | 1 | All cnidaria are carnivorous (Brusca and Brusca 1990), and anemones are typically microphagous suspension feeders with structures that can become clogged with oil.<br><br>Anemones can be smothered as oil is washed in with the tide (Blackburn et al. 2014). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>The anemone *Actinia equina* under chronic oil exposure (2.5 ml/L crude oil), ejected young prematurely, affecting their survival. Ovaries of these adults appear abnormal with few, if any, ova. Chronic treatment also resulted in anemones with mouths and tentacles expanded more, but with a slower response to food (Ormand and Caldwell 1982).<br><br>*Actinia* sp. after the Torrey Canyon spill were discoloured, flaccid, easy to detach, and some showed protruding gut structures (Clark and Finley 1977). *Anthopleura elegantissima* survived an hour of Bunker C oil exposure, possibly due to its wet tissues and mucous coating (Wicksten 1984). |
| | | | Worms | Bloodworms [Polychaeta]; Flatworms [Platyhelminthes]; Nemertean worms | 0 | Bloodworms, flatworms and nemerteans are not filter or suspension feeders (Brusca and Brusca 1990) so their feeding structures are not expected to become fouled. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>No information on the effects of pollution on bloodworms could be found. There has been very little work on the effects of pollution on turbellaria flatworms (Boaden 1995).<br><br>In a Monteiro et al. (2018) study on effects of oil-water soluble fraction (WSF) contamination on nematodes, most species experienced a moderate to high-level of mortality. They also found that closely related species had varied responses. |
| | | | Mollusca | Chitons [Polyplacophora]; Whelks, Limpets, Snails [Gastropoda] | 0 | Most species in this group are herbivory or predatory (macrophagous) feeders (Brusca and Brusca 1990) so their feeding structures are not expected to become fouled.<br><br>Gastropods overweighted with oil may be washed from the substratum where there is increased likelihood of predation or if washed into the supratidal zone, desiccation. Reduced speed and movement may affect ability to elicit an effective predatory response (Suchanek 1993). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Bayne et al. (1982) reported that sublethal concentrations of petroleum hydrocarbons depressed the rate of feeding in gastropods and bivalves and increased the rates of oxygen consumption.<br><br>Chitons, limpets and other gastropods experienced die offs after the 1967 Torrey Canyon spill, and the 1987 Nella Dan spill (Suchanek 1993). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Intertidal | Rock and rubble dwellers | Low mobility | Echinodermata | Sea stars [Asteroidea]; Sea urchins [Echinoidea]; Sea cucumbers [Holothuroidea] | 1 | Most species of sea cucumber are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Bokn et al. (1993) examined the long-term effects of continuous doses (average hydrocarbon concentrations 129.4 μg/L and 30.1 μg/L) of the water accommodated fraction (WAF) of diesel oil on rocky shore populations. The number of *Asterias rubens* decreased at all tidal levels and *Asterias rubens* disappeared entirely from upper sublittoral samples in the mesocosm receiving a high dose of WAF diesel oil suggesting a negative effect upon this species caused by exposure to high dose hydrocarbons. |
| | | | Arthropoda | Amphipods [Amphipoda]; Isopods [Isopoda] | 0 | Many decapods, amphipods, and isopods are scavengers and herbivores (Brusca and Brusca 1990), and as such have feeding structures that are not expected to become mechanically fouled.<br><br>Oil deposits on the strand line and amongst seaweed would probably incapacitate and kill, (e.g., by smothering), small crustaceans such as the isopod *Talitrus saltator* (Budd 2005).<br><br>Following the Torrey Canyon oil tanker spill in 1967 quantities of *Talitrus saltator* were found dead at Sennen, Cornwall, as were other scavengers of the strandline, e.g., *Ligia* and *Orchestia* (Budd 2005). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>In the 1977 Tsesis spill of No. 5 fuel oil and bunker oil, amphipods experienced over 90% mortality, and the few remaining amphipods showed approximately 10% abnormal or undifferentiated embryos, compared with typical levels of 1% (Suchanek 1993). |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] | 0 | Most decapods are scavengers or macrophagous feeders (Brusca and Brusca 1990) and as such do not have feeding structures that are not expected to become fouled by oil.<br><br>Crabs may be impacted by oil spills by smothering (Blackburn et al. 2014). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Negative changes in normal feeding behaviour of lobsters have been observed when exposed to 10 μL/L of crude oil (Bejarano and Michel 2016).<br><br>Crabs and lobsters have significantly reduced populations after oil spills, and many may be stranded on shore. Many crustaceans also burrow into the sediment, where oil can remained buried for decades, and this chronic exposure can lead to impaired feeding, mobility, development, and reproduction (Blackburn et al. 2014). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Intertidal | Sediment infauna | Low mobility | Worms | Sandworms, Lugworms, other burrowers [Polychaeta]; Nemertean worms [Paleonemertea]; Sipuncula worms [Sipunculidea]; Flatworms [Platyhelminthes] | 0 | Many species in this group are direct deposit feeders (Brusca and Brusca 1990) and as such have feeding structures that are not expected to become mechanically fouled. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Hailey (1995) cited substantial kills of *Nereis*, *Cerastoderma*, *Macoma*, *Arenicola* and *Hydrobia* as a result of the Sivand oil spill in the Humber estuary in 1983. Chemical sensitivity of polychaetes to oil can vary by species and by oil type. Bioaccumulation of polycyclic aromatic hydrocarbons (PAHs) has been recorded in individuals of *Arenicola marina* when exposed to the PAH pyrene, however individuals also showed a capacity to metabolize PAHs when returned to uncontaminated environments (Christensen et al. 2002).<br>Lewis et al. (2008) found exposure to crude oil water accommodated fraction (WAF) (equivalent to 0.38 $mgL^{-1}$) resulted in reproductive toxicity in *A. marina* and *Nereis virens*, which show a reduction in fertilization success to 26.8% and 76% respectively. In both species, the authors also noted reduced post-fertilization development rates and teratogenic effects in early embryo development. |
| | | | Mollusca | Clams, Astartes [Bivalvia]; Moonsnails [Gastropoda] | 1 | Most bivalves are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil.<br>Bivalves exhibit reduced feeding rates and/or food detection probably as a result of direct ciliary inhibition (Suchanek 1993).<br>Gastropods overweighted with oil may be washed from the substratum where there is increased likelihood of predation or if washed into the supratidal zone (Suchanek 1993). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Bayne et al. (1982) reported that sublethal concentrations of petroleum hydrocarbons depressed the rate of feeding in gastropods and bivalves and increased the rates of oxygen consumption.<br>In mesocosm studies, *Mercenaria mercenaria* exposed to 7 ppm to 0.06 ppm water soluble fraction (WSF) crude oil exhibited increased energy expenditure coupled with decreased feeding rates resulting in less energy available for growth and reproduction. All clams in the most polluted condition (7 ppm) died (Keck et al. 1978).<br>Increased energy expenditure coupled with decreased feeding rates results in less energy available for growth and reproduction and has been demonstrated to translate to reduced growth rates in juveniles of the bivalve *Mercenaria mercenaria* (Keck et al. 1978). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Intertidal | Sediment infauna | Low mobility | Arthropoda | Mud Crab [Decapoda, Panopeidae]; Tube-building gammarid amphipods [Amphipoda] | 1 | Although some members of this sub group are scavengers or predators, many small crustaceans may be selective deposit feeders (Brusca and Brusca 1990), and would have mouth parts that could become clogged with oil.<br><br>Tube building amphipods can be suspension/detritus feeders with feeding structures possibly fouled by oil (Brusca and Brusca 1990). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Ponat (1975) observed the narcotic effect of crude oil on *Gammarus salinus*, which reduced the species' oxygen consumption to 40% of normal levels.<br><br>Juvenile *Rhithropanopeus harrisii*, an estuarine mud crab, were exposed to non-dispersed and chemically dispersed water accommodated fraction (WAF) of crude oil using Louisiana sweet crude and Corexit® 9500A. In the non-dispersed treatments, the authors were unable to establish LD50, as after 96 h exposure, there was no mortality in any of the WAF treatments (Anderson et al. 2014). |
| | Sediment epifauna | Low mobility | Cnidaria | Starlet Anemones, Sand anemones [Anthozoa] | 1 | Anemones are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil.<br><br>Dahlia anemone may be susceptible to smothering effects and, in the case of thick oil, mortality seems likely (Jackson and Hiscock 2008). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>*Actinia equina* under chronic oil exposure (2.5 ml/L crude oil), ejected young prematurely, affecting their survival. Ovaries of these adults appear abnormal with few, if any, ova. Chronic treatment also resulted in anemones with mouths and tentacles expanded more, but with a slower response to food (Ormand and Caldwell 1982).<br><br>*Actinia* sp. after the Torrey Canyon spill were discoloured, flaccid, easy to detach, and some showed protruding gut structures (Clark and Finley 1977). *Anthopleura elegantissima* survived an hour of Bunker C oil exposure, possibly due to its wet tissues and mucous coating (Wicksten 1984). There is not specific information for Starlet and Sand anemones. |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Intertidal | Sediment epifauna | Low mobility | Mollusca | Nudibranchs [Gastropoda, Nudibranchia]; Snails [Gastropoda]; Scallops [Bivalvia] | 1 | Bivalves are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil.<br><br>Bivalves exhibit reduced feeding rates and/or food detection probably as a result of direct ciliary inhibition (Suchanek 1993).<br><br>Gastropods overweighted with oil may be washed from the substratum where there is increased likelihood of predation or if washed into the supratidal zone, desiccation (Suchanek 1993). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Bayne et al. (1982) reported that sublethal concentrations of petroleum hydrocarbons depressed the rate of feeding in gastropods and bivalves and increased the rates of oxygen consumption.<br><br>An 11-month monitoring study with mussels from two beaches impacted by the T/V Prestige oil spill found significantly higher DNA damage in mussel gills compared to reference animals. The damage was positively correlated with PAH concentrations in the seawater (Laffon et al. 2006 as cited in Bejarano and Michel 2016).<br><br>The dorid nudibranch, *Onchidoris bilamellata*, exposed to sea water soluble fraction of Prudhoe Bay crude oil (13–420 ppb) didn't move towards other non-oil exposed aggregated mating nudibranchs, indicating that chemotactic behavior was affected. In another study, the eggs of *Onchidoris bilamellata* were exposed to sea water soluble fractions of Prudhoe Bay crude oil (0, 8, 27, or 278 ppb), and displayed delayed development at the highest concentration, with close to 50% of the eggs showing abnormalities. All severe abnormalities involved non-encapsulation of the eggs (Hodgins 1978). |
| | | | Echinodermata | Brittle stars [Ophiuroidea]; Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea] | 1 | Most species of sea cucumber are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Bokn et al. (1993) examined the long-term effects of diesel water accommodated fraction (WAF) on rocky shore populations. The numbers of *Asterias rubens* decreased at all tidal levels (even in the control mesocosms during the study) and *Asterias rubens* disappeared entirely from upper sublittoral samples in the mesocosm receiving high doses of WAF diesel, suggesting a negative effect upon this species caused by the high dose treatment. |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Intertidal | Sediment epifauna | Low mobility | Arthropoda | Hermit crabs [Decapoda]; Sand fleas and other amphipods [Amphipoda]; Sea spiders [Pycnogonida]; Isopods [Isopoda] | 0 | Many decapods, amphipods, and isopods are scavengers and herbivores (Brusca and Brusca 1990) with feeding structures that are not expected to become mechanically fouled.<br><br>Oil deposits on the strand line and amongst seaweed would probably incapacitate and kill, e.g., by smothering, small crustaceans such as [isopod] *Talitrus saltator*.<br><br>Following the Torrey Canyon oil tanker spill in 1967 quantities of *Talitrus saltator* were found dead at Sennen, Cornwall, as were other scavengers of the strandline, e.g., *Ligia* and *Orchestia* (Budd 2005). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Amphipods and crabs were no longer found in oiled grass and oil-soaked sands after a 1975 spill of crude oil emulsion in the Florida Keys (Bejarano and Michel 2016).<br><br>Amphipods associated with wrack experienced mass mortality after the T/B Peck Slip bunker C spill in Peurto Rico (Bejarano and Michel 2016). |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] | 0 | Most decapods are scavengers or macrophagous feeders (Brusca and Brusca 1990) with feeding structures that are not expected to become mechanically fouled. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Negative changes in normal feeding behaviour of lobsters have been observed when exposed to 10 µL/L of crude oil (Bejarano and Michel 2016).<br><br>Crabs and lobsters have significantly reduced populations after oil spills, and many may be stranded on shore. Many crustaceans also burrow into the sediment, where oil can remain buried for decades, and this chronic exposure can lead to impaired feeding, mobility, development, and reproduction (Blackburn et al. 2014). |
| Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | Porifera | Boring sponges, Breadcrumb sponges, Encrusting sponges [CL. Demospongiae, Calcarea] | 1 | Sponges are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>In shallow water sponges, polycyclic aromatic hydrocarbons (PAHs) have been shown to disturb sponge larval settlement and development.<br><br>Oil and dispersants can persist in sediments, which may be a concern for deep sea sponges. Deep sea sponges can be slow to recover from anthropogenic activities. Knowledge is lacking for more specific effects of oil on deep sea sponges (Vad et al. 2018). |
| Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | Cnidaria | Colonial hydroids [Hydrozoa]; Soft corals [Anthozoa]; Stalked jellyfish [Staurozoa] | 1 | Filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>The water soluble fractions of Monterey crude oil and drilling muds were reported to cause polyp shedding and other sub-lethal effects in the athecate *Tubularia crocea* in laboratory tests (Michel and Case 1984, Michel et al. 1986). The athecate *Cordylophora caspia* may show similar sublethal effects assuming similar physiology. |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| | | | Worms | Tube worms [Polychaeta] | 1 | Many species of tube building polychaete are suspension or filter feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied as there is little research on this sub-group as a whole.<br>Figuerola et al. (2019) found no significant difference in the ability of marine calcifiers (*Spirobis* sp.) to build their exoskeleton/shell when comparing a control group to a group growing in sediment contaminated with polycyclic aromatic hydrocarbons (PAHs) and heavy metals.<br>Dorgan et al. (2020) found no significant impact to the feeding behaviour of *Owenia fusiformis* when exposed to sub-lethal concentrations of the water accommodated fraction (WAF) of oil. |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 1 | Lampshells are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Although they may tolerate some hydrocarbon pollution, it is likely that *Bugula* species will be adversely affected by oil spills (Tyler-Walters 2005). |
| | | | Mollusca | Slipper limpets [Gastropoda]; Mussels, Oysters, Comb bathyarks [Bivalvia] | 1 | Bivalves are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil.<br>Bivalves exhibit reduced feeding rates and/or food detection probably as a result of direct ciliary inhibition (Suchanek 1993).<br>Gastropods overweighted with oil may be washed from the substratum where there is increased likelihood of predation or if washed into the supratidal zone, desiccation. Reduced speed and movement may affect ability to elicit an effective predatory response (Suchanek 1993). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Bayne et al. (1982) reported that sublethal concentrations of petroleum hydrocarbons depressed the rate of feeding in gastropods and bivalves and increased the rates of oxygen consumption.<br>An 11-month monitoring study with mussels from two beaches impacted by the T/V Prestige oil spill found significantly higher DNA damage in mussel gills compared to reference animals. The damage was positively correlated with PAH concentrations in the seawater (Laffon et al. 2006 as cited in Bejarano and Michel 2016). |
| Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | Hemichordata | Ascidians (tunicates, sea squirts, sea grapes) [Ascidiacea] | 1 | Most ascidians are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>*Styela plicata,* a sea squirt, exposed to an acute, low dose (5% and 10%) of marine water-soluble fraction of diesel oil (WFDO) showed slower siphon closure and an inflammatory response (Barbosa et al. 2018). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| | | | Arthropoda | Barnacles [CL. Hexanauplia] | 1 | Barnacles are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied as conflicting information present in literature.<br>Unless directly covered and die from smothering, tolerant to oil (Suchanek 1993).<br>Goose barnacles often seen attached to tar balls (Suchanek 1993).<br>However, Johnson (1977), found that *Balanus balanoides* had reduced cirral sweeping rates after 6 hours of oil exposure, by 30 hours cirral activity stopped with the valves open and the cirri partially extended, and by 70 hours were dead. |
| | | Low mobility | Cnidaria | Anemones [Anthozoa]; Colonial hydroids [Hydrozoa] | 1 | Most species of cnidaria are suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>*Actinia equina* under chronic oil exposure (2.5 ml/L crude oil), ejected young prematurely, affecting their survival. Ovaries of these adults appear abnormal with few, if any, ova. Chronic treatment also resulted in anemones with mouths and tentacles expanded more, but with a slower response to food (Ormand and Caldwell 1982).<br>*Actinia* sp. after the Torrey Canyon spill were discoloured, flaccid, easy to detach, and some showed protruding gut structures (Clark and Finley 1977). *Anthopleura elegantissima* survived an hour of Bunker C oil exposure, possibly due to its wet tissues and mucous coating (Wicksten 1984). |
| Subtidal benthic | Rock and rubble dwellers | Low mobility | Worms | Ribbon worms [Hoplonemertea];<br>Polychaete worms [Polychaeta];<br>Flatworms [Platyhelminthes] | 1 | Ribbon worms are opportunists/scavengers or predators (Brusca and Brusca 1990).<br>Polychaetes have a variety of feeding strategies (surface deposit feeders, subsurface deposit feeders, filter/suspension feeders, opportunists/scavengers, predators) (Brusca and Brusca 1990). Filter or suspension feeding polychaetes may have feeding structures that can become clogged by oil.<br>Plathyhelminths are opportunists/scavengers or predators (Degan and Faulwetter 2019). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>There has been very little work on the effects of pollution on turbellaria flatworms (Boaden 1995). In a Monteiro et al. (2018) study on effects of oil-water soluble fraction (WSF) contamination on nematodes, most species experienced a moderate to high-level of mortality. They also found that closely related species had varied responses.<br>No information on the effects of oil on ribbon worms could be found. |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| | | | Mollusca | Nudibranchs, Whelks, Periwinkles [Gastropoda]; Scallops [Bivalvia] | 1 | Scallops are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. Bivalves exhibit reduced feeding rates and/or food detection probably as a result of direct ciliary inhibition (Suchanek 1993).<br><br>Gastropods overweighted with oil may be washed from the substratum where there is increased likelihood of predation or if washed into the supratidal zone, desiccation. Reduced speed and movement may affect ability to elicit an effective predatory response (Suchanek 1993). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Bayne et al. (1982) reported that sublethal concentrations of petroleum hydrocarbons depressed the rate of feeding in gastropods and bivalves and increased the rates of oxygen consumption.<br><br>Increased energy expenditure coupled with decreased feeding rates results in less energy available for growth and reproduction and has been demonstrated to translate to reduced growth rates in juveniles of the bivalve *Mercenaria mercenaria* (Keck et al. 1978).<br><br>The dorid nudibranch, *Onchidoris bilamellata*, exposed to sea water soluble fraction of Prudhoe Bay crude oil (13–420 ppb) did not move towards other non-oil exposed aggregated mating nudibranchs, indicating that chemotactic behavior was affected. In another study, the eggs of *Onchidoris bilamellata* were exposed to sea water soluble fractions of Prudhoe Bay crude oil (0, 8, 27, or 278 ppb), and displayed delayed development at the highest concentration, with close to 50% of the eggs showing abnormalities. All severe abnormalities involved non-encapsulation of the eggs (Hodgins 1978). |
| Subtidal benthic | Rock and rubble dwellers | Low mobility | Echinodermata | Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea]; Basket stars, Brittle stars [Ophiuroidea]; Sea urchins [Echinoidea] | 1 | Most species are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Sea stars have exhibited reduction in feeding rates, as well as reduced growth rates when exposed to concentrations of crude oil greater than 0.12 ppm. Additionally, sea urchins have showed embryological abnormalities (delayed embryogenesis, asynchronism and production of non-viable larvae) when exposed to hydrocarbon concentrations of 10–30 mg / L (Suchanek 1993). |
| | | High mobility | Mollusca | North Atlantic octopus [Cephalopoda] | 0 | This sub-group does not feed using filter or suspension feeding structures (Brusca and Brusca 1990). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>As referred to in Lacoue-Labarthe et al. (2016), there are very few toxicological studies examining the effect of oil on cephalopods. Of these, Long and Holdway (2002) found that after exposing *Octopus pallidus* hatchlings to crude water accommodated fraction (WAF), $LC_{50}$ was 1.8 ppm in a 48 h exposure test. |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| | | | Arthropoda | Crabs, Lobsters, [Decapoda] | 0 | Most decapods are scavengers or macrophagous feeders with feeding structures that are not expected to become clogged with oil (Brusca and Brusca 1990). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Negative changes in normal feeding behaviour of Lobsters have been observed when exposed to 10µL/L of crude oil (Bejarano and Michel 2016).<br>Crabs and Lobsters have significantly reduced populations after oil spills, and many may be stranded on shore. Many crustaceans also burrow into the sediment, where oil can remained buried for decades, and this chronic exposure can lead to impaired feeding, mobility, development, and reproduction (Blackburn et al. 2014). |
| Subtidal benthic | Sediment infauna | Low mobility | Cnidaria | Burrowing anemones [Anthozoa] | 1 | Filter or suspension feeders (Brusca and Brusca 1990), with feeding structures that can become clogged by oil.<br>Dahlia anemone may be susceptible to smothering effects and, in the case of thick oil, mortality seems likely (Jackson and Hiscock 2008). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>The anemone, *Actinia equine,* under chronic oil exposure (2.5 ml/L crude oil), ejected young prematurely, affecting their survival. Ovaries of these adults appear abnormal with few, if any, ova. Chronic treatment also resulted in anemones with mouths and tentacles expanded more, but with a slower response to food (Ormand and Caldwell 1982).<br>*Actinia* sp. after the Torrey Canyon spill were discoloured, flaccid, easy to detach, and some showed protruding gut structures (Clark and Finley 1977). The aggregating anemone, *Anthopleura elegantissima* survived an hour of Bunker C oil exposure, possibly due to its wet tissues and mucous coating (Wicksten 1984). |
| | | | Worms | Polychaete worms [Polychaeta]; Flatworms [Platyhelminthes]; Nemertean worms [Pilidiophora]; Peanut worms [Sipunculidea] | 1 | Tube building polychaete worms such as Sabellidae are suspension feeders (Brusca and Brusca1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Hailey (1995) cited substantial kills of *Nereis*, *Cerastoderma*, *Macoma*, *Arenicola* and *Hydrobia* as a result of the Sivand oil spill in the Humber estuary in 1983. |
| | | | Mollusca | Clams [Bivalvia] | 1 | Filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Clams exhibit slower burrowing rates, disorientation, and reduced activity when exposed to oil (Bejarano and Michel 2016).<br>Most species of clams were depleted following the 1978 Amoco Cadiz spill of light crude oil in France (Bejarano and Michel 2016). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| **1** | **2** | **3** | **4** | | **S** | **Justification** | **S** | **Justification** |
| | | | Echinodermata | Sea cucumbers (e.g., *Caudina arenata*), [Holothuroidea] | **1** | Most species are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Sea cucumbers remain understudied. In general, studies on echinoderms show consistent, acute impacts on benthic community's responses to oil spills, likely due to absorbing toxins through large areas of exposed epidermis (Blackburn et al. 2014, Suchanek 1993). |
| Subtidal benthic | Sediment infauna | Low mobility | Arthropoda | Amphipods [Amphipoda, Cumacea] | **1** | Some species of amphipod (e.g., *Coropium volutator*) are suspension feeders (Neal and Avant 2006) and have feeding structures that can become clogged with oil. | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Mean acute 96 h $LC_{50}$ values for exposure of the amphipod, *Allorchestes compressa*, to a water accommodated fraction (WAF) of crude oil was 311,000 ppm (Gulec et al. 1997). Lowest observable effect concentration (LOEC) of WAF of crude oil for the amphipod was 31,250 ppm, and the authors stipulate that the concentration of oil (crude) below the surface in a spill would likely be below the LOEC shown above (Gulec et al. 1997).<br>Ho et al. (1999) performed a 96 h static mortality sediment toxicity test using the amphipod *Ampellisca abdita* exposed to polycyclic aromatic hydrocarbon (PAH) laden sediment collected following a spill of over 3 million liters of No. 2 fuel oil. Sediment was collected on days 6, 13, 33, 62, 132, 189, and 270 post spill. Mortality as high as 95% was recorded up to 132 days following the spill. Toxicity was correlated with concentrations of PAHs in the sediment (Ho et al. 1999). |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | **1** | Filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Little toxicological information has been found relating to bryozoans and oil. Bryozoans are rarely reported when considering the impacts of oil spills (Keesing et al. 2018) and toxicological studies seem to focus primarily on antifouling paint rather than oil.<br>Burns et al. (1993) found that bryozoans were among the species groups that recovered most quickly after being impacted by oil (mangrove roots covered by oil). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Subtidal benthic | Sediment epifauna | Low Mobility | Cnidaria | Anemones [Anthozoa] | 1 | Filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil.<br>Dahlia anemone may be susceptible to smothering effects and, in the case of thick oil, mortality seems likely (Jackson and Hiscock 2008). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>The anemone, *Actinia equine,* under chronic oil exposure (2.5 ml/L crude oil), ejected young prematurely, affecting their survival. Ovaries of these adults appear abnormal with few, if any, ova. Chronic treatment also resulted in anemones with mouths and tentacles expanded more, but with a slower response to food (Ormand and Caldwell 1982).<br>After the Torrey Canyon spill, *Actinia* sp. were discoloured, flaccid, easy to detach, and some showed protruding gut structures (Clark and Finley 1977). *Anthopleura elegantissima* survived an hour of Bunker C oil exposure, possibly due to its wet tissues and mucous coating (Wicksten 1984). |
| | | | Worms | Sea mouse [Polychaeta] | 0 | Do not have filter or suspension feeding structures that are expected to be clogged by oil (Tyler-Walters and Hughes 2007). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group. |
| | | | Mollusca | Nudibranchs, Whelks, Moonsnails [Gastropoda]; Quahogs, Scallops [Bivalvia] | 1 | Scallops are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil.<br>Bivalves exhibit reduced feeding rates and/or food detection probably as a result of direct ciliary inhibition (Suchanek 1993).<br>Gastropods overweighted with oil may be washed from the substratum where there is increased likelihood of predation or if washed into the supratidal zone, desiccation (Suchanek 1993). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Bayne et al. (1982) reported that sublethal concentrations of petroleum hydrocarbons depressed the rate of feeding in gastropods and bivalves and increased the rates of oxygen consumption.<br>Increased energy expenditure coupled with decreased feeding rates results in less energy available for growth and reproduction and has been demonstrated to translate to reduced growth rates in juveniles of the bivalve *Mercenaria mercenaria* (Keck et al. 1978).<br>The dorid nudibranch, *Onchidoris bilamellata*, exposed to sea water soluble fraction of Prudhoe Bay crude oil (13–420 ppb) did not move towards other non-oil exposed aggregated mating nudibranchs, indicating that chemotactic behavior was affected. In another study, the eggs of *Onchidoris bilamellata* were exposed to sea water soluble fractions of Prudhoe Bay crude oil (0, 8, 27, or 278 ppb), and displayed delayed development at the highest concentration, with close to 50% of the eggs showing abnormalities. All severe abnormalities involved non-encapsulation of the eggs (Hodgins 1978). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Subtidal benthic | Sediment epifauna | Low mobility | Echinodermata | Sand dollars [Echinoidea]; Cushion stars, Mud stars [Asteroidea]; Sea cucumbers [Holothuroidea] | 1 | Most species are filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Bokn et al. (1993) examined the long-term effects of the water-accommodated fraction (WAF) of diesel oil on rocky shore populations. The numbers of *Asterias rubens* decreased at all tidal levels (even in the control mesocosms during the study) and *Asterias rubens* disappeared entirely from upper sublittoral samples in the mesocosm receiving a high dose of WAF diesel oil suggesting a negative effect upon this species caused by the high dose treatment. |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] | 0 | Most decapods are scavengers or macrophagous feeders (Brusca and Brusca 1990) that do not have feeding structures expected to become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Negative changes in normal feeding behaviour of lobsters have been observed when exposed to 10 µL/L of crude oil (Bejarano and Michel 2016).<br><br>Crabs and lobsters have significantly reduced populations after oil spills, and many may be stranded on shore. Many crustaceans also burrow into the sediment, where oil can remained buried for decades, and this chronic exposure can lead to impaired feeding, mobility, development, and reproduction (Blackburn et al. 2014). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Pelagic | N/A | Low mobility | Cnidaria | Moon jellies [Scyphozoa]; Hydromedusae [Hydrozoa]; Jellyfish [Scyphozoa] | 1 | Filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Swimming and predator avoidance impaired by oil (Suchanek 1993).<br><br>Echols et al. (2016), in a 96 h acute toxicity test for lethal response to crude oil, found that ephyrae of the *Aurelia aurita* (Schyphozoa) showed no acute toxic response ($LC_{50}$ > 100% water accommodated fraction (WAF). The authors measured the total polycyclic aromatic hydrocarbons (TPAHs) as the sum of 46 PAHs, which averaged out to be 21.1 and 152 µg TPAH/L for WAFs of weathered and unweathered oil, respectively (Echols et al. 2016).<br><br>Almeda et al. (2013) exposed adult and larval stages of the two Scyphozoans, *Pelagia noctiluca* and *Aurelia aurita* to crude oil emulsions, testing lethal effects. At concentrations of 20–40 µL/L, *P. noctiluca* showed 10% mortality after 16 h. The adult stages of *A. aurita* exhibited sub-lethal effects at concentrations ≤ 25 µL/L, including slight tissue damage and abnormal swimming behaviour. Survival of ephyra larvae of *A. aurita* decreased with increasing crude concentrations, decreasing to < 40% at crude concentrations of ≥ 1 µL/L (Almeda et al. 2013).<br><br>Additionally, Almeda et al. (2013) recorded bioaccumulation in adult stages of *A. aurita*, which exhibited 1.4, 2.3, 3.1 times higher total PAH concentrations than the control when exposed to 1, 5, and 25 µL/L of crude oil (Almeda et al. 2013). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Pelagic | N/A | Low mobility | Ctenophora | Comb jellies [CL. Nuda, Tentaculata] | 1 | Filter or suspension feeders (Brusca and Brusca 1990) with feeding structures that can become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Almeda et al. (2013) found that the comb jelly *Mnemiopsis leidyi,* were tolerant to high exposures of crude oil. *Mnemiopsis leidyi* cydippid larvae showed a high tolerance to crude oil exposure, suggesting that this species may be able to complete their development and life cycle at relatively high crude oil exposure concentrations. Adult and larval stages both experienced alterations in swimming behavior (low mobility, slow swimming speeds, inverse swimming), but it is not known if these sublethal effects are prolonged or reversible. If not, then other vital physiological activities, such as feeding, may be affected, and there may be an increase in predation. They also bioaccumulate polycyclic aromatic hydrocarbons (PAH's) which may enter the food web. More studies are needed on the survival and effects on earlier larval stages.<br><br>Peiffer and Cohen (2015) examined the effects of petroleum hydrocarbon on *M. leidyi* at seasonally relevant temperatures, using Corexit® 9500A dispersant, crude oil (WAF), and dispersed crude oil (CEWAF). The authors reported LC50 of 4.7 mg/L (24 hours at 23°C) and 29.5 mg/L (24 hours at 15°C) in crude oil WAF treatments. |
| Pelagic | N/A | Low mobility | Zooplankton | Copepods, Mysids | 1 | Both copepods and mysids have feeding structures that may become clogged by oil.<br><br>Copepods feed in one of two ways (sometimes both): ambush feeding and feeding-current feeding (Kiorboe 2011).<br><br>Most mysid are filter/suspension feeders (Degan and Faulwetter 2019). | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Olsen et al. (2013) examined impacts on *Calanus finmarchicus* in a 120-h exposure to concentrations of 0.022, 1.8, and 16.5 mg /L of dispersed North Sea crude oil. The authors noted mortality of 3%, 15%, and 42% in all concentrations, respectively. The authors also noted increased sluggishness when examining the swimming behavior of surviving females. The authors found a concentration-dependent depression on reproductive capacity in exposed groups, though egg production seemed to stabilize and recover following 25 day post-exposure recovery period, indicating they may be able to recover after a spill event (Olsen et al. 2013).<br><br>*Mysis oculata* exposed to oil in water dispersions and water soluble fractions had among the lowest median $LC_{50}$ of reported Arctic crustaceans, ranging from 0.49–0.62 mg/L for water soluble fractions and 4.51–7.57 mg/L for oil in water dispersions (Reibel and Percy 1990). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | **Mechanical Sensitivity**<br>**Reduction of feeding/photosynthesis/thermoregulation** | | **Chemical Sensitivity**<br>**Impairment due to toxicity** | |
| **1** | **2** | **3** | **4** | | **S** | **Justification** | **S** | **Justification** |
| | | High mobility | Mollusca | Squid [Cephalopoda] | **0** | Do not have filter or suspension feeding structures (Brusca and Brusca 1990) that are expected to become clogged by oil | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>As referred to in Lacoue-Labarthe et al. (2016), there are very few toxicological studies examining the effect of oil on cephalopods. Of these, Long and Holdway (2002) found that after exposing *Octopus pallidus* hatchlings to crude water accommodated fraction (WAF), $LC_{50}$ was 1.8 ppm in a 48 h exposure test. |
| Pelagic | LARVAE | | Porifera | | **0** | Known larvae are lecithotrophic (Brusca and Brusca 1990), therefore do not have feeding structures that will be clogged by oil. | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>There is a lack of research on the effects of hydrocarbons on Porifera larvae (Vad et al. 2018).<br>A recent study (Luter et al. 2019) on a coral reef sponge, *Rhopaloeides odorabile*, exposed larvae to water-accommodated fractions (WAF) of crude oil, chemically enhanced water accommodated fractions of crude oil (CEWAF), and dispersant (Corexit® EC9500A). Larval survival was not impacted by exposure to WAF of crude oil (107 µg / L).<br>Significant decreases in metamorphosis occurred at 13.9 µg/L WAF. Additionally, microbial shifts were detected at concentrations as low as 1.7 µg/L WAF, indicating microbial community impacts at low concentrations (Luter et al. 2019). |
| | | | Ctenophora | | **1** | Cydippid larvae have a mouth (Brusca and Brusca 1990) that may become clogged with oil. | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Cydippid larvae of the comb jelly *Mnemiopsis leidyi*, exhibited a high tolerance to crude oil exposure, suggesting that this species may be able to complete their development and life cycle at relatively high crude oil exposure concentrations. Adult and larval stages both experienced alterations in swimming behavior (low mobility, slow swimming speeds, inverse swimming), but it is not known if these sublethal effects are prolonged or reversible. If not, then other vital physiological activities, such as feeding, may be affected, and there may be an increase in predation. They also bioaccumulate polycyclic aromatic hydrocarbons (PAH's) which may enter the food web. More studies are needed on the survival and effects on earlier larval stages (Almeda et al. 2013). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Pelagic | LARVAE | | | Cnidaria | 1 | Typically have non-feeding planula larvae (Brusca and Brusca 1990), and will not have feeding structures that can be clogged by oil.<br>However, some Hydrozoans have an actinula larval stage (Brusca and Brusca 1990) which does have mouth structures that may become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Echols et al. (2016), in a 96 h acute toxicity test for lethal response to crude oil, found that ephyrae of the *Aurelia aurita* (Schyphozoa) showed no acute toxic response ($LC_{50}$ > 100% water accommodated fraction (WAF). The authors measured the total polycyclic aromatic hydrocarbons (TPAHs) as the sum of 46 PAHs, which averaged out to be 21.1 and 152 µg TPAH/L for WAFs of weathered and unweathered oil, respectively (Echols et al. 2016).<br>Almeda et al. (2013) exposed adult and larval stages of the two Scyphozoans, *Pelagia noctiluca* and *Aurelia aurita* to crude oil emulsions, testing lethal effects. At concentrations of 20–40 µL/L, *P. noctiluca* showed 10% mortality after 16 h. The adult stages of *A. aurita* exhibited sub-lethal effects at concentrations ≤ 25 µL/L, including slight tissue damage and abnormal swimming behaviour. Survival of ephyra larvae of *A. aurita* decreased with increasing crude concentrations, decreasing to < 40% at crude concentrations of ≥ 1 µL/L (Almeda et al. 2013). |
| | | | | Worms | 1 | Some worms have lecithotrophic larvae and some worms have planktotrophic larvae (Brusca and Brusca 1990) with mouth structures that may become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Larvae of sea urchins, sea stars, crustaceans, molluscs, and marine worms in the zooplankton are exposed to floating oil slicks and to small dissolved droplets of oil. Negative impacts include death, impaired growth, development and reproduction (Blackburn et al. 2014). |
| | | | | Lophophorates | 1 | Free swimming pelagic larvae (Brusca and Brusca 1990) with mouth structures that may become clogged with oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group. |
| | | | | Mollusca | 1 | Trocophore larval stages and some veliger larvae have mouth structures or feeding organs (Brusca and Brusca 1990) that may become clogged with oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Larvae of sea urchins, sea stars, crustaceans, molluscs, and marine worms in the zooplankton are exposed to floating oil slicks and to small dissolved droplets of oil. Negative impacts include death, impaired growth, development and reproduction (Blackburn et al. 2014). |

| SUB-GROUP LEVEL | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification |
| Pelagic | LARVAE | | Echinodermata | | 1 | Echinoderms have both planktonic and lecithotrophic larvae (Brusca and Brusca 1990). Planktonic species would have mouth structures that may become clogged with oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Larvae of sea urchins, sea stars, crustaceans, molluscs, and marine worms in the zooplankton are exposed to floating oil slicks and to small dissolved droplets of oil. Negative impacts include death, impaired growth, development and reproduction (Blackburn et al. 2014). |
| | | | Hemichordata | | 1 | Some species have planktotrophic larvae (Brusca and Brusca 1990) and would have mouth structures that may become clogged by oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Almeda et al. (2014a) exposed barnacle larvae (*Amphibalanus improvisus*) and tornaria larvae (*Schizocardium* sp.) to Louisiana sweet crude oil, chemically dispersed crude oil, and dispersant Corexit 9500A. Barnacle larvae was more sensitive as it ingested the crude oil. The tornaria larvae was lecithotrophic larvae and did not ingest the oil. Growth rates of both species were negatively affected. |
| | | | Arthropoda | | 1 | Many species have free swimming nauplius larvae that are planktotrophic (Brusca and Brusca 1990) and would have mouth structures that may become clogged with oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Larvae of sea urchins, sea stars, crustaceans, molluscs, and marine worms in the zooplankton are exposed to floating oil slicks and to small dissolved droplets of oil. Negative impacts include death, impaired growth, development and reproduction (Blackburn et al. 2014). |

*Table A6. Marine invertebrates sub-group scores for RECOVERY scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps).*

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | Porifera | Sponges [CL. Demospongiae, Calcarea] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1P | Species in this sub-group are generally long lived, reproducing both sexually and asexually. Reproductive success is impacted by environmental conditions. Additionally, asexual budding or fragmentation implies lower reproductive capacity than sexual reproduction in this sub-group, and in general. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| | | | Cnidaria | Colonial hydroids [Hydrozoa]; Stalked jellyfish [Staurozoa] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1P | Species in this sub-group reproduce both sexually and asexually.<br>Asexual budding implies lower reproductive capacity than sexual reproduction in this sub-group, and in general. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| | | | Worms | Tube worms [Polychaeta] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| Intertidal | Rock and rubble dwellers | Sessile (attached to hard substrate) | Mollusca | Oysters, Mussels [Bivalvia]; Snails [Gastropoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| | | | Hemichordata | Sea peaches, Sea squirts [Ascidiacea] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Arthropoda | Barnacles [CL. Hexanauplia] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| | | Low mobility | Cnidaria | Anemones [Anthozoa] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |
| | | | Worms | Bloodworms [Polychaeta]; Flatworms [Platyhelminthes]; Nemertean worms | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Rock and rubble dwellers | Low mobility | Mollusca | Chitons [Polyplacophora]; Whelks, Limpets, Snails [Gastropoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>Recent studies show no evidence of population decline for whelks (DFO 2020a). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |
| Intertidal | Rock and rubble dwellers | Low mobility | Echinodermata | Sea stars, [Asteroidea]; Sea urchins [Echinoidea]; Sea cucumbers [Holothuroidea] | 1 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>In SWNB Zone 1, there has been a decline (66%) in the catch rate indicator of sea cucumber from 2005 to 2019 (DFO 2021a). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |
| | | | Arthropoda | Amphipods [Amphipoda]; Isopods [Isopoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] | 1P | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>Based on population size structure, mature female abundance of Snow Crab is expected to decline for the next 3–4 years in all areas in the Maritimes Region (DFO 2020c).<br><br>There was no evidence of expected Lobster population decline (DFO 2020b, 2021b). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |
| | Sediment infauna | Low mobility | Worms | Sandworms, Lugworms, other burrowers [Polychaeta]; Nemertean worms [Paleonemertea]; Sipuncula worms [Sipunculidea]; Flatworms [Platyhelminthes] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment infauna, by definition, closely associate with unconsolidated substrates. |
| | | | Mollusca | Clams, Astartes [Bivalvia]; Moonsnails [Gastropoda] | 1 | Atlantic Mud-piddock: Threatened (COSEWIC 2009); SARA status: Schedule 1, Threatened (Government of Canada 2011). There are no other species within this group in the Maritimes Region that are listed by SARA, COSEWIC, or IUCN Red List.<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates | 1 | In Canada, the only habitat for the Atlantic Mud Piddock is found in Minas Basin, Nova Scotia. More specifically, at only 13 sites in Minas Basin. (COSEWIC 2009). | 1 | Sediment infauna, by definition, closely associate with unconsolidated substrates. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Intertidal | Sediment infauna | Low mobility | Arthropoda | Mud crab [Decapoda, Panopeidae]; Tube-building gammarid amphipods [Amphipoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment infauna, by definition, closely associate with unconsolidated substrates. |
| | Sediment epifauna | | Cnidaria | Starlet anemones, Sand anemones [Anthozoa] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |
| | | | Mollusca | Nudibranchs [Gastropoda, Nudibranchia]; Snails [Gastropoda], Scallops [Bivalvia] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Echinodermata | Brittle stars [Ophiuroidea]; Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea] | 1 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>In SWNB Zone 1, there has been a decline (66%) in the catch rate indicator for sea cucumber from 2005 to 2019 (DFO 2021a). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |
| | | | Arthropoda | Hermit crabs [Decapoda]; Sand fleas and other amphipods [Amphipoda]; Sea spiders [Pycnogonida]; Isopods [Isopoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |
| | | High mobility | Arthropoda | Crabs, Lobsters [Decapoda] | 1 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>Based on population size structure, mature female abundance of Snow Crab is expected to decline for the next 3–4 years in all areas in the Maritimes Region. (DFO 2020c).<br><br>There was no evidence of expected Lobster population decline (DFO 2020b, 2021b). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | Porifera | Boring sponges, breadcrumb sponges, encrusting sponges [CL. Demospongiae, Calcarea] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1P | Species in this sub-group are generally long lived, reproducing both sexually and asexually. Reproductive success is impacted by environmental conditions.<br>Additionally, asexual budding or fragmentation implies lower reproductive capacity than sexual reproduction in this sub-group, and in general. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| | | | Cnidaria | Colonial hydroids [Hydrozoa], Soft corals [Anthozoa] Stalked jellyfish [Staurozoa] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1P | Species in this sub-group reproduce both sexually and asexually.<br>Asexual budding implies lower reproductive capacity than sexual reproduction in this sub-group, and in general. | 0 | No evidence of endemism in the Maritimes Region within this sub-groups. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| | | | Worms | Tube worms [Polychaeta] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| | | | Mollusca | Slipper limpets [Gastropoda]; Mussels, Oysters, Comb bathyarks [Bivalvia] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| Subtidal benthic | Rock and rubble dwellers | Sessile (attached to hard substrate) | Hemichordata | Ascidians (Tunicates, Sea squirts, Sea grapes) [Ascidiacea] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Arthropoda | Barnacles [CL. Hexanauplia] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List. No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Sessile rock and rubble dwellers would not be in close association with unconsolidated substrate. |
| | | Low mobility | Cnidaria | Anemones [Anthozoa]; Colonial hydroids [Hydrozoa] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List. No recent population assessment information was found for this sub-group in the Maritimes Region. | 1P | Species in this sub-group reproduce both sexually and asexually. Asexual budding implies lower reproductive capacity than sexual reproduction in this sub-group, and in general. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |
| | | | Worms | Ribbon worms [Hoplonemertea]; Polychaete worms [Polychaeta]; Flatworms [Platyhelminthes] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List. No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Mollusca | Nudibranchs, Whelks, Periwinkles [Gastropoda]; Scallops [Bivalvia] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>Recent studies show no evidence of population decline for whelks (DFO 2020a). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |
| | | | Echinodermata | Sea stars [Asteroidea]; Sea cucumbers [Holothuroidea]; Basket stars, Brittle stars [Ophiuroidea]; Sea urchins [Echinoidea] | 1 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>In SWNB Zone 1, there has been a decline (66%) in the catch rate indicator for sea cucumber from 2005 to 2019 (DFO 2021a). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |
| Subtidal benthic | Rock and rubble dwellers | High mobility | Mollusca | North Atlantic Octopus [Cephalopoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1 | The North Atlantic Octopus broods eggs for over a year; the cost of a prolonged brooding period is reduced fecundity. They are also not found in high densities, so opportunities to mate may be limited (Wood et al. 1998).<br>A similar species, the Spoonarm Octopus is a brooding species, carrying limited number of eggs. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Arthropoda | Crabs, Lobsters [Decapoda] | 1P | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>Based on population size structure, mature female abundance of Snow Crab is expected to decline for the next 3–4 years in all areas in the Maritimes Region. (DFO 2020c).<br><br>There was no evidence of expected Lobster population decline (DFO 2020b, 2021b). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Rock and rubble dwellers would not be expected to spend a significant portion of the time in close association with unconsolidated substrate. |
| | Sediment infauna | Low mobility | Cnidaria | Burrowing anemones [Anthozoa] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment infauna, by definition, closely associate with unconsolidated substrates. |
| | | | Worms | Polychaete worms [Polychaeta]; Flatworms [Platyhelminthes]; Nemertean worms [Pilidiophora]; Peanut worms [Sipunculidea] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment infauna, by definition, closely associate with unconsolidated substrates. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Mollusca | Clams [Bivalvia] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List. No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment infauna, by definition, closely associate with unconsolidated substrates. |
| Subtidal benthic | Sediment infauna | Low mobility | Echinodermata | Sea cucumbers (e.g., *Caudina arenata*), [Holothuroidea] | 1 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List. In SWNB Zone 1, there has been a decline (66%) in the catch rate indicator for sea cucumber from 2005 to 2019 (DFO 2021a). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment infauna, by definition, closely associate with unconsolidated substrates. |
| | | | Arthropoda | Amphipods [Amphipoda, Cumacea] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List. No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment infauna, by definition, closely associate with unconsolidated substrates. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
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| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Lophophorates | Marine bryozoans [Bryozoa]; Lampshells [Branchiopoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment infauna, by definition, closely associate with unconsolidated substrates. |
| | Sediment epifauna | | Cnidaria | Anemones (Anthozoa] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |
| | | | Worms | Sea mouse [Polychaeta] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Mollusca | Nudibranchs, Whelks, Moonsnails [Gastropoda]; Quahogs, Scallops [Bivalvia] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>Recent studies show no evidence of population decline for whelks (DFO 2020a). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |
| | | | Echinodermata | Sand Dollars [Echinoidea]; Cushion stars, Mud stars [Asteroidea]; Sea cucumbers [Holothuroidea] | 1 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>In SWNB Zone 1, there has been a decline (66%) in the catch rate indicator for sea cucumber from 2005 to 2019 (DFO 2021a). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |
| Subtidal benthic | Sediment epifauna | High mobility | Arthropoda | Crabs , Lobsters [Decapoda] | 1 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>Based on population size structure, mature female abundance of Snow Crab is expected to decline for the next 3–4 years in all areas in the Maritimes Region (DFO 2020c).<br>There was no evidence of expected Lobster population decline (DFO 2020b, 2021b). | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1 | Sediment epifauna will generally have close association with unconsolidated substrate (living and foraging). |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Pelagic | N/A | Low mobility | Cnidaria | Moon jellies [Scyphozoa]; Hydromedusae [Hydrozoa]; Jelly fish [Scyphozoa] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Pelagic species do not have close association with unconsolidated substrate. |
| | | | Ctenophora | Comb jellies [CL. Nuda, Tentaculata] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Pelagic species do not have close association with unconsolidated substrate. |
| | | | Zooplankton | Copepods, Mysids | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Pelagic species do not have close association with unconsolidated substrate. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | High mobility | Mollusca | Squid [Cephalopoda] | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Most marine invertebrates are r-strategists and as such are considered to have high fecundity rates. | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1P | Adult squid are pelagic and do not have close association with unconsolidated substrate.<br>Squid will extrude egg masses that can be either benthic or pelagic and can interact with unconsolidated substrate. |
| Pelagic | LARVAE | | Porifera | | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | – | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1P | Precautionary scoring applied to this sub-group.<br>While early pelagic larval stages are not expected to interact with unconsolidated substrates, late larval settlement stages may do so when undergoing settlement. |
| Pelagic | LARVAE | | Ctenophora | | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | – | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 0 | Most members of this sub-group have an entirely pelagic life cycle and larvae are not expected to interact with the seafloor/vegetation. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Cnidaria | | **0** | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | **0** | - | **0** | No evidence of endemism in the Maritimes Region within this sub-group. | **1P** | Precautionary scoring applied to this sub-group.<br>While early pelagic larval stages are not expected to interact with unconsolidated substrates, late larval settlement stages may do so when undergoing settlement. |
| | | | Worms | | **0** | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | **0** | – | **0** | No evidence of endemism in the Maritimes Region within this sub-group. | **1P** | Precautionary scoring applied to this sub-group.<br>While early pelagic larval stages are not expected to interact with unconsolidated substrates, late larval settlement stages may do so when undergoing settlement. |
| Pelagic | LARVAE | | Lophophorates | | **0** | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | **0** | – | **0** | No evidence of endemism in the Maritimes Region within this sub-group. | **1P** | Precautionary scoring applied to this sub-group.<br>While early pelagic larval stages are not expected to interact with unconsolidated substrates, late larval settlement stages may do so when undergoing settlement. |

| SUB-GROUP LEVEL | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | Mollusca | | 1 | Atlantic Mud-piddock: Threatened (COSEWIC 2009); SARA status: Schedule 1, Threatened (Government of Canada 2011). There are no other species within this group in the Maritimes Region that are listed by SARA, COSEWIC, or IUCN Red List. | 0 | – | 1 | In Canada, the only habitat for the Atlantic Mud-piddock is found in Minas Basin, Nova Scotia. More specifically, at only 13 sites in Minas Basin. (COSEWIC 2009). | 1P | Precautionary scoring applied to this sub-group.<br>While early pelagic larval stages are not expected to interact with unconsolidated substrates, late larval settlement stages may do so when undergoing settlement. |
| | | | Echinodermata | | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List. | 0 | – | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1P | Precautionary scoring applied to this sub-group.<br>While early pelagic larval stages are not expected to interact with unconsolidated substrates, late larval settlement stages may do so when undergoing settlement. |
| Pelagic | LARVAE | | Hemichordata | | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List. | 0 | – | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1P | Precautionary scoring applied to this sub-group.<br>While early pelagic larval stages are not expected to interact with unconsolidated substrates, late larval settlement stages may do so when undergoing settlement. |
| | | | Arthropoda | | 0 | There are no species within this group in the Maritimes Region that are listed by SARA, COSEWIC or IUCN Red List. | 0 | – | 0 | No evidence of endemism in the Maritimes Region within this sub-group. | 1P | Precautionary scoring applied to this sub-group.<br>While early pelagic larval stages are not expected to interact with unconsolidated substrates, late larval settlement stages may do so when undergoing settlement. |

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# APPENDIX 3. DETAILED SCORING TABLES WITH JUSTIFICATIONS FOR MARINE FISH

*Table A7. Marine fishes sub-group scores for EXPOSURE scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps) (N/A = not applicable).*

| **SUB-GROUP LEVEL** | | | | | **Maritime example species** | **EXPOSURE Criteria** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Concentration (aggregation)** | | **Mobility and/or site fidelity** | | **Sea surface interacting** | | **Seafloor or vegetation interacting** | |
| **1** | **2** | **3** | **4** | **5** | | **S** | **Justification** | **S** | **Justification** | **S** | **Justification** | **S** | **Justification** |
| Marine | Intertidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/ gravel) | Snailfishes (Liparidae) | Atlantic Snailfish | **0** | Not expected to aggregate in the benthic intertidal zone for a specific purpose or in significantly large numbers (Scott and Scott 1988). | **1P** | Precautionary scoring applied to small fish species, as small body size assumed to confer lower mobility and a relatively limited home range.<br>Snailfish size ranges from 9.5 cm to a maximum size of 14.4 cm (Scott and Scott 1988).<br>Maturing adult Snailfish make only short migrations from shallow inshore waters to the intertidal zone for spawning. | **1** | Intertidal organisms are assumed to have regular surface interaction due to tidal movements.<br>Surface interaction is very likely in this group because they will remain in the intertidal as the tide drops (Lamb and Edgell 2010). | **1** | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |
| | | | | Pout (Zoarcidae) | Ocean Pout | **0** | Not expected to aggregate in the benthic intertidal zone for a specific purpose or in significantly large numbers (Scott and Scott 1988). | **0** | Species in this sub-group have been known to perform seasonal migration from intertidal or shallow coastal waters to deeper water in autumn, returning to shallower waters in spring (Scott and Scott 1988). | **1** | Intertidal organisms are assumed to have regular surface interaction due to tidal movements.<br>Surface interaction is very likely in this group because they will remain in the intertidal as the tide drops (Lamb and Edgell 2010). | **1** | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |
| | | | | Cryptacanthodidae | Wrymouth | **0** | Not expected to aggregate in the in the benthic intertidal zone for a specific purpose or in significantly large numbers (Scott and Scott 1988). | **1** | Builds system of burrows so likely to exhibit site fidelity (Scott and Scott 1988). | **1** | Intertidal organisms are assumed to have regular surface interaction due to tidal movements.<br>Surface interaction is very likely in this group because they will remain in the intertidal as the tide drops (Lamb and Edgell 2010). | **1** | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Intertidal | Benthic | Associated with consolidated substrates (rock/ boulder/ bedrock) | Snailfishes (Liparidae) | Atlantic Snailfish | 0 | Not expected to aggregate in the benthic intertidal zone for a specific purpose or in significantly large numbers. | 1P | Precautionary scoring applied to small fish species, as small body size assumed to confer lower mobility and a relatively limited home range.<br>Snailfish size ranges from 9.5 cm to a maximum size of 14.4 cm (Scott and Scott 1988).<br>Maturing adult Snailfish make only short migrations from shallow inshore waters to the intertidal zone for spawning. | 1 | Intertidal organisms are assumed to have regular surface interaction due to tidal movements.<br>Surface interaction is very likely in this group because they will remain in the intertidal as the tide drops (Lamb and Edgell 2010). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |
| | | | | Pout (Zoarcidae) | Ocean Pout | 0 | Not expected to aggregate in the benthic intertidal zone for a specific purpose or in significantly large numbers. | 0 | Species in this sub-group have been known to perform seasonal migration from intertidal or shallow coastal waters to deeper water in autumn, returning to shallower waters in spring (Scott and Scott 1988). | 1 | Intertidal organisms are assumed to have regular surface interaction due to tidal movements.<br>Surface interaction is very likely in this group because they will remain in the intertidal as the tide drops (Lamb and Edgell 2010). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |
| | | | | Pholidae | Rock Gunnel | 0 | Not expected to aggregate in the benthic intertidal zone for a specific purpose or in significantly large numbers. | 0 | Sawyer (1967) as cited in Scott and Scott (1988), assume that there is an offshore migration in December off the coast when spawning is believed to occur, and a return inshore in March. | 1 | Intertidal organisms are assumed to have regular surface interaction due to tidal movements.<br>Surface interaction is very likely in this group because they will remain in the intertidal as the tide drops (Lamb and Edgell 2010). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988).<br>Hides under stones, in crevices, and under seaweed (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Intertidal | Non-benthic (pelagic and demersal) | N/A | Sticklebacks (Gasterosteidae) | Blackspotted Stickleback, Fourspine Stickleback, Threespine Stickleback | 1P | Precautionary scoring as sticklebacks aggregate in estuarine waters but it is unknown whether they also aggregate in the marine environment. | 1 | Sticklebacks hover in the water column and are not highly active swimmers. They can maintain typical teleost swimming behavior for short periods of time, such as when excited, escaping a predator, chasing a rival or approaching a female (Wootton 1984).<br>May show site fidelity on spawning grounds from May to July in the Maritimes Region (Scott and Scott 1998). | 1 | Intertidal organisms are assumed to have regular surface interaction due to tidal movements.<br>Surface interaction is very likely in this group because they will remain in the intertidal as the tide drops (Lamb and Edgell 2010). | 1 | Demersal species are expected to have regular interactions with the seafloor (Scott and Scott 1988). |
| | | | | Silversides (Atherinopsidae) | Atlantic Silverside | 1 | Atlantic Silverside is a schooling species (Scott and Scott 1988). | 1P | Precautionary scoring applied to small fish species, as small body size assumed to confer lower mobility and a relatively limited home range.<br>Maximum size observed for the Atlantic Silverside is 13.7 cm (Scott and Scott 1988).<br>Atlantic Silverside make short migrations from shallow inshore waters into estuaries for spawning. | 1 | Intertidal organisms are assumed to have regular surface interaction due to tidal movements.<br>Surface interaction is very likely in this group because they will remain in the intertidal as the tide drops (Lamb and Edgell 2010). | 1 | Demersal species are expected to have regular interactions with the seafloor (Scott and Scott 1988).<br>Atlantic Silversides feed on mud flats during ebb tide (Scott and Scott 1988). |
| | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Skates (Rajidae) | Little Skate, Thorny Skate, Smooth Skate | 0 | Not expected to aggregate in benthic environment for a specific purpose or in significantly large numbers. | 0 | Species in this sub-group move inshore in winter and offshore into deeper water in summer (Scott and Scott 1988). | 0 | Subtidal benthic species are not expected to interact with the sea surface (Scott and Scott 1988). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Flatfishes (Pleuronectidae) | Winter Flounder, Yellowtail Flounder, Atlantic Halibut, Windowpane, American Plaice | 0 | Not expected to aggregate in benthic environment for a specific purpose or in significantly large numbers. | 0 | Winter Flounder undergo more or less regular onshore-offshore migrations and tend to move offshore in winter (Scott and Scott 1988). | 0 | Subtidal benthic species are not expected to interact with the sea surface (Scott and Scott 1988). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |
| | | | | Sculpins (Cottidae) | Shorthorn Sculpin, Longhorn Sculpin, Moustache Sculpin | 0 | Not expected to aggregate in benthic environment for a specific purpose or in significantly large numbers. | 1P | Precautionary scoring for this sub-group due to lack of research on mobility/site fidelity.<br>The Shorthorn Sculpin, when disturbed, swims slowly and only for a short distance (Scott and Scott 1988). | 0 | Subtidal benthic species are not expected to interact with the sea surface (Scott and Scott 1988). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |
| | | | | Pout (Zoarcidae) | Ocean Pout | 0 | Not expected to aggregate in benthic environment for a specific purpose or in significantly large numbers. | 0 | Species in this sub-group have been known to perform seasonal migration from intertidal or shallow coastal waters to deeper water in autumn, returning to shallower waters in spring (Scott and Scott 1988). | 0 | Subtidal benthic species are not expected to interact with the sea surface (Scott and Scott 1988). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |
| | | | | Redfish (Sebastidae) | Acadian Redfish | 1 | Known to aggregate in exceedingly large schools (Scott and Scott 1988). | 1 | Redfish have been classified as "deep water sedentary" and make only short migrations of 10–100 km (Pikanowski et al. 1999). | 0 | Subtidal benthic species are not expected to interact with the sea surface (Scott and Scott 1988). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988).<br>Live over rocky or clay-silt bottom (Scott and Scott 1988). |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Lophiidae | Monkfish | 0 | Not expected to aggregate in benthic environment for a specific purpose or in significantly large numbers. | 1P | Precautionary scoring for this sub-group due to lack of research on mobility/site fidelity.<br>Monkfish is a sluggish fish (Scott and Scott 1988). | 0 | Subtidal benthic species are not expected to interact with the sea surface (Scott and Scott 1988). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988).<br>Found on muddy bottoms of continental slope (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | | Myxinidae | Atlantic Hagfish | 1 | Can be found in large numbers when feeding (Scott and Scott 1988). | 1P | Precautionary scoring for this sub-group due to lack of research on mobility/site fidelity.<br><br>Atlantic Hagfish can remain inactive for long periods either completely buried or on top of, soft sediment (Scott and Scott 1988). | 0 | Not expected to interact with surface as it lives at depths of below 30 m (Scott and Scott 1988). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988).<br><br>Live on soft, muddy bottoms (Scott and Scott 1988). |
| | | | | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 1 | Atlantic Sturgeon have been shown to aggregate for feeding (Dadswell et al. 2016).<br><br>Atlantic Sturgeon aggregate to feed from May to October in the Minas Basin, NS (Dadswell et al. 2016). | 1P | Precautionary scoring applied as there is limited research on mobility or site fidelity in the marine environment | 0 | Subtidal benthic species are not expected to interact with the sea surface (Scott and Scott 1988). | 1 | Anadromous bottom living sub-group (Scott and Scott 1988). |
| | | | Associated with consolidated substrates (cobble/boulder/bedrock) | Sculpins (Cottidae) | Snowflake Hookear Sculpin, Longhorn Sculpin, Shorthorn Sculpin | 0 | Not expected to aggregate in benthic environment for a specific purpose or in significantly large numbers. | 1P | Precautionary scoring for this sub-group due to lack of research on mobility/site fidelity.<br><br>The Shorthorn Sculpin, when disturbed, swims slowly and only for a short distance (Scott and Scott 1988). | 0 | Subtidal benthic species are not expected to interact with the sea surface (Scott and Scott 1988). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988). |
| Marine | Subtidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Lumpfishes (Cyclopteridae) | Atlantic Spiny Lumpsucker, Lumpfish | 0 | Not expected to aggregate in benthic environment for a specific purpose or in significantly large numbers. | 1P | Precautionary scoring for this sub-group due to lack of research on mobility/site fidelity.<br><br>Juvenile lumpsuckers are poor swimmers (Frantzen 2015). | 1 | Young Lumpfish remain in the top 1m of water for the first year before taking up life on or near bottom (Scott and Scott 1988). | 1 | Benthic species are expected to be in constant contact with seafloor (Scott and Scott 1988).<br><br>Lumpfish is primarily a bottom fish of cold to temperate waters, though it is frequently semi-pelagic during early life (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | | Wolffishes (Anarhichadidae) | Atlantic Wolffish, Spotted Wolffish, Northern Wolffish | 0 | Wolffish do not form large schools (Scott and Scott 1988).<br>Atlantic Wolffish is a solitary species (Le François et al. 2021). | 1 | Atlantic Wolffish have been shown to exhibit homing behavior and site fidelity to spawning and feeding grounds (Gunnarsson et al. 2019). | 0 | Species in this sub-group are not reported to interact with the surface regularly (COSEWIC 2012d, 2012e, 2012f). | 1 | Species in this sub-group have regular interactions with the sea floor (COSEWIC 2012d, 2012e, 2012f). |
| | | | | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 1 | Atlantic Sturgeon have been shown to aggregate for feeding (Dadswell et al. 2016).<br>Atlantic Sturgeon aggregate to feed from May to October in the Minas Basin, NS (Dadswell et al. 2016). | 1P | Precautionary scoring applied as there is limited research on mobility or site fidelity in the marine environment | 0 | Subtidal benthic species are not expected to interact with the sea surface (Scott and Scott 1988). | 1 | Anadromous bottom living sub-group (Scott and Scott 1988). |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Cod (Gadidae) | Atlantic Cod, Arctic Cod, Tomcod, Pollock | 1 | Known to aggregate in exceedingly large shoals (Scott and Scott 1988). | 0 | Species in this sub-group exhibit high mobility.<br>The maximum distance travelled by a tagged Atlantic Cod is 3,228 km over a four year period (Scott and Scott 1988). | 0 | Species in this sub-group are not reported to interact with the surface regularly (COSEWIC 2010b). | 1 | Adapted for bottom feeding so will have regular interaction with the sea floor (Scott and Scott 1988). |
| | | | | Elasmobranchs | Shortfin Mako, Porbeagle, Blue Shark | 1 | Porbeagles aggregate on mating grounds on Georges Bank in the Maritimes Region (COSEWIC 2014). | 0 | Species in this sub-group exhibit high mobility.<br>Shortfin Mako is considered the fastest shark and one of the swiftest fishes (Scott and Scott 1988). | 1 | Blue Sharks are often found near the surface (Scott and Scott 1988). The Porbeagle is a pelagic, epipelagic, or littoral species (COSEWIC 2014). | 0 | The Porbeagle is a pelagic, epipelagic, or littoral species that feeds on smaller pelagic species, so is unlikely to come into contact with the seafloor. (COSEWIC 2014, Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | | Osmeridae | Rainbow Smelt, Capelin | 1 | Known to aggregate for mass spawning, which takes place when fish are 3–4 years old (Scott and Scott 1988). | 0 | Intensive migration inshore by coastal Capelin populations takes place prior to spawning activities on beaches (Scott and Scott 1988). | 1 | Expected to interact with the sea surface during spawning activities.<br><br>Beach spawning Capelin eggs are buried by wave action (Scott and Scott 1988). | 1 | While not expected to have regular interaction with the seafloor, when spawning, species in this sub-group will have contact with sandy/gravel shores and beaches (Scott and Scott 1988). |
| | | | | Salmon (Salmonidae) | Atlantic Salmon | 0 | Not expected to aggregate in pelagic and demersal environments for a specific purpose or in significantly large numbers. | 0 | Species in this sub-group exhibit high mobility.<br><br>Atlantic Salmon exhibit extensive movement while at sea (e.g., Atlantic Salmon from some Canadian rivers are known to travel as far as Greenland) (Scott and Scott 1988). | 1 | A pelagic sub-group, so may interact with the sea surface (Scott and Scott 1988). | 0 | Can be found in deeper water but not expected to be in frequent contact with sea floor (Scott and Scott 1988). |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Scombridae | Atlantic Mackerel. Atlantic Bluefin Tuna | 1 | Atlantic Mackerel is a strong schooling species (Scott and Scott 1988).<br><br>Tuna school, often in groupings of less than 50 fish (Scott and Scott 1988). | 0 | Species in this sub-group exhibit high mobility.<br><br>Tuna feature morphological adaptations for high performance swimming (Gliess et al. 2019).<br><br>In addition to extensive spawning migrations, tagged Atlantic Mackerel have been shown to travel long distances (e.g., from Newfoundland to Long Island, NY) (Scott and Scott 1988).<br><br>Tuna undergo extensive migrations along the Atlantic coast as well as trans-Atlantic (Scott and Scott 1988). | 1 | A pelagic sub-group, so may interact with the sea surface (Scott and Scott 1988).<br><br>Young tuna live in sea surface layers (Scott and Scott 1988). | 0 | Can be found in deeper water but not expected to be in frequent contact with sea floor (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | | Clupeidae | Atlantic Herring, American Shad, Blueback Herring, Alewife | 1 | Species in this sub-group exhibit schooling behavior (Scott and Scott 1988). | 0 | Species in this sub-group are highly mobile and highly migratory (Scott and Scott 1988). | 1P | A pelagic sub-group, so may interact with the sea surface (Scott and Scott 1988). | 1 | Shad consume benthic amphipods (Scott and Scott 1988).<br>Blueback Herring prefer to spawn in fast currents over hard substrate whereas the alewife uses a wide variety of spawning sites and substrates (Mullen et al. 1986). |
| | | | | Eels (Anguillidae) | American Eel | 1P | Precautionary scoring for this sub-group as there is limited research on the marine life stage. | 1P | Precautionary scoring for this sub-group as there is limited research on its movements in the marine environment. | 1P | Precautionary scoring for this sub-group as there is limited research on the marine life stage. | 1P | Precautionary scoring for this sub-group as there is limited research on the marine life stage. |
| Estuarine | Estuarine transient | Benthic | Associated with unconsolidated substrates (silt/mud/sand/ gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 1 | Atlantic Sturgeon have been shown to aggregate for feeding (Dadswell et al. 2016).<br>Atlantic Sturgeon aggregate to feed from May to October in the Minas Basin, NS (Dadswell et al. 2016). | 1 | Species in this sub-group are known to exhibit site fidelity.<br>Some populations are known to have breeding grounds (Scott and Scott 1988).<br>Atlantic Sturgeon migrate from the Saint John River, NB and Kennebec River, NB to feed (Dadswell et al. 2016). | 1P | Precautionary scoring applied as aggregations migrating through confined waters are more likely to interact with the sea surface. | 1 | Anadromous bottom living sub-group (Scott and Scott 1988). |
| | | | | Eels (Anguillidae) | American Eel | 1 | Eels aggregate in shallow estuarine waters for seasonal spawning migrations (Scott and Scott 1988).<br>Formation of 'eel balls' have been observed but only in fresh water (Scott and Scott 1988). | 1 | In the freshwater phase of their lives, eels become sluggish in cooler water and overwinter buried in muddy bottoms of lakes and rivers (Scott and Scott 1988). | 1 | In estuaries, eels exhibit regular surface interaction as they aggregate in shallow estuarine waters for seasonal mating (Scott and Scott 1988). | 1 | Overwinter buried in muddy bottoms of lakes and rivers (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| **1** | **2** | **3** | **4** | **5** | | **S** | **Justification** | **S** | **Justification** | **S** | **Justification** | **S** | **Justification** |
| | | | Associated with consolidated substrates (cobble/boulder/bedrock) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | **1** | Atlantic Sturgeon have been shown to aggregate for feeding (Dadswell et al. 2016).<br>Atlantic Sturgeon aggregate to feed from May to October in the Minas Basin, NS (Dadswell et al. 2016). | **1** | Species in this sub-group are known to exhibit site fidelity.<br>Some sturgeon populations are known to have breeding grounds (Scott and Scott 1988).<br>Atlantic Sturgeon migrate from the Saint John River, NB and Kennebec River, NB to feed (Dadswell et al. 2016). | **1P** | Precautionary scoring applied as aggregations migrating through confined waters are more likely to interact with the sea surface. | **1** | Anadromous bottom living sub-group (Scott and Scott 1988). |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Clupeidae | American Shad, Blueback Herring, Alewife | **1** | American Shad is a schooling species.<br>Alewife form spawning groups and move through estuaries en route to freshwater spawning grounds in tributary rivers and streams (Scott and Scott 1988). | **1P** | American Shad is highly migratory (Scott and Scott 1988). Shad also exhibit homing to their natal stream (Scott and Scott 1988). | **1P** | Precautionary scoring applied as aggregations migrating through confined waters are more likely to interact with the sea surface. | **0** | Pelagic feeders, so not expected to interact with the sea floor in the marine and estuarine environment (Scott and Scott 1988). |
| | | | | Salmon (Salmonidae) | Atlantic Salmon | **1** | Atlantic Salmon are a schooling anadromous species and thus are expected to pass through estuaries from fresh water in aggregations as they smoltify; and when they return as adults from salt water to spawn (Scott and Scott 1988). | 1 | Adult salmon in estuaries exhibit high site fidelity as they prepare for spawning migration up their river of origin (Scott and Scott 1988). | **1P** | Precautionary scoring applied as aggregations migrating through confined waters are more likely to interact with the sea surface. | **1** | Atlantic Salmon parr are known to use cobble and aquatic vegetation as cover (Beland, et al. 2004). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | | Silversides (Atherinopsidae) | Atlantic Silverside | 1 | Atlantic Silverside is a schooling species, and forms spawning masses in estuaries (Scott and Scott 1988). | 1P | Precautionary scoring applied to small fish species, as small body size assumed to confer lower mobility and a relatively limited home range.<br>Maximum size observed for the Atlantic Silverside is 13.7 cm (Scott and Scott 1988).<br>Atlantic Silverside make short migrations from shallow inshore waters into estuaries for spawning. | 1P | Precautionary scoring applied as aggregations migrating through confined waters are more likely to interact with the sea surface. | 1 | Feed on mud flats during ebb tide (Scott and Scott 1988). |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Sticklebacks (Gasterosteidae) | Threespine Stickleback | 1P | Threespine Sticklebacks spend most of their lives in schools (Love 2011). Some populations are anadromous, spawning in rivers, but not in large aggregations (Love 2011). | 1 | Sticklebacks hover in the water column and are not highly active swimmers. They can maintain typical teleost swimming behavior for short periods of time, such as when excited, escaping a predator, chasing a rival or approaching a female (Wootton 1984).<br>May show site fidelity on spawning grounds from May to July in the Maritimes Region (Scott and Scott 1988). | 1P | Though not considered a regular behaviour, Threespine Sticklebacks can rise into surface waters at night (Love 2011) | 1 | Excavate soft substrates to build nests (Love 2011). |
| | | | | Petromyzontidae | Sea Lamprey | 1 | Sea Lampreys spawn in the spring. Adults congregate in the estuaries of rivers during late winter, starting to move upstream during the dark hours. As many as 25,000 adults may migrate into the same river (Scott and Crossman 1973). | 0 | As many as 25,000 adults may migrate into the same river, moving upstream as far as 200 miles (Scott and Crossman 1973).<br>Migrating adults can manage rapids easily by alternately swimming and attaching to stones. They can surmount nearly vertical barriers (of 5–6 feet), by creeping up the face with their suctorial disc (Scott and Crossman 1973). | 1 | In estuaries, fishes in this sub-group are scored for regular surface interaction as they mill in dense aggregations at all depths in the water column in preparation for seasonal spawning migrations (Scott and Crossman 1973). | 1 | Although they may at times act like a pelagic fish, most of their life is spent near or on the bottom (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Estuarine | Estuarine resident | Non-benthic (pelagic and demersal) | N/A | Fundulidae | Mummichog | 0 | Not expected to aggregate in the pelagic and demersal environments for a specific purpose or in significantly large numbers. | 1P | Precautionary scoring applied to small fish species, as small body size assumed to confer lower mobility and a relatively limited home range.<br>Maximum size observed for the Mummichog is 13 cm (Scott and Scott 1988).<br>No evidence that the Mummichog engages in regular or predictable migrations (Scott and Scott 1988). | 1 | In estuaries, fishes in this sub-group are scored for regular surface interaction.<br>They can be trapped by tidal movement or dry up in small pools (Scott and Scott 1988). | 1 | Mummichogs prefer habitat where there is submergent or emergent vegetation. Eggs are deposited in clutches on the outer side of aquatic plants, on masses of algae, or in sand and mud substrate (Scott and Scott 1988). |
| | | | | Syngnathidae | Northern Pipefish | 0 | Pipefish live an independent life from time of emergence from the brood pouch (Scott and Scott 1988). | 1 | Pipefish are not considered highly mobile as evidenced by low genetic connectivity between populations (de Graaf 2006). | 1 | In estuaries, fishes in this sub-group are scored for regular surface interaction.<br>Pipefish live in association with seaweeds and eelgrass (Scott and Scott 1988), which have regular interaction with the sea surface. | 1 | Not expected to have regular interaction with the seafloor, but will be in close association with eelgrass and beds of seaweed (Scott and Scott 1988). |

*Table A8. Marine fishes sub-group scores for SENSITIVITY scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps) (N/A = not applicable).*

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Marine | Intertidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/ gravel) | Snailfishes (Liparidae) | Atlantic Snailfish | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in snailfishes.<br>Thomas (1973) reported 12 dead snailfish (*Liparis atlanticus*) in field surveys following the *Arrow* spill in the Chedabucto Bay area of Nova Scotia (Thomas 1973). |
| | | | | Pout (Zoarcidae) | Ocean Pout | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in ocean pout (*Zoarces americanus*).<br>There have been few studies on the Eelpout (*Zoarces viviparous*).<br>Celander et al. (1994) examined induction of hepatic cytochrome P450 in individuals intraperitoneally injected with North Sea crude oil. Over 14 days, the injection of oil resulted in temporal responses in P450 1A protein content and P450 catalytic activity. Additionally, it was found that pooled bile of injected organism contained Polycyclic Aromatic Hydrocarbons (PAHs) (phenantrenes, anthracene, pyrenes, fluoranthene, benzo (a) anthracene and chrysene, compounds not found in the bile of control fish (Celander et al. 1994). |
| | | | | Cryptacanthodidae | Wrymouth | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in wrymouth.<br>There were no toxicity studies found on *Cryptacanthodes maculatus* nor the Cryptacanthodidae family. |
| | | | | Snailfishes (Liparidae) | Atlantic Snailfish | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in snailfishes.<br>Thomas (1973) reported 12 dead snailfish (*Liparis atlanticus*) in field surveys following the *Arrow* spill in the Chedabucto Bay area of Nova Scotia (Thomas 1973). |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Marine | Intertidal | Benthic | Associated with consolidated substrates (rock/ boulder/ bedrock) | Pout (Zoarcidae) | Ocean Pout | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in Ocean Pout (*Zoarces americanus*).<br>There have been few studies on the Eelpout (*Zoarces viviparous*).<br>Celander et al. (1994) examined induction of hepatic cytochrome P450 in individuals intraperitoneally injected with North Sea crude oil. Over 14 days, the injection of oil resulted in temporal responses in P450 1A protein content and P450 catalytic activity. Additionally, it was found that pooled bile of injected organism contained Polycyclic Aromatic Hydrocarbons (PAHs), phenantrenes, anthracene, pyrenes, fluoranthene, benzo (a) anthracene and chrysene, compounds not found in the bile of control fish. |
| | | | | Pholidae | Rock Gunnel | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in Rock Gunnels.<br>Exposure to *Exxon Valdez* oil in Crescent Gunnel induced higher levels of cytochrome P4501A, a protein that can result in deleterious physiological effects (Jewett et al. 2002).<br>Thomas (1973) performed a survey of the intertidal and lagoonal biota in Chedabucto Bay, Nova Scotia following a crude oil spill from the *Arrow* (> 1,400,000 gallons). Surveys were performed from March 1970 to 1972. During the surveys, Thomas found 1 dead Rock Gunnel in which cause of death is unknown. |
| Marine | Intertidal | Non-benthic (pelagic and demersal) | N/A | Sticklebacks (Gasterosteidae) | Blackspotted Stickleback, Fourspine Stickleback, Threespine Stickleback | 1 | Blackspotted Stickleback (*Gasterosteus wheatlandi*) have gill rakers (Scott and Scott\ 1988). Note that sticklebacks are primarily active feeders but, in polymorphic population of *G. wheatlandi*, the two morphs fed on different prey types (primarily benthic organisms versus swimming or surface organisms).<br>Associated with this difference in diet was a difference in the mean number of gill rakers. The author contends that gill rakers may thus play a role in feeding as a filtering device, and are more numerous and finer in planktivorous fish (Wootton 1984). Since gill rakers are used in feeding, they may become clogged with oil. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>A few studies have investigated the toxic effects of oil on sticklebacks (mostly Threespine, not Blackspotted or Fourspine) (e.g., Geoghegan et al. 2008).<br>Exposure to dibenzathracene and 17β-oestradiol (E2) in Threespine Sticklebacks has been linked to endocrine disruption (Geoghegan et al. 2008).<br>Blenkinsopp et al. (1996) conducted 96 h $LC_{50}$ exposure tests with Threespine Sticklebacks, testing the effect (lethality) of weathered crude oil and found no adverse direct effects at any time during the test at concentrations of petroleum hydrocarbons up to 1.10 µg/L.<br>In 2013, Knag and Taugbøl found that acute exposure to offshore produced water (PW) (wastewater from offshore petroleum production) containing Polycyclic Aromatic Hydrocarbons (PAHs) had an effect on stress and secondary stress responses in adult Threespine Stickleback. Low dose PW exposure resulted in an upregulation of cytochrome (CYP1A) and UDP-glucuronsyltransferase (UDP-GT), both of which are associated with toxicant stress. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| | | | | Silversides (Atherinopsidae) | Atlantic Silverside | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Gardner et al. (1975) studied the effects of waste motor oil on Atlantic Silversides, using both long and short-term exposures. In a 96 h static bioassay (short-term), fish were exposed to 0, 10, 50, 250, 1000, and 5000 ppm of waste motor oil with $LC_{50}$ of 2,200 ppm (48 h) and 1,700 ppm (96 h).<br>In the long-term assay, individuals were subsequently exposed to waste oil at concentrations of 0, 20, 100 and 500 ppm. In the long-term assay, 100% mortality occurred at 250 ppm after 7 days, with no mortality found at 100 ppm after 36 days, nor at 20 ppm after 60 days. At concentrations of 20 ppm or higher, vascular system lesions were found in both moribund Atlantic Silversides and surviving individuals. Note that the authors were aiming to examine the morphological effects of waste motor oil, and toxicity data in long-term exposures are not intended to be definitive.<br>Note that there is very little information regarding the effects of oil on the Atlantic Silverside, but there are multiple studies on inland silversides (*Menidia beryllina*). |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Skates (Rajidae) | Little Skate, Thorny Skate, Smooth Skate | 0 | Species in this do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>There appears to be little or no information concerning the chemical toxicity to oil of the Family Rajidae. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| | | | | Flatfishes (Pleuronectidae) | Winter Flounder, Yellowtail Flounder, Atlantic Halibut, Windowpane, American Plaice | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>A handful of studies have investigated the toxic effects of oil on flatfishes.<br>Yellowfin Sole, a flat fish, sampled after the *Exxon Valdez* Oil Spill displayed lowered plasma levels of estradiol, a reproductive hormone involved in regulation of gonadal development and spawning (Varanasi et al. 1995).<br>Payne et al. (1995) exposed male Winter Flounder to sand contaminated with oil well drill cuttings (various concentrations) for approximately 80 days in an effort to assess effects of chronic exposure. Total petroleum hydrocarbons (TPH) concentration in 5 treatments were measured at beginning and ending of exposure period. The authors note that there were no statistically significant observable effects in the treatments, though at the highest concentration 4000 µg/L (beginning) MFO enzyme activities were observed to decrease (Payne et al. 1995).<br>When examining long-term effects of the Amoco Cadiz crude oil spill in France, organ samples were collected from American Plaice (*Pleuronectes platessa*) from highly oiled areas from 1978–1980 (Haensly et al. 1982). Histopathology indicated chronically exposed plaice exhibited fin and tail necrosis, hyperplasia and hypertrophy of gill lamellar mucous cells, gastric gland degeneration, decreased hepatocellular vacuolation and more (Haensley et al. 1982). |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Sculpins (Cottidae) | Shorthorn Sculpin, Longhorn Sculpin, Moustache Sculpin | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Gardiner et al. (2013) assessed the acute toxicity (96 h) of larval sculpin (*Myoxocephalus* sp.) to crude oil (Water Accommodated Fraction (WAF) and Breaking Wave WAF (BWWAF) and found the mean $LC_{50}$ to be 4.0 (SD 1.3) mg/L and 2.3 (1.0 SD) mg/L Total Petroleum Hydrocarbon (TPH) respectively. The authors found that the $LC_{50}$ based on total Polycyclic Aromatic Hydrocarbon (PAH) concentrations (parent form) (mg/L PAH) in the WAF and BWWAF to be 0.04 mg/L PAH and 0.05 mg/L PAH (Gardiner et al. 2013).<br>Khan and Payne (2005), while assessing effects of Corexit® 9527, reported on effects of Hibernia Light Crude oil on Longhorn Sculpin. The authors found that when exposed to a WAF of crude oil, there were no changes in behaviour in sculpin, though some limited mortality was noted (4%) over control. In those individuals that died, 100% were found to have epithelial rupture/lifting, epithelial hyperplasia and telangiectasis. In surviving individuals exposed to a WAF of crude, individuals exhibited epithelial hyperplasia (100%), fusion of secondary lamellae (80%), basal hyperplasia (80%) and telangiectasis (25%) (Khan and Payne 2005). |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| | | | | Pout (Zoarcidae) | Ocean Pout | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in Ocean Pout (*Zoarces americanus*).<br>There have been few studies on the Eelpout (*Zoarces viviparous*).<br>Celander et al. (1994) examined induction of hepatic cytochrome P450 in individuals intraperitoneally injected with North Sea crude oil. Over 14 days, the injection of oil resulted in temporal responses in P450 1A protein content and P450 catalytic activity.<br>Additionally, it was found that pooled bile of injected organism contained Polycyclic Aromatic Hydrocarbons (PAHs) (phenantrenes, anthracene, pyrenes, fluoranthene, benzo (a) anthracene and chrysene, compounds not found in the bile of control fish (Celander et al. 1994). |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Redfish (Sebastidae) | Acadian Redfish | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>There have been some studies assessing PAH and oil toxicity in (*Sebastes schlegeli,* the Korean Rockfish).<br>Lee et al. (2018) examined adverse effects and immune dysfunction in *Sebastes schlegeli* when exposed, through oral ingestion, to weathered Iranian crude oil (10, 100 and 200 mg/kg of body weight). Individuals were sampled at intervals over 96 h post ingestion. The authors found that the Total Polycyclic Aromatic Hydrocarbon (TPAH) concentrations in treatment groups increased significantly within the first 6 hours, followed by a rapid decrease to control levels within 24 hours but PAH metabolite concentrations remained relatively high throughout the 96 hour period.<br>The authors also found that crude oil exposure to juvenile Rockfish can significantly affect immune related genes, disturbing the cell cycle, apoptosis and phagocytosis (Lee et al. 2018). |
| | | | | Lophiidae | Monkfish | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group. |
| | | | | Myxinidae | Atlantic Hagfish | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in in this sub-group.<br>There is a lack of information in the literature regarding toxicity of oil to sturgeon species found in the Maritimes Region.<br>Rostami and Soltani (2016) examined the impact of acute exposure of crude oil to *Acipenser persicus* (Persian Sturgeon). The authors exposed juveniles to crude oil at concentrations of 15, 16, 17, 18, and 19 ppm in a 96 h toxicity test and found the mean $LC_{50}$ to be 16.5 ppm crude oil. In addition to the $LC_{50}$, the authors found that, in organisms exposed to the $LC_{50}$ concentration, neutrophils and monocytes increase while lymphocytes and eosionphils decreased. Total protein, ALT, AST, ALP and LDH enzymes decreased significantly. |
| Marine | Subtidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Sculpins (Cottidae) | Snowflake Hookear Sculpin, Longhorn Sculpin, Shorthorn Sculpin | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Gardiner et al. (2013) assessed the acute toxicity (96 h) of sculpin (*Myoxocephalus* sp.) to crude oil Water Accommodated Fraction (WAF) and Breaking Wave WAF (BWWAF) and found the mean $LC_{50}$ to be 4.0 (SD 1.3) mg/L and 2.3 (1.0 SD) mg/L Total Petroleum Hydrocarbon (TPH) respectively. The authors found that the $LC_{50}$ based on total Polycyclic Aromatic Hydrocarbon (PAH) concentrations (parent form) (mg/L PAH) in the WAF and BWWAF to be 0.04 mg/L PAH and 0.05 mg/L PAH (Gardiner et al. 2013).<br>Khan and Payne (2005), while assessing effects of Corexit® 9527, reported on effects of Hibernia Light Crude oil on Longhorn Sculpin. The authors found that when exposed to a WAF of crude oil, there were no changes in behaviour in sculpin, though some limited mortality was noted (4%) over control. In those individuals that died, 100% were found to have epithelial rupture/lifting, epithelial hyperplasia and telangiectasis. In surviving individuals exposed to a WAF of crude, individuals exhibited epithelial hyperplasia (100%), fusion of secondary lamellae (80%), basal hyperplasia (80%) and telangiectasis (25%) (Khan and Payne 2005). |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Marine | Subtidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Lumpfishes (Cyclopteridae) | Atlantic Spiny Lumpsucker, Lumpfish | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in lumpfishes.<br><br>However, in one study acute (48 h) and long-term (42-day recovery period) effects of mechanically dispersed oil were assessed on juvenile Lumpsucker (*Cyclopterus lumpus*) (Frantzen et al. 2015). No mortality was observed in treatments, but the 24-h $EC_{50}$ for narcosis were found to be 22.1 (NAPH; Naphthalene), and 45.1 (SUM 16 EPA PAH; Polycyclic Aromatic Hydrocarbons), and the 48-h $EC_{50}$ for narcosis to be 24.7 (NAPH) and 40.9 (SUM 16 EPA PAH). Specific growth rates were found to be lower in exposed treatments than control, though long-term studies were ended prematurely due to water supply issues (Frantzen et al. 2015). |
| | | | | Wolffishes (Anarhichadidae) | Atlantic Wolffish, Spotted Wolffish, Northern Wolffish | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Sandrini-Neto et al. (2016) assessed the effects of 48 h oil exposure on biomarker response in juvenile wolffish (*Anarchichas denticulatus*) and monitored growth for 5 weeks post-exposure. The authors found that Polycyclic Aromatic Hydrocarbons (PAH) biliary metabolites, ethoxyresorufin-O-deethylase (EROD) and acetylcholinesterase (AChE) to be appropriate biomarkers for assessing exposure in wolffish and, more relevantly here, that growth rate (length and weight) was significantly lower in exposed treatments than control (Sandrini-Neto et al. 2016). |
| | | | | Sturgeon (Acipenseridae) | Shortnosed Sturgeon, Atlantic Sturgeon | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in in this sub-group.<br><br>There is a lack of information in the literature regarding toxicity of oil to sturgeon species found in the Maritimes Region.<br><br>Rostami and Soltani (2016) examined the impact of acute exposure of crude oil to *Acipenser persicus* (Persian Sturgeon). The authors exposed juveniles to crude oil at concentrations of 15, 16, 17, 18, and 19 ppm in a 96 h toxicity test and found the mean $LC_{50}$ to be 16.5 ppm crude oil. In addition to the $LC_{50}$, the authors found that, in organisms exposed to the $LC_{50}$ concentration, neutrophils and monocytes increase while lymphocytes and eosionphils decreased. Total protein, ALT, AST, ALP and LDH enzymes decreased significantly. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Cod (Gadidae) | Atlantic Cod, Arctic Cod, Tomcod, Pollock | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>A handful of studies have investigated the toxic effects of oil on Cod.<br>Kiceniuk and Khan (1987) found that food consumption was significantly reduced in male cod chronically exposed to petroleum. Further, condition factor and somatic indices of some organs were lower in oil-treated fish. Gall bladders were enlarged in oil-treated fish.<br>Hansen et al. (2019a) performed exposed Cod larvae to five different concentration of mechanically dispersed oil (25–2500 µg/L) for 5 days, followed by a four-day recovery period in clean water. The authors found that the $LC_{50}$ of unfiltered and filtered mechanically dispersed Troll Oil to be 9 µg/L and 6 µg/L, respectively. Hansen et al. (2019b) discovered embryonic exposure to produced water can cause cardiac toxicity and deformations in Atlantic Cod (*Gadus morhua*) and Haddock (*Melanogrammus aeglefinus*) larvae.<br>Arctic Cod (*Boreogadus saida*) exposed to Water Accommodated Fraction (WAF) and Breaking Wave WAF (BWWAF) of Alaskan Northern Slope (ANS) Crude, the mean $LC_{50}$ (based on Total Petroleum Hydrocarbons) was 1.6 mg/L and 3.3 mg/L, respectively (Gardiner et al. 2013).<br>Sørhus et al. (2015) exposed fertilized eggs of Atlantic Haddock (Gadidae) to weathered blend crude oil from the Heidrum oil field of the Norwegian Sea. Over 18 days, the authors collected embryos and larvae at 11 time points from three treatments: low (130 µg/L nominal), high (1200 µg/L nominal), and pulse (1200 µg/L nominal, for 2.4 hours in a 24 hour period). The authors noted that adhesion of oil micro-droplets to embryos resulted in higher buoyancy. Hatching success in the high dose group was very poor (17%), and the majority of larvae were severely deformed resulting in the termination of the high dose group after 8 days. Reduced growth was noted in exposed groups; exposed groups were significantly shorter than in the control group. Other effects noted after 7 days included morphological defects (pericardial and yolk sac edema) as well as increased mortality in all exposed groups (Sørhus et al. 2015). |
| | | | | Elasmobranchs | Shortfin Mako, Porbeagle, Blue Shark | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>While a single study (Al-Hassan et al. 2000) has shown that sharks have the potential to accumulate Polycyclic Aromatic Hydrocarbons (PAHs), there is a marked lack of research into chemical sensitivity or impairment on sharks due to oil exposure. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Osmeridae | Rainbow Smelt, Capelin | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Paine et al. (1991) found lethal effects of hydrocarbons on Capelin larvae and embryos, with sub-lethal effects on growth, pigmentation, developmental rate, and hatch time.<br><br>In 1992, Paine et al. found lethal effects on Capelin embryos exposed to high doses (27–37 mg/L x days) of Hibernia crude over long exposure periods (21 d). The authors found that lethal effects on larvae were observed at lower concentrations and/or shorter exposure time (1.3–7.1 mg/L x days). Sub-lethal effects (growth, pigmentation, developmental rate, time to hatch) were observed at concentrations < 10–50% of lethal concentrations.<br><br>Freshly fertilized capelin eggs were exposed to a Water Accommodated Fraction (WAF) of heavy fuel oil (IFO30) for 72 hours at Total Hydrocarbon concentrations of 0.02, 0.1, 0.6, 2.9, and 14.5 mg/L. The authors found a significant relationship between mortality and concentration in WAF exposure (Tairova et al. 2019).<br><br>It has been found that oiled sediment (0–400 ppm Total Polycyclic Aromatic Hydrocarbon [TPAH]) may not negatively impact emergence of capelin larvae following incubation (Paine et al. 1991). Capelin embryos were continuously exposed (from blastula to larval emergence) to oiled sediment (Hibernia crude and gravel) at 0, 25, 50, 100, 200 and 400 ppm TPAH. The authors found that exposed embryos (gravel and Hibernia crude oil mix) emerged slightly earlier (0.5–1 days) and in higher numbers than the control. Long-term sublethal or lethal effects were not assessed in this study. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| **1** | **2** | **3** | **4** | **5** | | **S** | **Justification** | **S** | **Justification** |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Salmon (Salmonidae) | Atlantic Salmon | **0** | Species in this sub-group do not have filter feeding structures. | **1P** | Precautionary scoring applied due to limited research on oil toxicity in Atlantic Salmon.<br><br>Several studies have documented the toxic effects of oil on salmonids but results are inconclusive.<br><br>Wang et al. (1993) found that growth of juvenile Pink Salmon was inversely related to the level of crude oil contamination in food.<br><br>Gagnon and Holdway (2000) exposed immature Atlantic Salmon to Water Accommodated Fraction (WAF) of Bass Strait Crude and found that Hepatic ethoxyresorufin-O-deethylase (EROD) activity was induced within 2 days following the onset of exposure, persisting for 2–4 days following transfer to clean water. The aim of the study was to compare exposure to a WAF of crude to dispersed oil, noting differences in hepatic activity.<br><br>Incardona et al. (2015) tested the effect on Pink Salmon embryo development of low level exposure to crude oil (Σ Polycyclic Aromatic Hydrocarbon (PAH) 0.2, 9.8, 15.4, 30.0, 45.4 µg/L).The authors found that PAH accumulation occurs in salmon embryos, and that while there were low levels of visibly malformed embryos (11% of embryos at high dose), other effects included reduce juvenile growth (specific growth rate declined significantly with dose), and reduced juvenile cardiorespiratory function (critical swimming speed as proxy). Assessed after 8 and 10 months of growth in clean water, altered cardiac structure and outflow tract in juvenile hearts was observed.<br><br>When exposed to diluted bitumen for 24 days, Atlantic Salmon smolts showed no lasting change in seawater acclimation, other than an CYP1A immune response in the pillar cells of gill lamellae when exposed to 67.9 µg/L of polycyclic aromatic compounds (PAC) (Alderman et al. 2020). |
| | | | | Scombridae | Atlantic Mackerel. Atlantic Bluefin Tuna | **1** | Atlantic Mackerel use gill rakers for filter feeding (Scott and Scott 1988). | **1P** | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Tuna embryos exposed to MC252 oil displayed defects in cardiac dysfunction and secondary malformations (Incardona et al. 2014). |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Clupeidae | Atlantic Herring, American Shad, Blueback Herring, Alewife | 1 | Species in this sub-group have feeding structures that may become clogged with oil.<br>Shad are filter feeders (Scott and Scott 1988). Alewives also exhibit filter feeding behaviour (Mullen et al. 1986). | 1P | Precautionary scoring applied due to limited research on oil toxicity in in this sub-group.<br>Tagatz (1961) performed 24 and 48 h toxicity tests with American Shad, testing a variety of concentrations of gasoline, diesel fuel oil and Bunker C. The author noted that the $LC_{50}$ (termed $TL_m$ - Median Tolerance Limit) for juvenile American Shad in the 24 h exposures were 91 mg/L and 204 mg/L for gasoline and diesel fuel oil, respectively. In the 48 h exposure test, $LC_{50}$ was measured at 91 mg/L, 167 mg/L and 2,417 mg/L for gasoline, diesel fuel oil and Bunker C, respectively. Note that Tagatz (1961) did not observe any mortality in the 24 h test with Bunker C, but noted that at 96 h, the $LC_{50}$ was 1,952 mg/L.<br>Atlantic Herring (*Clupea harengus*) embryos were exposed to a Water Accommodated Fraction (WAF) of Medium South American (MESA) crude oil for 19 days (Adams et al. 2014). Embryos exposed to a nominal concentration of 0.32% v/v WAF appeared abnormal. The authors calculated an $EC_{50}$ of approximately 0.15 mg/L of oil (estimated by fluorescence). 19 day $EC_{50}$ on hatching success was found to be 1.02 mg/L Total Petroleum Hydrocarbons (Adams et al. 2014). |
| | | | | Eels (Anguillidae) | American Eel | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Nava and Englehardt (1980) found rapid uptake of hydrocarbons in American Eels resulting in absorption through the gut and deposition in key organs and tissues of treated fish.<br>In 1982, Nava and Englehardt exposed American Eels to crude oil by ingestion of 0.1ml of a crude oil and beef liver homogenate (10, 100, or 500 µL/kg fish) per day for 5 days followed by a 12 day depuration. The authors found that exposure to crude oil resulted in enhanced hepatic MFO activity (measured as BaPH and cytochrome P-450), and was maximal by the third day of exposure (Nava and Englehardt 1982). |
| Estuarine | Estuarine transient | Benthic | Associated with unconsolidated substrates (silt/mud/sand/ gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in in this sub-group.<br>There is a lack of information in the literature regarding toxicity of oil to sturgeon species found in the Maritimes Region.<br>Rostami and Soltani (2016) examined the impact of acute exposure of crude oil to *Acipenser persicus* (Persian Sturgeon). The authors exposed juveniles to crude oil at concentrations of 15, 16, 17, 18, and 19 ppm in a 96 h toxicity test and found the mean $LC_{50}$ to be 16.5 ppm crude oil. In addition to the $LC_{50}$, the authors found that, in organisms exposed to the $LC_{50}$ concentration, neutrophils and monocytes increase while lymphocytes and eosionphils decreased. Total protein, ALT, AST, ALP and LDH enzymes decreased significantly. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| | | | | Eels (Anguillidae) | American Eel | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br>Nava and Engelhardt (1980) found rapid uptake of hydrocarbons in American Eels resulting in absorption through the gut and deposition in key organs and tissues of treated fish.<br>In 1982, Nava and Englehardt exposed American Eels to crude oil by ingestion of 0.1ml of a crude oil and beef liver homogenate (10, 100, or 500 µL/kg fish) per day for 5 days followed by a 12 day depuration. The authors found that exposure to crude oil resulted in enhanced hepatic MFO activity (measured as BaPH and cytochrome P-450), and was maximal by the third day of exposure (Nava and Englehardt 1982). |
| | | | Associated with consolidated substrates (cobble/boulder/bedrock) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in in this sub-group.<br>There is a lack of information in the literature regarding toxicity of oil to sturgeon species found in the Maritimes Region.<br>Rostami and Soltani (2016) examined the impact of acute exposure of crude oil to *Acipenser persicus* (Persian Sturgeon). The authors exposed juveniles to crude oil at concentrations of 15, 16, 17, 18, and 19 ppm in a 96 h toxicity test and found the mean $LC_{50}$ to be 16.5 ppm crude oil. In addition to the $LC_{50}$, the authors found that, in organisms exposed to the $LC_{50}$ concentration, neutrophils and monocytes increase while lymphocytes and eosionphils decreased. Total protein, ALT, AST, ALP and LDH enzymes decreased significantly. |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Clupeidae | American Shad, Blueback Herring, Alewife | 1 | Species in this sub-group have feeding structures that may become clogged with oil.<br>Shad are filter feeders (Scott and Scott 1988). Alewives also exhibit filter feeding behaviour (Mullen et al. 1986). | 1P | Precautionary scoring applied due to limited research on oil toxicity in in this sub-group.<br>Tagatz (1961) performed 24 and 48 h toxicity tests with American Shad, testing a variety of concentrations of gasoline, diesel fuel oil and Bunker C. The author noted that the $LC_{50}$ (termed $TL_m$ - Median Tolerance Limit) for juvenile American Shad in the 24 h exposures were 91 mg/L and 204 mg/L for gasoline and diesel fuel oil, respectively. In the 48 h exposure test, $LC_{50}$ was measured at 91 mg/L, 167 mg/L and 2,417 mg/L for gasoline, diesel fuel oil and Bunker C, respectively. Note that Tagatz (1961) did not observe any mortality in the 24 h test with Bunker C, but noted that at 96 h, the $LC_{50}$ was 1,952 mg/L.<br>Atlantic Herring (*Clupea harengus*) embryos were exposed to a Water Accommodated Fraction (WAF) of Medium South American (MESA) crude oil for 19 days (Adams et al. 2014). Embryos exposed to a nominal concentration of 0.32% v/v WAF appeared abnormal. The authors calculated an $EC_{50}$ of approximately 0.15 mg/L of oil (estimated by fluorescence). 19 day $EC_{50}$ on hatching success was found to be 1.02 mg/L Total Petroleum Hydrocarbons (Adams et al. 2014). |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| **1** | **2** | **3** | **4** | **5** | | **S** | **Justification** | **S** | **Justification** |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Salmon (Salmonidae) | Atlantic Salmon | **0** | Species in this sub-group do not have filter feeding structures. | **1P** | Precautionary scoring applied due to limited research on oil toxicity in Atlantic salmon.<br>Several studies have documented the toxic effects of oil on salmonids but results are inconclusive.<br>Wang et al. (1993) found that growth of juvenile Pink Salmon was inversely related to the level of crude oil contamination in food.<br>Gagnon and Holdway (2000) exposed immature Atlantic Salmon to Water Accommodated Fraction (WAF) of Bass Strait Crude and found that hepatic ethoxyresorufin-O-deethylase (EROD) activity was induced within 2 days following the onset of exposure, persisting for 2–4 days following transfer to clean water. The aim of the study was to compare exposure to a WAF of crude to dispersed oil, noting differences in hepatic activity.<br>Incardona et al. (2015) tested the effect on Pink Salmon embryo development of low level exposure to crude oil (Σ Polycyclic Aromatic Hydrocarbon (PAH) 0.2, 9.8, 15.4, 30.0, 45.4 µg/L).The authors found that PAH accumulation occurs in salmon embryos, and that while there were low levels of visibly malformed embryos (11% of embryos at high dose), other effects included reduce juvenile growth (specific growth rate declined significantly with dose), and reduced juvenile cardiorespiratory function (critical swimming speed as proxy). Assessed after 8 and 10 months of growth in clean water, altered cardiac structure and outflow tract in juvenile hearts was observed.<br>When exposed to diluted bitumen for 24 days, Atlantic Salmon smolts showed no lasting change in seawater acclimation, other than an CYP1A immune response in the pillar cells of gill lamellae when exposed to 67.9 µg/L of polycyclic aromatic compounds (PAC) (Alderman et al. 2020). |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity<br>Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity<br>Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Silversides (Atherinopsidae) | Atlantic Silverside | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Gardner et al. (1975) studied the effects of waste motor oil on Atlantic Silversides, using both long and short-term exposures. In a 96 h static bioassay (short-term), fish were exposed to 0, 10, 50, 250, 1000, and 5000 ppm of waste motor oil with $LC_{50}$ of 2,200 ppm (48 h) and 1,700 ppm (96 h).<br><br>In the long-term assay, individuals were subsequently exposed to waste oil at concentrations of 0, 20, 100 and 500 ppm. In the long-term assay, 100% mortality occurred at 250 ppm after 7 days, with no mortality found at 100 ppm after 36 days, nor at 20 ppm after 60 days. At concentrations of 20 ppm or higher, vascular system lesions were found in both moribund Atlantic Silversides and surviving individuals. Note that the authors were aiming to examine the morphological effects of waste motor oil, and toxicity data in long-term exposures are not intended to be definitive.<br><br>Note that there is very little information regarding the effects of oil on the Atlantic Silverside, but there are multiple studies on Inland Silversides (*Menidia beryllina*). |
| | | | | Sticklebacks (Gasterosteidae) | Threespine Stickleback | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>Exposure to dibenzathracene and 17β-oestradiol (E2) in Threespine Sticklebacks has been linked to endocrine disruption (Geoghegan et al. 2008). Blenkinsopp et al. (1996) conducted 96 hour $LC_{50}$ exposure tests with Threespine Sticklebacks, testing the effect (lethality) of weathered crude oil and found no adverse direct effects at any time during the test at concentrations of petroleum hydrocarbons up to 1.10 µg/L.<br><br>In 2013, Knag and Taugbøl found that acute exposure to offshore produced water (wastewater from offshore petroleum production) containing Polycyclic Aromatic Hydrocarbons (PAHs) has an effect on stress and secondary stress responses in adult Threespine Stickleback. Low dose PW exposure resulted in an upregulation of cytochrome (CYP1A) and UDP-glucuronsyltransferase (UDP-GT), both of which are associated with toxicant stress. |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Petromyzontidae | Sea Lamprey | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in this sub-group.<br><br>A handful of studies that have examined the toxic effects of environmental contaminants on Sea Lamprey, and most of these focus on PCBs, Hg, and dioxins and furans (PCDD/F) (Madenjian et al. 2020). Also note that Lamprey are considered invasive species in some areas, which has resulted in a myriad of toxicological testing on lampricides. |

| SUB-GROUP LEVEL | | | | | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Sensitivity Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity Impairment due to toxicity | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification |
| | Estuarine resident | | | Fundulidae | Mummichog | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in Mummichog.<br><br>Boudreau et al. (2009) studied the toxicity of Orimulsion-400® (emulsion of 70% bitumen in 30% water) and No. 6 fuel oil on Mummichog during embryonic development (Boudreau et al.,2009). In exposure tests with Orimulsion, the survival of Mummichog embryos was significantly reduced at concentrations ≥ 0.1% and 0.0032% with $LC_{50}$s of 0.0478% and 0.0421%.<br><br>At lower concentrations of Orimulsion, development was significantly affected with $EC_{50}$'s of 0.0157% and 0.0082%. Most common developmental abnormalities observed were delayed growth and development, pericardial edema, hemorrhaging, hemostasis, craniofacial and spinal abnormalities and non-inflated swim bladders. Also observed was reduced time to hatch and smaller larvae at hatch for all treatments (Boudreau et al. 2009).<br><br>When exposed to No.6 Fuel Oil, $LC_{50}$ was recorded as 6.12% and 2.81% in two assays. Developmental abnormalities increased significantly at concentrations ≥ 1%, with an $EC_{50}$ of 2.39% and 1.11% in the two assays (Boudreau et al. 2009).<br><br>Couillard et al. (2005) exposed newly hatched Mummichog to a Water Accommodate Fraction (WAF) of weathered Mesa Light crude oil in a 96 h static renewal assay, assessing effects on survival, body length or ethoxyresorufin-*O*-deethylase (EROD) activity. The authors found that WAF prepared with 1 g oil/L (Total Polycyclic Aromatic Hydrocarbon (TPAH) of 243 ± 6 ng/L) resulted in 22% mortality. Body length in individuals exposed to WAF prepared with 0.5 to 1 g oil/L was reduced by 3.8–6.0 % respectively (Couillard et al. 2005). |
| | | | | Syngnathidae | Northern Pipefish | 0 | Species in this sub-group do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in Syngnathids. |

*Table A9: Marine fishes sub-group scores for RECOVERY scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps) (N/A = not applicable).*

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Intertidal | Benthic | Associated with unconsolidated substrates (silt/mud/sand/gravel) | Snailfishes (Liparidae) | Atlantic Snailfish | 0 | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1 | Family Liparidae exhibit low to very low fecundity (Chernova 2004). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Species in this sub-group exhibit a close association with unconsolidated substrate. They live on soft, muddy bottoms (Scott and Scott 1988), and feed benthically on amphipods, polychaete worms, and other benthic invertebrates in unconsolidated substrates (Coad 2018). |
| | | | | Pout (Zoarcidae) | Ocean Pout | 1P | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information found for Pout in the Maritimes Region. NOAA fisheries indicates a decline (NFSC 2017, NOAA 2020). | 0 | A female ocean pout may produce 1200–4200 eggs, the number increasing with the size of the female (Scott and Scott 1988).<br>Age at maturity of ocean pout (approx. 2–3 yrs.) varies geographically, and is confounded by difficulty in identifying mature females (Steimle et al. 1999a). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Found over all types of bottom, but more numerous on hard and semi-hard substrate than on muddy substrate (Scott and Scott 1988).<br>Bottom type has been found to vary by season for Ocean Pout, with rocky shelter being more important during spawning (autumn). In soft sediments, ocean pout may burrow tail first, leaving a depression on the sediment surface (Steimle et al. 1999a). |
| | | | | Cryptacanthodidae | Wrymouth | 0 | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1P | Precautionary scoring applied due to limited research on the fecundity in this sub-group. | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Species in this sub-group exhibit a close association with unconsolidated substrate. They live on soft, muddy bottoms (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Intertidal | Benthic | Associated with consolidated substrates (rock/ boulder/ bedrock) | Snailfishes (Liparidae) | Atlantic Snailfish | **0** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1 | Family Liparidae exhibit low to very low fecundity (Chernova 2004). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1P | This species can live on soft, muddy bottoms (Scott and Scott 1988) and consolidated substrates (attached via a basal disk under rocks) (Coad 2018), but feeds benthically on amphipods, polychaete worms, and other benthic invertebrates in unconsolidated substrates (Coad 2018). |
| | | | | Pout (Zoarcidae) | Ocean Pout | **1P** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information found for the Pout in the Maritimes Region. NOAA fisheries indicates a decline (NFSC 2017, NOAA 2020). | 0 | A female Ocean Pout may produce 1200–4200 eggs, the number increasing with the size of the female (Scott and Scott 1988).<br>Age at maturity of Ocean Pout (approx. 2–3 years) varies geographically, and is confounded by difficulty in identifying mature females (Steimle et al. 1999a). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1P | Found over all types of bottom, but more numerous on hard and semi-hard substrate than on muddy substrate (Scott and Scott 1988). |
| | | | | Pholidae | Rock Gunnel | **0** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1P | Precautionary scoring applied due to limited research on the fecundity in this sub-group. | 0 | No evidence of endemism or isolation within the Maritimes Region. | 0 | Rock Gunnels avoid muddy bottoms (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Intertidal | Non-benthic (pelagic and demersal) | N/A | Sticklebacks (Gasterosteidae) | Blackspotted Stickleback, Fourspine Stickleback, Threespine Stickleback | **0** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN for the Maritimes Region (Note that Threespine Stickleback is listed on COSEWIC, but these are continental populations (Little Quarry Lake and lakes in the Vananda Creek watershed) – marine fish in the Maritimes Region are not at risk).<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1P | Fecundity varies by body size at maturity (females). Age specific fecundity is further complicated by the effect of food on the number of spawnings within a breeding season.<br><br>Generally speaking, female fecundity is enough to produce (given that a male can successfully take up a territory and build a nest) several hundred free swimming fry in a breeding season (Wootton 1984, Scott and Scott 1988).<br><br>*Gasterosteus aculeatus* (Threespine Stickleback): generally reaches sexual maturity at 1 year (though maximum lifespan varies by population) (this is generally shared throughout Gasterosteidae).<br><br>As many as 300 eggs have been counted in Threespine Stickleback nests (Scott and Scott 1988).<br><br>Fourspine Stickleback females spawn at intervals of 3 or 4 days, depositing 15–20 eggs at each spawning (Scott and Scott 1988, Rowland 1974). | 0 | No evidence of endemism or isolation within the Maritimes Region.<br><br>Most Gasterosteidae have extremely large home ranges (other than those continental species); of these species, the Blackspotted Stickleback is endemic to the North Atlantic coast of North America, but their range extends into the St. Lawrence Estuary, through Newfoundland and south to New Jersey, far beyond the Maritimes Regional boundaries (Wootton 1984). | 1 | Expected to come into contact with unconsolidated substrates due to nesting behaviour.<br><br>Fourspine Stickleback spawning is commonly associated with aquatic vegetation on intertidal spawning areas (Scott and Scott 1988)<br><br>Males build nests around, or at the base of vegetation or other protuberances from the substrate (Courtenay and Keenleyside 1983). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Intertidal | Non-benthic (pelagic and demersal) | N/A | Silversides (Atherinopsidae) | Atlantic Silverside | 0 | There are no species in this sub-group listed on SARA, COSEWIC or IUCN for the Maritimes Region.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Atlantic Silverside: is considered an annual species, completing its life-cycle within 1 year (northernmost distributed individuals may take 2 years) (Sargent et al. 2008).<br>Silversides (age 2+) can produce up to 5000 eggs (Scott and Scott1988). | 0 | No evidence of endemism or isolation within the Maritimes Region. Sargent et al. (2008) found the distribution of the Atlantic Silverside can extend well past the Maritimes Regional Boundary. | 1 | Feed on mud flats during ebb tide (Scott and Scott 1988). |
| | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Skates (Rajidae) | Little Skate, Thorny Skate, Smooth Skate | 1 | Smooth Skate: endangered [Funk Island Deep population, Assessed 2012/05], special concern, [Laurentian-Scotian population, assessed 2012] (COSEWIC 2012a).<br>Thorny Skate: special concern, assessed 2012/05 (COSEWIC 2012b); Winter Skate: endangered (Eastern Scotian Shelf) assessed 2015/05; not at risk (Western Scotian Shelf–Georges Bank Population) assessed 2015/05 (COSEWIC 2015). | 1 | Reproductive capacity per female of Little Skates is expected to be low (Scott and Scott,1988); Winter Skates are slow to mature (5 years) and exhibit long gestation (approx. 22 months) (COSEWIC 2015). | 0 | Smooth Skate: no evidence for endemism within the Maritimes Regional Boundary (Laurentian–Scotian Designatable Unit (DU) range includes QC, PEI, NS and NB) (COSEWIC 2012a).<br>Thorny Skate: no evidence of endemism or isolation within the Maritimes Regional Boundary (COSEWIC 2012b). Winter Skate – endemic to Northwest Atlantic Ocean, but contains 3 DUs, all of which are not isolated or endemic to the Maritimes Regional boundaries (COSEWIC 2015). | 1 | Benthic species living over sand and gravel bottoms (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Flatfishes (Pleuronectidae) | Winter Flounder, Yellowtail Flounder, Atlantic Halibut, Windowpane, American Plaice | **1** | Atlantic Halibut: not at risk, assessed 2011/11 (Government of Canada 2021). American Plaice: threatened, Maritime population and Newfoundland and Labrador population, assessed 2009/04 (COSEWIC 2009a). | 1P | American Plaice has a relatively long time to maturity with the shortest time to maturity 3–5 years (in warmest water, i.e., Passamaquoddy Bay, NB) and longest in cold water off NL (10–13 years) (Johnson 1999).<br>Once mature, a 70 cm American Plaice can produce 1.5 million eggs. Witch flounder can produce 200,000–450,000 eggs. Female Halibut weighing 90kg may produce over 2 million eggs (Scott and Scott 1988). | 1 | American Plaice: Maritimes designated unit (DU) falls within the Maritimes Region Boundary, indicating some isolation (COSEWIC 2009a). | 1 | Bottom dwelling group closely associated with mud and sand (Scott and Scott 1988). |
| | | | | Sculpins (Cottidae) | Shorthorn Sculpin, Longhorn Sculpin, Moustache Sculpin | **1** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>Species in this sub-group show evidence of declining population (DFO 2020). | 0 | Species in this sub-group exhibit high fecundity (Scott and Scott 1988). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Bottom dwelling group expected to come into close contact with unconsolidated substrates (Scott and Scott 1988). |
| | | | | Pout (Zoarcidae) | Ocean Pout | **1P** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information found for the Pout in the Maritimes Region.<br>NOAA fisheries indicates a decline (NFSC 2017, NOAA 2020). | 0 | A female Ocean Pout may produce 1200–4200 eggs, the number increasing with the size of the female (Scott and Scott 1988).<br>Age at maturity of Ocean Pout (approx. 2–3 years) varies geographically, and is confounded by difficulty in identifying mature females (Steimle et al. 1999a). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Found over all types of bottom, but more numerous on hard and semi-hard substrate than on muddy substrate (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Redfish (Sebastidae) | Acadian Redfish | **1** | Threatened (Atlantic Population); special concern (Bonne Bay population), both assessed 2010/04 (COSEWIC 2010c). | 1P | A 50 cm female redfish can produce 50,000 fertilized eggs and release 15–20,000 live young (Scott and Scott 1988).<br>Fecundity is relatively low (Pikanowski et al. 1999). Slow growing and long lived. Females extrude 15,000 to 20,000 larvae (live bearing species) (Pikanowski et al. 1999).<br>Age at maturity estimates vary from 5.5 years to 8–9 years. | 0 | Two designatable units (COSEWIC 2010c): Atlantic population and Bonne Bay population. Neither of which lie solely within the Maritimes Region. | 1 | No direct evidence of substrate preference, but most often found over clay-silt bottom (Scott and Scott 1988); and mud, and rocky substrate (Pikanowski et al. 1999). |
| | | | | Lophiidae | Monkfish | **1P** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>Species in this subgroup show evidence of widespread decreasing trends in body size (Charbonneau et al. 2020). | 1 | Slow growing species (Smith et al. 2008), reaching maturity at about 32.0–43.3 cm and 4 years old for males, and 36.1–48.0 cm and 5 years old for females (Steimle et al. 1999b). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Found over muddy bottoms (Scott and Scott 1988). |
| | | | | Myxinidae | Atlantic Hagfish | **0** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1 | The Hagfish exhibits low fecundity.<br>Spawning occurs throughout the year, female Hagfish may carry 1–30 large eggs (Scott and Scott 1988). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Live on soft, muddy bottoms (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Subtidal | Benthic | Associated with unconsolidated substrates (silt/mud/ sand/ gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | **1** | Atlantic Sturgeon: threatened, Maritimes and St. Lawrence populations, assessed 2011/05 (COSEWIC 2011a); Shortnose Sturgeon: special concern, assessed 2015/05 (COSEWIC 2005). | 1P | Sturgeon are very slow to sexually mature. Female Shortnose Sturgeon in Saint John estuary only sexually mature at age 18.<br>Female Atlantic Sturgeon in St. Lawrence estuary reach sexual maturity at age 27–28 (Scott and Scott 1988).<br>Atlantic Sturgeon: the Maritimes population has a relatively small breeding population (COSEWIC 2011a), but due to their large size, females of the species are extremely fecund (350 kg female may exhibit potential fecundity of 7–8 million eggs) (COSEWIC 2011a). That being said, there can be long periods of reproductive quiescence, from 1–5 years for females (COSEWIC 2011a).<br>Shortnose Sturgeon: spawn every 3 years and females can produce up to 200,000 eggs (COSEWIC 2005). | 1 | Atlantic Sturgeon have three designatable units (DU) (COSEWIC 2011a): Great lakes and upper St. Lawrence, Lower St. Lawrence, and the Maritimes. The Maritimes DU is endemic/isolated in the Maritimes Region and the Saint John River area is the only spawning ground for this population (COSEWIC 2011a).<br>Shortnose Sturgeon: endemic/isolated in the Saint John River in New Brunswick (COSEWIC 2005). | 1 | Bottom feeding sub-group (Scott and Scott 1988); which prey on benthic organisms via a suctorial mouth and buccal cavity-created vacuum (COSEWIC 2011a).<br>Atlantic Sturgeon spawn over rocky and gravel substrates (COSEWIC 2011a). |
| | | | Associated with consolidated substrates (cobble/boulder/ bedrock) | Sculpins (Cottidae) | Snowflake Hookear Sculpin, Longhorn Sculpin, Shorthorn Sculpin | **1** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List.<br>Species in this sub-group show evidence of declining population (DFO 2020). | 0 | Species in this sub-group exhibit high fecundity (Scott and Scott 1988).<br>Sea Raven may produce on average 15,000 eggs (Scott and Scott 1988). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Bottom dwelling group expected to come into close contact with consolidated and unconsolidated substrates (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Subtidal | Benthic | Associated with consolidated substrates (cobble/boulder/ bedrock) | Lumpfishes (Cyclopteridae) | Atlantic Spiny Lumpsucker, Lumpfish | **1** | Lumpfish: Threatened, assessed 2017/11 (COSEWIC 2017). | 0 | Lumpfishes exhibit high fecundity.<br>Female Lumpfish can produce 140,000 eggs or more (Scott and Scott 1988). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Bottom dwelling group expected to come into close contact with consolidated and unconsolidated substrates (Scott and Scott 1988). |
| | | | | Wolffishes (Anarhichadidae) | Atlantic Wolffish, Spotted Wolffish, Northern Wolffish | **1** | Atlantic Wolffish: special concern, COSEWIC, assessed 2012/11 (COSEWIC 2012d); Northern Wolffish: threatened, COSEWIC Assessed 2012/11 (COSEWIC 2012e); threatened, SARA Schedule 1, 2003/06/05. Spotted Wolffish: threatened, COSEWIC, Assessed 2012/11 (COSEWIC 2012f); threatened, (SARA Schedule 1, 2003/06/05). | 1 | Species in this sub-group are not expected to exhibit high fecundity (Scott and Scott 1988).<br>Northern Wolffish: generation time is approx. 10.5 years (COSEWIC 2012e).<br>Atlantic Wolffish: generation time estimated at 15 years, females exhibit low egg production, and age at maturity for 50% of female population estimated at 8–15 years (COSEWIC 2012d). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1 | Wolffish feed on a variety of benthic species (Scott and Scott 1988), so likely to come into contact with unconsolidated substrates.<br>Northern Wolffish: believed to be more common over sandy substrate (with shell hash) (COSEWIC 2012e).<br>Atlantic Wolffish: primarily live on rocky or sandy substrates (COSEWIC 2012d). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Subtidal | Benthic | Associated with consolidated substrates (cobble/boulder/bedrock) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | **1** | Atlantic Sturgeon: threatened, Maritimes and St. Lawrence populations, assessed 2011/05 (COSEWIC 2011a); Shortnose Sturgeon: special concern, assessed 2015/05 (COSEWIC 2005). | 1 | Sturgeon are very slow to sexually mature. Female Shortnose Sturgeon in Saint John estuary only sexually mature at age 18.<br>Female Atlantic Sturgeon in St. Lawrence estuary reach sexual maturity at age 27–28 (Scott and Scott 1988).<br>Atlantic Sturgeon: the Maritimes population has a relatively small breeding population (COSEWIC 2011a), but due to their large size, females of the species are extremely fecund (350 kg female may exhibit potential fecundity of 7–8 million eggs) (COSEWIC 2011a). That being said, there can be long periods of reproductive quiescence, from 1–5 years for females (COSEWIC 2011a).<br>Shortnose Sturgeon: spawn every 3 years and females can produce up to 200,000 eggs (COSEWIC 2005). | 1 | Atlantic Sturgeon have three designatable units (DU) (COSEWIC 2011a): Great lakes and upper St. Lawrence, Lower St. Lawrence, and the Maritimes<br>The Maritimes DU is endemic/isolated in the Maritimes Region and the Saint John River area is the only spawning ground for this population (COSEWIC 2011a). Shortnose Sturgeon: endemic/isolated in the Saint John River in New Brunswick (COSEWIC 2005). | 1 | Bottom feeding sub-group (Scott and Scott 1988); which prey on benthic organisms via a suctorial mouth and buccal cavity-created vacuum (COSEWIC 2011a).<br>Atlantic Sturgeon spawn over rocky and gravel substrates (COSEWIC 2011a). |
| | | Non-benthic (pelagic and demersal) | N/A | Cod (Gadidae) | Atlantic Cod, Arctic Cod, Tomcod, Pollock | **1** | Atlantic Cod: endangered (Laurentian North population, Laurentian South population, Newfoundland and Labrador population, Southern population) assessed 2010/04 (COSEWIC 2010b); Cusk: endangered, assessed 2012/11 (COSEWIC 2012c). | 0 | Atlantic Cod: a 50 cm female can produce 200,000 eggs (Scott and Scott 1988). Species in this sub-group exhibit high fecundity (Scott and Scott 1988).<br>Average egg production per female Atlantic Cod per spawning year can range from 300,000 to several million (COSEWIC 2010b; Lough 2004). | 0 | Of the four designatable units (DUs) for cod, two exist within the Maritimes Region, though the geographic range of the DUs extend beyond the Maritime Regional Boundary. | 1 | Atlantic Cod feed on a variety of benthic species (Scott and Scott 1988), so likely to come into contact with unconsolidated substrates.<br>Some studies show a preference in adults for coarse sediment (Fahay et al. 1999). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Elasmobranchs | Shortfin Mako, Porbeagle, Blue Shark | 1 | Shortfin Mako: endangered, Atlantic population, assessed 2019/05 (COSEWIC 2019); Porbeagle: endangered, assessed 2014/05 (COSEWIC 2014); Blue Shark: not at risk, North Atlantic Population, assessed 2016/11 (COSEWIC 2016). Basking Shark: special concern, assessed 2009/11 (COSEWIC 2009b). | 1 | Most sharks produce few offspring and reach sexual maturity slowly.<br>Shortfin Mako sharks have a long generation time (approximately 25 years) relative to others in this group (also late maturity 7–18 years) (Government of Canada 2019, COSEWIC 2019).<br>Porbeagle exhibit late maturity (8–13 years) and low fecundity (COSEWIC 2014).<br>Basking Shark has a generation time of approximately 22 years (COSEWIC 2009b). | 0 | No evidence of endemism or isolation for Shortfin Mako or Porbeagle; designatable unit (DU) range continues outside of the Maritimes Regional Boundaries for both species (COSEWIC 2019, COSEWIC 2014). | 0 | Species in this sub-group are not expected to have a close association with unconsolidated substrate. |
| | | | | Osmeridae | Rainbow Smelt, Capelin | 0 | There are no species in this sub-group listed on SARA, COSEWIC or IUCN Red List for the Maritimes Region.<br>The Lake Utopia population of Rainbow Smelt is listed by COSEWIC. Not included in this framework as it is not a Marine population.<br>Capelin stock information revolves mostly around the Newfoundland region. Some data is available on the Scotian Shelf Capelin population, though very minimal, from 1997 and not enough to identify trends in the population within the Maritimes Region. | 0 | A large female Capelin can produce 50,000 eggs.<br>A large female smelt can produce up to 60,000 eggs (Scott and Scott 1988).<br>Smelt produce 7,000 (12.7 cm adult) to 69,000 eggs (20.9 cm adult) (Buckley 1989). | 0 | Smelt and Capelin show no evidence of endemism or isolation within the Maritimes Region. Species range extends outside of the Maritimes (Buckley 1989). | 1 | Smelt deposit eggs over gravel substrate. Eggs are demersal and adhesive (Buckley 1989).<br>In the Northwest Atlantic Ocean, Capelin spawn on bottom, on intertidal gravel beaches (Kenchington et al. 2015). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Salmon (Salmonidae) | Atlantic Salmon | 1 | Not at risk: Labrador population, Northeast Newfoundland population, Northwest Newfoundland population, Southwest Newfoundland population, assessed 2010/11 (COSEWIC 2010a); special concern: Gaspe – Southern Gulf of St. Lawrence population, Inner St. Lawrence population, South Newfoundland population assessed 2010/11 (COSEWIC 2010a); endangered: Eastern Cape Breton population, Inner Bay of Fundy population, Nova Scotia Southern Upland population, Outer Bay of Fundy population, assessed 2010/11 (COSEWIC 2010a); Inner Bay of Fundy population: endangered, SARA, Listed on 2003/06/05. | 1P | Precautionary scoring as fecundity in Atlantic Salmon is highly variable and dependent on a number of factors including age, body size, stock, and river.<br>Relative fecundity (eggs/kg) can range from 33 (dwarf or stunted resident population) to 16,585, but on average, a female deposits 700–800 eggs per pound of body weight (Scott and Scott 1988).<br>Average generation time is 5 years (O'Connell et al. 2006). Survival across life stages is low, 0.03%–3.0% from egg to smolt (COSEWIC 2010a). | 1 | Eleven designatable units (DU) (COSEWIC 2010a): Labrador population, Northeast Newfoundland population, Northwest Newfoundland population, Southwest Newfoundland population, Gaspe – Southern Gulf of St. Lawrence population, Inner St. Lawrence population, South Newfoundland population, Eastern Cape Breton (ECB) population, Inner Bay of Fundy (iBoF) population, Nova Scotia Southern Upland (SU) population, Outer Bay of Fundy population (oBoF).<br>Justification for the scoring of 1 is due to the genetic isolation (and geographic extent) of 4 DUs (ECB, iBoF, oBoF, and SU) (COSEWIC 2010a). Atlantic Salmon exhibit some of the widest ranging migration patterns of salmonids. Typically, the extensive geographic range of the species would result in a score of 0 however, due to the reproductive behaviour of the species, and the limited (or non-existence of) genetic transfer between DUs, this receives a 1. | 0 | Interaction with sediment in Atlantic Salmon is limited to spawning events in fresh water environments. When at sea, species in this sub-group are not expected to interact with unconsolidated substrates. |
| Marine | Subtidal | Non-benthic (pelagic and demersal) | N/A | Scombridae | Atlantic Mackerel. Atlantic Bluefin Tuna | 1 | Atlantic Bluefin Tuna: endangered, assessed 2011/05 (COSEWIC 2011b). | 0 | A 35 cm female Mackerel is estimated to produce 200,000 eggs (Scott and Scott 1988).<br>Large female Bluefin Tuna may produce over 60 million eggs, though not in Canadian waters (Scott and Scott 1988). | 0 | No evidence of endemism or isolation within the Maritimes Region (COSEWIC 2011b, DFO 2017). | 0 | Can be found in deeper water but not expected to be in frequent contact with sea floor (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| | | | | Clupeidae | Atlantic Herring, American Shad, Blueback Herring, Alewife | **1P** | American Shad and Alewife have not been nor are they currently being assessed by COSEWIC, but are considered a mid-priority candidate for assessment (COSEWIC 2021);<br>Blueback Herring: not at risk, assessed 1980/04 (Government of Canada 2021).<br>Declining stocks of Atlantic Herring in the Northwest Atlantic. (NFSC 2022). | 0 | Female Blueback Herring can produce up to 400,000 eggs.<br>Shad and Alewife display similar fecundity (Scott and Scott 1988).<br>Fecundity estimates for Alewives ranges from 60,000 eggs to 206,000 eggs (Mullen et al. 1986).<br>Shad are prolific and can produce up to 600,000 eggs (Scott and Scott 1988). | 0 | No evidence of endemism or isolation in the Maritimes Region.<br>Geographic ranges extend outside of the Maritimes, down the eastern shore of North American (Mullen et al. 1986). | 1P | Shad consume benthic amphipods (Scott and Scott 1988).<br>Blueback Herring prefer to spawn in fast currents over hard substrate whereas the alewife uses a wide variety of spawning sites and substrates (Mullen et al. 1986). |
| | | | | Eels (Anguillidae) | American Eel | **1** | Threatened, assessed 2012/05 (COSEWIC 2012g); COSEWIC report singles out St. Lawrence and Ontario as areas of concern. | 1P | Precautionary scoring as there is a lack of research to quantify fecundity in American Eels (Scott and Crossman 1973). | 0 | No evidence of endemism or isolation within the Maritimes Region (ranked as secure in NB and NS) (COSEWIC 2012g). | 1 | American Eel is a benthic species, preferring rock, sand and muddy substrate (COSEWIC 2012g). Overwinter buried in muddy bottoms of lakes and rivers (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Estuarine | Estuarine transient | Benthic | Associated with unconsolidated substrates (silt/mud/sand/ gravel) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | 1 | Atlantic Sturgeon: threatened, Maritimes and St. Lawrence populations, assessed 2011/05 (COSEWIC 2011a); Shortnose Sturgeon: special concern, assessed 2015/05 (COSEWIC 2005). | 1P | Sturgeon are very slow to sexually mature. Female Shortnose Sturgeon in Saint John estuary only sexually mature at age 18.<br>Female Atlantic Sturgeon in St. Lawrence estuary reach sexual maturity at age 27–28 (Scott and Scott 1988).<br>Atlantic Sturgeon: the Maritimes population has a relatively small breeding population (COSEWIC 2011a), but due to their large size, females of the species are extremely fecund (350 kg female may exhibit potential fecundity of 7–8 million eggs) (COSEWIC 2011a). That being said, there can be long periods of reproductive quiescence, from 1–5 years for females (COSEWIC 2011a).<br>Shortnose Sturgeon: spawn every 3 years and females can produce up to 200,000 eggs (COSEWIC 2005). | 1 | Atlantic Sturgeon have three designatable units (DU) (COSEWIC 2011a): Great lakes and upper St. Lawrence, Lower St. Lawrence, and the Maritimes. The Maritimes DU is endemic/isolated in the Maritimes Region and the Saint John River area is the only spawning ground for this population (COSEWIC 2011a).<br>Shortnose Sturgeon: endemic/isolated in the Saint John River in New Brunswick (COSEWIC 2005). | 1 | Bottom feeding sub-group (Scott and Scott 1988); which prey on benthic organisms via a suctorial mouth and buccal cavity-created vacuum (COSEWIC 2011a).<br>Atlantic Sturgeon spawn over rocky and gravel substrates (COSEWIC 2011a). |
| | | | | Eels (Anguillidae) | American Eel | 1 | Threatened, assessed 2012/05 (COSEWIC 2012g); COSEWIC report singles out St. Lawrence and Ontario as areas of concern. | 1P | Precautionary scoring as there is a lack of research to quantify fecundity in American Eels (Scott and Crossman 1973). | 0 | No evidence of endemism or isolation within the Maritimes Region (ranked as secure in NB and NS) (COSEWIC 2012g). | 1 | American Eel is a benthic species, preferring rock, sand and muddy substrate (COSEWIC 2012g). Overwinter buried in muddy bottoms of lakes and rivers (Scott and Scott 1988). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Estuarine | Estuarine transient | Benthic | Associated with consolidated substrates (cobble/boulder/ bedrock) | Sturgeon (Acipenseridae) | Shortnose Sturgeon, Atlantic Sturgeon | **1** | Atlantic Sturgeon: threatened, Maritimes and St. Lawrence populations, assessed 2011/05 (COSEWIC 2011a); Shortnose Sturgeon: special concern, assessed 2015/05 (COSEWIC 2005). | 1P | Sturgeon are very slow to sexually mature. Female Shortnose Sturgeon in Saint John estuary only sexually mature at age 18.<br><br>Female Atlantic Sturgeon in St. Lawrence estuary reach sexual maturity at age 27–28 (Scott and Scott 1988).<br><br>Atlantic Sturgeon: the Maritimes population has a relatively small breeding population (COSEWIC 2011a), but due to their large size, females of the species are extremely fecund (350 kg female may exhibit potential fecundity of 7–8 million eggs) (COSEWIC 2011a). That being said, there can be long periods of reproductive quiescence, from 1–5 years for females (COSEWIC 2011a).<br><br>Shortnose Sturgeon: spawn every 3 years and females can produce up to 200,000 eggs (COSEWIC 2005). | 1 | Atlantic Sturgeon have three designatable units (DU) (COSEWIC 2011a): Great lakes and upper St. Lawrence, Lower St. Lawrence, and the Maritimes<br><br>The Maritimes DU is endemic/isolated in the Maritimes Region and the Saint John River area is the only spawning ground for this population (COSEWIC 2011a).<br><br>Shortnose Sturgeon: endemic/isolated in the Saint John River in New Brunswick (COSEWIC 2005). | 1 | Bottom feeding sub-group (Scott and Scott 1988); which prey on benthic organisms via a suctorial mouth and buccal cavity-created vacuum (COSEWIC 2011a).<br><br>Atlantic Sturgeon spawn over rocky and gravel substrates (COSEWIC 2011a). |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Clupeidae | American Shad, Blueback Herring, Alewife | **1P** | American Shad and Alewife have not been nor are they currently being assessed by COSEWIC, but are considered a mid-priority candidate for assessment (COSEWIC 2021);<br><br>Blueback Herring: not at risk, assessed 1980/04 (Government of Canada 2021).<br><br>Declining stocks of Atlantic Herring in the Northwest Atlantic. (NEFSC 2022). | 0 | Female Blueback Herring can produce up to 400,000 eggs.<br><br>Shad and Alewife display similar fecundity (Scott and Scott 1988).<br><br>Fecundity estimates for Alewives ranges from 60,000 eggs to 206,000 eggs (Mullen et al. 1986).<br><br>Shad are prolific and can produce up to 600,000 eggs (Scott and Scott 1988). | 0 | No evidence of endemism or isolation in the Maritimes Region.<br><br>Geographic ranges extend outside of the Maritimes, down the eastern shore of North American (Mullen et al. 1986). | 1P | Shad consume benthic amphipods (Scott and Scott 1988).<br><br>Blueback Herring prefer to spawn in fast currents over hard substrate whereas the Alewife uses a wide variety of spawning sites and substrates (Mullen et al. 1986). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Salmon (Salmonidae) | Atlantic Salmon | 1 | Not at risk: Labrador population, Northeast Newfoundland population, Northwest Newfoundland population, Southwest Newfoundland population, assessed 2010/11 (COSEWIC 2010a); special concern: Gaspe – Southern Gulf of St. Lawrence population, Inner St. Lawrence population, South Newfoundland population, assessed 2010/11 (COSEWIC 2010a); endangered: Eastern Cape Breton population, Inner Bay of Fundy population, Nova Scotia Southern Upland population, Outer Bay of Fundy population, assessed 2010/11 (COSEWIC 2010a); Inner Bay of Fundy Population endangered, SARA, Listed on 2003/06/05. | 1P | Precautionary scoring as fecundity in Atlantic Salmon is highly variable and dependent on a number of factors including age, body size, stock, and river.<br><br>Relative fecundity (eggs/kg) can range from 33 (dwarf or stunted resident population) to 16,585, but on average, a female deposits 700–800 eggs per pound of body weight (Scott and Scott 1988).<br><br>Average generation time is 5 years (O'Connell et al. 2006).<br><br>Survival across life stages is low, 0.03%–3.0% from egg to smolt (COSEWIC 2010a). | 1 | Eleven designatable units (DU) (COSEWIC 2010a): Labrador population, Northeast Newfoundland population, Northwest Newfoundland population, Southwest Newfoundland population, Gaspe – Southern Gulf of St. Lawrence population, Inner St. Lawrence population, South Newfoundland population, Eastern Cape Breton (ECB) population, Inner Bay of Fundy (iBOF) population, Nova Scotia Southern Upland (SU) population, Outer Bay of Fundy population (oBOF).<br><br>Justification for the scoring of 1 is dues to the genetic isolation (and geographic extent) of 4 DUs (ECB, iBoF, oBoF, and SU) (COSEWIC 2010a). Atlantic Salmon exhibit some of the widest ranging migration patterns of salmonids. Typically, the extensive geographic range of the species would result in a score of 0 however, due to the reproductive behaviour of the species, and the limited (or non-existent) genetic transfer between DUs, this receives a 1.. | 0 | Atlantic Salmon deposit eggs in nests or 'redds' in gravel substrates in freshwater (Scott and Scott 1988, COSEWIC 2010a).<br><br>They do not spawn in estuaries, therefore not expected to have a close association with unconsolidated substrates in estuaries. |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Silversides (Atherinopsidae) | Atlantic Silverside | 0 | There are no species in this sub-group listed on SARA, COSEWIC or IUCN for the Maritimes Region.<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Atlantic Silverside: is considered an annual species, completing its life-cycle within 1 year (northernmost distributed individuals may take 2 years) (Sargent et al. 2008).<br><br>Silversides (age 2 +) can produce up to 5000 eggs (Scott and Scott 1988). | 0 | No evidence of endemism or isolation within the Maritimes Region. Sargent et al. (2008) found the distribution of the Atlantic Silverside can extend well past the Maritimes Regional Boundary. | 1 | Feed on mud flats during ebb tide (Scott and Scott 1988). |
| | | | | Sticklebacks (Gasterosteidae) | Threespine Stickleback | 0 | There are no species in this sub-group listed on SARA, COSEWIC or IUCN for the Maritimes Region (Note that Threespine Stickleback is listed on COSEWIC, but these are continental populations (Little Quarry Lake and lakes in the Vananda Creek watershed) – marine fish in the Maritimes Region are not at risk).<br><br>No recent population assessment information was found for this sub-group in the Maritimes Region | 1P | As many as 300 eggs have been counted in Threespine Stickleback nests (Scott and Scott 1988).<br><br>Gasterosteus aculeatus generally reaches sexual maturity at 1 year (though maximum lifespan varies by population).<br><br>Fecundity varies by body size at maturity (females). Age specific fecundity is further complicated by the effect of food on the number of spawnings within a breeding season.<br><br>Generally speaking, female fecundity is enough to produce (given that a male can successfully take up a territory and build a nest), several hundred free swimming fry in a breeding season (Wootton 1984). | 0 | No evidence of endemism or isolation within the Maritimes Region.<br><br>Most Gasterosteidae have extremely large home ranges (other than those continental species), of these species, the Blackspotted Stickleback is endemic to the North Atlantic coast of North America, but their range extends into the St. Lawrence Estuary, through Newfoundland and south to New Jersey, far beyond the Maritimes Regional boundaries (Wootton 1984). | 1 | Expected to be found in close association with substrate due to nest building behavior when in fresh water.<br><br>Most stickleback species will build nests off the substrate, usually closely associated with vegetation. Some, such as the Blackspotted Stickleback will build their nest on the substrate, and show no preference for sandy or muddy bottoms over hard substrate (can be found in all) (Wootton 1984). |

| SUB-GROUP LEVEL | | | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Population Status | | Reproductive Capacity | | Endemism or Isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | 4 | 5 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Estuarine | Estuarine transient | Non-benthic (pelagic and demersal) | N/A | Petromyzontidae | Sea Lamprey | **0** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN for the Maritimes Region.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 0 | Females can produce up to 300,000 eggs (Scott and Scott 1988). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 0 | Make nests on stream beds so likely to come into contact with unconsolidated substrate (Scott and Scott 1988). |
| Estuarine | Estuarine resident | Non-benthic (pelagic and demersal) | N/A | Fundulidae | Mummichog | **0** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN for the Maritimes Region.<br>No recent population assessment information was found for this sub-group in the Maritimes Region.<br>NL has a Mummichog population nearing threatened levels (not applicable to the Maritimes application). | 1P | Low fecundity species. Eggs number between 460 (Scott and Crossma 1973) and 740 (Katz 1954 as cited in Scott and Scott 1988). | 0 | No evidence of endemism or isolation within the Maritimes Region. | 1P | Eggs are deposited on substrate (Scott and Scott 1988).<br>Mummichog spend their entire life cycle in close association with salt marshes and shallow estuarine waters (Scott and Scott 1988).<br>Those in salt marshes have a close association with *Spartina alterniflora*, which grows in unconsolidated substrate (Scott and Scott 1988). |
| Estuarine | Estuarine resident | Non-benthic (pelagic and demersal) | N/A | Syngnathidae | Northern Pipefish | **0** | There are no species in this sub-group listed on SARA, COSEWIC or IUCN for the Maritimes Region.<br>No recent population assessment information was found for this sub-group in the Maritimes Region. | 1P | Brooding species with a highly unique reproductive strategy (relative to other marine fish) – male pregnancy (Wilson and Orr 2011). Sexual maturity reached between 1–2 years (Dawson and Vari 1982). | 0 | No evidence of endemism or isolation within the Maritimes Region.<br>Geographic range reported to extend beyond the Maritimes Regional Boundary (from PEI and Cape Breton, NS to Florida, USA) (Dawson and Vari 1982). | 1 | Species is expected to have close association with marine vegetation, particularly eelgrass, *Zostera* sp., which grows in unconsolidated substrates. (Dawson and Vari 1982). |

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# APPENDIX 4. DETAILED SCORING TABLES WITH JUSTIFICATIONS FOR MARINE MAMMALS

*Table A10. Marine mammals sub-group scores for EXPOSURE scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps) (– = not applicable).*

| SUB-GROUP LEVEL | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Cetaceans | Toothed | Discrete | Killer Whale, Long-finned Pilot Whale, Northern Bottlenose Whale, Atlantic White-sided Dolphin | 1 | Species in this sub-group have been observed to form concentrations or aggregations (Olson 2018, Cipriano 2018, Ford 2018). | 0 | All marine mammals can be described as highly mobile (Tyack 2018). | 1 | All marine mammals surface to breathe (Miller and Roos 2018, Tyack 2018). | 1P | Diet composition studies indicate that species in this sub-group have the ability to interact with the sea floor (Reeves et al. 1999, Cipriano 2018). |
| Cetaceans | Toothed | Dispersed | Harbour Porpoise, Sperm Whale, Cuvier's Beaked Whale, Sowerby's Whale, True's Beaked Whale, Blainville's Beaked Whale | 1 | Species in this sub-group have been observed to form concentrations or aggregations (Baird 2018, Bjørge and Tolley 2018, Whitehead 2018). | 0 | All marine mammals can be described as highly mobile (Tyack 2018). | 1 | All marine mammals surface to breathe (Miller and Roos 2018, Tyack 2018). | 1 | All beaked whales tend to forage at or near the seabed (MacLeod 2018). |
| Cetaceans | Baleen | Discrete | Fin Whale, Humpback Whale, North Atlantic Right Whale | 1 | Species in this sub-group have been observed to form concentrations or aggregations (COSEWIC,2013 , Cole et al. 2013, Brown et al. 2008, Mitchell 1974, Perkins and Whitehead 1977, DFO 2016, Aguilar and Garcia-Vernet 2018). | 0 | All marine mammals can be described as highly mobile (Tyack 2018) | 1 | All marine mammals surface to breathe (Miller and Roos 2018, Tyack 2018). | 1P | Humpback Whales exhibit feeding behaviour resulting in interaction with the sea floor (Hain et al. 1995, Ware et al. 2013). |
| Cetaceans | Baleen | Dispersed | Minke Whale, Blue Whale, Sei Whale | 1 | Species in this sub-group have been observed to form concentrations or aggregations (Horwood 2018, Perrin et al. 2018). | 0 | All marine mammals can be described as highly mobile (Tyack 2018). | 1 | All marine mammals surface to breathe (Miller and Roos 2018, Tyack 2018). | 1P | In the North Atlantic, Minke Whale diet includes species generally associated with the sea floor (Sand Eel, Sand Lance, Cod) (Perrin et al. 2018). |

| SUB-GROUP LEVEL | | | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| 1 | 2 | 3 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Pinnipeds | Thermoregulate with fur | None Found | | – | – | – | – | – | – | – | – |
| | Other pinnipeds | Discrete | Harbour Seal, Harp Seal, | 1 | Species in this sub-group have been observed to form concentrations or aggregations (breeding, haul-out, at-sea) (Teilmann and Galatius 2018, Lavigne 2018). | 1P | All marine mammals can be described as highly mobile (Tyack 2018), but pinnipeds haul out on land for periods of rest and reproduction where mobility is reduced. | 1 | All marine mammals surface to breathe (Miller and Roos 2018, Tyack 2018). Species in this sub-group also surface to breed and rest (Hall and Russel 2018). | 0 | Species in this sub-group feed primarily on small pelagic fish (Lavigne 2018). |
| | | Dispersed | Grey Seal, Ringed Seal, Bearded Seal, Hooded Seal | 1 | Species in this sub-group have been observed to form concentrations or aggregations (Hammill 2018, Kovacs 2018a). | 1P | All marine mammals can be described as highly mobile (Tyack 2018), but pinnipeds haul out on land for periods of rest and reproduction where mobility is reduced. | 1 | All marine mammals surface to breathe (Miller and Roos 2018, Tyack 2018). | 1 | This sub-group contains species that are largely benthic and semi-demersal feeders (Hall and Russell 2018, Hammill 2018, Kovacs 2018b, Kovacs and Lavigne 1986). |

*Table A11. Marine mammals sub-group scores for SENSITIVITY scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps) (– = not applicable).*

| SUB-GROUP LEVEL | | | Maritime example species | Sensitivity Criteria | | | |
|---|---|---|---|---|---|---|---|
| | | | | Mechanical Sensitivity Reduction of feeding/photosynthesis/thermoregulation | | Chemical Sensitivity Impairment due to toxicity | |
| 1 | 2 | 3 | | S | Justification | S | Justification |
| Cetaceans | Toothed | Discrete | Killer Whale, Long-finned Pilot Whale, Northern Bottlenose Whale, Atlantic White-sided Dolphin | 0 | Do not rely on fur for thermoregulation and do not have filter feeding structures. | 1P | Limited research regarding toxicological effects on toothed cetaceans. Lack of baseline data and standardized methods make results difficult to compare. |
| | | Dispersed | Harbour Porpoise, Sperm Whale, Cuvier's Beaked Whale, Sowerby's Whale, True's Beaked Whale, Blainville's Beaked Whale | 0 | Do not rely on fur for thermoregulation and do not have filter feeding structures. | 1P | Limited research regarding toxicological effects on toothed cetaceans. Lack of baseline data and standardized methods make results difficult to compare. |
| | Baleen | Discrete | Fin Whale, Humpback Whale, North Atlantic Right Whale | 1P | Potential obstruction of baleen plates by oil, with a potential to reduce efficacy of or ability to feed (Gubbay and Earll 2000, Geraci and St. Aubin 1988). | 1P | Limited research regarding toxicological effects on baleen cetaceans. Lack of baseline data and standardized methods make results difficult to compare. |
| | | Dispersed | Minke Whale, Blue Whale, Sei Whale | 1P | Potential obstruction of baleen plates by oil, with a potential to reduce efficacy of or ability to feed (Gubbay and Earll 2000, Geraci and St. Aubin 1988). | 1P | Limited research regarding toxicological effects on baleen cetaceans. Lack of baseline data and standardized methods make results difficult to compare. |
| Pinnipeds | Thermoregulate with fur | None Found | | – | – | – | – |
| | Other pinnipeds | Discrete | Harbour Seal, Harp Seal | 0 | Do not rely on fur for thermoregulation and do not have filter feeding structures | 1P | Limited research regarding toxicological effects on pinnipeds. Lack of baseline data and standardized methods make results difficult to compare. |
| | | Dispersed | Grey Seal, Ringed Seal, Bearded Seal, Hooded Seal | 1P | Grey Seal pups are born with a white lanugo to assist in thermoregulation (Jenssen 1996, Hall and Russell 2018). While the lanugo is shed during moulting, young pups have the potential to experience a loss in thermoregulation if exposed to oil (Davis and Anderson 1976). | 1P | Limited research regarding toxicological effects on pinnipeds. Lack of baseline data and standardized methods make results difficult to compare. |

*Table A12. Marine mammals sub-group scores for RECOVERY scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps) (– = not applicable).*

| SUB-GROUP LEVEL | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Cetaceans | Toothed | Discrete | Killer Whale, Long-Finned Pilot Whale, Northern Bottlenose Whale, Atlantic White-sided Dolphin | 1 | The Northwest Atlantic/Eastern Arctic population of Killer Whale are listed as Special Concern by COSEWIC (2008–11) and are under consideration for addition to Schedule 1 (SARA). The Scotian Shelf population of Northern Bottlenose Whale is listed as Endangered by COSEWIC (2011–05) and as Endangered on Schedule 1 of SARA (2006–04). | 1 | All cetaceans are K-strategists (Estes 1979, Fordyce 2018). | 1 | The Northern Bottlenose Whale sub-population in the Maritimes Region is endemic/genetically isolated to the Scotian Shelf Gullies (COSEWIC 2011). | 1P | Diet composition studies show that some species in this sub-group consume Sand Lance, indicating that there is an association with unconsolidated substrates (Reeves et al. 1999, Cipriano 2018, Staudinger et al. 2020). |
| Cetaceans | Toothed | Dispersed | Harbour Porpoise, Sperm Whale, Cuvier's Beaked Whale, Sowerby's Whale, True's Beaked Whale, Blainville's Beaked Whale | 1 | This sub-group contains species that are listed on COSEWIC and SARA. The Northwest Atlantic population of Harbour Porpoise is listed as Special Concern by COSEWIC (2006–04) and Schedule 2 Threatened under SARA.<br><br>Sowerby's Beaked Whale is listed as Special Concern under COSEWIC (2019–05) and is Schedule 1 – Special Concern under SARA (2011-06-23). | 1 | All cetaceans are K-strategists (Estes 1979, Fordyce 2018, Whitehead 2018). | 0 | No evidence of endemism or isolation in this sub-group. | 1 | All beaked whales tend to forage at or near the seabed, consuming prey whose habitat includes unconsolidated substrate (MacLeod 2018, Staudinger et al. 2020). |
| Cetaceans | Baleen | Discrete | Fin Whale, Humpback Whale, North Atlantic Right Whale | 1 | This sub-group contains species listed under COSEWIC and SARA. The Atlantic population of Fin Whale is listed as Special Concern under COSEWIC (2019–05) and Schedule 1 Special Concern under SARA (2006-08-15).<br><br>The North Atlantic Right Whale is listed as Endangered by both COSEWIC (2013–11) and SARA (Schedule 1) (2005-01-01). | 1 | All cetaceans are K-strategists (Estes 1979, Fordyce 2018, Brown et al. 2008 , Baird 2003). | 0 | No evidence of endemism or isolation in this sub-group. | 1P | Humpback Whales exhibit feeding behaviour on sand lance indicating association with unconsolidated substrate (Hain et al. 1995, Staudinger et al. 2020). |

| SUB-GROUP LEVEL | | | Maritime example species | RECOVERY Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Population status | | Reproductive capacity | | Endemism or isolation | | Close association with unconsolidated substrates | |
| 1 | 2 | 3 | | S | Justification | S | Justification | S | Justification | S | Justification |
| Cetaceans | Baleen | Dispersed | Minke Whale, Blue Whale, Sei Whale | 1 | This sub-group contains species listed under COSEWIC and SARA. The Atlantic population of the Sei Whale is listed as Endangered by COSEWIC (2019–05) but not listed by SARA though is under consideration for addition. | 1 | All cetaceans are K-strategists (Estes 1979, Fordyce 2018). | 0 | No evidence of endemism or isolation in this sub-group. | 1P | In the North Atlantic, Minke Whale diet includes species generally associated unconsolidated substrate (Sand Eel, Sand Lance) (Perrin et al. 2018, Staudinger et al. 2020). |
| Pinnipeds | Thermoregulate with fur | None Found | | – | – | – | – | – | – | – | – |
| | Other pinnipeds | Discrete | Harbour Seal, Harp Seal | 1 | This sub-group does not contain species listed on COSEWIC or SARA Registry. The Harbour Seal (2007–11) was assessed by COSEWIC as Not at Risk.<br>Harbour Seal – Trend unknown (COSEWIC 2008), Population declining on sable island (Blanchet et al. 2021)<br>No evidence for Harp Seal declines. | 1 | All pinnipeds are K-strategists (Estes 1979, Berta 2018). | 0 | No evidence of endemism or isolation in this sub-group. | 0 | Species in this sub-group feed primarily on small pelagic fish (Lavigne 2018). |
| | | Dispersed | Grey Seal, Ringed Seal, Bearded Seal, Hooded Seal | 1 | This sub-group contains species that are listed by COSEWIC. The Ringed Seal is listed as Special Concern by COSEWIC (2019–11) and though not listed by SARA, is under consideration for addition to Schedule 1. The Bearded Seal is listed by COSEWIC as Data Deficient (2007–04).<br>Grey Seal (1999–04) was assessed by COSEWIC as Not at Risk. | 1 | All pinnipeds are K-strategists (Estes 1979, Berta 2018). | 0 | No evidence of endemism or isolation in this sub-group. | 1 | This sub-group contains species that are largely benthic and semi-demersal feeders ((Hall and Russell 2018, Hammill 2018, Kovacs 2018b, Kovacs and Lavigne 1986). |

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## APPENDIX 5. DETAILED SCORING TABLES WITH JUSTIFICATIONS FOR MARINE REPTILES

*Table A13. Marine reptiles sub-group scores for EXPOSURE scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps).*

| SUB-GROUP LEVEL | Maritime example species | EXPOSURE Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Concentration (aggregation) | | Mobility and/or site fidelity | | Sea surface interacting | | Seafloor or vegetation interacting | |
| | | S | Justification | S | Justification | S | Justification | S | Justification |
| Sea turtles | Leatherback Sea Turtle (*Dermochelys coriacea)*<br>Loggerhead Sea Turtle (*Caretta caretta)*<br>Kemp's Ridley (*Lepidochelys kempii)* | 1 | Sea turtles are migratory visitors to offshore waters in the Atlantic. Dodge et al. (2014) determined that Leatherbacks were highly aggregated in temperate shelf and slope waters during summer, early fall, and late spring in the Northwest Atlantic. | 1P | Behavioural experiments conducted by Vargo et al. (1986) determined that both Loggerhead (aged 3–20 mo.) and Green turtles (aged 3–16 mo.) had very little ability to avoid oil slicks.<br><br>Hays et al. (2006) found that while Leatherback Turtles may range across very large spatial scales, there is evidence that some site fidelity to foraging ranges occur in the Atlantic region. | 1 | Sea turtles interact with the sea surface regularly to breathe. | 1 | The Loggerhead Turtle will interact with the seafloor foraging for prey. (Patel et al. 2016).<br><br>The Leatherback Turtle primarily eats pelagic gelatinous prey and is not expected to have interactions with the seafloor.<br><br>Adult Kemp's Ridley are predominately benthic feeders and eat mostly crabs (Shaver 1991). |

*Table A14. Marine reptiles sub-group scores for SENSITIVITY scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps).*

| SUB-GROUP LEVEL | Maritime example species | SENSITIVITY Criteria | | | |
|---|---|---|---|---|---|
| | | Mechanical sensitivity (reduction in feeding/photosynthesis/thermoregulation) | | Chemical sensitivity (impairment due to toxicity) | |
| | | S | Justification | S | Justification |
| Sea turtles | Leatherback Sea Turtle (*Dermochelys coriacea)*<br>Loggerhead Sea Turtle (*Caretta caretta)*<br>Kemp's Ridley (*Lepidochelys kempii)* | 0 | Sea turtles do not depend on fur for thermoregulation and do not have filter feeding structures. | 1P | Precautionary scoring applied due to limited research on oil toxicity in the sub-group.<br><br>The only laboratory work investigating the direct impacts of oil on sea turtles was completed by Lutcavage et al. (1995). Results indicate that loggerhead turtles (15–18 mo.) experienced major negative impacts on physiological systems during both chronic and acture oil exposures (skin sloughing, intestinal bleeding, anemia, decreases in red blood cells). |

*Table A15. Marine reptiles sub-group scores for RECOVERY scoring criteria, the column labelled "S" indicates the score assigned (note: species lists are not exhaustive; scores with a "P" indicate a precautionary score due to knowledge gaps).*

| **SUB-GROUP LEVEL** | **Maritime example species** | **RECOVERY Criteria** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Population status** | | **Reproductive capacity** | | **Endemism or isolation** | | **Close association with unconsolidated substrates** | |
| | | **S** | **Justification** | **S** | **Justification** | **S** | **Justification** | **S** | **Justification** |
| Sea turtles | Leatherback Sea Turtle (*Dermochelys coriacea)*<br>Loggerhead Sea Turtle (*Caretta caretta)*<br>Kemp's Ridley (*Lepidochelys kempii)* | **1** | The Leatherback Turtle was designated endangered in May 2012 (COSEWIC 2012) and listed as Schedule 1 Endangered under SARA (2003-06-05).<br>Loggerhead Turtle was designated endangered in April 2010 (COSEWIC 2010) and listed as Schedule 1 Endangered under SARA (2017-04-13). | **1** | Marine reptiles have a low reproductive capacity compared to other groups assessed.<br>Mature female Loggerhead Turtles nest on a 2–3 year interval, laying 3–4 clutches of eggs of approx. 112 eggs each. (COSEWIC 2010).<br>Mature female Leatherback Turtles nest on a 2–4 year interval, laying approx. 80 eggs several times over a nesting season (COSEWIC 2012). | **0** | Sea turtles are migratory visitors to offshore waters in North Atlantic waters. There is no evidence of endemism or isolated populations in the Atlantic region. | **1P** | Members of this sub-group forage benthically for food. There is no evidence that this species group would not have a close association with unconsolidated substrates. |

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# APPENDIX 6. LIST OF VERIFIED SPECIES FOR THE MARITIMES REGION APPLICATION SUB-GROUP CREATION

*Table A16. Verified Species for the Marine Plants and Algae Group.*

| Group | Species |
|---|---|
| Vascular | *Achillea millefolium* |
| Vascular | *Aster novi-belgii* |
| Vascular | *Aster subulatus* |
| Vascular | *Atriplex acadiensis* |
| Vascular | *Atriplex littoralis* |
| Vascular | *Atriplex patula* |
| Vascular | *Blysmus rufus* |
| Vascular | *Bolboschoenus maritimus* |
| Vascular | *Carex hormathodes* |
| Vascular | *Carex mackenziei* |
| Vascular | *Carex paleacea* |
| Vascular | *Carex recta* |
| Vascular | *Atriplex subspicata* |
| Vascular | *Chenopodium glaucum* |
| Vascular | *Chenopodium rubrum* |
| Vascular | *Comarum palustre* |
| Vascular | *Convolvulus sepium americanus* |
| Vascular | *Crassula aquatica* |
| Vascular | *Distichlis spicata* |
| Vascular | *Eleocharis parvula* |
| Vascular | *Elymus repens* |
| Vascular | *Elatine americana* |
| Vascular | *Festuca rubra* |
| Vascular | *Eriocaulon parkeri* |
| Vascular | *Glaux maritima* |
| Vascular | *Hierochloe odorata* |
| Vascular | *Honckenya peploides* |
| Vascular | *Hordeum jubatum* |
| Vascular | *Juncus arcticus* |
| Vascular | *Juncus gerardii* |
| Vascular | *Ligusticum scoticum* |
| Vascular | *Limonium carolinianum* |
| Vascular | *Limonium carolinianumnashii* |
| Vascular | *Limosella australis* |
| Vascular | *Lysimachia maritima* |
| Vascular | *Myrica pensylvanioca* |
| Vascular | *Phragmites australis* |
| Vascular | *Plantago maritima* |
| Vascular | *Polygonum fowleri* |
| Vascular | *Polygonum ramosissimum* |
| Vascular | *Potentilla anserina/Argentina anserina* |
| Vascular | *Puccinellia distans* |
| Vascular | *Puccinellia fasciculata* |
| Vascular | *Puccinellia maritima* |
| Vascular | *Puccinellia nutkaensis* |
| Vascular | *Puccinellia phryganodes* |
| Vascular | *Ranunculus cymbalaria* |
| Vascular | *Rumex maritimus* |

| Group | Species |
| --- | --- |
| Vascular | *Rumex salicifolius* |
| Vascular | *Ruppia maritima* |
| Vascular | *Salicornia europae/S.depressa* |
| Vascular | *Salsola kali/Kali turgidum* |
| Vascular | *Schoenoplectus pungens* |
| Vascular | *Solidago sempervirens* |
| Vascular | *Spartina alterniflora* |
| Vascular | *Spartina patens* |
| Vascular | *Spartina pectinata* |
| Vascular | *Spergularia canadensis* |
| Vascular | *Spergularia salina* |
| Vascular | *Stuckenia filiformis* |
| Vascular | *Stuckenia pectinata* |
| Vascular | *Suaeda maritima* |
| Vascular | *Symphyotrichum novi-belgii* |
| Vascular | *Symphyotrichum subulatum* |
| Vascular | *Triglochin maritima* |
| Vascular | *Triglochin gaspensis* |
| Vascular | *Zannichellia palustris* |
| Vascular | *Zostera marina* |
| Vascular | *Deschampsia cespitosa* |
| Vascular | *Triglochin maritimum* |
| Non-vascular | *Agarum clathratum* |
| Non-vascular | *Ahnfeltia plicata* |
| Non-vascular | *Alaria esculenta* |
| Non-vascular | *Antithamnion sp.* |
| Non-vascular | *Ascophyllum nodosum* |
| Non-vascular | *Ceramium deslongchampsii* |
| Non-vascular | *Ceramium virgatum* |
| Non-vascular | *Chaetomorpha melagonium* |
| Non-vascular | *Chondrus crispus* |
| Non-vascular | *Chorda filum* |
| Non-vascular | *Chorda tomentosa* |
| Non-vascular | *Chordaria chordaeformis* |
| Non-vascular | *Cladophora sericea* |
| Non-vascular | *Codium fragile* |
| Non-vascular | *Corallina officinalis* |
| Non-vascular | *Cystoclonium purpureum* |
| Non-vascular | *Desmarestia aculeata* |
| Non-vascular | *Desmarestia viridis* |
| Non-vascular | *Devaleraea ramentacea* |
| Non-vascular | *Dumontia contorta* |
| Non-vascular | *Euthora cristata* |
| Non-vascular | *Fucus distichus* |
| Non-vascular | *Fucus edentatus* |
| Non-vascular | *Fucus endentatus* |
| Non-vascular | *Fucus spiralis* |
| Non-vascular | *Furcellaria lumbricalis* |
| Non-vascular | *Gloiosiphonia capillaris* |
| Non-vascular | *Gracilaria multipartita* |
| Non-vascular | *Halosiphon tomentosus* |
| Non-vascular | *Laminaria digitata* |
| Non-vascular | *Laminaria longicruris* |
| Non-vascular | *Lithothamnion glaciale* |
| Non-vascular | *Mastocarpus stellatus* |

| Group | Species |
| --- | --- |
| Non-vascular | *Monostroma grevillei* |
| Non-vascular | *Palmaria palmata* |
| Non-vascular | *Petalonia fascia* |
| Non-vascular | *Phycodrys rubens* |
| Non-vascular | *Phyllophora pseudoceranoides* |
| Non-vascular | *Plumaria plumosa* |
| Non-vascular | *Polyides rotunda* |
| Non-vascular | *Polysiphonia lanosa/Vertebrata lanosa* |
| Non-vascular | *Polysiphonia stricta* |
| Non-vascular | *Porphyra purpurea* |
| Non-vascular | *Porphyra umbilicalis* |
| Non-vascular | *Ptilota elegans* |
| Non-vascular | *Rhodomela confervoides* |
| Non-vascular | *Saccharina latissima* |
| Non-vascular | *Fucus vesiculosus* |
| Non-vascular | *Spongomorpha arcta* |
| Non-vascular | *Ulva intestinalis* |
| Non-vascular | *Ulva lactuca* |

*Table A17. Verified Species for the Marine Invertebrates Group.*

| Group | Species |
| --- | --- |
| Porifera | *Amphilectus lobatus* |
| Porifera | *Chalinula loosanoffi* |
| Porifera | *Clathria prolifera* |
| Porifera | *Clathrina cancellata* |
| Porifera | *Cliona acelata* |
| Porifera | *Cliona sp.* |
| Porifera | *Crella (Yvesia) rosea* |
| Porifera | *Halichondria bowerbanki* |
| Porifera | *Halichondria oculata* |
| Porifera | *Halichondria panicea* |
| Porifera | *Halichondria (Eumastia) sitiens* |
| Porifera | *Haliclona (Flagellia) flagellifera* |
| Porifera | *Haliclona (Rhizoniera) canaliculata* |
| Porifera | *Hymedesmia (Hymedesmia) canadensis* |
| Porifera | *Lophon hyndmani* |
| Porifera | *Lophon nigrcans* |
| Porifera | *Isodictya deichmannae* |
| Porifera | *Isodictya palmata* |
| Porifera | *Leucosolenia variabilis* |
| Porifera | *Leucosolenia sp.* |
| Porifera | *Melonanchora elliptica* |
| Porifera | *Melonanchora sp.* |
| Porifera | *Mycale (Mycale) lingua* |
| Porifera | *Myxilla (Myxilla) fimbriata* |
| Porifera | *Myxilla (Myxilla) incrustans* |
| Porifera | *Myxilla incrustans* |
| Porifera | *Phakellia sp.* |
| Porifera | *Pione vastifica* |
| Porifera | *Polymastia boletiformis* |
| Porifera | *Protosuberites epiphytum* |
| Porifera | *Suberites ficus* |
| Porifera | *Sycon ciliatum* |
| Ctenophora | *Beroe cucumis* |

| Group | Species |
|---|---|
| Ctenophora | *Bolinopsis infundibulum* |
| Ctenophora | *Hormiphora cucumis* |
| Ctenophora | *Mertensia ovum* |
| Ctenophora | *Pleurobrachia pileus* |
| Cnidaria | *Abietinaria abietina* |
| Cnidaria | *Abietinaria filicula* |
| Cnidaria | *Acaulis primarius* |
| Cnidaria | *Aequorea albida* |
| Cnidaria | *Aequorea sp.* |
| Cnidaria | *Agalma elegans* |
| Cnidaria | *Aglantha digitale* |
| Cnidaria | *Alcyonium digitatum* |
| Cnidaria | *Antennularia sp.* |
| Cnidaria | *Aulactinia stella* |
| Cnidaria | *Aurelia aurita* |
| Cnidaria | *Aurelia aurita (scyphistoma stage)* |
| Cnidaria | *Bougainvillia superciliaris* |
| Cnidaria | *Calycella syringa* |
| Cnidaria | *Campanularia groenlandica* |
| Cnidaria | *Campanularia sp.* |
| Cnidaria | *Campanularia volubilis* |
| Cnidaria | *Candelabrum phrygium* |
| Cnidaria | *Catablema vesicarium* |
| Cnidaria | *Cerianthus lloydii* |
| Cnidaria | *Chrysaora quinquecirrha* |
| Cnidaria | *Clava multicornis* |
| Cnidaria | *Clytia hemisphaerica* |
| Cnidaria | *Corymorpha pendula* |
| Cnidaria | *Aurelia aurita (medusa stage)* |
| Cnidaria | *Coryne pusilla* |
| Cnidaria | *Craterolophus convolvulus* |
| Cnidaria | *Cyanea capillata* |
| Cnidaria | *Diadumene lineata* |
| Cnidaria | *Diphasia fallax* |
| Cnidaria | *Diphasia margareta* |
| Cnidaria | *Dynamena pumila* |
| Cnidaria | *Ectopleura crocea* |
| Cnidaria | *Ectopleura larynx* |
| Cnidaria | *Edwardsia sipunculoides* |
| Cnidaria | *Eudendrium capillare* |
| Cnidaria | *Eudendrium cochleatum* |
| Cnidaria | *Eudendrium dispar* |
| Cnidaria | *Eudendrium ramosum* |
| Cnidaria | *Eudendrium vaginatum* |
| Cnidaria | *Gersemia rubiformis* |
| Cnidaria | *Gonionemus vertens* |
| Cnidaria | *Halcampa duodecimcirrata* |
| Cnidaria | *Halecium articulosum* |
| Cnidaria | *Halecium beanii* |
| Cnidaria | *Halecium halecinum* |
| Cnidaria | *Halecium muricatum* |
| Cnidaria | *Halecium sessile* |
| Cnidaria | *Haliclystus auricula* |
| Cnidaria | *Haliclystus octoradiatus* |
| Cnidaria | *Haliclystus salpinx* |

| Group | Species |
|---|---|
| Cnidaria | *Halistaura sp.* |
| Cnidaria | *Haloclava producta* |
| Cnidaria | *Hydractinia echinata* |
| Cnidaria | *Hydractinia polyclina* |
| Cnidaria | *Hydrallmania falcata* |
| Cnidaria | *Lafoea dumosa* |
| Cnidaria | *Laomedea flexuosa* |
| Cnidaria | *Leuckartiara octona* |
| Cnidaria | *Lucernaria quadricornis* |
| Cnidaria | *Lytocarpia myriophyllum* |
| Cnidaria | *Manania auricula* |
| Cnidaria | *Melicertum octocostatum* |
| Cnidaria | *Mesacmaea laevis* |
| Cnidaria | *Metridium senile* |
| Cnidaria | *Mitrocoma sp.* |
| Cnidaria | *Nanomia cara* |
| Cnidaria | *Nematostella vectensis* |
| Cnidaria | *Nemertesia americana* |
| Cnidaria | *Nemertesia antennina* |
| Cnidaria | *Nemertesia sp.* |
| Cnidaria | *Obelia bidentata* |
| Cnidaria | *Obelia geniculata* |
| Cnidaria | *Obelia longissima* |
| Cnidaria | *Obelia sp. (polyp)* |
| Cnidaria | *Orthopyxis integra* |
| Cnidaria | *Pelagia noctiluca* |
| Cnidaria | *Phacellophora camtschatica* |
| Cnidaria | *Physalia physalis* |
| Cnidaria | *Polyplumaria gracillima* |
| Cnidaria | *Podocoryna americana* |
| Cnidaria | *Podocoryna borealis* |
| Cnidaria | *Rhacostoma atlanticum* |
| Cnidaria | *Rhizocaulus verticillatus* |
| Cnidaria | *Rhizogeton fusiformis* |
| Cnidaria | *Rhizorhagium roseum* |
| Cnidaria | *Sarsia lovenii* |
| Cnidaria | *Sarsia tubulosa* |
| Cnidaria | *Sagartiogeton verrilli* |
| Cnidaria | *Sertularella polyzonias* |
| Cnidaria | *Sertularella rugosa* |
| Cnidaria | *Sertularia argentea* |
| Cnidaria | *Sertularia cupressina* |
| Cnidaria | *Sertularia latiuscula* |
| Cnidaria | *Sertularia pumila* |
| Cnidaria | *Sertularia similis* |
| Cnidaria | *Stauromedusae sp.* |
| Cnidaria | *Staurostoma mertensii* |
| Cnidaria | *Symplectoscyphus tricuspidatus* |
| Cnidaria | *Tamarisca tamarisca* |
| Cnidaria | *Tubularia sp.* |
| Cnidaria | *Urticina felina* |
| Worms | *Alaurina composita* |
| Worms | *Alitta virens* |
| Worms | *Amblyosyllis finmarchica* |
| Worms | *Ampharete acutifrons* |

| Group | Species |
|---|---|
| Worms | *Ampharete octocirrata* |
| Worms | *Ampharete trilobata* |
| Worms | *Amphiporus angulatus* |
| Worms | *Amphiporus bioculatus* |
| Worms | *Amphiporus caecus* |
| Worms | *Amphiporus frontalis* |
| Worms | *Amphiporus groenlandicus* |
| Worms | *Amphiporus heterosorus* |
| Worms | *Amphiporus lactifloreus* |
| Worms | *Amphitrite brunnea* |
| Worms | *Amphitrite cirrata* |
| Worms | *Amphitrite ornata* |
| Worms | *Apistobranchus tullbergi* |
| Worms | *Aphrodita aculeata* |
| Worms | *Aphrodita hastata* |
| Worms | *Arabella iricolor* |
| Worms | *Arenicola brasiliensis* |
| Worms | *Arenicola cristata* |
| Worms | *Arenicola marina* |
| Worms | *Aricidea (Acmira) catherinae* |
| Worms | *Aricidea nolani* |
| Worms | *Aricidea (Strelzovia) quadrilobata* |
| Worms | *Artacama proboscidea* |
| Worms | *Astrotorhynchus bifidus* |
| Worms | *Autolytus varians* |
| Worms | *Bispira crassicornis* |
| Worms | *Brada granosa* |
| Worms | *Brada sublaevis* |
| Worms | *Bradabyssa setosa* |
| Worms | *Bradabyssa villosa* |
| Worms | *Capitella capitata* |
| Worms | *Cephalothrix linearis* |
| Worms | *Cephalothrix spiralis* |
| Worms | *Cerebratulus lacteus* |
| Worms | *Chaetozone setosa* |
| Worms | *Chitinopoma serrula* |
| Worms | *Circeis spirillum* |
| Worms | *Cirratulus cirratus* |
| Worms | *Cirrifera cirrifera* |
| Worms | *Cistenides granulata* |
| Worms | *Clitellio (Clitellio) arenarius* |
| Worms | *Clymenella torquata* |
| Worms | *Clymenella zonalis* |
| Worms | *Coelogynopora erotica* |
| Worms | *Coelogynopora schulzii* |
| Worms | *Cossura longocirrata* |
| Worms | *Cyanophthalma cordiceps* |
| Worms | *Cyanophthalma obscura* |
| Worms | *Dipolydora concharum* |
| Worms | *Dipolydora quadrilobata* |
| Worms | *Dodecaceria concharum* |
| Worms | *Drilonereis longa* |
| Worms | *Drilonereis magna* |
| Worms | *Dysponetus pygmaeus* |
| Worms | *Enchytraeus albidus* |

| Group | Species |
|---|---|
| Worms | *Epigamia alexandri* |
| Worms | *Erinaceusyllis erinaceus* |
| Worms | *Eteone flava* |
| Worms | *Eteone longa* |
| Worms | *Eteone trilineata* |
| Worms | *Eulalia aurea* |
| Worms | *Eulalia bilineata* |
| Worms | *Eulalia viridis* |
| Worms | *Eunice pennata* |
| Worms | *Eunoe nodosa* |
| Worms | *Eunoe oerstedi* |
| Worms | *Euphrosine borealis* |
| Worms | *Eusyllis blomstrandi* |
| Worms | *Exogone dispar* |
| Worms | *Exogone longicirrus* |
| Worms | *Exogone verugera* |
| Worms | *Fabricia stellaris* |
| Worms | *Filograna implexa* |
| Worms | *Flabelligera affinis* |
| Worms | *Flabelligera grubei* |
| Worms | *Foviella affinis* |
| Worms | *Fragilonemertes rosea* |
| Worms | *Gattyana cirrhosa* |
| Worms | *Glycera capitata* |
| Worms | *Glycera dibranchiata* |
| Worms | *Glycera robusta* |
| Worms | *Gyptis vittata* |
| Worms | *Harmothoe extenuata* |
| Worms | *Harmothoe imbricata* |
| Worms | *Harmothoe rarispina* |
| Worms | *Hediste diversicolor* |
| Worms | *Heteromastus filiformis* |
| Worms | *Hydroides dianthus* |
| Worms | *Hypereteone heteropoda* |
| Worms | *Hypereteone lactea* |
| Worms | *Isodiametra hortulus* |
| Worms | *Laetmatonice filicornis* |
| Worms | *Laonice cirrata* |
| Worms | *Leitoscoloplos acutus* |
| Worms | *Leitoscoloplos fragilis* |
| Worms | *Leitoscoloplos robustus* |
| Worms | *Lepidametria commensalis* |
| Worms | *Lepidonotus squamatus* |
| Worms | *Levinsenia gracilis* |
| Worms | *Lineus ruber* |
| Worms | *Lineus sanguineus* |
| Worms | *Lineus sp.* |
| Worms | *Lineus viridis* |
| Worms | *Lumbrineris acicularum* |
| Worms | *Lumbrineris hebes* |
| Worms | *Macrochaeta leidyi* |
| Worms | *Macrochaeta sexoculata* |
| Worms | *Marenzelleria viridis* |
| Worms | *Marionina spicula* |
| Worms | *Melinna cristata* |

| Group | Species |
|---|---|
| Worms | *Microphthalmus aberrans* |
| Worms | *Microphthalmus pettiboneae* |
| Worms | *Micrura affinis* |
| Worms | *Micrura dorsalis* |
| Worms | *Monocelis durhami* |
| Worms | *Monocelis lineata* |
| Worms | *Myriochele heeri* |
| Worms | *Mystides borealis* |
| Worms | *Myrianida prolifera* |
| Worms | *Myxicola infundibulum* |
| Worms | *Naineris quadricuspida* |
| Worms | *Neoleanira tetragona* |
| Worms | *Neoamphitrite figulus* |
| Worms | *Nephasoma (Nephasoma) diaphanes diaphanes* |
| Worms | *Nephasoma (Nephasoma) eremita* |
| Worms | *Nephtys bucera* |
| Worms | *Nephtys caeca* |
| Worms | *Nephtys ciliata* |
| Worms | *Nephtys discors* |
| Worms | *Nephtys incisa* |
| Worms | *Nephtys longosetosa* |
| Worms | *Nephtys paradoxa* |
| Worms | *Nereis pelagica* |
| Worms | *Nereis zonata* |
| Worms | *Nicolea zostericola* |
| Worms | *Nicomache lumbricalis* |
| Worms | *Ninoe nigripes* |
| Worms | *Nothria conchylega* |
| Worms | *Notomastus latericeus* |
| Worms | *Notoplana atomata* |
| Worms | *Oerstedia dorsalis* |
| Worms | *Ophelina acuminata* |
| Worms | *Otocelis sandara* |
| Worms | *Owenia fusiformis* |
| Worms | *Paedomecynostomum bruneum* |
| Worms | *Paramacrostomum tricladoides* |
| Worms | *Paradexiospira (Paradexiospira) violacea* |
| Worms | *Paranaitis speciosa* |
| Worms | *Paraonis fulgens* |
| Worms | *Parasagitta elegans* |
| Worms | *Parougia caeca* |
| Worms | *Parexogone hebes* |
| Worms | *Pectinaria gouldii* |
| Worms | *Phascolion (Phascolion) strombus strombus* |
| Worms | *Phascolopsis gouldii* |
| Worms | *Pherusa affinis* |
| Worms | *Pherusa aspera* |
| Worms | *Pherusa plumosa* |
| Worms | *Philocelis brueggemanni* |
| Worms | *Pholoe minuta* |
| Worms | *Phyllodoce citrina* |
| Worms | *Phyllodoce groenlandica* |
| Worms | *Phyllodoce maculata* |
| Worms | *Phyllodoce mucosa* |
| Worms | *Pista maculata* |

| Group | Species |
|---|---|
| Worms | *Platynereis dumerilii* |
| Worms | *Plehnia ellipsoides* |
| Worms | *Polycirrus eximius* |
| Worms | *Polycirrus medusa* |
| Worms | *Polycirrus phosphoreus* |
| Worms | *Polydora ciliata* |
| Worms | *Polydora cornuta* |
| Worms | *Polydora gracilis* |
| Worms | *Pontonema vulgare* |
| Worms | *Potamilla neglecta* |
| Worms | *Praeaphanostoma wadsworthi* |
| Worms | *Praeconvoluta tigrina* |
| Worms | *Praeconvoluta tornuva* |
| Worms | *Praxillella praetermissa* |
| Worms | *Priapulus caudatus* |
| Worms | *Prionospio steenstrupi* |
| Worms | *Proceraea cornuta* |
| Worms | *Proceraea prismatica* |
| Worms | *Procerodes littoralis* |
| Worms | *Pseudopotamilla reniformis* |
| Worms | *Protodriloides chaetifer* |
| Worms | *Psammodrilus balanoglossoides* |
| Worms | *Pygospio elegans* |
| Worms | *Rhodine loveni* |
| Worms | *Sabaco elongatus* |
| Worms | *Sagitta sp.* |
| Worms | *Scalibregma inflatum* |
| Worms | *Scoletoma fragilis* |
| Worms | *Scoletoma tenuis* |
| Worms | *Serratosagitta tasmanica* |
| Worms | *Sphaerodoridium minutum* |
| Worms | *Sphaerosyllis hystrix* |
| Worms | *Spinther citrinus* |
| Worms | *Spio filicornis* |
| Worms | *Spio setosa* |
| Worms | *Spiophanes bombyx* |
| Worms | *Spiophanes wigleyi* |
| Worms | *Spirorbis (Spirobis) spirobis* |
| Worms | *Sternaspis fossor* |
| Worms | *Streblospio benedicti* |
| Worms | *Streptosyllis varians* |
| Worms | *Stylochus ellipticus* |
| Worms | *Syllides benedicti* |
| Worms | *Syllides convolutus* |
| Worms | *Syllides eburneus* |
| Worms | *Syllis cornuta* |
| Worms | *Syllis gracilis* |
| Worms | *Terebellides stroemii* |
| Worms | *Tetrastemma candidum* |
| Worms | *Thalassoanaperus gardineri* |
| Worms | *Tomopteris helgolandica* |
| Worms | *Tubifex sp.* |
| Worms | *Uteriporus vulgaris* |
| Lophophorates | *Aeverrillia setigera* |
| Lophophorates | *Amathia gracilis* |

| Group | Species |
|---|---|
| Lophophorates | *Amphiblestrum auritum* |
| Lophophorates | *Biflustra tenuis* |
| Lophophorates | *Bugulina fulva* |
| Lophophorates | *Bugulina simplex* |
| Lophophorates | *Bugula sp.* |
| Lophophorates | *Caberea ellisii* |
| Lophophorates | *Callopora craticula* |
| Lophophorates | *Cauloramphus cymbaeformis* |
| Lophophorates | *Celleporella hyalina* |
| Lophophorates | *Cribrilina (Juxtacribrilina) annulata* |
| Lophophorates | *Crisia eburnea* |
| Lophophorates | *Crisularia turrita* |
| Lophophorates | *Dendrobeania decorata* |
| Lophophorates | *Dendrobeania murrayana* |
| Lophophorates | *Disporella hispida* |
| Lophophorates | *Electra pilosa* |
| Lophophorates | *Eucratea loricata* |
| Lophophorates | *Flustra foliacea* |
| Lophophorates | *Flustrellidra hispida* |
| Lophophorates | *Microporella ciliata* |
| Lophophorates | *Patinella verrucaria* |
| Lophophorates | *Posterula sarsii* |
| Lophophorates | *Tegella unicornis* |
| Lophophorates | *Terebratulina septentrionalis* |
| Molluscs | *Acanthodoris pilosa* |
| Molluscs | *Acirsa borealis* |
| Molluscs | *Adalaria proxima* |
| Molluscs | *Admete viridula* |
| Molluscs | *Aeolidia papillosa* |
| Molluscs | *Alvania pseudoareolata* |
| Molluscs | *Ameritella agilis* |
| Molluscs | *Ancula gibbosa* |
| Molluscs | *Anomia simplex* |
| Molluscs | *Antalis entalis* |
| Molluscs | *Arctica islandica* |
| Molluscs | *Arcuatula sp.* |
| Molluscs | *Arrhoges occidentalis* |
| Molluscs | *Asperspina riseri* |
| Molluscs | *Astarte borealis* |
| Molluscs | *Astarte castanea* |
| Molluscs | *Astarte crenata* |
| Molluscs | *Astarte elliptica* |
| Molluscs | *Astarte subaequilatera* |
| Molluscs | *Astarte undata* |
| Molluscs | *Astyris lunata* |
| Molluscs | *Astyris rosacea* |
| Molluscs | *Bathyarca pectunculoides* |
| Molluscs | *Bathypolypus arcticus* |
| Molluscs | *Bathypolypus bairdii* |
| Molluscs | *Borealea nobilis* |
| Molluscs | *Boreochiton ruber* |
| Molluscs | *Boreoscala greenlandica* |
| Molluscs | *Boreotrophon clathratus* |
| Molluscs | *Boreotrophon truncatus* |
| Molluscs | *Buccinum ciliatum* |

| Group | Species |
|---|---|
| Molluscs | *Buccinum undatum* |
| Molluscs | *Bulbus smithii* |
| Molluscs | *Cadlina laevis* |
| Molluscs | *Calliostoma occidentale* |
| Molluscs | *Catriona gymnota* |
| Molluscs | *Carronella pellucida* |
| Molluscs | *Chlamys islandica* |
| Molluscs | *Ciliatocardium ciliatum* |
| Molluscs | *Clione limacina* |
| Molluscs | *Colus islandicus* |
| Molluscs | *Colus pubescens* |
| Molluscs | *Colus pygmaeus* |
| Molluscs | *Colus stimpsoni* |
| Molluscs | *Coryphella sp.* |
| Molluscs | *Coryphella verrucosa* |
| Molluscs | *Couthouyella striatula* |
| Molluscs | *Cratena pilata* |
| Molluscs | *Crenella decussata* |
| Molluscs | *Crepidula plana* |
| Molluscs | *Crassostrea virginica* |
| Molluscs | *Crepidula fornicata* |
| Molluscs | *Crucibulum striatum* |
| Molluscs | *Cryptonatica affinis* |
| Molluscs | *Curtitoma decussata* |
| Molluscs | *Curtitoma incisula* |
| Molluscs | *Curtitoma violacea* |
| Molluscs | *Cuspidaria pellucida* |
| Molluscs | *Cuthonella concinna* |
| Molluscs | *Cyclocardia borealis* |
| Molluscs | *Cyclocardia novangliae* |
| Molluscs | *Cyclocardia ovata* |
| Molluscs | *Cylichnoides occultus* |
| Molluscs | *Dendronotus frondosus* |
| Molluscs | *Dendronotus robustus* |
| Molluscs | *Diaphoreolis viridis* |
| Molluscs | *Doryteuthis pealeii* |
| Molluscs | *Doto coronata* |
| Molluscs | *Doto formosa* |
| Molluscs | *Ecrobia truncata* |
| Molluscs | *Ensis directus /Ensis leei* |
| Molluscs | *Ennucula delphinodonta* |
| Molluscs | *Ennucula tenuis* |
| Molluscs | *Eubranchus pallidus* |
| Molluscs | *Eubranchus sanjuanensis* |
| Molluscs | *Eubranchus tricolor* |
| Molluscs | *Eulimella polita* |
| Molluscs | *Eumetula arctica* |
| Molluscs | *Euspira heros* |
| Molluscs | *Euspira levicula* |
| Molluscs | *Euspira pallida* |
| Molluscs | *Euspira triseriata* |
| Molluscs | *Facelina bostoniensis* |
| Molluscs | *Fargoa bartschi* |
| Molluscs | *Frigidoalvania pelagica* |
| Molluscs | *Gemma gemma* |

| Group | Species |
|---|---|
| Molluscs | *Geukensia demissa* |
| Molluscs | *Gyroscala rupicola* |
| Molluscs | *Hanleya hanleyi* |
| Molluscs | *Heteranomia squamula* |
| Molluscs | *Hiatella arctica* |
| Molluscs | *Illex illecebrosus* |
| Molluscs | *Lacuna pallidula* |
| Molluscs | *Lacunavincta* |
| Molluscs | *Lepeta caeca* |
| Molluscs | *Leptochiton cancellatus* |
| Molluscs | *Limacina retroversa* |
| Molluscs | *Limatula subauriculata* |
| Molluscs | *Limecola balthica* |
| Molluscs | *Limneria undata* |
| Molluscs | *Littorina littorea* |
| Molluscs | *Littorina obtusata* |
| Molluscs | *Littorina saxatilis* |
| Molluscs | *Lyonsia arenosa* |
| Molluscs | *Lyonsia hyalina* |
| Molluscs | *Macoma calcarea* |
| Molluscs | *Mactromeris polynyma* |
| Molluscs | *Margarites argentatus* |
| Molluscs | *Margarites costalis* |
| Molluscs | *Margarites groenlandicus* |
| Molluscs | *Margarites helicinus* |
| Molluscs | *Margarites olivaceus* |
| Molluscs | *Margarites sp.* |
| Molluscs | *Margarites striatus* |
| Molluscs | *Marsenina ampla* |
| Molluscs | *Marsenina glabra* |
| Molluscs | *Megayoldia thraciaeformis* |
| Molluscs | *Menestho albula* |
| Molluscs | *Mercenaria mercenaria* |
| Molluscs | *Microchlamylla gracilis* |
| Molluscs | *Modiolus modiolus* |
| Molluscs | *Moelleria costulata* |
| Molluscs | *Musculus discors* |
| Molluscs | *Musculus glacialis* |
| Molluscs | *Musculus niger* |
| Molluscs | *Musculus sp.* |
| Molluscs | *Mya arenaria* |
| Molluscs | *Mya truncata* |
| Molluscs | *Myosotella myosotis* |
| Molluscs | *Mytilus edulis* |
| Molluscs | *Neoterebra dislocata* |
| Molluscs | *Neptunea decemcostata* |
| Molluscs | *Neverita duplicata* |
| Molluscs | *Nucella lapillus* |
| Molluscs | *Nucula proxima* |
| Molluscs | *Nuculana tenuisulcata* |
| Molluscs | *Nuculana sp.* |
| Molluscs | *Odostomia striata* |
| Molluscs | *Oenopota elegans* |
| Molluscs | *Oenopota pingelii* |
| Molluscs | *Oenopota pyramidalis* |

| Group | Species |
|---|---|
| Molluscs | *Onchidoris bilamellata* |
| Molluscs | *Onchidoris grisea* |
| Molluscs | *Onchidoris muricata* |
| Molluscs | *Onchidoris sp.* |
| Molluscs | *Onchidoris tenella* |
| Molluscs | *Onoba aculeus* |
| Molluscs | *Onoba mighelsii* |
| Molluscs | *Ostreidae* |
| Molluscs | *Ostreidae* |
| Molluscs | *Palio dubia* |
| Molluscs | *Pandora gouldiana* |
| Molluscs | *Pandora trilineata* |
| Molluscs | *Panomya norvegica* |
| Molluscs | *Parvicardium pinnulatum* |
| Molluscs | *Periapta pandion* |
| Molluscs | *Periploma fragile* |
| Molluscs | *Periploma leanum* |
| Molluscs | *Petricolaria pholadiformis* |
| Molluscs | *Pitar morrhuanus* |
| Molluscs | *Placopecten magellanicus* |
| Molluscs | *Polinices immaculatus* |
| Molluscs | *Propebela cancellata* |
| Molluscs | *Propebela exarata* |
| Molluscs | *Propebela harpularia* |
| Molluscs | *Propebela nobilis* |
| Molluscs | *Pseudopolinices nanus* |
| Molluscs | *Ptychatractus ligatus* |
| Molluscs | *Puncturella noachina* |
| Molluscs | *Retusa obtusa* |
| Molluscs | *Scabrotrophon fabricii* |
| Molluscs | *Semirossia tenera* |
| Molluscs | *Skeneopsis planorbis* |
| Molluscs | *Solamen glandula* |
| Molluscs | *Solariella obscura* |
| Molluscs | *Solemya velum* |
| Molluscs | *Spisula solidissima* |
| Molluscs | *Stenosemus albus* |
| Molluscs | *Tachyrhynchus erosus* |
| Molluscs | *Taranis moerchii* |
| Molluscs | *Tergipes tergipes* |
| Molluscs | *Testudinalia testudinalis* |
| Molluscs | *Tonicella marmorea* |
| Molluscs | *Tritia obsoleta* |
| Molluscs | *Tritia trivittata* |
| Molluscs | *Velutina velutina* |
| Molluscs | *Yoldia sapotilla* |
| Molluscs | *Ziminella salmonacea* |
| Echinoderms | *Amphipholis squamata* |
| Echinoderms | *Asterias rubens* |
| Echinoderms | *Crossaster papposus* |
| Echinoderms | *Cucumaria frondosa* |
| Echinoderms | *Echinarachnius parma* |
| Echinoderms | *Epitomapta roseola* |
| Echinoderms | *Gorgonocephalus arcticus* |
| Echinoderms | *Henricia eschrichti* |

| Group | Species |
| --- | --- |
| Echinoderms | *Henricia sp.* |
| Echinoderms | *Leptasteria (Leptasterias) muelleri* |
| Echinoderms | *Leptasterias tenera* |
| Echinoderms | *Leptasterias sp.* |
| Echinoderms | *Ophiacantha bidentata* |
| Echinoderms | *Ophiura sarsii* |
| Echinoderms | *Psolus phantapus* |
| Echinoderms | *Pteraster militaris* |
| Echinoderms | *Pteraster pulvillus* |
| Echinoderms | *Rhabdomolgus ruber* |
| Echinoderms | *Solaster endeca* |
| Echinoderms | *Stephansterias albula* |
| Echinoderms | *Strongylocentrotus droebachiensis* |
| Echinoderms | *Thyonidium drummondii* |
| Hemichordates | *Aplidium glabrum* |
| Hemichordates | *Aplidium pallidum* |
| Hemichordates | *Ascidia callosa* |
| Hemichordates | *Ascidia prunum* |
| Hemichordates | *Boltenia echinata* |
| Hemichordates | *Boltenia ovifera* |
| Hemichordates | *Bostrichobranchus pilularis* |
| Hemichordates | *Botrylloides diegensis* |
| Hemichordates | *Botryllus schlosseri* |
| Hemichordates | *Botryllus sp.* |
| Hemichordates | *Ciona intestinalis* |
| Hemichordates | *Cnemidocarpa mollis* |
| Hemichordates | *Dendrodoa carnea* |
| Hemichordates | *Dendrodoa grossularia* |
| Hemichordates | *Dendrodoa pulchella* |
| Hemichordates | *Didemnum albidum* |
| Hemichordates | *Didemnum vexillum* |
| Hemichordates | *Distaplia clavata* |
| Hemichordates | *Halocynthia pyriformis* |
| Hemichordates | *Lissoclinum aureum* |
| Hemichordates | *Molgula arenata* |
| Hemichordates | *Molgula citrina* |
| Hemichordates | *Molgula complanata* |
| Hemichordates | *Molgula manhattensis* |
| Hemichordates | *Molgula retortiformis* |
| Hemichordates | *Molgula siphonalis* |
| Hemichordates | *Molgula sp.* |
| Hemichordates | *Oikopleura (Vexillaria) labradoriensis* |
| Hemichordates | *Polycarpa fibrosa* |
| Hemichordates | *Saccoglossus kowalevskii* |
| Hemichordates | *Styela clava* |
| Hemichordates | *Styela canopus* |
| Hemichordates | *Styela coriacea* |
| Arthropods | *Acanthonotozoma serratum* |
| Arthropods | *Achelia spinosa* |
| Arthropods | *Aeginina longicornis* |
| Arthropods | *Ameira curviseta* |
| Arthropods | *Amphiascus parvulus* |
| Arthropods | *Ampelisca abdita* |
| Arthropods | *Ampelisca macrocephala* |
| Arthropods | *Ampelisca vadorum* |

| Group | Species |
|---|---|
| Arthropods | *Amphiporeia lawrenciana* |
| Arthropods | *Ampithoe rubricata* |
| Arthropods | *Ampithoe sp.* |
| Arthropods | *Anonyx lilljeborgi* |
| Arthropods | *Anonyx nugax* |
| Arthropods | *Anonyx sarsi* |
| Arthropods | *Anoplodactylus lentus* |
| Arthropods | *Apohyale prevostii* |
| Arthropods | *Balanus balanus* |
| Arthropods | *Balanus crenatus* |
| Arthropods | *Byblis gaimardii* |
| Arthropods | *Byblis serrata* |
| Arthropods | *Calanus sp.* |
| Arthropods | *Calathura brachiata* |
| Arthropods | *Calliopius laeviusculus* |
| Arthropods | *Cancer borealis* |
| Arthropods | *Cancer irroratus* |
| Arthropods | *Caprella linearis* |
| Arthropods | *Caprella penantis* |
| Arthropods | *Caprella septentrionalis* |
| Arthropods | *Caprella sp.* |
| Arthropods | *Caprella unica* |
| Arthropods | *Carcinus maenas* |
| Arthropods | *Caridion gordoni* |
| Arthropods | *Casco bigelowi* |
| Arthropods | *Chionoecetes opilio* |
| Arthropods | *Chiridotea coeca* |
| Arthropods | *Chiridotea tuftsii* |
| Arthropods | *Corophium volutator* |
| Arthropods | *Crangon septemspinosa* |
| Arthropods | *Crassicorophium bonellii* |
| Arthropods | *Crassicorophium crassicorne* |
| Arthropods | *Cyathura polita* |
| Arthropods | *Deflexilodes intermedius* |
| Arthropods | *Dexamine thea* |
| Arthropods | *Diastylis lucifera* |
| Arthropods | *Diastylis quadrispinosa* |
| Arthropods | *Dichelopandalus leptocerus* |
| Arthropods | *Dosima fascicularis* |
| Arthropods | *Dyspanopeus sayi* |
| Arthropods | *Echinogammarus finmarchicus* |
| Arthropods | *Echninogammarus obtusatus* |
| Arthropods | *Edotia triloba* |
| Arthropods | *Epimeria (Epimeria) loricata* |
| Arthropods | *Ericthonius difformis* |
| Arthropods | *Ericthonius rubicornis* |
| Arthropods | *Eualus fabricii* |
| Arthropods | *Eualus gaimardii* |
| Arthropods | *Eualus pusiolus* |
| Arthropods | *Eusirus cuspidatus* |
| Arthropods | *Gammarellus angulosus* |
| Arthropods | *Gammaropsis melanops* |
| Arthropods | *Gammaropsis nitida* |
| Arthropods | *Gammarus annulatus* |
| Arthropods | *Gammarus duebeni* |

| Group | Species |
|---|---|
| Arthropods | *Gammarus lawrencianus* |
| Arthropods | *Gammarus oceanicus* |
| Arthropods | *Gammarus setosus* |
| Arthropods | *Gammarus tigrinus* |
| Arthropods | *Gronella groenlandica* |
| Arthropods | *Haploops fundiensis* |
| Arthropods | *Haploops setosa* |
| Arthropods | *Haploops tubicola* |
| Arthropods | *Harpinia plumosa* |
| Arthropods | *Harpinia propinqua* |
| Arthropods | *Heterolaophonte discophora* |
| Arthropods | *Heterolaophonte minuta* |
| Arthropods | *Hippomedon serratus* |
| Arthropods | *Homarus americanus* |
| Arthropods | *Hyas araneus* |
| Arthropods | *Hyas coarctatus* |
| Arthropods | *Hyperia galba* |
| Arthropods | *Idotea balthica* |
| Arthropods | *Idotea metallica* |
| Arthropods | *Idotea phosphorea* |
| Arthropods | *Ischyrocerus anguipes* |
| Arthropods | *Ischyrocerus megacheir* |
| Arthropods | *Jaera (Jaera) albifrons* |
| Arthropods | *Janira alta* |
| Arthropods | *Jassa marmorata* |
| Arthropods | *Laophonte trilobata* |
| Arthropods | *Lebbeus groenlandicus* |
| Arthropods | *Lebbeus polaris* |
| Arthropods | *Leimia vaga* |
| Arthropods | *Lepas (Anatifa) anatifera* |
| Arthropods | *Lepas sp.* |
| Arthropods | *Leptocheirus pinguis* |
| Arthropods | *Leucon (Leucon) Nasicoides* |
| Arthropods | *Libinia dubia* |
| Arthropods | *Libinia emarginata* |
| Arthropods | *Lignorium lignorium* |
| Arthropods | *Limnoria lignorum* |
| Arthropods | *Lithodes maja* |
| Arthropods | *Lycaea pulex* |
| Arthropods | *Maera danae* |
| Arthropods | *Mancocuma stellifera* |
| Arthropods | *Meganyctiphanes norvegica* |
| Arthropods | *Megamoera dentata* |
| Arthropods | *Monocorophium insidiosum* |
| Arthropods | *Metopa alderi* |
| Arthropods | *Metopa groenlandica* |
| Arthropods | *Microarthridion littorale* |
| Arthropods | *Munna fabricii* |
| Arthropods | *Munnopsis typica* |
| Arthropods | *Mysis gaspensis* |
| Arthropods | *Mysis mixta* |
| Arthropods | *Mysis sp.* |
| Arthropods | *Mysis stenolepis* |
| Arthropods | *Nannopus palustris* |
| Arthropods | *Natatolana borealis* |

| Group | Species |
| --- | --- |
| Arthropods | *Neomysis sp.* |
| Arthropods | *Nymphon grossipes* |
| Arthropods | *Nymphon hirtipes* |
| Arthropods | *Nymphon longitarse* |
| Arthropods | *Nymphon sp.* |
| Arthropods | *Nymphon stroemi* |
| Arthropods | *Orchestia gammarellus* |
| Arthropods | *Orchomene macroserratus* |
| Arthropods | *Orchomenella minuta* |
| Arthropods | *Orchomenella pinguis* |
| Arthropods | *Pagurus acadianus* |
| Arthropods | *Pagurus arcuatus* |
| Arthropods | *Pagurus longicarpus* |
| Arthropods | *Pagurus pubescens* |
| Arthropods | *Palaemon pugio* |
| Arthropods | *Pandalus borealis* |
| Arthropods | *Pandalus montagui* |
| Arthropods | *Paramphithoe hystrix* |
| Arthropods | *Paroediceros lynceus* |
| Arthropods | *Photis reinhardi* |
| Arthropods | *Phoxichilidium femoratum* |
| Arthropods | *Phoxocephalus holbolli* |
| Arthropods | *Pleustes (Pleustes) panoplus* |
| Arthropods | *Pleusymtes glaber* |
| Arthropods | *Platorchestia platensis* |
| Arthropods | *Politolana concharum* |
| Arthropods | *Praunus flexuosus* |
| Arthropods | *Pseudunciola obliquua* |
| Arthropods | *Ptilanthura tenuis* |
| Arthropods | *Pontogeneia inermis* |
| Arthropods | *Pycnogonum litorale* |
| Arthropods | *Sclerocrangon boreas* |
| Arthropods | *Semibalanus balanoides* |
| Arthropods | *Spirontocaris phippsii* |
| Arthropods | *Spirontocaris sp.* |
| Arthropods | *Spirontocaris spinus* |
| Arthropods | *Stegocephalus inflatus* |
| Arthropods | *Stenopleustes inermis* |
| Arthropods | *Stenula solsbergi* |
| Arthropods | *Strongylacron buchholtzi* |
| Arthropods | *Syrrhoe crenulata* |
| Arthropods | *Tanystylum orbiculare* |
| Arthropods | *Unciola irrorata* |
| Arthropods | *Wecomedon nobilis* |

*Table A18. Verified Species for the Marine Fishes Group.*

| Species |
| --- |
| *Acipenser brevirostrum* |
| *Acipenser oxyrinchus* |
| *Alosa aestivalis* |
| *Alosa pseudoharengus* |
| *Alosa sapidissima* |
| *Amblyraja radiata* |
| *Ammodytes americanus* |

| Species |
|---|
| *Ammodytes dubius* |
| *Anarhichas denticulatus* |
| *Anarhichas lupus* |
| *Anarhichas minor* |
| *Anguilla rostrata* |
| *Apeltes quadracus* |
| *Artediellus uncinatus* |
| *Aspidophoroides monopterygius* |
| *Boreogadus saida* |
| *Brosme brosme* |
| *Clupea harengus* |
| *Cryptacanthodes maculatus* |
| *Cyclopterus lumpus* |
| *Enchelyopus cimbrius* |
| *Eumicrotremus spinosus* |
| *Fundulus heteroclitus* |
| *Gadus morhua* |
| *Gasterosteus aculeatus* |
| *Gasterosteus wheatlandi* |
| *Glyptocephalus cynoglossus* |
| *Hemitripterus americanus* |
| *Hippoglossoides platessoides* |
| *Hippoglossus hippoglossus* |
| *Isurus oxyrinchus* |
| *Lamna nasus* |
| *Leucoraja erinacea* |
| *Leucoraja ocellata* |
| *Limanda ferruginea* |
| *Liparis atlanticus* |
| *Lophius americanus* |
| *Lumpenus lumpretaeformis* |
| *Lycodes lavalaei* |
| *Malacoraja senta* |
| *Mallotus villosus* |
| *Melanogrammus aeglefinus* |
| *Menidia menidia* |
| *Merluccius bilinearis* |
| *Microgadus tomcod* |
| *Morone saxatilis* |
| *Myoxocephalus aenaeus* |
| *Myoxocephalus octodecemspinosus* |
| *Myoxocephalus scorpius* |
| *Myxine glutinosa* |
| *Osmerus mordax* |
| *Paralichthys dentatus* |
| *Peprilus triacanthus* |
| *Petromyzon marinus* |
| *Pholis gunnellus* |
| *Pleuronectes putnami* |
| *Pollachius virens* |
| *Prionace glauca* |
| *Prionotus carolinus* |
| *Pseudopleuronectes americanus* |
| *Pungitius pungitius* |
| *Raja laevis* |

| Species |
| --- |
| *Raja ocellata* |
| *Raja senta* |
| *Rajella bathyphila* |
| *Reinhardtius hippoglossoides* |
| *Salmo salar* |
| *Salvelinus fontinalis* |
| *Scomber scombrus* |
| *Scophthalmus aquosus* |
| *Sebastes fasciatus* |
| *Sebastes norvegicus* |
| *Squalus acanthias* |
| *Stenotomus chrysops* |
| *Syngnathus fuscus* |
| *Tautogolabrus adspersus* |
| *Thunnus thynnus* |
| *Triglops murrayi* |
| *Ulvaria subbifurcata* |
| *Urophycis chuss* |
| *Urophycis tenuis* |
| *Xiphias gladius* |
| *Zoarces americanus* |

*Table A19. Verified Species for the Marine Mammals Group.*

| **Species** |
|---|
| *Balaenoptera musculus* |
| *Balaenoptera borealis* |
| *Megaptera novaeangliae* |
| *Eubalaena glacialis* |
| *Balaenoptera physalus* |
| *Balaenoptera acutorostrata* |
| *Physeter macrocephalus* |
| *Hyperoodon ampullatus* |
| *Delphinapterus leucas* |
| *Globicephala melas* |
| *Lagenorhynchus albirostris* |
| *Lagenorhynchus acutus* |
| *Delphinus delphis* |
| *Orcinus orca* |
| *Phocoena phocoena* |
| *Ziphius cavirostris* |
| *Mesoplodon bidens* |
| *Mesoplodon mirus* |
| *Stenella coeruleoalba* |
| *Tursiops truncatus* |
| *Grampus griseus* |
| *Halichoerus grypus* |
| *Phoca vitulina* |
| *Pusa hispida* |
| *Cystophora cristata* |
| *Pagophilus groenlandicus* |
| *Erignathus barbatus* |

*Table A20. Verified Species for the Marine Reptiles Group.*

| **Species** |
|---|
| *Dermochelys coriacea* |
| *Caretta caretta* |
| *Lepidochelys kempii* |