2022 UPDATE TO THE APPLICATION OF A FRAMEWORK TO ASSESS THE VULNERABILITY OF BIOLOGICAL COMPONENTS TO SHIP-SOURCE OIL SPILLS IN THE MARINE ENVIRONMENT IN THE PACIFIC REGION

Context

Under Canada's World Class Tanker Safety System Initiative (WCTSS) a national framework was developed to identify marine biological organisms most vulnerable to ship-source oil (Thornborough et al. 2017) in the event of an oil spill. The Pacific Regional application of this framework (Hannah et al. 2017) identified 27 highly vulnerable biological groups, with sea grasses, salt marsh grasses/succulents, Sea Otters, and baleen whales being most vulnerable. At present, the vulnerability framework is the best tool available for Government of Canada Environmental Incident Coordinators (EICs) to prioritize which species or species assemblages are most vulnerable to oil. EICs use the framework as the foundation to prioritize 'resources at risk' for ecological concerns and, consequently, to inform spill response planning processes, emergency response operations during spills, and subsequently to inform mitigation options for impacted species.

Additional information that impacts the scoring of species' vulnerability to oil has become available since the publication of the original application of the Framework in 2017. Science staff, EICs, and other responders require the most up to date assessment of species' vulnerability to the worst-case scenario of whole oil when responding to oil spills. Therefore, to ensure that the assessment includes the most current information, Fisheries and Oceans Canada (DFO) Fish and Fish Habitat Protection Program (FFHPP), Ecosystem Management Branch, requested that Science Branch provide the first update to the Pacific application. Like the original application, this first update to the Pacific application of the oil vulnerability framework will focus on the acute effects of direct contact with crude oil that contains the whole spectrum of oil from very heavy to very light fractions. The assessment, and advice arising from this Canadian Science Advisory Secretariat (CSAS) Science Response (SR), will be used to inform spill response planning processes, emergency response operations during spills in the Pacific Region, as well as mitigation options and other marine spatial planning initiatives.

Here, we use "National Framework" when referring to "A framework to assess vulnerability of biological components to ship-source oil spills in the marine environment" (Thornborough et al. 2017), "original Pacific Application" when referring to "Application of a framework to assess vulnerability of biological components to ship-source oil spills in the marine environment in the Pacific Region" (Hannah et al. 2017), and "2022 Pacific Application update" or "the update" when referring to the current document.

This Science Response Report results from the regional peer review of April 14, 2022 on the 2022 Update to the application of a framework to assess the vulnerability of biological components to ship-source oil spills in the marine environment in the Pacific Region.

Canada

Analysis and Response

Scope

Like the original application, this update will focus on the acute effects of direct contact with the worst-case scenario of crude oil that contains the whole spectrum of oil from very heavy to very light fractions. The framework (as outlined in Thornborough et al. 2017 and Hannah et al. 2017):

- Is limited to considering only the direct effects of oil and was not designed to incorporate potentially significant indirect and food web effects such as consumption of contaminated food sources (e.g., contaminated plankton impacts on baleen whales), or cumulative effects from multiple stressors;
- This application is limited to marine biological components within DFO's jurisdiction in the Pacific Region. However, it serves as an example of a method that could be applicable to biological components in other jurisdictions (e.g., marine birds);
- Does not assess species based on their socio-economic status (fishery and conservation status) or cultural value (other branches of DFO are responsible for this);
- Does not directly assess habitats but includes them as important areas associated with vulnerable biological components, such as areas of aggregation for species within a subgroup. Biogenic habitats (e.g., Eelgrass beds, Glass Sponge Reefs) are assessed on a subgroup level, rather than as separate habitats (e.g., Eelgrasses, Porifera);
- Does not consider shoreline type due to the existence of a well-established shoreline classification system that ranks the physical shoreline types by sensitivity to spilled oil and potential mitigation measures; and
- Does not assess spatial planning areas such as Ecologically or Biologically Significant Marine Areas (EBSAs) and Marine Protected Areas (MPAs).

Methods

For the 2022 Pacific Application update we included information that has been published since the original scoring process in 2017. We also included information that existed at the time but was not captured due to the limitations of scoring several criteria for such a large number of subgroups. Using the updated information, we followed the methods laid out in Hannah et al. (2017) with one change to the screening process, as outlined below.

Overview of Methods for Original Pacific Application for all oil Types

An overview of the Pacific Application of the National Framework can be seen in Figure 1.

In the first step of the Pacific Application, organisms with similar characteristics and life histories were organized into subgroups that would be similarly vulnerable to oil. There were five major taxonomic groupings, Marine Plants and Algae, Marine Invertebrates, Marine Fishes, Marine Reptiles, and Marine Mammals, within which subgroups were further broken down by life history, habitat, and taxonomy. The full list of subgroups in the Pacific Region can be found in Hannah et al. (2017). We used this same list of subgroups for the 2022 Pacific Application Update.

In the second step, criteria were used to assess the subgroups for various aspects of vulnerability. Vulnerability criteria were divided into three categories: exposure, sensitivity, and recovery. Exposure criteria assessed characteristics that make organisms more likely to be exposed to oil. Sensitivity criteria assessed characteristics that make organisms more likely to be sensitive if exposed to oil, as well as documented evidence of severe, irreversible effects or death from direct contact with oil. Recovery criteria assessed characteristics that make organisms less likely to recover if they were exposed and sensitive to oil. A list of criteria, with associated definitions, can be found in Hannah et al. (2017). We used this same list of criteria for the 2022 Pacific Application update. To assess vulnerability, every subgroup received a score of either 0 (does not fulfill the criterion) or 1 (fulfills the criterion) for each of the criteria. This produced a total vulnerability score out of 10 for each subgroup.

Scoring was precautionary. If at least one species within a subgroup was known to fulfill the criterion, then the whole subgroup was scored as fulfilling the criterion. The drawback to this approach is that the score for a whole subgroup may be driven by one species. However, further in the process, if resources were available, regions could populate identified subgroups with species and score each species to identify the most vulnerable species within those groups. This species-level scoring was done for the Marine Mammals during the 2022 Pacific Application update. There are 25 distinct ecotypes and species of Marine Mammal in the Pacific Region and a wealth of information, making species-level scoring feasible within the timeframe for this update. We did not score all individual species for the other major groups because of the large number of species and time involved. For species with distinct life stages, adult stages were scored first; if these scored a zero, then juvenile stages were considered. In some cases, further subgroups were broken out to accommodate a difference in scoring between adults and juveniles (e.g. Marine Fishes>intertidal>benthic>associated with unconsolidated substrates>Salmonidae (juvenile)).

In the Pacific Application, once all subgroups were scored against the exposure criteria, they were screened. If any subgroup scored 0 for all exposure criteria, they were screened out based on a low likelihood of being exposed in the event of an oil spill. Subsequently, if any of the remaining subgroups scored 0 for all sensitivity criteria, they were screened out based on a low likelihood of being sensitive to oil if exposed. In the original application only two subgroups were screened out using this method. We therefore did not include this screening process in the 2022 Pacific Application Update, as it would not have saved much effort. Instead, we retained all subgroups in the final ranked list, along with the justification information for all scores in the scoring tables in Appendices C through G in the Research Document.

In the third step of the Pacific Application, the remaining subgroups were ranked based on their total vulnerability score, with a score of 10 being the most vulnerable. We used this relative ranking procedure for the 2022 Pacific Application Update. Subgroups with scores between 7 and 10 were considered to have high vulnerability, scores between 4 and 6 were considered to have medium vulnerability, and scores between 0 and 3 were considered to have low vulnerability.

A more detailed description of scoring methods and considerations can be found in the Pacific Application document (Hannah et al. 2017).

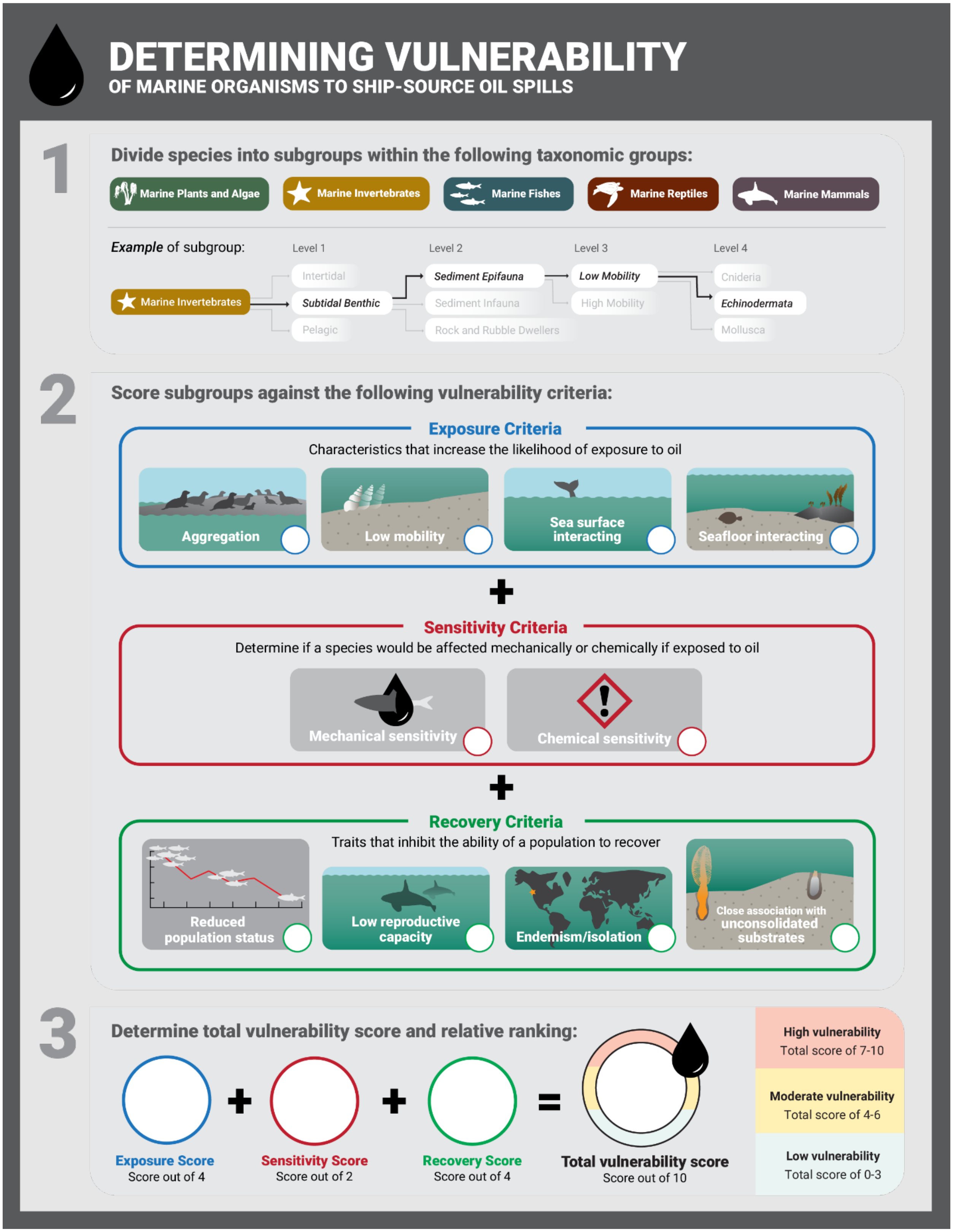

Figure 1. Overview of framework to identify vulnerable biological components.

Results

Biological Groupings

Upon review of the biological groupings presented in the Pacific Application, the groupings were deemed appropriate to capture differences in the vulnerability of the different groups of organisms. However, for some species we found evidence of aggregation (Best et al. 2015; Ford 2014) where previously we had found none. As a result, two marine mammal species moved from subgroups for dispersed organisms to those for discrete aggregations of organisms.

- False Killer Whale moved from cetaceans-toothed-dispersed to cetaceans-toothed-discrete
- Fin Whale moved from cetaceans-baleen-dispersed to cetaceans-baleen-discrete

Scoring

The update resulted in sixteen scoring changes. Two of these scoring changes, both in invertebrate subgroups, resulted in an upgrade of vulnerability category from medium to high. One change for a marine mammal subgroup caused a downgrade in vulnerability category from high to medium. The other thirteen changes were in Marine Invertebrates, Fishes, and Mammals subgroups, and, while the total vulnerability scores changed, there were no changes in vulnerability category (low, medium, high). Table 1 summarizes the subgroups that underwent scoring changes during the update. Detailed scoring for all subgroups with justifications can be found in Appendix A. Similar to the original Pacific Application, subgroups within most major taxonomic groups (e.g., Marine Invertebrates) received scores across a range of total scores from 1-9, while none received the maximum score of 10.

Marine Invertebrates

The largest number of changes for this update occurred within Marine Invertebrates. Total vulnerability scores ranged from 3 to 9 in the update, while they ranged from 3 to 8 in the original Pacific Application. After the update, the highest vulnerability scores for this group included one subgroup that scored 9, five subgroups that scored 8, and ten subgroups that scored 7. The lowest vulnerability scores included two marine invertebrate subgroups with scores of 3. For the highest and lowest scores in the original Pacific Application, three subgroups scored 8, eleven scored 7, and two scored 3.

Two Marine Invertebrate subgroups were upgraded from medium to high vulnerability:

- Marine Invertebrates>Intertidal>rock and rubble>sessile>Porifera (e.g., encrusting sponges) (total vulnerability score changed from 6 to 8)
- Marine Invertebrates>Subtidal benthic>rock and rubble>sessile>Cnidaria (e.g., Cup Coral, Bubblegum Coral) (total vulnerability score changed from 6 to 7)

Five Marine Invertebrate subgroups had changes in total vulnerability score, but remained in the same vulnerability category:

- Marine Invertebrates>Intertidal>sediment infauna>low mobility>worms (e.g., burrowing polychaete worms; 7 to 9)
- Marine Invertebrates>Intertidal>sediment infauna>low mobility>Arthropoda (e.g., Ghost Shrimp; 7 to 8)
- Marine Invertebrates>Subtidal benthic>rock and rubble dwellers>sessile>Arthropoda (e.g., Gant Barnacle; 5 to 6)

- Marine Invertebrates>Subtidal benthic>rock and rubble dwellers>sessile>Urochordata (e.g., Sea Peach Tunicate; 5 to 6)
- Marine Invertebrates>Subtidal benthic>rock and rubble dwellers>low mobility>Mollusca (e.g., Hairy Triton Snail; 4 to 5)

The majority of total vulnerability scores for Marine Invertebrates were in the medium to high vulnerability categories (Figure 2), with a median score of 6 (Figure 3). This group scored highest for exposure and sensitivity criteria, with median scores for exposure criteria of 3 (out of 4), sensitivity 2 (out of 2), and recovery 1 (out of 4) (Figure 3).

Marine Fishes

Total vulnerability scores for Marine Fishes ranged from 1 to 8, as in the original Pacific Application. The highest total vulnerability scores for this group included two subgroups with scores of 8, and two subgroups with scores of 7. The lowest scores included nine subgroups that scored 3, one that scored 2, and one that scored 1. For the highest and lowest scores in the original Pacific Application, one subgroup scored 8, two scored 7, ten scored 3, one scored 2, and two scored 1.

Five Marine Fishes subgroups had changes in total vulnerability score, but remained in the same vulnerability category:

- Marine Fishes>Intertidal>Benthic>Associated with unconsolidated substrates> Smelts and sand lance (e.g., Pacific Sand Lance, Surf Smelt; 5 to 6)
- Marine Fishes>Subtidal>Benthic> Associated with unconsolidated substrate> Hagfishes (e.g., Pacific Hagfish; 3 to 5)
- Marine Fishes>Non-benthic (Pelagic and demersal)>Rockfishes (juvenile) (e.g., Black Rockfish, Copper Rockfish; 3 to 4)
- Marine Fishes>Subtidal> Non-benthic (Pelagic, midwater, demersal)>Miscellaneous species (e.g., Sablefish, salmon, surfperch, Herring) (2 to 3)
- Marine Fishes>Subtidal> Non-benthic (Pelagic, midwater, demersal)>Mackerels and Tunas (e.g., Pacific Chub Mackerel) (1 to 2)

The majority of total vulnerability scores for Marine Fishes were in the low to medium vulnerability categories (Figure 2), with a median score of 4 (Figure 3). This group scored low to medium for all categories of criteria, with median scores for exposure criteria of 2 (out of 4), sensitivity 1 (out of 2), and recovery 1 (out of 4) (Figure 3).

Marine Plants and Algae and Reptiles

There were no changes in the Marine Plants and Algae vulnerability scores for the 2022 Pacific Application update. As in the original Pacific Application, total vulnerability scores ranged from 4 to 9. Similarly, there were no changes in the Marine Reptile vulnerability score for the 2022 Pacific Application update. As in the original Pacific Application, this group comprised only one subgroup, sea turtles, which received a medium to low score of 4.

Marine Mammals

Marine mammal vulnerability scores ranged from 5 to 9, slightly different than in the original Pacific Application, where they ranged from 4 to 9. The highest vulnerability scores for this group included two subgroups that scored 9 and no subgroups that scored 8 or 7. The lowest vulnerability scores for this group included three subgroups with scores of 5. For the highest and lowest scores in the original Pacific Application, two subgroups scored 9, one scored 7, and two scored 4.

One Marine Mammal subgroup was downgraded from high to medium vulnerability:

- Marine Mammals>Cetaceans>Toothed>Discrete (e.g., Killer Whales: residents (Northern and Southern) and offshore populations; Pacific White Sided Dolphin, False Killer Whale; 7 to 6)

Three Marine Mammal subgroups had changes in total vulnerability score, but remained in the same vulnerability category:

- Marine Mammals>Pinnipeds>Other pinnipeds>Discrete (e.g., Steller Sea Lion, Harbour Seal, California Sea Lion; 5 to 6)
- Marine Mammals>Pinnipeds>Other pinnipeds>Dispersed (e.g., Northern Elephant Seal; 4 to 6)
- Marine Mammals>Cetaceans>Toothed>Dispersed (e.g., Sperm Whales, Killer Whales (W.Coast transients), Beaked Whales whales (Baird's, Hubbs' and Stejneger's), Harbour Porpoise, Dall's Porpoise; 4 to 5)

The majority of total vulnerability scores for Marine Mammals were in the medium to high vulnerability categories (Figure 2), with a median score of 5 (Figure 3). This group scored medium to high for all criteria categories, with median scores for exposure criteria of 2 (out of 4), sensitivity 1.5 (out of 2), and recovery 2.5 (out of 4) (Figure 3).

Table 1. Updated and original total vulnerability scores for Pacific Application subgroups that were updated with new information. Arrows beside updated scores indicate when a subgroup has upgraded (↑) or downgraded (↓) to a different vulnerability category; alternating light grey and white are used to highlight the transitions between different total vulnerability scores within the table. Note: only subgroups with changes in total vulnerability score are presented in this table. The full list of subgroups with scores and justifications can be found in Appendix A.

Subgroups					Subgroup ID	Pacific example species	Updated vulnerability score (0-10)	Original vulnerability score (0-10)
Subgroup level 1	**Subgroup level 2**	**Subgroup level 3**	**Subgroup level 4**	**Subgroup level 5**				
MARINE INVERTEBRATES	Intertidal	Sediment infauna	Low mobility	Worms	32	e.g. burrowing polychaete worms	9	7
MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Sessile (attached to hard substrate)	Porifera	19	e.g. encrusting sponges	8 ↑	6
		Sediment infauna	Low mobility	Arthropoda	33	e.g. Ghost Shrimp	8	7
MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Sessile (attached to hard substrate)	Cnidaria	41	e.g. Cup Coral, Bubblegum Coral	7 ↑	6
MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Sessile (attached to hard substrate)	Arthropoda	39	e.g. Giant Barnacle	6	5
				Urochordata	44	e.g. Sea Peach Tunicate	6	5
MARINE FISHES	Intertidal	Benthic	Associated with unconsolid-ated substrates (Silt/Sand/ Gravel) (including eelgrass environments)	Smelts and sand lance	90	e.g. Pacific Sand Lance, Surf Smelt	6	5

Subgroups					Subgroup ID	Pacific example species	Updated vulnerability score (0-10)	Original vulnerability score (0-10)
Subgroup level 1	Subgroup level 2	Subgroup level 3	Subgroup level 4	Subgroup level 5				
MARINE MAMMALS	Cetaceans	Toothed	Discrete	NA	111	e.g. Killer Whales: residents (Northern and Southern) and offshore populations; Pacific White Sided Dolphin, False Killer Whale	6 ↓	7
MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Low mobility	Mollusca	49	e.g. Hairy Triton Snail	5	4
MARINE FISHES	Subtidal	Benthic	Associated with unconsolid-ated substrate (Silt/Sand/ Gravel)	Hagfishes	98	e.g. Pacific Hagfish	5	3
MARINE MAMMALS	Cetaceans	Toothed	Dispersed	NA	112	e.g. Sperm Whales, Killer Whales (W.Coast transients), Beaked Whales (Baird's, Hubbs' and Stejneger's), Harbour Porpoise, Dall's Porpoise	5	4
MARINE MAMMALS	Pinnipeds	Other pinnipeds	Dispersed	NA	117	e.g. Northern Elephant Seal	5	4
MARINE FISHES	Intertidal	Non-benthic (pelagic and demersal)	N/A	Rockfishes (juvenile)	81	e.g. Black Rockfish, Copper Rockfish	4	3
MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Misc species	102	e.g. Sablefish, salmon, surfperch, Herring	3	2
MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Mackerels and Tunas	105	e.g. Pacific Chub Mackerel	2	1

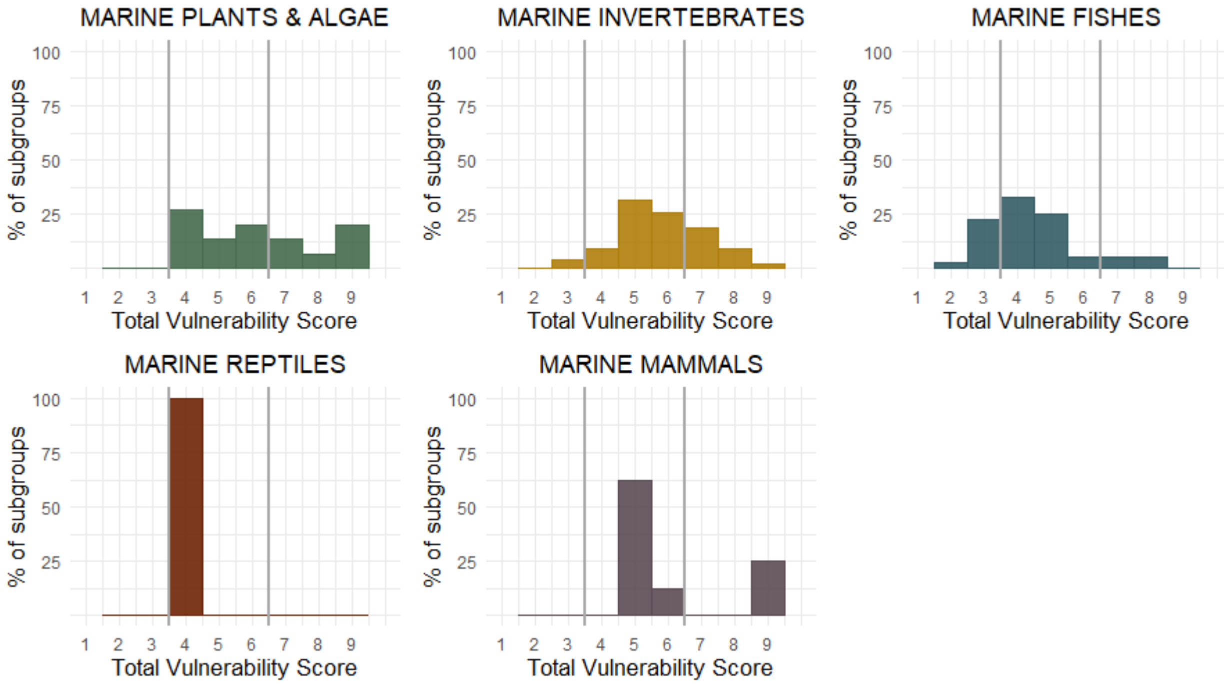

Figure 2. Distribution of total vulnerability scores among subgroups for each of the 5 major taxonomic groupings. Vertical bars illustrate the division between low, medium and high vulnerability categories.

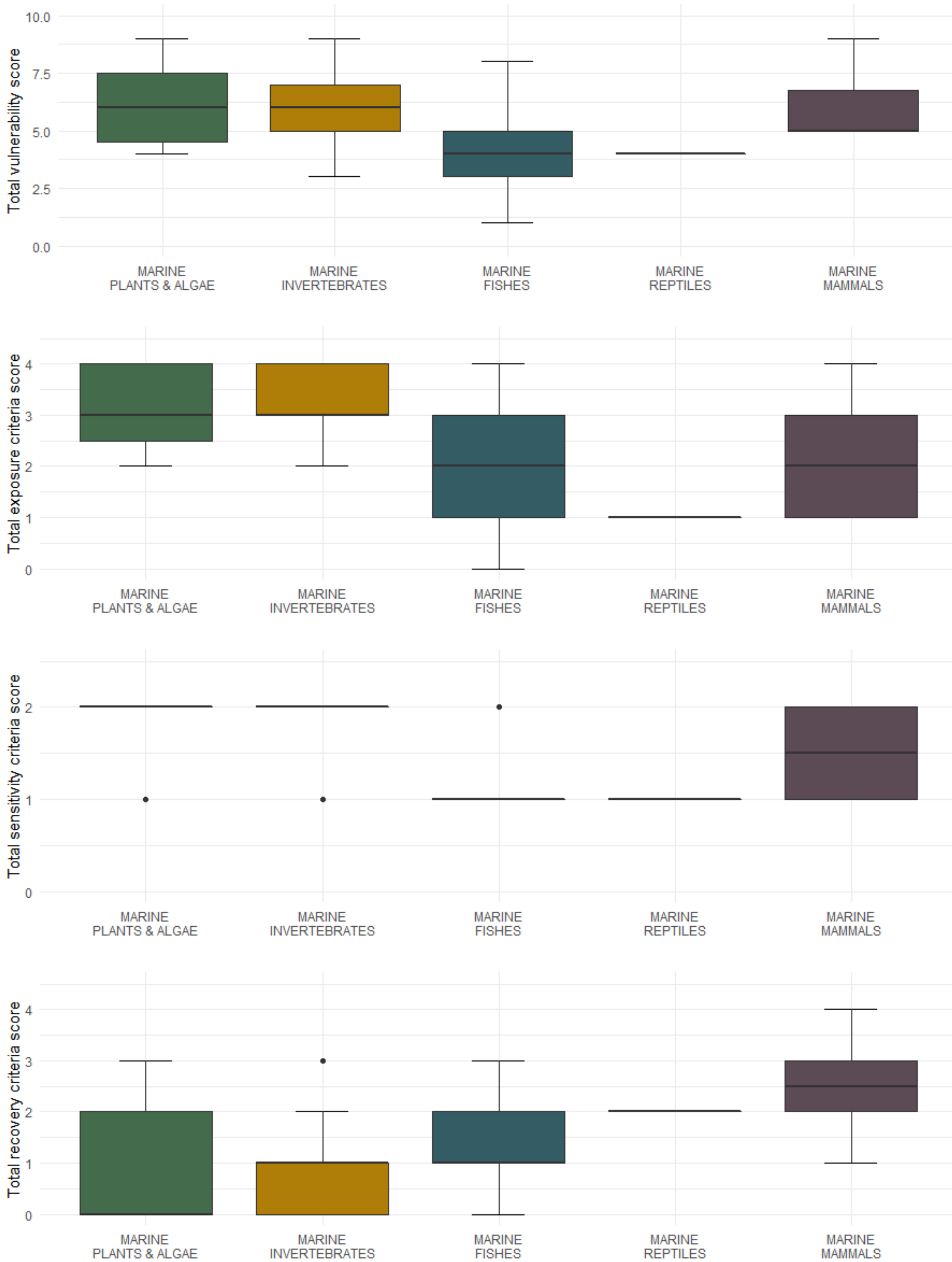

Figure 3. Average scores for each taxonomic grouping for total vulnerability and for the exposure, sensitivity, and recovery categories of criteria. Center line of the boxes represents the median, the lower and upper hinges represent the 25th and 75th percentiles, respectively, whiskers represent minimum and maximum values, and points represent outliers.

Discussion

As in the original Pacific Application, this update contained 118 subgroups identified for the Pacific Region and ranked by their total vulnerability score. The ranked list was compared to other studies examining the impacts of oil spills on marine organisms to assess its validity. Specifically, comparisons were made to studies on the impacts to biota following the *Exxon Valdez* oil spill (Alaska in 1989); the *Deepwater Horizon* well blowout (Gulf of Mexico in 2010); and the *Nestucca* oil spill (Washington in 1988 - impacting British Columbia (BC) waters). It is important to note that, though the *Deepwater Horizon* spill was a well blowout, and not a ship-source spill, the findings on impacts are still relevant for making comparisons to this application.

Marine Plants and Algae

Marine Plant and Algae scores remained unchanged in the 2022 Pacific Application Update. As in the original Pacific Application, the plant and algae subgroups that ranked highest for vulnerability to oil were the intertidal vascular plants (including all seagrasses and salt marsh plants) from low energy unconsolidated shore habitat (all scoring 9), and the intertidal vascular plant seagrasses from high energy rocky shore habitat (with a score of 8). These results align with several *Deepwater Horizon* oil spill studies that found large-scale destruction of seagrass beds (Beyer et al. 2016), reduced standing crop of marsh vegetation (Hester et al. 2016), and increased erosion following vegetation loss that will hinder recovery (Silliman et al. 2012). The *Nestucca* oil spill, which impacted the west coast of Vancouver Island in BC, also resulted in mortality and damage to intertidal plants, particularly in rocky and sandy habitats (Duval et al. 1989). A recent review paper indicates that, though there are many oiling events where impacts to seagrass have been observed, there are also others where no discernible effects were reported (Fonseca et al. 2016). The impacts to vascular plants likely depend on the severity of fouling, and long-term impacts will depend on whether below-ground roots and rhizomes are affected.

Phytoplankton received a low total vulnerability score. Findings for phytoplankton in the literature are variable, with some studies reporting local short term decreases in abundance and productivity of phytoplankton, while others report increases in primary productivity (Duval et al. 1989). A main driver for the low vulnerability score in this analysis was recovery, as phytoplankton are expected to have high recovery regardless of their exposure or sensitivity.

Other Marine Plant and Algae subgroups that had low vulnerability scores include many groups in subtidal, rocky habitat. These groups have moderate likelihood of exposure and sensitivity, but high recovery potential, which makes them less vulnerable. In fact, high recovery potential was a trend across most Marine Plant and Algae subgroups. These results are in keeping with many studies on the effects of oil spills on subtidal algae, which have found either rapid recovery of algal communities, or very little impact of the spill (Pecko et al. 1990; Dean et al. 1996).

Marine Invertebrates

The Marine Invertebrates group had the largest number of scoring changes during the 2022 Pacific Application update. Most notably, the changed scores for two Marine Invertebrate subgroups were sufficient to move them from medium to high vulnerability categories:

- Marine Invertebrates>Intertidal>rock and rubble>sessile>Porifera (e.g., encrusting sponges) (total vulnerability score changed from 6 to 8)
- Marine Invertebrates>Subtidal benthic>rock and rubble>sessile>Cnidaria (e.g., Cup Coral, Bubblegum Coral) (total vulnerability score changed from 6 to 7)

These changes have direct implications on oil spill response, as the highly vulnerable subgroups are used, together with species of conservation concern, culturally important species and areas, and other socio-economic priorities, to inform the identification of resources at risk during an oil spill emergency. Changes in the scores for both of these subgroups were based on Austin (2000), a list of rare and endangered marine invertebrate species of BC compiled in consultation with species experts. There was evidence that both subgroups have endemic and isolated populations of species, and an assessment from the author that they consider the Sand Sponge, *Psammopemma* new *sp*. (Porifera subgroup), threatened. Scores in both subgroups changed from 0 to 1 for the recovery criterion: endemism or isolation, and in the Porifera subgroup from 0 to 1 for the recovery criterion: population status.

Another notable change within the high vulnerability category included the intertidal, infaunal, low mobility, worms (e.g., burrowing polychaete worms). The increase in score for this subgroup, from 7 to 9, makes it the highest ranked marine invertebrate subgroup in terms of vulnerability. This change was also based on Austin 2000. The author considers the Orange Acorn Worm, *Saccoglossus sp.*, threatened, and reports that it is known from only 5 sites (lagoons) in BC and has not been found outside of BC Scores in this subgroup changed from 0 to 1 for the recovery criterion: endemism or isolation, and from 0 to 1 for the recovery criterion: population status.

Additionally, the score for intertidal, sediment infaunal, low mobility, Arthropoda (e.g., ghost shrimp) changed from 7 to 8 within the high vulnerability category. This change was because Blue Mud Shrimp, *Upogebia pugettensis*, populations on Calvert Island, BC, were recently found to be infected with a parasitic isopod. Population declines have not been reported for BC, but the parasite has been implicated in host population declines in the southern portion of its known invasive range (Whalen et al. 2020). As a result, the subgroup received a precautionary score of 1* for the recovery criterion: population status.

Changes to scores for the three subgroups within the medium vulnerability category also resulted from evidence for endemism or isolation from Austin 2000. These subgroups included subtidal benthic, rock and rubble dwelling, sessile Arthropoda (e.g., Giant Barnacle; 5 to 6), subtidal benthic, rock and rubble dwelling, sessile Urochordata (e.g., Sea Peach Tunicate; 5 to 6), and subtidal benthic, rock and rubble dwelling, low mobility Mollusca (e.g., Hairy Triton Snail; 4 to 5).

As in the original Pacific Application, intertidal, epifaunal, low mobility subgroups including Mollusca, Cnidaria, and Echinodermata (all with scores of 8) ranked among the highest for vulnerability to oil. This aligns with findings that clam, mussel, and intertidal communities were still recovering from the *Exxon Valdez* oil spill 20 years later (*Exxon Valdez* Oil Spill Trustee Council 2009). Intertidal marine invertebrates are often one of the most visibly affected biological resources following oil spills (Duval et al. 1989). In the *Deepwater Horizon* spill, shallow water species that were identified as most affected included Cnidarians such as Gorgonian Corals (Etnoyer et al. 2015, 2016) and stony coral larvae (Goodbody-Gringley et al. 2013), aligning with the outputs of this pilot assessment. Impacts to mollusc groups appear to vary, with some groups appearing to be sensitive, while others were not (Washburn et al. 2016). Bivalves are particularly sensitive to crude oil, as they can consume oil droplets while filter-feeding and their low mobility stops them from moving away from contaminated waters (Dupuis and Ucan-Marin 2015). In the 2022 Pacific Application update, most subgroups containing oysters and mussels were ranked as highly vulnerable, while one was ranked as mediumly vulnerable.

In the *Deepwater Horizon* spill, offshore deep-water groups, including sea pens, glass sponges, and colonial tunicates (Valentine and Benfield 2013) as well as deep water corals (Hsing et al.

2013; White et al. 2012), were among those groups most affected, likely because the source of the oil spill was at depth. Other *Deepwater Horizon* reports state that echinoderms and crustaceans tended to be more sensitive to contaminants than many members of the phylum Annelida (reviewed in Washburn et al. 2016). The vulnerability of the echinoderm groups in this application aligns with these observations (no echinoderm group received a total score below 6); however, crustacean arthropod and worm subgroups were represented throughout the range of scoring. These differences may be driven by different study species and habitats.

As in the original Pacific Application, most high mobility invertebrate subgroups (including arthropods) received low vulnerability scores (scores of 3, 4, and 5). This is in contrast with findings following the *Nestucca* oil spill, where crabs (mobile arthropods) appeared to be highly impacted; large numbers of dead crabs were reported, with oil adhering to the carapaces of Dungeness Crabs (Duval et al. 1989). However, these results were based on observations following within months of a spill and did not take into account recovery. Given their life history characteristics, arthropods are expected to have high recovery potential which could justify their low vulnerability rating in this assessment.

Marine Fishes

During the 2022 Pacific Application update, the vulnerability scores of five Marine Fishes subgroups changed. All remained within the same vulnerability category, and all changes were restricted to subgroups in the low and medium vulnerability categories, with no changes in the high vulnerability category subgroups. In four of the subgroups, the recovery criterion: population status score changed from 0 to 1 or 1* because evidence of population decline was found. These subgroups include:

- Marine Fishes>Intertidal>Benthic>Associated with unconsolidated substrates>Smelts and sand lance (e.g., Pacific Sand Lance, Surf Smelt; 5 to 6)
- Marine Fishes>Non-benthic (Pelagic and demersal)>Rockfishes (juvenile) (e.g., Black Rockfish, Copper Rockfish; 3 to 4)
- Marine Fishes>Subtidal>Non-benthic (Pelagic, midwater, demersal)>Miscellaneous species (e.g., Sablefish, salmon, surfperch, Herring; 2 to 3)
- Marine Fishes>Subtidal> Non-benthic (Pelagic, midwater, demersal)>Mackerels and Tunas (e.g., Pacific Chub Mackerel; 1 to 2)

In one of the subgroups, the exposure criterion: aggregation changed from 0 to 1 because evidence for aggregation around food sources (whale carcasses in the deep sea) was found (Smith and Baco 2003), and the recovery criterion: reproductive capacity changed from 0 to 1 because evidence for low fecundity was found (CalCoFI 2015). This subgroup was:

- Marine Fishes>Subtidal>Benthic>Associated with unconsolidated substrate>Hagfishes (e.g. Pacific Hagfish; 3 to 5)

Subgroups ranking highest for vulnerability to oil included salmon, sturgeon, and Herring. These findings align well with the literature that has examined the impacts on fish from the *Exxon Valdez* spill. For instance, the growth of Dolly Varden, Cutthroat Trout and Pink Salmon was reduced in the years following the *Exxon Valdez* oil spill (Hepler et al. 1996; Wertheimer and Celewycz 1996; Willette 1996), Sockeye Salmon smolt mortality was higher, and Herring stocks were severely depleted following the *Exxon Valdez* oil spill. In the years after the oil spill, some salmon species were seen to recover, but this was not the case for Herring that had not recovered after 20 years, although there are conflicting opinions over whether this can be solely attributed to the spill (*Exxon Valdez* Oil Spill Trustee Council 2009; Marty 2008).

As in the original Pacific Application, Marine Fishes subgroups with the lowest vulnerability scores include subtidal non-benthic scombrids (e.g., Pacific Chub Mackerel) and estuarine transient cod (e.g., Pacific Tomcod and Walleye Pollock juveniles). In the original Pacific Application these subgroups were screened out in the exposure screening step, while in this update we did not include the screening step and all subgroups were included in the final ranked list. The results align well with findings from studies following the *Exxon Valdez* oil spill that found higher numbers of Pacific Cod in shallow subtidal habitats that had been oiled, compared to those that were not oiled, as well as higher stomach content volumes at oiled sites (Laur and Halderson 1996). Other fish subgroups with low scores include many non-benthic, benthic, and estuarine subgroups such as subtidal, non-benthic cod, and ocean sunfish. The abundance of non-benthic (pelagic, mid-water, and demersal) fish subgroups in the lower range of vulnerability scores aligns with information reviewed in Beyer et al. (2016) which summarized that pelagic fishes appear to be relatively unharmed by exposure to oil. In this assessment, fish subgroups with low vulnerability scores have life history traits that cause them to have a low likelihood of exposure, low sensitivity, and a high potential for recovery.

Marine Reptiles

Scores for marine reptiles were unchanged during the 2022 Pacific Application update. Sea turtles, the sole group for marine reptiles, had a low vulnerability score (4) which is in contrast with the low recovery potential of this group. This can be explained by the fact that, although areas outside of the Pacific Region are important for critical life functions, such as breeding (Gregr et al. 2015), sea turtles in the Pacific Region are transient and usually seen swimming and foraging individually. Their score in this assessment is understandable given that sea turtle sightings are infrequent in the Pacific Region of Canada making it difficult to draw conclusions about the distribution and habitat use of sea turtles in BC waters.

Marine Mammals

The most notable change in the Marine Mammals during the 2022 Pacific Application update was a decrease in score for one subgroup that moved it from the high to the medium vulnerability category:

- Marine Mammals>Cetaceans>Toothed>Discrete (e.g., Killer Whales: residents (Northern and Southern) and offshore populations; Pacific White Sided Dolphin, False Killer Whale; total vulnerability score changed from 7 to 6)

As mentioned in the Marine Invertebrates section, this change has direct implications on oil spill response, as the highly vulnerable subgroups are used, together with species of conservation concern, culturally important species and areas, and other socio-economic priorities, to inform the resources at risk during an oil spill emergency. This change was in the exposure criterion: seafloor or vegetation interacting. The score was changed from 1* to 0* to reflect the fact that, while northern resident Killer Whales do interact with the hard seafloor at rubbing beaches (Ford et al. 2000) they do not forage in substrates below the seafloor surface, putting them at a reduced risk of exposure under this criterion.

The other two scoring changes in Marine Mammals that resulted from the update occurred within the medium vulnerability category. Both subgroups increased in total vulnerability score, but remained in the same vulnerability category. For dispersed other pinnipeds (e.g. northern elephant seal) the score changed from 0 to 1* for the recovery criterion: population status. The overall Northern Elephant Seal population is not in decline, reflected in the ‘Not at Risk’ designation under Committee on the Status of Endangered Wildlife in Canada (COSEWIC). However, the establishment of the first, small breeding colony in BC in 2014 (Race Rocks) led to the BC breeding population being designated as ‘Critically imperiled’ provincially (BC provincial status S1B). For dispersed toothed cetaceans (e.g., Sperm Whales, Killer Whales [W.Coast transients], Beaked Whales [Baird's, Hubbs' and Stejneger's], Harbour Porpoise, Dall's Porpoise) the score change was in the recovery criterion: endemism or isolation. The score was changed from 0 to 1 because evidence was found that the west coast transient Killer Whale ecotype is a small, isolated population (DFO 2007).

Additionally, during the update, evidence was found for aggregation for the False Killer Whale and Fin Whale (Best et al. 2015; Ford 2014), causing these two species to move from subgroups for dispersed toothed and baleen whales to those for toothed and baleen whales that form discrete aggregations. These results are more representative of the behavior of both whales; thus, they better capture the vulnerability of these two species.

Marine mammal subgroups that ranked the highest for oil vulnerability were the mustelids (Sea Otters; score of 9) and discrete Baleen Whales (e.g., Grey Whales; score of 9). The high vulnerability ranking for Sea Otters (Mustelids) corresponds with reports of extensive Sea Otter deaths following the *Exxon Valdez* oil spill (EVOS) indicating population level injuries (Garshelis and Johnson 2013; Marty 2008), and at least one Sea Otter reported dead due to oil from the smaller *Nestucca* spill, which impacted the west coast of Vancouver Island (Waldichuck 1988; Duval et al. 1989). The results may also correspond with a report by Loughlin (2013), where acute effects were suspected following the EVOS when post EVOS surveys in 1989 found 26 Grey Whale carcasses, a higher number than found than earlier years. However, the cause of these deaths has not been conclusively linked to the EVOS and may be due to increased survey effort.

A risk-based, marine mammal-focused framework (Jarvela-Rosenberger et al. 2017) also found Sea Otters to be at high risk from an oil spill, along with Humpback Whales (discrete baleen whales), Resident Killer Whales (discrete toothed whales), Bigg’s Killer Whales (dispersed toothed whales, and Steller Sea Lions (discreet other pinnipeds). This study took into account oil exposure routes, behavioural ecology, and physiological characteristics to assess hypothetical impacts of oil exposure in BC. Under the 2022 Pacific Application update, discrete and dispersed toothed whales and discrete other pinnipeds scored in the medium vulnerability category (total vulnerability scores of 6, 5, and 6, respectively), which is in contrast to the Jarvela-Rosenberger et al. (2017) results. Some of these differences can be attributed to the broader range of more detailed marine mammal-specific factors considered in the Jarvela-Rosenberger et al. report, such as social structure and level of dietary specialization, as well as secondary effects that aren’t considered here. For example, Steller sea lions ranked high in the Jarvela-Rosenberger et al. study as they were considered to have a high likelihood of population-level effects due to year-round residency in BC waters and a reliance on a small number of rookeries along the BC coastline. In the 2022 Pacific Application update, although discrete pinnipeds (including the Steller Sea Lion) did score high for exposure (3 out of 4 exposure criteria fulfilled), they did not score highly for recovery (1 out of 4 recovery criteria fulfilled). The population in BC is not in decline and has recovered to similar levels as before harvesting and predator-control programs began in the 1900s (COSEWIC 2013). Similarly, Harbour Seals, another species of discrete pinniped highly affected by the EVOS, also appear to have recovered, according to a study 20 years later (*Exxon Valdez* Oil Spill Trustee Council 2009). The higher level of detail in the Jarvela-Rosenberger et al. (2017) report is not functional for the current assessment, which is broader in scope and is a relative approach across biological groups, rather than within the marine mammals. However, it may be possible to incorporate some of these factors in future iterations of the framework if they are more focused in scope.

Marine mammal subgroups that had a lower vulnerability ranking in the 2022 Pacific Application update include the dispersed toothed whales (e.g., Transient Killer Whales) dispersed baleen whales (e.g., Sei Whale), and the dispersed “other” pinnipeds (e.g., Northern Elephant Seal). For all of these subgroups, life history traits cause them to have a lower likelihood of exposure, lower sensitivity, and a higher potential for recovery than other marine mammals. That said, all of these subgroups had total scores of 5, which is higher than the minimum score of other major groups (i.e., Marine Fishes). In fact, there were no Marine Mammals scores in the low vulnerability category. This high minimum score for Marine Mammals indicates that, as a group, Marine Mammals have a number of traits and behaviours that make them more vulnerable to spilled oil than other major groups.

Regardless of their total vulnerability score, Fisheries and Oceans Canada has a mandate to protect Marine Mammal species of conservation concern, including Southern Resident Killer Whale (endangered), Northern Resident Killer Whale (threatened), Offshore Killer Whale (threatened), Transient Killer Whale (threatened), Harbour Porpoise (special concern), Humpback Whale (special concern), Grey Whale (two of three Pacific populations endangered), Fin Whale (special concern), Sei Whale (endangered), Blue Whale (endangered), North Pacific Right Whale (endangered), Northern Fur Seal (threatened), Steller Sea Lion (special concern), Northern Elephant Seal (critically imperiled, BC provincial status), and Sea OtterOtter (special concern). In the event of an oil spill, these species will automatically be considered when EICs are determining resources at risk.

Conclusions

The 2022 Pacific Application update resulted in sixteen scoring changes: seven in Marine Invertebrate subgroups, five in Marine Fish subgroups, and four in Marine Mammal subgroups. Both Marine Plants and Algae, and Marine Reptile subgroups had no scoring changes. Three of the changes resulting from this update have direct implications on oil spill response, as the subgroups moved either into, or out of, the high vulnerability category. This is the category that is used, together with species of conservation concern, culturally important species and areas, and other socio-economic priorities, to inform EICs of the Resources At Risk during an oil spill emergency. The updated ranked list and scoring justification tables resulting from the 2022 Pacific Application update should be used in place of those resulting from the original Pacific Application (Hannah et al. 2017).

Subgroups that moved into the high vulnerability category were:

- Marine Invertebrates>Intertidal>rock and rubble>sessile>Porifera (e.g. encrusting sponges; total vulnerability score changed from 6 to 8)
- Marine Invertebrates>Subtidal benthic>rock and rubble>sessile>Cnidaria (e.g., Cup Coral, Bubblegum Coral; total vulnerability score changed from 6 to 7)

The subgroup that moved out of the high vulnerability category was:

- Marine Mammals>Cetaceans>Toothed>Discrete (e.g., Killer Whales: Residents (Northern and Southern) and offshore populations; Pacific White-Sided Dolphin, False Killer Whale; total vulnerability score changed from 7 to 6)

Additionally, two marine mammal species, the False Killer Whale and the Fin Whale, moved from subgroups for dispersed toothed and baleen whales to those for toothed and baleen whales that form discrete aggregations.

Subgroups with the highest total vulnerability score of 9 were intertidal seagrasses, salt marsh grasses, and salt marsh succulents in moderate to low energy unconsolidated habitat; intertidal, sediment infaunal low mobility worms; baleen whales that form discrete aggregations; and mustelids. These high scores were mostly in agreement with studies examining the impacts of oil spills on marine organisms.

There were subgroups containing species of conservation status that did not score in the high vulnerability category. It should be noted that, regardless of their total vulnerability score, Fisheries and Oceans Canada has a mandate to protect species of conservation concern. In the event of an oil spill, these species will be prioritized when EICs are developing the Resources at Risk within the Environmental Unit. The work presented here contributes to the wider prioritization of environmental, cultural-archaeological, and socio-economic resources, as identified by other government agencies such as Environment and Climate Change Canada, the Canadian Wildlife Service, and the BC Ministry of Environment and Climate Change Strategy, as well as First Nations. This Framework is particularly useful for groups that are under-represented on conservation lists, such as Marine Invertebrates.

As in the original Pacific Application, a key uncertainty was that the chemical sensitivity (impairment due to toxicity) literature was either lacking or ambiguous in most cases, causing us to assign precautionary scores for most subgroups for this criterion. As a result, this criterion was not effective at differentiating between subgroups based on vulnerability to chemical impacts of oil. Future work should focus on a better, more consistent and comparable, characterization of chemical vulnerability of the species within subgroups. There is currently a Regional Peer Review (RPR) process underway to adapt and apply the framework for different oil types commonly transported in the Pacific Region (gasoline/diesel, Bunker C, and diluted bitumen), which will help to tease out some of the ambiguity in the oil toxicity literature. Additionally, we recommend that this Pacific Regional Application of the framework be updated every five to ten years to ensure that the assessment is based on the most current information available. Development of an online database to track changes to scores and updated information would streamline the update process.

Contributors

Contributor	Affiliation
Candice St. Germain	Fisheries and Oceans Canada, Science, Pacific Region
Sharon Jeffery	Fisheries and Oceans Canada, Science, Pacific Region
Lucie Hannah	Fisheries and Oceans Canada, Science, Pacific Region
Jessica Finney	Fisheries and Oceans Canada, Science, Pacific Region

Approved by

Andrew Thomson
Regional Director
Science Branch, Pacific Region
Fisheries and Oceans Canada

November 16, 2022

Sources of Information

Austin, W.C. 2000. Rare and endangered marine invertebrates in British Columbia. In Proceedings of a conference on the biology and management of species and habitats at risk, Kamloops, BC, 15 - 19 Feb.,1999. Volume One. 490 pg.

Beyer, J., Trannum, H.C., Bakke, T., Hodson, P.V and Collier, T.K. 2016. Environmental effects of the Deepwater Horizon oil spill: A review. Mar. Pollut. Bull. 110(1):28-51.

CalCOFI. 2015. Review selected California fisheries for 2014: Coastal pelagic finfish, market squid, groundfish, Pacific herring, Dungeness crab, ocean salmon, true smelts, hagfish, and deep water ROV surveys of MPAs and surrounding nearshore habitat. Fisheries Review. CalCOFI report., Vol 56, 2015.

COSEWIC. 2013. COSEWIC assessment and status report on the steller sea lion Eumetopias jubatus in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 54 pp.

Dean, T.A., Stekoll, M.S., and Smith, R.O. 1996. Kelps and oil: The effects of the Exxon Valdez oil spill on subtidal algae. In Proceedings of the Exxon Valdez oil spill Symposium, Anchorage, Alaska, 2-5 February 1993. American Fisheries Society. pp. 412-423.

DFO. 2007. Recovery strategy for the transient Killer Whale (*Orcinus orca*) in Canada.

Dupuis, A., and Ucan-Marin, F. 2015. A literature review on the aquatic toxicology of petroleum oil: An overview of oil properties and effects to aquatic biota. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/007. vi + 52 p.

Duval, W., Hopkinson, S., Olmstead, R., and Kashino, R. 1989. The Nestucca oil spill: preliminary evaluation of impacts on the west coast of Vancouver Island. Prepared by ESL Environmental Sciences Ltd. for Environment Canada.

Etnoyer, P.J., MacDonald, I.R., Wickes, L.N., Dubick, J.D., Salgado, E., and Balthis, L. 2015. Decline in condition of sea fans on mesophotic reefs in the Northern Gulf of Mexico before and after Deepwater Horizon oil spill. Gulf of Mexico Oil Spill and Ecosystem Science Conference, Houston, TX, USA.

Etnoyer, P.J., Wickes, L.N., Silva, M., Dubick, J.D., Balthis, L., Salgado, E., and MacDonald, I.R. 2016. Decline in condition of gorgonian octocorals on mesophotic reefs in the Northern Gulf of Mexico: before and after the Deepwater Horizon oil spill. Coral Reefs. 35: 77-90.

Exxon Valdez Oil Spill Trustee Council. 2009. Legacy of an oil spill 20 years after the Exxon Valdez.

Fonseca, M., Piniak, G.A., and Cosentino-Manning, N. 2016. Susceptibility of seagrass to oil spills: A case study with eelgrass, *Zostera marina* in San Francisco Bay, USA. Marine Pollution Bulletin 115(1-2): 29-38.

Ford, J.K.B., Ellis, G.E., and Balcomb, K.C. 2000. Killer whales: the natural history and geneology of *Orcinus orca* in British Columbia and Washington State 2nd edition. UBC Press, Vancouver, BC

Garshelis, D.L., and Johnson, C.B. 2013. Prolonged recovery of sea otters from the Exxon Valdez oil spill? A re-examination of the evidence. Mar. Pollut. Bull. 71: 7–19.

Goodbody-Gringley, G., Wetzel, D. L., Gillon, D., Pulster, E., Miller, A., and Ritchie, K.B. 2013. Toxicity of Deepwater Horizon source oil and the chemical dispersant, Corexit® 9500, to coral larvae. PloS One 8(1): e45574.

Gregr, E.J., Gryba, R., James, M.C., Brotz, L., and Thornton, S.J. 2015. Information relevant to the identification of critical habitat for Leatherback Sea Turtles (*Dermochelys coriacea*) in Canadian Pacific waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/079. vii + 32p.

Hannah, L., St. Germain, C., Jeffery, S., Patton, S., and O, M. 2017. Application of a framework to assess vulnerability of biological components to ship-source oil spills in the marine environment in the Pacific Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/057. ix + 145 p.

Hepler, K.R., Halderson, P.A., and Bernard, D.R. 1996. Impact of oil spilled from the Exxon Valdez on survival and growth of Dolly Varden and cutthroat trout in Prince William Sound. In Proceedings of the Exxon Valdez oil spill Symposium, Anchorage, Alaska, 2-5 February 1993. American Fisheries Society. pp. 645-658.

Hester, M.W., Willis, J.M., Rouhani, S., Steinhoff, M A., and Baker, M.C. 2016. Impacts of the Deepwater Horizon oil spill on the salt marsh vegetation of Louisiana. Environ. Poll. 216: 361-370.

Hsing, P.Y., Fu, B., Larcom, E.A., Berlet, S.P., Shank, T.M., Govindarajan, A.F., and Fisher, C.R. 2013. Evidence of lasting impact of the Deepwater Horizon oil spill on a deep Gulf of Mexico coral community. Elementa: Sci.Anth. 1: 000012.

Jarvela-Rosenberger, A.L., MacDuffee, M., Rosenberger, A.G.J., and Ross, P.S. 2017. Oil spills and marine mammals in British Columbia, Canada: development and application of a risk-based conceptual framework. Archives of Environmental Contamination and Toxicology 71(1): 131-153.

Laur, D. and Halderson, L. 1996. Coastal habitat studies: The effect of the Exxon Valdez oil spill on shallow subtidal fishes in Prince William Sound. American Fisheries Society symposium 18: 659-670.

Loughlin, T.R. 2013. Marine mammals and the Exxon Valdez. Academic Press.

Marty, G.D. 2008. Chapter 23. Effects of the Exxon Valdez Oil spill on Pacific Herring in Prince William Sound, Alaska. In The Toxicology of Fishes. Edited by R.T. Di Giulio and D.E . Hinton. CRC Press. 925–932.

Pecko, P., Levings, S.C., and Garrity, S.D. 1990. Kelp response following the World Prodigy oil spill. Mar. Poll. Bull. 21: 473-476.

Silliman, B.R., van de Koppel, J., McCoy, M. W., Diller, J., Kasozi, G.N., Earl, K., Adams, P.N., and Zimmerman, A.R. 2012. Degradation and resilience in Louisiana salt marshes after the BP- Deepwater Horizon oil spill. PNAS 109: 11234-11239.

Smith, C. and Baco, A. 2003. Ecology of whale falls at the deep-sea floor. Oceanogr. Mar. Biol. 41.

St. Aubin, D.J. 1990. Chapter 4: Physiologic and toxic effects on pinnipeds. In Sea mammals and oil: confronting the risks. Academic Press Inc. pp. 103-123.

Thornborough, K., Hannah, L., St. Germain, C., and O, M. 2017. A framework to assess vulnerability of biological components to ship-source oil spills in the marine environment. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/038. vi + 24 p.

Valentine, M.M., and Benfield, M.C. 2013. Characterization of epibenthic and demersal megafauna at Mississippi Canyon 252 shortly after the Deepwater Horizon Oil Spill. Mar. Poll. Bull. 77(1-2): 196–209.

Waldichuk, M.1988. The Nestucca oil spill. Mar. Poll. Bull. 20(9): 419-420.

Washburn, T., Rhodes, A.C.E., and Montagna, P.A. 2016. Benthic taxa as potential indicators of a deep-sea oil spill. Ecological Indicators. 71: 587–597.

Wertheimer, A.C., and Celewycz, A.G. 1996. Abundance and growth of juvenile pink salmon in oiled and non-oiled locations of western Prince William Sound after the Exxon Valdez oil spill. In Proceedings of the Exxon Valdez oil spill Symposium, Anchorage, Alaska, 2-5 February 1993. American Fisheries Society. 18: 518-532.

Whalen, M.A., Millard-Martin, B.R., Cox, K.D., Lemay, M.A., and Paulay, G. 2020. Poleward range expansion of invasive bopyrid isopod, *Orthione griffenis* Markham, 2004, confirmed by establishment in Central British Columbia, Canada. BioInvasions Records 9(3): 538– 548.

White, H.K., Hsing, P.Y., Cho, W., Shank, T.M., Cordes, E.E., Quattrini, A.M., Nelson, R.K., Camilli, R., Demopoulos, A.W., German, C.R., Brookes, J.M., Roberts, H.H., Shedd, W., Reddy, C.M., and Fisher, C.R. 2012. Impact of the Deepwater Horizon oil spill on a deep-water coral community in the Gulf of Mexico. Proceedings of the National Academy of Sciences of the United States of America. 109(50): 20303-20308.

Willette, M. 1996. Impacts of the Exxon Valdez oil spill on the migration, growth and survival of juvenile pink salmon in Prince William Sound. In Proceedings of the Exxon Valdez oil spill Symposium, Anchorage, Alaska, 2-5 February 1993. American Fisheries Society. 18: 533-55.

Appendix A. Detailed Scoring Tables with Justifications

*Table A-1. Scores and associated justifications for all subgroups for all criteria. Grey highlight indicates scores that changed during the 2022 Pacific Application update; scores with a * indicate a precautionary score due to lack of knowledge. Note: Species lists are not exhaustive.*

SG ID 1	MARINE PLANTS and ALGAE	Intertidal	Vascular Plants	High energy, rocky habitat	Seagrasses
Example species: ***Phyllospadix scouleri, P. torreyi, P. serrulatus***					Total Score: 8

Category	Criterion	Score	Justification
Exposure	Concentration/Aggregation	1 *	Phyllospadix plants can grow in large single species aggregations, or occur in smaller patches.
	Low mobility	1	All plants are immobile.
	Sea surface interacting	1	Primary habitat for surfgrasses ranges from the upper intertidal to shallow subtidal- plants would interact with the surface from either location (Green and Short 2003.)
	Seafloor interacting	1	Phyllospadix roots are in close association with a thin layer of sediment trapped between the rhizomes and directly attached to rocks (O'Brien and Dixon 1976).
Sensitivity	Mechanical sensitivity	1	Phyllospadix plants have been documented to trap oil between their blades (Foster et al. 1971). As reviewed in O'Brien and Dixon (1976) several species have strong adsorptive tendencies, causing oil to adhere to blades and/or stipes, smothering the organism by inhibiting gas exchange and/or light penetration and potentially increased breakage under the weight of oil. *Phyllospadix torreyi* is one of these species (Foster et al. 1970, 1971).
	Chemical sensitivity	1 *	Soluble oil compounds are hydrophobic and are concentrated in the thylakoid membrane where they impair the photosynthetic ability of the plant (Runcie et al. 2004), but a lack of baseline data and standardised methods make results difficult to compare. After the 1971 spill of Bunker C in San Francisco Bay, Chan (1973) found that Phyllospadix plants experienced a slight die-off at the outer tips of the blades initially, but growth of the surf grass during the remaining spring and into the summer months appeared normal.
Recovery	Reduced population status	0	-
	Low reproductive capacity	1 *	-
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	1	Phyllospadix roots are in close association with the thin layer of sediment trapped around the rhizomes, but the amount of sediment is minimal compared to Zostera roots (O'Brien and Dixon 1976).

SG ID 2	MARINE PLANTS and ALGAE	Intertidal	Vascular Plants	Moderate to low energy unconsolidated habitat	Seagrasses
Example species: Zostera marina, Z. japonica					Total Score: 9

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Both native and non-native Zostera species frequently grow in large single species stands (Phillips et al. 1983).
	Low mobility	1	All plants are immobile.
	Sea surface interacting	1	Primary habitat for eelgrasses is mid-low intertidal and shallow subtidal; intertidal and some subtidal plants would interact with the surface (Green and Short 2003).
	Seafloor interacting	1	Vascular plants are rooted in unconsolidated substrates.
Sensitivity	Mechanical sensitivity	1	Photosynthetic impairment due to smothering is documented in marine algae, and is related to thickness of oil (O'Brien and Dixon 1976).
	Chemical sensitivity	1 *	Soluble oil compounds are hydrophobic and are concentrated in the thylakoid membrane where they impair the photosynthetic ability of the plant (Runcie et al. 2004), but a lack of baseline data and standardised methods make results difficult to compare. Much of the literature investigating the effects of crude oil on *Zostera marina* in situ indicates little to no effect of exposure, and burnt blades initially observed on eelgrass are a temporary phenomenon (Den Hartog and Jacobs 1980; Jacobs 1980; Dean et al. 1998; Macinnis-Ng and Ralph 2003; Fonseca et al. 2017). However, the body of literature remains inconsistent, as some studies show a reduction in the average density of shoots and an ultimate loss of beds in certain areas (Fonseca et al. 2017, Juday and Foster 1990, Houghton et al. 1993). The waxy protective coating of the blades may act as a barrier to contaminants dissolved in the water column (Howard et al. 1989). Furthermore, it has been suggested that the structure and growth strategies of seagrass may allow certain species to resist and recover from disturbances (Duarte et al., 1994; Vermaat et al. 1997). After the 2007 Cosco Busan spill of IFO 380 Bunker fuel in San Francisco Bay, Fonseca et al.(2017) found no significant effect of the oil on eelgrass rhizome growth, shoot density, or electron transport rate. Clark et al. (1973, 1975) found that after the 1972 spill of Navy Special Fuel Oil (fuel oil No. 5) from the General M.C. Meigs near Cape Flattery, Washington, the sea grass *Phyllospadix scouleri* lost photosynthetic pigment. Specimens in un-oiled pools suffered no pigment loss. After experimental exposure to dilbit water-accommodated fractions (WAF) (1%-100%), under both short-term (9 days) and long-term (4 weeks) treatments, Banning (2010) found that there was no change in the general health of each shoot prior to and following treatment, and no statistically significant difference in mean leaf growth or mean chlorophyll-a content (mg/m^2) among shoots in all treatment groups and the control.
Recovery	Reduced population status	1	Eelgrass has been documented to be in decline in many areas of the Salish Sea (Thom et al. 2011)
	Low reproductive capacity	1 *	*Zostera marina* beds rely on asexual rhizome expansion rather than seeds for bed expansion and persistence in British Columbia (Phillips et al. 1983). Eelgrass beds have been documented to recover quickly after damage from oils spills when only leaves are damaged (Dean et al. 1998), but recovery is predicted to be slow if damage to rhizomes occurs (Zieman et al. 1984)

Category	Criteria	Score	Justification
	Endemism/Isolation	0	No evidence of endemic/isolated populations
	Association with unconsolidated substrates	1	The roots and rhizomes of *Zostera* grow within unconsolidated substrates

SG ID 3	MARINE PLANTS and ALGAE	Intertidal	Vascular Plants	Moderate to low energy unconsolidated habitat	Salt marsh grasses
Example species: Carex lyngbyei, Leymus mollis					**Total Score: 9**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Low species diversity is typical; *Carex lyngbyei* often occurs in dense, monospecific stands (Mackenzie and Moran 2004).
	Low mobility	1	All plants are immobile.
	Sea surface interacting	1	Primary habitat for saltmarsh grasses is mid intertidal to supratidal; all plants would interact with the surface (Mackenzie and Moran 2004).
	Seafloor interacting	1	Vascular plants are rooted in soft substrates.
Sensitivity	Mechanical sensitivity	1 *	Tall, reedy or stiff grassy stems are more likely to stand above the oil, so photosynthetic impairment may not occur for some species in this subgroup (Morris and Harper 2006). Plants that are coated do experience photosynthetic impairment (Pezeshki et al. 2000).
	Chemical sensitivity	1 *	Sensitivity in this group is mixed. A study on the effects of the 1976 Chesapeake Bay spill of No. 6 fuel oil showed increased growth of oiled *Spartina alterniflora* (Hershner and Moore 1977). After experimental treatment with No. 6 fuel oil, salt marsh plots showed a temporary decrease in above-ground biomass of *S. alterniflora* (Alexander and Webb, 1985). After oiling with No. 6 fuel oil, *S. alterniflora* showed Initial total loss of above-ground biomass but resprouted in 4 months (Proffitt and Devlin, unpublished data in Pezeshki et al. 2000).After the DWH blowout, severe reductions in root and rhizome biomass of *Juncus roemerianus* (Lin and Mendelssohn 2012; Lin et al. 2016) ultimately changed the shoreline structure from a mixed *Spartina alterniflora* and *J. roemerianus* marsh to a predominately *S. alterniflora* marsh (Lin et al. 2016). While above ground biomass and below ground biomass of both marsh plants were equivalent in moderately oiled areas to reference marshes 24-30 months post spill (Lin et al. 2016), shoreline erosion persisted for at least 30 months (Rabalais and Turner 2016).
Recovery	Reduced population status	1 *	-
	Low reproductive capacity	1 *	Perennial plants are generally faster to recover than annuals (Hampson and Moul 1978).

Category	Criteria	Score	Justification
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	1	The roots of all vascular marsh plants are in close association with unconsolidated substrates. Oil can persist in marshes for decades and hinder recovery (Culbertson et al. 2008).

SG ID 4	MARINE PLANTS and ALGAE	Intertidal	Vascular Plants	Moderate to low energy unconsolidated habitat	Salt marsh succulents
Example species: Sarcocornia pacifica, Glaux maritima					**Total Score: 9**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	*Sarcocornia and Glaux maritima* often occur in dense, pure stands (Mackenzie and Moran 2004).
	Low mobility	1	All plants are immobile.
	Sea surface interacting	1	Primary habitat for saltmarsh succulents is mid intertidal to supratidal; all plants would interact with the surface (Mackenzie and Moran 2004).
	Seafloor interacting	1	Vascular plants are rooted in unconsolidated substrates.
Sensitivity	Mechanical sensitivity	1	Marsh plants coated in oil experience photosynthetic impairment (Pezeshki et al. 2000).
	Chemical sensitivity	1 *	Succulent type plants may be particularly sensitive to oil (Davy et al. 2001), but a lack of baseline data and standardised methods make results difficult to compare.
Recovery	Reduced population status	1 *	-
	Low reproductive capacity	1 *	-
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	1	The roots of all vascular marsh plants are in close association with unconsolidated substrates. Oil can persist in marshes for decades and hinder recovery (Culbertson et al. 2008.)

SG ID 5	MARINE PLANTS and ALGAE	Intertidal	Canopy Algae	N/A	N/A
Example species: Feather Boa					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Species in this subgroup are concentrated in areas where habitat conditions meet their specific needs; in particular at certain tidal elevations; but, as these bands are not discrete, and the species are often ubiquitous across them, it is not considered to aggregate.
	Low mobility	1	All algae are immobile.
	Sea surface interacting	1	Egregia grows in the low intertidal and shallow subtidal; given their length, plants at any tidal elevation could interact with the surface (Mondragon and Mondragon 2003).
	Seafloor interacting	1 *	Species in the intertidal will interact with the seafloor when they are exposed on a low tide, although it is possible this habitat would not retain oil for long periods.
Sensitivity	Mechanical sensitivity	1 *	High energy environments do not retain oil for as long as low energy environments (Pecko et al. 1990), so photosynthetic impairment maybe less than in wave sheltered environments.
	Chemical sensitivity	1 *	Following the Santa Barbara spill of crude oil, *Egregia laevigata Setch*. experienced loss of lateral blades in the basal region of stipes where oil could accumulate (Foster et al. 1970, 1971).
Recovery	Reduced population status	0	-
	Low reproductive capacity	0	Algae species can have either opportunistic or late successional life history strategies, but most are classified as having a relatively high reproductive capacity when compared to other ecosystem components (such as whales) (Lobban and Harrison 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 6	MARINE PLANTS and ALGAE	Intertidal	Understory / Turf Algae	High energy, rocky habitat	N/A
Example species: Sea Palm Kelp					**Total Score: 7**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	*Postelsia palmaeformis* has been documented to have very limited dispersal abilities (Paine 1979), which can lead to aggregated populations.
	Low mobility	1	All algae are immobile.
	Sea surface interacting	1	By definition, intertidal species will interact with the surface on a low tide.
	Seafloor interacting	1 *	Species in the intertidal will interact with the seafloor when they are exposed on a low tide, although it is possible this habitat would not retain oil for long periods.
Sensitivity	Mechanical sensitivity	1 *	High energy environments do not retain oil for as long as low energy environments (Pecko et al. 1990), so photosynthetic impairment may be less than in wave sheltered environments. Futhermore, algae that grow directly beneath fronds of taller species may avoid smothering by oil in the same fashion that the inner portion of a profusely branched algae can remain uncoated (O'Brien and Dixon 1976).
	Chemical sensitivity	1 *	Clark et al. (1973, 1975) found that after the 1972 spill of Navy Special Fuel Oil (fuel oil No. 5) from the General M.C. Meigs near Cape Flattery, Washington, *Laminaria andersoni* (now *L. setchellii*) lost it's distal fronds when exposed to the oil at extreme low tides. This did not happen in control specimens beyond the zone of pollution. Also, Several Rhodophyta, including *Corallina vancouveriensis Yendo, Prionitis lanceolata Harv., Bossiella sp.,* and *Ceramium sp*., lost photosynthetic pigment. In oil covered pools, bleaching was noted on emergent *Ceramium sp.* and *Prionitis lanceolata* while submerged parts appeared healthy. Specimens in un-oiled pools suffered no pigment loss and long-term bleaching of a previously oiled species was not apparent. After a 1971 San Francisco Bay oil spill of Bunker C, upper shore algae, (*Endocladia muricata Gigartina cristata*), were coated with oil but growth in the following summer appeared normal (Chan 1972; 1973).
Recovery	Reduced population status	0	-
	Low reproductive capacity	1	*Laminaria setchelli* does not become reproductive until 3-5 years after establishment and can live for up to 25 years (Lobban and Harrison 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 7	MARINE PLANTS and ALGAE	Intertidal	Understory / Turf Algae	Moderate to low energy rocky habitat	N/A
Example species: Fucus gardneri, Desmarestia sp., Laminaria saccharina					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Limited embryo dispersal and a reliance of embryos on adult plants for shelter has been documented for *Fucus gardneri* (Stekoll and Deysher 1996), which can lead to aggregated populations.
	Low mobility	1	All algae are immobile.
	Sea surface interacting	1	By definition, intertidal species will interact with the surface on a low tide.
	Seafloor interacting	1	Species in the intertidal will interact with the seafloor when they are exposed on a low tide.
Sensitivity	Mechanical sensitivity	1 *	Algae that grow directly beneath fronds of taller species may avoid smothering by oil in the same fashion that the inner portion of a profusely branched algae can remain uncoated (O'Brien and Dixon 1976).
	Chemical sensitivity	1 *	During the EVOS, the intertidal zone was impacted by both direct oil and cleanup treatments, reducing fucoid algal cover for up to eight years after the spill (Peterson 2001). After the 1970 spill of Bunker C in Chedabucto Bay, NS, *Fucus spiralis*, an alga forming a narrow zone at about M.H.W., was reduced or eliminated at locations where oiling was severe. There was no evidence of recolonization except at one location during the summer of 1972. The new plants were minute, and identification impossible; they died during the following winter. *F. spiralis* did not die abruptly when oiled but declined gradually in the 10 months or so following initial oiling (Thomas 1973). Clark et al. (1973, 1975) found that after the 1972 spill of Navy Special Fuel Oil (fuel oil No. 5) from the General M.C. Meigs near Cape Flattery, Washington, *Fucus gardneri* samples were considered "unhealthy" and appeared dark and flaccid compared with specimens taken from unpolluted areas. After a 1971 San Francisco Bay oil spill of Bunker C, on protected flats which had experienced up to 75 % oil coating, Iridaea flaccida was apparently normal although Halosaccion glandiforme growth was thicker than usual. Abundant growth of *Enteromorpha intestinalis and Urospora penicilliformis* on coated mussel beds as well as heavier than normal covering of *Ralfsia pacifica Hollenb*. were also noted, possibly caused by reduction in grazers (Chan 1972, 1973). By summer 1973 pre-spill algal densities were restored (Chan 1975).
Recovery	Reduced population status	0	-
	Low reproductive capacity	0	See explanation for 'intertidal, canopy, high energy rocky shore' (*Egregia*) (Lobban and Harrison 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 8	MARINE PLANTS and ALGAE	Intertidal	Encrusting Algae	Rocky habitat	N/A
Example species: Coralline algae, Codium setchellii					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Some species are found in isolated patches (*Codium setchelli*), while others are very widespread (*coralline algae*); none should be considered aggregating (Mondragon and Mondragon 2003).
	Low mobility	1	All algae are immobile.
	Sea surface interacting	1	By definition, intertidal species will interact with the surface on a low tide.
	Seafloor interacting	1	Species in the intertidal will interact with the seafloor when they are exposed on a low tide.
Sensitivity	Mechanical sensitivity	1	Photosynthetic impairment due to smothering is documented in marine algae, and is related to thickness of oil (O'Brien and Dixon 1976).
	Chemical sensitivity	1 *	Following the grounding of the General M. C. Meigs near Cape Flattery, Washington, and the release of Navy Special fuel oil, *Corallina vancouveriensis* and *Bossiella sp*. lost photosynthetic pigment (Clark et al. 1973; Clark et al. 1975).
Recovery	Reduced population status	0	-
	Low reproductive capacity	0	See explanation for ‘intertidal, canopy, high energy rocky shore’ (*Egregia*) (Lobban and Harrison 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 9	MARINE PLANTS and ALGAE	Subtidal	Canopy Algae	High energy, rocky habitat	N/A
Example species: Bull Kelp, Feather Boa					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Nereocystis forms extensive beds in the shallow subtidal (Mondragon and Mondragon 2003).
	Low mobility	1	All algae are immobile.
	Sea surface interacting	1	Due to their height and presence of floats, these species interact with the surface from the subtidal zone.
	Seafloor interacting	0	Species in this subgroup have floats that keep their fronds above the seafloor and out of contact with unconsolidated substrates.
Sensitivity	Mechanical sensitivity	1 *	High energy environments do not retain oil for as long as low energy environments (Pecko et al. 1990, so photosynthetic impairment may be less than in wave sheltered environments.
	Chemical sensitivity	1 *	Impairment of photosynthesis has been documented for Nereocystis after exposure to oil for 4 and 24 hrs (Antrim et al. 1995), but a lack of baseline data and standardised methods make results difficult to compare. After the EVOS, Dean et al (1996a) found that total algal density, biomass, and cover were statistically indistinguishable between oiled and control sites for subtidal kelps in exposed, moderately exposed, and sheltered rocky habitats. However, a general pattern emerged from these contrasts in which one of the dominant species of kelp typically exhibited significantly higher density on the oiled shores because of a greater number of smaller plants in the population. This pattern may reflect recovery of the kelp from losses that were related to either the toxic effects of the oil or the intense boating activity associated with the shoreline treatment and assessment programs (Stekoll et al. 1993; Dean et al. 1996a). *Saccharina latissima* (a common shallow sub-tidal kelp) did not exhibit decreased growth after the World Prodigy Oil Spill in Rhode Island (Pecko et al. 1990). Following the Santa Barbara spill of crude oil, *Egregia laevigata Setch*. experienced loss of lateral blades in the basal region of stipes where oil could accumulate (Foster et al. 1970, 1971).
Recovery	Reduced population status	1 *	There have been increasing reports of canopy kelp decline in past few years (*Nereocystis* and *Macrocystis*). Most recent kelp report from DNR in Wash showed declines (Ecoscan Resource Data 2015), and many local community groups in BC are reporting declines (eg. Help the Kelp).
	Low reproductive capacity	0	See explanation for ‘intertidal, canopy, high energy rocky shore’ (*Egregia*) (Lobban and Harrison 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 10	MARINE PLANTS and ALGAE	Subtidal	Canopy Algae	Moderate to low energy rocky habitat	N/A
Example species: Giant Kelp					**Total Score: 7**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Macrocystis forms extensive beds in the shallow subtidal (Mondragon and Mondragon 2003).
	Low mobility	1	All algae are immobile.
	Sea surface interacting	1	Given their height, and presence of floats/woody stipe, canopy species often reach the sea surface from the subtidal zone.
	Seafloor interacting	0	Species in this subgroup have floats or woody stipes that keep their fronds above the seafloor and out of contact with unconsolidated substrates.
Sensitivity	Mechanical sensitivity	1	Photosynthetic impairment due to smothering is documented in marine algae, and is related to thickness of oil (O'Brien and Dixon 1976).
	Chemical sensitivity	1 *	Precautionary scoring due to a lack of research on the toxic effects of oil on this group. After the EVOS, Dean et al (1996a) found that total algal density, biomass, and cover were statistically indistinguishable between oiled and control sites for subtidal kelps in exposed, moderately exposed, and sheltered rocky habitats. However, a general pattern emerged from these contrasts in which one of the dominant species of kelp typically exhibited significantly higher density on the oiled shores because of a greater number of smaller plants in the population. This pattern may reflect recovery of the kelp from losses that were related to either the toxic effects of the oil or the intense boating activity associated with the shoreline treatment and assessment programs (Stekoll et al. 1993; Dean et al. 1996a). In 1957 the Tempico Maru spilled 60 000 barrels of diesel into a small cove in Santa Barbara, California over 8 months. Profuse young *Macrocystis* growth was seen after 6 months, and the algae was apparently unaffected by the oil, but also favoured by the elimination of the grazing fauna (North 1967).
Recovery	Reduced population status	1 *	There have been increasing reports of canopy kelp decline in past few years (*Nereocystis* and *Macrocystis*). Most recent kelp report from DNR in Wash showed declines (Ecoscan Resource Data 2015), and many local community groups in BC are reporting declines (eg. Help the Kelp).
	Low reproductive capacity	1	Recruitment density of Giant Kelp is significantly reduced as little as 3m from the parent plants (Reed et al. 1988).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 11	MARINE PLANTS and ALGAE	Subtidal	Understory Algae	Rocky habitat	With tall, woody stipes or floats
Example species: Pterygophera californica, Sargassum muticum					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Recruitment of Pterygophera has been found to be significantly lower just 3 m away from adult plants (Reed 1988), which can lead to aggregated populations.
	Low mobility	1	All algae are immobile.
	Sea surface interacting	1	Some woody stipe species, or those with floats, in this subgroup may be tall enough to reach the sea surface from the shallow subtidal environment.
	Seafloor interacting	0	Species in this subgroup may be held out of contact with the seafloor by their stiff stipes or floats.
Sensitivity	Mechanical sensitivity	1	Photosynthetic impairment due to smothering is documented in marine algae, and is related to thickness of oil (O'Brien and Dixon 1976).
	Chemical sensitivity	1 *	Lack of research on subtidal species specifically. Refer to justification for subgroup 6.
Recovery	Reduced population status	0	-
	Low reproductive capacity	1	Pterygophera does not become reproductive until 3-5 years after establishment and can live for up to 25 years (Lobban and Harrison 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 12	MARINE PLANTS and ALGAE	Subtidal	Understory Algae	Rocky habitat	Without tall, woody stipes or floats
Example species: Desmarestia sp, Agarum fimbriatum, Laminaria sp.					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	See explanation for 'High energy, intertidal, rocky habitat canopies (*Egregia*)' above.
	Low mobility	1	All algae are immobile.
	Sea surface interacting	0	Species in this subgroup lack stiff stipes or floats that would allow them to reach the sea surface from the subtidal environment.
	Seafloor interacting	1	Species in this subgroup do not have a stiff stipe or floats to hold them away from the seafloor and so will be in contact with it.
Sensitivity	Mechanical sensitivity	1	Photosynthetic impairment due to smothering is documented in marine algae, and is related to thickness of oil (O'Brien and Dixon 1976).
	Chemical sensitivity	1 *	Lack of research on subtidal species specifically. Refer to justification for subgroup 7.
Recovery	Reduced population status	0	-
	Low reproductive capacity	0	See explanation for 'intertidal, canopy, high energy rocky shore' (*Egregia*) (Lobban and Harrison 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 13	MARINE PLANTS and ALGAE	Subtidal	Turf Algae	Rocky habitat	N/A
Example species: Callophyllis sp.; Dictyota binghamiae					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	See explanation for 'High energy, intertidal, rocky habitat canopies (*Egregia*)' above.
	Low mobility	1	All algae are immobile.
	Sea surface interacting	0	The species in this subgroup are not expected to be tall enough to reach the sea surface from the subtidal environment.
	Seafloor interacting	1	Algae in this subgroup are not tall, and will be in contact with the substrate to which they are anchored.
Sensitivity	Mechanical sensitivity	1	Photosynthetic impairment due to smothering is documented in marine algae, and is related to thickness of oil (O'Brien and Dixon 1976).
	Chemical sensitivity	1 *	Lack of research on subtidal species specifically. Refer to justification for subgroup 7.
Recovery	Reduced population status	0	-
	Low reproductive capacity	0	See explanation for 'intertidal, canopy, high energy rocky shore' (Egregia) (Lobban and Harrison 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 14	MARINE PLANTS and ALGAE	Subtidal	Encrusting Algae	Rocky habitat	N/A
Example species: coralline algal crusts, Hildenbrandia sp.					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Coralline algae crusts are widespread in many areas.
	Low mobility	1	All algae are immobile.
	Sea surface interacting	0	An encrusting seaweed in the subtidal would not interact with the sea surface.
	Seafloor interacting	1	Encrusting algae grow directly over rocks, thereby interacting with the substrate.
Sensitivity	Mechanical sensitivity	1	Photosynthetic impairment due to smothering is documented in marine algae, and is related to thickness of oil (O'Brien and Dixon 1976).
	Chemical sensitivity	1 *	Following the grounding of the General M. C. Meigs near Cape Flattery, Washington, and the release of Navy Special fuel oil, *Corallina vancouveriensis* and *Bossiella sp*. lost photosynthetic pigment (Clark et al. 1973, Clark et al. 1975).
Recovery	Reduced population status	0	-
	Low reproductive capacity	0	See explanation for ‘intertidal, canopy, high energy rocky shore’ (Egregia) (Lobban and Harrison 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	Algae have no roots and grow on rocks; therefore, not in close association with unconsolidated substrates.

SG ID 15	MARINE PLANTS and ALGAE	Pelagic	Phytoplankton	N/A	N/A
N/A					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	Phytoplankton are ubiquitous, but can also occur in discrete, single species blooms that could be considered an aggregation.
	Low mobility	1	All algae are immobile.
	Sea surface interacting	1	Phytoplankton are found throughout the water column and many would interact with the surface.
	Seafloor interacting	0	This subgroup is pelagic and not expected to interact with the seafloor.
Sensitivity	Mechanical sensitivity	0	Phytoplankton are unlikely to be smothered by oil due to their small size and the fact that they are pelagic.
	Chemical sensitivity	1 *	At low concentrations, exposure to oil can actually stimulate growth of some species (< 1.0 mg/L), but at higher concentrations causes growth inhibition (Ozhan et al. 2014).
Recovery	Reduced population status	0	-
	Low reproductive capacity	0	See explanation for ‘intertidal, canopy, high energy rocky shore’ (*Egregia*).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	This subgroup is pelagic and not expected to interact with unconsolidated substrates.

SG ID 16	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Sessile (attached to hard substrate)	Arthropoda
Example species: Acorn Barnacle					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Several barnacles have gregarious recruitment (e.g. *Balanus nubilus*) (Burke 1986; Rudy and Rudy 1983).
	Low mobility	1	Sessile subgroup.
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1 *	In an experimental study investigating the effects of fuel oil on the barnacle *Balanus amphitrite*, only adults exposed to 5 ppm concentrations of water soluble fraction recovered after 96 hours, and not those exposed to 10, 15, or 20 ppm. Cirral beating was altered at 5 and 10 ppm, affecting nutritional activity, and stopped altogether at 15 and 20 ppm resulting in organism death (Hashim 2010). However, Suchanek (1993) found that most barnacles seem to have a tremendous tolerance for oil. Unless they are directly covered, and thereby die from smothering, they survive quite well even with oil surrounding their shell. Larvae even settle and survive on recently spilled oil, but may die when that layer eventually sloughs from the substratum. Goose-neck Barnacles are often seen attached to floating tar balls at sea.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 17	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Sessile (attached to hard substrate)	Mollusca
Example species: Pacific Oyster, California Mussel					**Total Score: 7**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	*Crassostrea gigas* oysters have gregarious recruitment (Vasquez et al. 2013).
	Low mobility	1	Sessile subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	In addition to diffusion of dissolved fractions across membranes, filter-feeding mussels, oysters, and clams are especially susceptible to ingesting oil droplets and oil adsorbed to particles while filter-feeding (Payne and Driskell 2003). Studies following EVOS showed that oil spills have acute and chronic effects on mussel health and that oil that has seeped beneath mussel beds can linger for years (reviewed in Herunter et al. 2017). LC50 values (96 h) reported for early-life stages of molluscs exposed to crude oil are in the range of 1.14 – 1.83 mg TPH/L (reviewed in NRC 2005). In *Mytilus edulis*, exposure to sublethal concentrations of crude oil caused increased levels of estradiol in non-gonadal tissue (e.g. gills, mantle) and estradiol sulfation increased in digestion glands, potentially reducing estradiol affinity for estrogen receptors (Lavado et al. 2006). Studies have noted that phagocytosis, the predominant mechanism of immunity in bivalves, tends to decrease when bivalves (*Mytilus edulis*; *Mya arenaria*) are exposed to PAH (Grundy et al. 1996a; Grundy et al. 1996b; Frouin et al. 2007). After experimental exposure of the Arctic Scallop, *Chlamys islandica*, to the WAF of crude oil (21 days), mortalities and reductions in immunocompetence were observed, with significant impairment of phagocytosis and cell membrane stability. Scallops were also subjected to oxidative stress, with a significant reduction in glutathione levels and induction of lipid peroxidation. After the acute oil exposure had subsided, no recovery of immune function was observed indicating potential for prolonged sublethal effects (Hannam et al. 2010).
Recovery	Reduced population status	1	Northern Abalone (Endangered - COSEWIC 2016); Olympia Oyster (Special Concern - COSEWIC 2016)
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 18	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Sessile (attached to hard substrate)	Cnidaria
Example species: Red Soft Coral					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1 *	Lower reproduction rates after an oil spill cause damage to a coral reef by decreasing the number of planulae available for settlement (Kushmaro et al. 1997). According to Suchanek (1993) some jellyfish seem especially resistant to oil. The anemones *Anthopleura* and *Actinia* are species found surviving in waters with some of the most serious pollution, both from individual spills and chronic inputs (Nelson-Smith, 1972). However, other Cnidaria, such as the hydroid *Tubularia*, are much more sensitive, experiencing substantial mortality when subjected to only low concentrations of crude oil. There were few applicable references found for this group and the following study likely includes the effect of dispersants. Corals were impacted at several study sites after the Deepwater Horizon crude oil blowout. In the 7 years following the spill, patchy coverings of hydroids on exposed skeleton were noted at impacted sites as well as significantly higher rates of unhealthy, hydroid colonized, and broken branches. Results of the study suggest that many more years will be necessary for coral recovery and that colonies with more extensive injury may never recover (summarized in Girard and Fisher 2018).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 19	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Sessile (attached to hard substrate)	Porifera
Example species: encrusting sponges					**Total Score: 8**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	Larvae of the sponge *Rhopaloeides odorabile* survived exposure to high concentrations of petroleum hydrocarbons; however, their ability to settle and metamorphose was adversely affected at environmentally relevant concentrations, and these effects were paralleled by marked changes in sponge gene expression and preceded by disruption of the symbiotic microbiome. (Luter et al. 2019). Exposure to PAH induced DNA damage in *Tethya lyncurium* (Zahn et al. 1983). The marine sponge *Halichondria panicea* exposed to the WAF of crude oil displayed lowered clearance rates even 48 h after the end of the exposure time. It is likely that stopping its filtration activity for extensive periods of time will strongly impact survival of *H. panicea*, by lowering the energy input the sponge receives (Vad et al. 2020).
Recovery	Reduced population status	1	Austin (2000) considers the sand sponge (*Psammopemma new sp*) threatened.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	1	The Flattened Sac Sponge (*Grantia sp. aff. Compressa*) is known only from one littoral cave in British Columbia and has not been reported outside of BC. The Sand Sponge (*Psammopemma new sp.*) is known only from one littoral cave in BC and has not been reported outside of BC (Austin 2000).
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 20	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Sessile (attached to hard substrate)	Worms
Example species: tube worms					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	*Eudistylia vancouveri* have gregarious recruitment (Rudy and Rudy 1983).
	Low mobility	1	Sessile subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	After a diesel spill into Puget sound in 1971, polychaetes and nemerteans were among the most heavily affected marine invertebrates (Chia 1971). During experimental exposure of the Marine Polychaetes *Capitella capitata* and *Neanthes arenaceodentata* to different oils, Bunker C was more toxic than No. 2 fuel oil for *C. capitata* (48 hour TLm values of 1.1 ppm and 3.5 ppm, respectively), while the reverse was observed for *N. arenaceodentata* (48 hour TLm values of 4.6 ppm and 3.2 ppm, respectively). Both oils were more toxic than the control treatments (where no mortality was observed) and the two types of crude oil tested (16.2 and >10.4 for *C. capitata*; 13.9 and >10.4 for *N. arenaceodentata*) (Rossi et al. 1976).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 21	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Sessile (attached to hard substrate)	Urochordata
Example species: horseshoe tunicate					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	After the 2002 Prestige spill of heavy fuel oil in Spain, it took 2–5 years for the tunicate *Botryllus schlosseri* to reappear at one study site (Castege et al. 2014).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 22	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Sessile (attached to hard substrate)	Lophophorata
Example species: encrusting bryozoans					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Lophophorates filter feed using the lophophore (Pechenik 2005) which can become clogged with oil.
	Chemical sensitivity	1 *	Few references found for sensitivity of lophophorates. In one study investigating larval recruitment onto clay tiles fouled with various treatments of crude oil, Bryozoan (*Membranipora savartii*) recruitment was significantly reduced in all experiments (Banks and Brown 2002). Precautionary scoring used because it is unknown whether this was because of toxicity.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 23	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Low mobility	Worms
Example species: peanut worms, ribbon worms					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Spawning aggregations (Blake 1975)
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	Most feed by eversion of muscular pharynx (Pechenik 2005.)
	Chemical sensitivity	1	After a diesel spill into Puget sound in 1971, polychaetes and nemerteans were among the most heavily affected marine invertebrates (Chia 1971).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 24	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Low mobility	Arthropoda
Example species: Rockweed Isopod					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Isopods aggregate for social and reproductive reasons (Heip 1976)
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	Results of several studies have shown that amphipods are sensitive to oil spills and they may be slow to recover (Bonsdorff and Nelson 1981; the "Amoco Cadiz" in Dauvin, 1982, 1987; Dauvin and Gentil, 1990; the “Tsesis" in Linden et al. 1979, Elmgren et al. 1983; and the "Braer" in Kingston et al. 1995).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 25	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Low mobility	Cnidaria
Example species: Green Surf Anemone					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	*Anthopleura elegantissima* displays gregarious settlement (Ford 1964).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Some species suspension feed (Pechenik 2005).
	Chemical sensitivity	1	Crude oil treatments (concentration of 2.5 ml/L) on the sea anemone *Actinia equina* resulted, for about seven weeks, in ejection of increased numbers of the young which are normally brooded within the gastric cavity. Subsequently the numbers of surviving young being produced fell to zero, and the ovaries were found to be regressed and lacking ova. The anemones were also more frequently observed with tentacles expanded and mouth open, but the response to food offered to the tentacles was slow or absent (Ormond and Caldwell 1982). According to Suchanek (1993) some jellyfish seem especially resistant to oil. The Anemones *Anthopleura* and *Actinia* are species found surviving in waters with some of the most serious pollution, both from individual spills and chronic inputs (Nelson-Smith, 1972). However, other Cnidaria, such as the hydroid *Tubularia*, are much more sensitive, experiencing substantial mortality when subjected to only low concentrations of crude oil.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 26	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Low mobility	Mollusca
Example species: Gumboot Chiton, Turban Snail					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Breeding aggregations (Heip 1976)
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	Don't filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1	After the Amoco Cadiz spill of light crude oil, a variety of animals, particularly limpets and periwinkles, were killed. Effects were due to oil alone since they were observed in areas where no detergents were used (Hess 1978). After the EOVS, the Periwinkle (*Littorina sitkana*) and the drill (*Nucella spp*) showed reduced numbers 15-17 months after the spill on beaches that were oiled, but not pressure washed (Houghton et al. 1997). Littorinids have been noted to display alterations in feeding, aggression and alarm responses, as well as altered gametogenesis. Among molluscs, most limpets seem particularly sensitive to oil with severely reduced populations following an oil spill (Suchanek 1993).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 27	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	Low mobility	Echinodermata
Example species: Purple Urchin, Orange Sea Cucumber, Purple Ochre Star					Total Score: 7

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Sea urchins aggregate for defense and feeding (Vadas et al. 1986).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Some sea cucumbers suspension feed (Pechenik 2005).
	Chemical sensitivity	1	After the EVOS, Dermasterias imbricata and Evasterias troschelii (Stimpson) both exhibited significantly lower densities in oiled kelp beds. No significant differences in abundance were demonstrated for three other seastar species that were common enough to test (Dean et al 1996b). Experimental exposure of the seastar *Evasterias* troschelii to the WSF of crude oil resulted in LC50 (19 d) values of 0.82 ppm, daily feeding rates were significantly reduced at all concentrations above 0.12 ppm, and at the two highest concentrations (0.97 and 1.31 ppm) the sea stars did not feed. Slower growth was noted above 0.12 ppm (O'Clair and Rice 1985). During the first 10 months of observations following the General M.C. Meigs spill of Navy special fuel oil, many Purple sea urchins (*Strongylocentrotus purpuratus*) in localized areas were dead or had lost enough of their spines to make their survival improbable (Clark et al. 1978). According to Suchanek (1993), echinoderms seem especially sensitive to the toxic effects of oil, likely because of the large amount of exposed epidermis. Both seastars (*Pisaster*) and sea urchins (*Strongylocentrotus*) were eliminated for several years following the 1957 wreck of the Tampico Maru off the coast of Baja California (Nelson-Smith, 1972). Abnormal embryogenesis and non-viable larvae for *Strongylocentrotus* exposed to hydrocarbon concentrations of 10 to 30 mg/L (Mageau et al. 1987). Inhibition of feeding and growth in seastar *Evaserias trsochelli* at crude oil WSF >0.12 mg/L.
Recovery	Reduced population status	1	Seastar wasting disease has caused population declines (Hewson et al. 2014). The Sunflower Seastar (*Pycnopodia helianthoides*) is listed as critically endangered with a decreasing population trend on IUCN Red List (Gravem et al. 2020).
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 28	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	High mobility	Arthropoda (other)
Example species: Red Rock Crab					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Several crabs form breeding aggregations (Stevens et al. 1994; Stevens et al. 1992).
	Low mobility	0	High mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	Don't filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1	After the EVOS, the Helmet Crab, *Telmessus cheiragonus*, had an 80% lower density in oiled kelp beds than in unoiled controls (Dean et al 1996b). In a laboratory experiment, Premolt and postmolt juvenile male Tanner crabs, *Chionoecetes bairdi* , exposed to crude oil were similarly susceptible, and estimated 48-hour TLm (median tolerance limits) values were 0.56 ml oil/L. Molting success decreased with increasing exposure of crabs to oil, and newly molted crabs autolized limbs during exposure to oil (Karinen and Rice 1974). Experimental exposure of Dungeness Crabs (*Cancer magister*) to sediment contaminated with crude oil (0, 1.2, 3.7, or 8.6 ul oil/g) resulted in lowered reproductive activity and the larvae produced were not as robust, as indicated by shorter survival times compared with control larvae (Karinen et al. 1985).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 29	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	High mobility	Arthropoda (filter feeders)
Example species: Porcelain Crabs					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Porcelain crabs have gregarious recruitment behaviour (Jensen 1989).
	Low mobility	0	High mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1 *	No references found for the sensitivity of organisms in this group. Refer to subgroup 28 for more information.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 30	MARINE INVERTEBRATES	Intertidal	Rock and rubble dwellers	High mobility	Mollusca
Example species: Giant Pacific Octopus					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Giant Pacific Octopus is solitary (Kubodera 1991).
	Low mobility	1	High mobility subgroup, but exhibits site fidelity (Kubodera 1991).

Category	Criteria	Score	Justification
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	Don't filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1 *	No references found for the sensitivity of organisms in this group.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	1	Giant Pacific Octopus females reach sexual maturity at 3-5 years and die after spawning and tending eggs (Kubodera 1991) - this gives a much lower reproductive capacity and is as low as some marine mammals.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 31	MARINE INVERTEBRATES	Intertidal	Sediment infauna	Low mobility	Mollusca
Example species: Littleneck Clams, Razor Clam, Olive Snails					**Total Score: 7**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Conspecific aggregation is common for many bivalve species and is important for spawning synchronization and fertilization success (Sastry 1979).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Sediment infauna live within the seafloor substrate, so have regular interaction.

Category	Criteria	Score	Justification
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	In addition to diffusion of dissolved fractions across membranes, filter-feeding mussels, oysters, and clams are especially susceptible to ingesting oil droplets and oil adsorbed to particles while filter-feeding (Payne and Driskell 2003). Soft-shell clams (*Mya arenaria*) fed PAH-contaminated algae showed delayed gametogenesis in both males and females, possibly related to alteration in steroid synthesis (Frouin et al. 2007). Studies have noted that phagocytosis, the predominant mechanism of immunity in bivalves, tends to decrease when bivalves (Mytilus edulis; Mya arenaria) are exposed to PAH (Grundy et al. 1996a; Grundy et al. 1996b; Frouin et al. 2007). Studies following EVOS suggest that Littleneck Clams (*Protothaca staminea*) accumulate more polycyclic aromatic hydrocarbons (PAHs) than mussels and recover more slowly from oiling and cleanup activity (reviewed in Herunter et al. 2017).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment infauna live within unconsolidated substrates, so have a high degree of interaction.

SG ID 32	MARINE INVERTEBRATES	Intertidal	Sediment infauna	Low mobility	Worms
Example species: Burrowing Polychaete Worms					Total Score: 9

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Sediment infauna live within the seafloor substrate, so have regular interaction.

Category	Criteria	Score	Justification
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	Within 16 days of the Tsesis medium grade fuel oil spill, the marine worm *Harrnothoe sarsi* showed reduction to less than 5% of pre-spill biomasses and meiofaunal turbellarians also showed clear reductions in abundance, while nematodes appeared unaffected (Elmgren et al 1983). After the Exxon-Valdez spill, there was a widespread and substantial enhancement of oligochaete worm populations, likely due to an enhancement of production by oil-degrading microbes (sedimentary microbes are part of oligochaete diets) (summarized in Peterson 2001). Lugworms (Arenicola spp.) have been shown to be relatively resistant to oil pollution (Gordon et al 1978; Gundlach et al. 1981).
Recovery	Reduced population status	1	Austin (2000) considers the Orange Acorn Worm (*Saccoglossus sp*.) threatened.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	1	The orange acorn worm (*Saccoglossus sp*.) is known from only 5 sites (lagoons) in BC and has not been found outside BC (Austin 2000).
	Association with unconsolidated substrates	1	Sediment infauna live within unconsolidated substrates, so have a high degree of interaction.

SG ID 33	MARINE INVERTEBRATES	Intertidal	Sediment infauna	Low mobility	Arthropoda
Example species: Ghost Shrimp					Total Score: 8

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	More highly aggregated during breeding season (Perry 1980).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Sediment infauna live within the seafloor substrate, so have regular interaction.

Category	Criteria	Score	Justification
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	Within 16 days of the Tsesis medium grade fuel oil spill, meiofaunal ostracods and harpacticoids showed clear reductions in abundance (Elmgren et al. 1983). Results of several studies have shown that amphipods are sensitive to oil spills and they may be slow to recover (Bonsdorff and Nelson 1981; the "Amoco Cadiz" in Dauvin, 1982, 1987; Dauvin and Gentil, 1990; the "Tsesis" in Linden et al. 1979, Elmgren et al., 1983; and the "Braer" in Kingston et al. 1995). After the Florida spill of No. 2 fuel oil, Fiddler crabs (*Uca pugnax*) in the oiled marsh were reduced in density, had slower movement, and dug shallower burros than normal. Newly settled crabs were more affected than adults and settling was reduced (Krebs and Burns 1977). Amphipods in general, and ampeliscid amphipods in particular, seem especially sensitive to oil, often not returning to prespill abundances for 5 or more years, which is likely related to the persistence of oil within sediments (Southward, 1982 - as reported in Suchanek, 1993).
Recovery	Reduced population status	1 *	Blue Mud Shrimp (*Upogebia pugettensis*) populations on Calvert Island, BC recently found to be infected with parasitic isopod. Population declines not reported for BC, but parasite has been implicated in host population declines in the southern portion of its known invasive range (Whalen et al. 2020).
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment infauna live within unconsolidated substrates, so have a high degree of interaction.

SG ID 34	MARINE INVERTEBRATES	Intertidal	Sediment infauna	Low mobility	Lophophorata
Example species: Horseshoe Worms					**Total Score: 7**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Sediment infauna live within the seafloor substrate, so have regular interaction.

Category	Criteria	Score	Justification
Sensitivity	Mechanical sensitivity	1	Lophophorates filter feed using the lophophore (Pechenik 2005) which can become clogged with oil.
	Chemical sensitivity	1 *	No references found for the sensitivity of organisms in this group.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment infauna live within unconsolidated substrates, so have a high degree of interaction.

SG ID 35	MARINE INVERTEBRATES	Intertidal	Sediment epifauna	Low mobility	Mollusca
Example species: whelks					Total Score: 8

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Can be highly aggregated, particularly during breeding; e.g. *Nucella lamellosa* (was *Thais lamellosa*) (Spight 1974).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Sediment epifauna live in close contact with the seafloor, so have regular interaction.
Sensitivity	Mechanical sensitivity	1	Some species suspension feed (Pechenik 2005).
	Chemical sensitivity	1	After the Amoco Cadiz spill of light crude oil, a variety of animals, particularly limpets and periwinkles, were killed. Effects were due to oil alone since they were observed in areas where no detergents were used (Hess 1978). After the EOVS, the periwinkle (*Littorina sitkana*) and the drill (*Nucella spp*) showed reduced numbers 15-17 months after the spill on beaches that were oiled, but not pressure washed (Houghton et al. 1997). After the Isla Payardi refinery spill of medium crude oil onto a tropical reef flat, there was immediate mortality of several snail species (at least ten) in heavily oiled areas before cleanup was initiated (Garrity and Levings 1990).

Category	Criteria	Score	Justification
Recovery	Reduced population status	1	Newcomb Periwinkle (*Algamorda subrotundata*) is listed as a species of concern under the US Federal Endangered Species Act (Gaydos and Gilardi 2003).
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment epifauna live in close contact with unconsolidated substrates and may forage within them.

SG ID 36	MARINE INVERTEBRATES	Intertidal	Sediment epifauna	Low mobility	Cnidaria
Example species: Stubby Rose Anemone					Total Score: 8

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001); Sea whips aggregate as well (Lindholm et al. 2008).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Sediment epifauna live in close contact with the seafloor, so have regular interaction.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1 *	No references found for the sensitivity of organisms in this group, but refer to subgroups 18 and 25 for information on the sensitivity of other cnidarians.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	1	Some sea pens take over 5 years to mature (Reviewer comment: Anya Dunham, DFO).
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment epifauna live in close contact with unconsolidated substrates and may forage within them.

SG ID 37	MARINE INVERTEBRATES	Intertidal	Sediment epifauna	Low mobility	Echinodermata
Example species: Bat Star					**Total Score: 8**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Feeding aggregations; e.g.Pisaster ochraceus feeding on mussel beds (Mcclintock and Robnett 1986).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Sediment epifauna live in close contact with the seafloor, so have regular interaction.
Sensitivity	Mechanical sensitivity	1	Some species suspension feed (Pechenik 2005)….
	Chemical sensitivity	1	After the EVOS, *Dermasterias imbricata* and *Evasterias troschelii* (Stimpson) both exhibited significantly lower densities in oiled kelp beds. No significant differences in abundance were demonstrated for three other seastar species that were common enough to test (Dean et al 1996b). Experimental exposure of the seastar *Evasterias troschelii* to the WSF of crude oil resulted in LC50 (19 d) values of 0.82 ppm, daily feeding rates were significantly reduced at all concentrations above 0.12 ppm, and at the two highest concentrations (0.97 and 1.31 ppm) the sea stars did not feed. Slower growth was noted above 0.12 ppm (O'Clair and Rice 1985).
Recovery	Reduced population status	1	Seastar wasting disease has caused population declines (Hewson et al. 2014). The Sunflower Seastar (*Pycnopodia helianthoides*) is listed as critically endangered with a decreasing population trend on IUCN Red List (Gravem et al. 2020).
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity
	Endemism/Isolation	0	No evidence of endemism or isolation could be found
	Association with unconsolidated substrates	1	Sediment epifauna live in close contact with unconsolidated substrates and may forage within them.

SG ID 38	MARINE INVERTEBRATES	Intertidal	Sediment epifauna	High mobility	Arthropoda
Example species: Dungeness Crab					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Several crabs form breeding aggregations (Stevens et al. 1994; Stevens et al. 1992).
	Low mobility	0	High mobility subgroup
	Sea surface interacting	1	Primary habitat is the intertidal, which is in regular contact with the sea surface.
	Seafloor interacting	1	Sediment epifauna live in close contact with the seafloor, so have regular interaction.
Sensitivity	Mechanical sensitivity	0	Don't filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1	Hippolytid Shrimp (*Eualus spp*.) had low LC50 (96 h) values (0.0016-0.0017 mg TPAH/L; high acute toxicity) when exposed to crude oil (Korn et al. 1979). Within 16 days of the Tsesis medium grade fuel oil spill, amphipods of the genus Pontoporeia showed reduction to less than 5% of pre-spill biomasses (Elmgren et al. 1983). After the EVOS, the Helmet Crab, *Telmessus cheiragonus*, had an 80% lower density in oiled kelp beds than in unoiled controls (Dean et al 1996b). In a laboratory experiment, Premolt and postmolt juvenile male Tanner Crabs, *Chionoecetes bairdi* , exposed to crude oil were similarly susceptible, and estimated 48-hour TLm (median tolerance limits) values were 0.56 ml oil/L. Molting success decreased with increasing exposure of crabs to oil, and molted crabs autolized limbs during exposure to oil (Karinen and Rice 1974). Experimental exposure of Dungeness Crabs (*Cancer magister*) to sediment contaminated with crude oil (0, 1.2, 3.7, or 8.6 ul oil/g) resulted in lowered reproductive activity and the larvae produced were not as robust, as indicated by shorter survival times compared with control larvae (Karinen et al. 1985).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment epifauna live in close contact with unconsolidated substrates and may forage within them.

SG ID 39	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Sessile (attached to hard substrate)	Arthropoda
Example species: Giant Barnacle					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1 *	In an experimental study investigating the effects of fuel oil on the Barnacle *Balanus amphitrite*, only adults exposed to 5 ppm concentrations of water soluble fraction could be recovered after 96 hours, and not those exposed to 10, 15, or 20 ppm. Cirral beating was altered at 5 and 10 ppm, affecting nutritional activity, and stopped altogether at 15 and 20 ppm resulting in organism death (Hashim 2010). However, Suchanek (1993) found that most barnacles seem to have a tremendous tolerance for oil. Unless they are directly covered, and thereby die from smothering, they survive quite well even with oil surrounding their shell. Larvae even settle and survive on recently spilled oil, but may die when that layer eventually sloughs from the substratum. Goose-neck barnacles are often seen attached to floating tar balls at sea.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	1	While the Goose Barnacle (*Pollicipes polymerus*) is not rare in BC on wave-exposed intertidal coasts, 2 populations in unique subtidal habitat exist at Nakwakto Rapids, where tidal currents reach 16 knots (Austin 2000).
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 40	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Sessile (attached to hard substrate)	Mollusca
Example species: Rock Scallop					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Conspecific aggregation is common for many bivalve species and is important for spawning synchronization and fertilization success (Sastry 1979).
	Low mobility	1	Sessile subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	In addition to diffusion of dissolved fractions across membranes, filter-feeding mussels, oysters, and clams are especially susceptible to ingesting oil droplets and oil adsorbed to particles while filter-feeding (Payne and Driskell 2003). Studies following EVOS showed that oil spills have acute and chronic effects on mussel health and that oil that has seeped beneath mussel beds can linger for years (reviewed in Herunter et al. 2017). LC50 values (96 h) reported for early-life stages of molluscs exposed to crude oil are in the range of 1.14 – 1.83 mg TPH/L (reviewed in NRC 2005). In *Mytilus edulis*, exposure to sublethal concentrations of crude oil caused increased levels of estradiol in non-gonadal tissue (e.g. gills, mantle) and estradiol sulfation increased in digestion glands, potentially reducing estradiol affinity for estrogen receptors (Lavado et al. 2006). Studies have noted that phagocytosis, the predominant mechanism of immunity in bivalves, tends to decrease when bivalves (*Mytilus edulis*; *Mya arenaria*) are exposed to PAH (Grundy et al. 1996a; Grundy et al. 1996b; Frouin et al. 2007). After experimental exposure of the Arctic Scallop, *Chlamys islandica*, to the WAF of crude oil (21 days), mortalities and reductions in immunocompetence were observed, with significant impairment of phagocytosis and cell membrane stability. Scallops were also subjected to oxidative stress, with a significant reduction in glutathione levels and induction of lipid peroxidation. After the acute oil exposure had subsided, no recovery of immune function was observed indicating potential for prolonged sublethal effects (Hannam et al. 2010).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion

SG ID 41	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Sessile (attached to hard substrate)	Cnidaria
Example species: Cup Coral, Bubblegum Coral					**Total Score: 7**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	Lower reproduction rates after an oil spill cause damage to a coral reef by decreasing the number of planulae available for settlement (Kushmaro et al. 1997). According to Suchanek (1993) some jellyfish seem especially resistant to oil. The anemones *Anthopleura* and *Actinia* are species found surviving in waters with some of the most serious pollution, both from individual spills and chronic inputs (Nelson-Smith, 1972). However, other Cnidaria, such as the hydroid Tubularia, are much more sensitive, experiencing substantial mortality when subjected to only low concentrations of crude oil. There were few applicable references found for this group and the following study likely includes the effect of dispersants. Corals were impacted at several study sites after the Deepwater Horizon crude oil blowout. In the 7 years following the spill, patchy coverings of hydroids on exposed skeleton were noted at impacted sites as well as significantly higher rates of unhealthy, hydroid colonized, and broken branches. Results of the study suggest that many more years will be necessary for coral recovery and that colonies with more extensive injury may never recover (summarized in Girard and Fisher 2018).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	1	Some coral species are slow to reach maturity (e.g. Gorgonian Corals) (Reviewer comment: Anya Dunham).
	Endemism/Isolation	1	The Raspberry Hydroid (*Corymorpha sp.*) is known only from 3 sites (10-30 m depth) in one local region in BC. The White Stubby Hydrocoral (*Stylaster? sp.*) is known only from 1 site (18 m depth, Biosphere Reserve) in BC. The Bamboo Coral (*Isadella sp.*) is known only from 2 sites (238+ m, fjord, seamount) in BC. The Tall Deep Sea Anemone (*Synhalcurias sp.*) is known only from 1 site (80 m, unique habitat) in BC. None of these species have been reported outside BC (Austin 2000).
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 42	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Sessile (attached to hard substrate)	Porifera
Example species: Glass Sponges (Boot Sponge, Cloud Sponge)					Total Score: 7

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	Larvae of the sponge *Rhopaloeides odorabile* survived exposure to high concentrations of petroleum hydrocarbons; however, their ability to settle and metamorphose was adversely affected at environmentally relevant concentrations, and these effects were paralleled by marked changes in sponge gene expression and preceded by disruption of the symbiotic microbiome. (Luter et al. 2019). Exposure to PAH induced DNA damage in *Tethya lyncurium* (Zahn et al. 1983). The marine sponge *Halichondria panicea* exposed to the WAF of crude oil displayed lowered clearance rates, even 48 h after the end of the exposure time. It is likely that stopping its filtration activity for extensive periods of time will strongly impact survival of *H. panicea*, by lowering the energy input the sponge receives (Vad et al 2020).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	1	Some sponge species are slow to reach maturity and glass sponges are data limited (Reviewer comment: Anya Dunham).
	Endemism/Isolation	1	While glass sponges are not endemic to the area, the glass sponge reefs are a unique feature (*Rhabdocalyptus dawsoni, Aphrocallistes vastus*) (Austin 2000). The Thick White Felt Sponge (*Halichondria sp. aff. Fibrosa*) has only been reported from one location in BC (at 70 m depth) and has not been reported outside of BC (Austin 2000).
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion

SG ID 43	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Sessile (attached to hard substrate)	Worms
Example species: Feather Duster Worms					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil
	Chemical sensitivity	1	After a diesel spill into Puget Sound in 1971, polychaetes and nemerteans were among the most heavily affected marine invertebrates (Chia 1971). During experimental exposure of the marine polychaetes *Capitella capitata* and *Neanthes arenaceodentata* to different oils, Bunker C was more toxic than No. 2 fuel oil for *C. capitata* (48 hour TLm values of 1.1 ppm and 3.5 ppm, respectively), while the reverse was observed for *N. arenaceodentata* (48 hour TLm values of 4.6 ppm and 3.2 ppm, respectively). Both oils were more toxic than the control treatments (where no mortality was observed) and the two types of crude oil tested (16.2 and >10.4 for *C. capitata*; 13.9 and >10.4 for *N. arenaceodentata*) (Rossi et al. 1976).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity
	Endemism/Isolation	0	No evidence of endemism or isolation could be found
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion

SG ID 44	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Sessile (attached to hard substrate)	Urochordata
Example species: Sea Peach Tunicate					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil
	Chemical sensitivity	1	After the 2002 Prestige spill of heavy fuel oil in Spain, it took 2–5 years for the tunicate *Botryllus schlosseri* to reappear at one study site (Castege et al. 2014)
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity
	Endemism/Isolation	1	The brown spot plated sea squirt (*Pyura sp. cf. tesselata*) is only found at 1 site in BC (unique habitat, 30 m) and has not been reported outside BC (Austin 2000)
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion

SG ID 45	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Sessile (attached to hard substrate)	Lophophorata
Example species: Bryozoans, lampshells					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Sessile subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Lophophorates filter feed using the lophophore (Pechenik 2005) which can become clogged with oil.
	Chemical sensitivity	1 *	Few references found for sensitivity of lophophorates. In one study investigating larval recruitment onto clay tiles fouled with various treatments of crude oil, bryozoan (*Membranipora savartii*) recruitment was significantly reduced in all experiments (Banks and Brown 2002).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 46	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Low mobility	Worms
Example species: Scale Worms					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Breeding aggregations (Blake 1975)
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	After a diesel spill into Puget sound in 1971, polychaetes and nemerteans were among the most heavily affected marine invertebrates (Chia 1971).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 47	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Low mobility	Cnidaria
Example species: Fish-Eating Anemone					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Anemones display gregarious settlement (Ford 1964)
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Some species filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1	Crude oil treatments (concentration of 2.5 ml/L) on the sea anemone *Actinia equina* resulted, for about seven weeks, in ejection of increased numbers of the young which are normally brooded within the gastric cavity. Subsequently the numbers of surviving young being produced fell to zero, and the ovaries were found to be regressed and lacking ova. The anemones were also more frequently observed with tentacles expanded and mouth open, but the response to food offered to the tentacles was slow or absent (Ormond and Caldwell 1982). According to Suchanek (1993) some jellyfish seem especially resistant to oil. The anemones *Anthopleura* and *Actinia* are species found surviving in waters with some of the most serious pollution, both from individual spills and chronic inputs (Nelson-Smith, 1972). However, other Cnidaria, such as the hydroid Tubularia, are much more sensitive, experiencing substantial mortality when subjected to only low concentrations of crude oil.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 48	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Low mobility	Echinodermata
Example species: Red Sea Urchin, Sunflower Star					Total Score: 7

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Sea urchins aggregate for defense and feeding (Vadas et al. 1986).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Some species filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1	After the EVOS, *Dermasterias imbricata* and *Evasterias troschelii* (Stimpson) both exhibited significantly lower densities in oiled kelp beds. No significant differences in abundance were demonstrated for three other seastar species that were common enough to test (Dean et al 1996b). Experimental exposure of the seastar *Evasterias troschelii* to the WSF of crude oil resulted in LC50 (19 d) values of 0.82 ppm, daily feeding rates were significantly reduced at all concentrations above 0.12 ppm, and at the two highest concentrations (0.97 and 1.31 ppm) the sea stars did not feed. Slower growth was noted above 0.12 ppm (O'Clair and Rice 1985). During the first 10 months of observations following the General M.C. Meigs spill of Navy special fuel oil, many Purple Sea Urchins (*Strongylocentrotus purpuratus*) in localized areas were dead or had lost enough of their spines to make their survival improbable (Clark et al. 1978).
Recovery	Reduced population status	1	Seastar wasting disease has caused population declines (Hewson et al. 2014). The Sunflower Seastar (*Pycnopodia helianthoides*) is listed as critically endangered with a decreasing population trend on IUCN Red List (Gravem et al. 2020).
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	1	The Husky Tan Serpent Star, *Ophioplocus esmarki*, has isolated populations in BC and California and no records of sightings in middle of range. This is a live-bearer, so migration in the plankton is unlikely. The Brooding Feather Star (*Antedon sp. aff. petasus*) is known from only 2 sites in BC (2 specimens, N. fjords) and has not been reported outside of BC (Austin 2000).
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 49	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	Low mobility	Mollusca
Example species: Hairy Triton Snail					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Can be highly aggregated, particularly during breeding; e.g. *Nucella lamellosa* (was *Thais lamellosa*) (Spight 1974).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	Don't filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1	After the Amoco Cadiz spill of light crude oil, a variety of animals, particularly limpets and periwinkles, were killed. Effects were due to oil alone since they were observed in areas where no detergents were used (Hess 1978). After the EOVS, the Periwinkle (*Littorina sitkana*) and the Drill (*Nucella spp*) showed reduced numbers 15-17 months after the spill on beaches that were oiled, but not pressure washed (Houghton et al. 1997). Littorinids have been noted to display alterations in feeding, aggression and alarm responses, as well as altered gametogenesis. Among molluscs, most limpets seem particularly sensitive to oil with severely reduced populations following an oil spill (Suchanek 1993).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	1	The limpet like Yellow Sea Slug (*Anidolyta spongotheres*) is known from only 2 sites (100+ m, rare, 2 specimens) in BC. The Vancouver's Okenia Sea Slug (*Okenia vancouverensis*) is known from only 2 sites (20 m, cryptic) in BC. The Snowy Flabellina Sea Slug (*Flabellina sp.*) is known from only 2 sites (harbours) in BC. The Pomegranate Aeolid Sea Slug (*Cuthona punicea*) is known from only 1 site on Red Corymorpha in BC. None of these species have been reported outside BC (Austin 2000).
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 50	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	High mobility	Arthropoda
Example species: Red Rock Crab					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Several crabs form breeding aggregations (Stevens et al. 1994; Stevens et al. 1992).
	Low mobility	0	High mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	Don't filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1	After the EVOS, the Helmet Crab, *Telmessus cheiragonus*, had an 80% lower density in oiled kelp beds than in unoiled controls (Dean et al 1996b). In a laboratory experiment, Premolt and postmolt juvenile male Tanner Crabs, *Chionoecetes bairdi* , exposed to crude oil were similarly susceptible. Estimated 48-hour TLm (median tolerance limits) values were 0.56 ml oil/L. Molting success decreased with increasing exposure of crabs to oil, and newly molted crabs autolized limbs during exposure to oil (Karinen and Rice 1974). Experimental exposure of Dungeness Crabs (*Cancer magister*) to sediment contaminated with crude oil (0, 1.2, 3.7, or 8.6 ul oil/g) resulted in lowered reproductive activity and the larvae produced were not as robust, as indicated by shorter survival times compared with control larvae (Karinen et al. 1985).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 51	MARINE INVERTEBRATES	Subtidal benthic	Rock and rubble dwellers	High mobility	Mollusca
Example species: Giant Pacific Octopus					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Giant Pacific Octopus is solitary (Kubodera 1991)
	Low mobility	1	Giant Pacific Octopus exhibits site fidelity (Kubodera 1991)
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Rock and rubble dwellers live in contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	Don't filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1 *	No references found for the sensitivity of organisms in this group.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	1	Giant Pacific Octopus females reach sexual maturity at 3-5 years and die after spawning and tending eggs (Kubodera 1991) - this gives a much lower reproductive capacity and is as low as some marine mammals.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 52	MARINE INVERTEBRATES	Subtidal benthic	Sediment infauna	Low mobility	Mollusca
Example species: Butter Clam					Total Score: 7

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Conspecific aggregation is common for many bivalve species and is important for spawning synchronization and fertilization success (Sastry 1979).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Sediment infauna live within the seafloor substrate, so have regular interaction.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	In addition to diffusion of dissolved fractions across membranes, filter-feeding mussels, oysters, and clams especially susceptible to ingesting oil droplets and oil adsorbed to particles while filter-feeding (Payne and Driskell 2003). Soft-Shell Clams (*Mya arenaria*) fed PAH-contaminated algae showed delayed gametogenesis in both males and females, possibly related to alteration in steroid synthesis (Frouin et al. 2007). Studies have noted that phagocytosis, the predominant mechanism of immunity in bivalves, tends to decrease when bivalves (*Mytilus edulis; Mya arenaria*) are exposed to PAH (Grundy et al. 1996a; Grundy et al. 1996b; Frouin et al. 2007). Studies following EVOS suggest that Littleneck Clams (*Protothaca staminea*) accumulate more PAHs than mussels and recover more slowly from oiling and cleanup activity (reviewed in Herunter et al. 2017).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	1	Geoducks are slow to mature (7+) years and experience low recruitment and high egg, larval, and juvenile mortality rates (reviewed in Willner 2006). The average recovery time for a harvested geoduck population is predicted to be 39 years (Palazzi et al. 2001).
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment infauna live within unconsolidated substrates, so have a high degree of interaction.

SG ID 53	MARINE INVERTEBRATES	Subtidal benthic	Sediment infauna	Low mobility	Worms
Example species: Burrowing Polychaete Worms					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Spawning aggregations (Blake 1975)
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Sediment infauna live within the seafloor substrate, so have regular interaction.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	Within 16 days of the Tsesis medium grade fuel oil spill, the Marine Worm *Harrnothoe sarsi* showed reduction to less than 5% of pre-spill biomasses and meiofaunal turbellarians also showed clear reductions in abundance, while nematodes appeared unaffected (Elmgren et al 1983). After the Exxon-Valdez spill, there was a widespread and substantial enhancement of oligochaete worm populations, likely due to an enhancement of production by oil-degrading microbes (sedimentary microbes are part of oligochaete diets) (summarized in Peterson 2001). Lugworms (*Arenicola spp*.) have been shown to be relatively resistant to oil pollution (Gordon et al 1978; Gundlach et al. 1981).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment infauna live within unconsolidated substrates, so have a high degree of interaction.

SG ID 54	MARINE INVERTEBRATES	Subtidal benthic	Sediment infauna	Low mobility	Lophophorata
Example species: Horseshoe Worms, Lampshells					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Gregarious recruitment (Shanks 2001)
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Sediment infauna live within the seafloor substrate, so have regular interaction.
Sensitivity	Mechanical sensitivity	1	Lophophorates filter feed using the lophophore (Pechenik 2005) which can become clogged with oil.
	Chemical sensitivity	1 *	No references found for the sensitivity of organisms in this group.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment infauna live within unconsolidated substrates, so have a high degree of interaction.

SG ID 55	MARINE INVERTEBRATES	Subtidal benthic	Sediment epifauna	Low mobility	Mollusca
Example species: whelks					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Some groups/species are almost always found in at least small aggregations eg Bittium (Reviewer comment: Heidi Gartner).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Sediment epifauna live in close contact with the seafloor, so have regular interaction.
Sensitivity	Mechanical sensitivity	1	Some species filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1	After the Amoco Cadiz spill of light crude oil, a variety of animals, particularly Limpets and Periwinkles, were killed. Effects were due to oil alone since they were observed in areas where no detergents were used (Hess 1978). After the EOVS, the Periwinkle (*Littorina sitkana*) and the Drill (*Nucella spp*) showed reduced numbers 15-17 months after the spill on beaches that were oiled, but not pressure washed (Houghton et al. 1997). After the Isla Payardi refinery spill of medium crude oil onto a tropical reef flat, there was immediate mortality of several snail species (at least ten) in heavily oiled areas before cleanup was initiated (Garrity and Levings 1990). Littorinids have been noted to display alterations in feeding, aggression and alarm responses, as well as altered gametogenesis. Among molluscs, most Limpets seem particularly sensitive to oil with severely reduced populations following an oil spill (Suchanek 1993).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment epifauna live in close contact with unconsolidated substrates and may forage within them.

SG ID 56	MARINE INVERTEBRATES	Subtidal benthic	Sediment epifauna	Low mobility	Cnidaria
Example species: Orange Sea Pen					**Total Score: 7**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	*Ptilosarcus guerneyi* and several other cnidarians have gregarious recruitment (Burke 1986).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Sediment epifauna live in close contact with the seafloor, so have regular interaction.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1 *	No references found for the sensitivity of organisms in this group, but refer to subgroups 18 and 25 for information on the sensitivity of other cnidarians.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	1	Some sea pens take 5+ years to mature (Reviewer comment: Anya Dunham).
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment epifauna live in close contact with unconsolidated substrates and may forage within them

SG ID 57	MARINE INVERTEBRATES	Subtidal benthic	Sediment epifauna	Low mobility	Echinodermata
Example species: Sand Star					**Total Score: 7**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Feeding aggregations; e.g.*Pisaster ochraceus* feeding on mussel beds (Mcclintock and Robnett 1986).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Sediment epifauna live in close contact with the seafloor, so have regular interaction.
Sensitivity	Mechanical sensitivity	1	Feather stars suspension feed (Pechenik 2005).
	Chemical sensitivity	1	After the EVOS, *Dermasterias imbricata* and *Evasterias troschelii* (Stimpson) both exhibited significantly lower densities in oiled kelp beds. No significant differences in abundance were demonstrated for three other seastar species that were common enough to test (Dean et al 1996b). Experimental exposure of the Sea Star *Evasterias troschelii* to the WSF of crude oil resulted in LC50 (19 d) values of 0.82 ppm, daily feeding rates were significantly reduced at all concentrations above 0.12 ppm, and at the two highest concentrations (0.97 and 1.31 ppm) the Sea Stars did not feed. Slower growth was noted above 0.12 ppm (O'Clair and Rice 1985).
Recovery	Reduced population status	1	Seastar wasting disease has caused population declines (Hewson et al. 2014).
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment epifauna live in close contact with unconsolidated substrates and may forage within them.

SG ID 58	MARINE INVERTEBRATES	Subtidal benthic	Sediment epifauna	High mobility	Arthropoda
Example species: Dungeness Crab					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Several crabs form breeding aggregations (Stevens et al. 1994; Stevens et al. 1992).
	Low mobility	0	High mobility subgroup
	Sea surface interacting	0	Primary habitat is subtidal, so are not expected to be in regular contact with the sea surface.
	Seafloor interacting	1	Sediment epifauna live in close contact with the seafloor, so have regular interaction.
Sensitivity	Mechanical sensitivity	0	Don't filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1	Hippolytid Shrimp (*Eualus spp*.) had low LC50 (96 h) values (0.0016-0.0017 mg TPAH/L; high acute toxicity) when exposed to crude oil (Korn et al. 1979). Within 16 days of the Tsesis medium grade fuel oil spill, amphipods of the genus Pontoporeia showed reduction to less than 5% of pre-spill biomasses (Elmgren et al 1983). After the EVOS, the Helmet Crab, Telmessus cheiragonus, had an 80% lower density in oiled kelp beds than in unoiled controls (Dean et al 1996b). In a laboratory experiment, Premolt and postmolt juvenile male Tanner Crabs, *Chionoecetes bairdi* , exposed to crude oil were similarly susceptible, and estimated 48-hour TLm (median tolerance limits) values were 0.56 ml oil/L. Molting success decreased with increasing exposure of crabs to oil, and newly molted crabs autolized limbs during exposure to oil (Karinen and Rice 1974). Experimental exposure of Dungeness Crabs (Cancer magister) to sediment contaminated with crude oil (0, 1.2, 3.7, or 8.6 ul oil/g) resulted in lowered reproductive activity and the larvae produced were not as robust, as indicated by shorter survival times compared with control larvae (Karinen et al. 1985).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	1	Sediment epifauna live in close contact with unconsolidated substrates and may forage within them.

SG ID 59	MARINE INVERTEBRATES	Pelagic	N/A	Low mobility	Zooplankton (other than larvae)
Example species: N/A					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	There may be patchiness or aggregations where a large number of individuals would be affected at once.
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Several pelagic zooplankton have regular interaction with surface waters.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Filter or suspension feeders (Pechenik 2005) with feeding appendages that can become clogged by oil.
	Chemical sensitivity	1	The marine copepod *Calanus finmarchicus* had relatively low LC50 (96 h) values (0,7-1 mg THC/L; high acute toxicity) when exposed to crude oil (Hansen et al. 2012). After the Tsesis medium grade fuel oil spill, zooplankton in the immediate vicinity of the spill declined substantially. Zooplankton biomass was re-established after 5 days, but oil contamination of the zooplankton was recorded for over three weeks (Johansson et al. 1980). Results of several studies have shown that amphipods are sensitive to oil spills and they may be slow to recover (e.g. Bonsdorff and Nelson 1981; the "Amoco Cadiz" in Dauvin 1982, 1987; Dauvin and Gentil, 1990; the "Tsesis" in Linden et al. 1979, Elmgren et al. 1983; and the "Braer" in Kingston et al. 1995). When exposed to crude oil, the pelagic copepod Centropages hamatus had reduced feeding and egg viability (Cowles and Remillard 1983) and altered food perception (Cowles 1983). A study on crude oil's effect on mesozooplankton survival was conducted and mortality ranged from 12 % to 96 %, depending on curde oil concentrations. Mortality (5) increased as crude oil concentrations increased (Almeda et al. 2013).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion

SG ID 60	MARINE INVERTEBRATES	Pelagic	N/A	Low mobility	Cnidaria
Example species: Moon Jellyfish					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Jellyfish form large spawning aggregations (e.g. *Aurelia aurita*)(Hamner et al. 1994).
	Low mobility	1	Low mobility subgroup
	Sea surface interacting	1	Several pelagic jellyfish have regular interaction with surface waters.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Fine tentacles may become clumped by oil.
	Chemical sensitivity	1	In a study determining the effects of light crude oil on the scyphozoans *Pelagia noctiluca* and *Aurelia aurita* and the ctenophore *Mnemiopsis leidyi*, the authors found that *P. noctiluca* was highly sensitive to crude oil, while *A. aurita* and *M. leidyi* adults had a high tolerance compared to other zooplankton, the larval stages of gelatinous zooplankton were more sensitive to crude oil than adult stages, and some of the most toxic PAHs of crude oil can be bioaccumulated in gelatinous zooplankton (Almeda et al. 2013). Spangenberg (1987) documented numerous effects on Cnidarians from exposure to Alaska Crude Petroleum (ACP). For the jellyfish *Aurelia*, all compounds of ACP elicited retardation of strobilation initiation, and for some, cessation of strobilation (reported in Suchanek, 1993). For some of the constituent compounds a variety of teratological effects was observed.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 61	MARINE INVERTEBRATES	Pelagic	N/A	High mobility	Mollusca
Example species: Opalescent Squid					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Squid form spawning aggregations (Forsythe et al. 2004).
	Low mobility	0	High mobility subgroup
	Sea surface interacting	1	Pelagic squid perform regular migrations to surface waters for feeding and spawning.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	Don't filter or suspension feed (Pechenik 2005).
	Chemical sensitivity	1 *	No references found for the sensitivity of organisms in this group.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 62	MARINE INVERTEBRATES	Pelagic	Larvae	N/A	Porifera
Example species: N/A					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	There may be patchiness or aggregations where a large number of larvae would be affected at once.
	Low mobility	1	Larvae have low mobility
	Sea surface interacting	1	Pelagic larvae likely to have regular interaction with the sea surface

Category	Criteria	Score	Justification
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	Larvae don't feed in the plankton (Shanks 2001)
	Chemical sensitivity	1	Larvae of the sponge *Rhopaloeides odorabile* survived exposure to high concentrations of petroleum hydrocarbons; however, their ability to settle and metamorphose was adversely affected at environmentally relevant concentrations, and these effects were paralleled by marked changes in sponge gene expression and preceded by disruption of the symbiotic microbiome. (Luter et al. 2019).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 63	MARINE INVERTEBRATES	Pelagic	Larvae	N/A	Cnidaria
Example species: N/A					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	There may be patchiness or aggregations where a large number of larvae would be affected at once.
	Low mobility	1	Larvae have low mobility.
	Sea surface interacting	1	Pelagic larvae likely to have regular interaction with the sea surface.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.

Category	Criteria	Score	Justification
Sensitivity	Mechanical sensitivity	1	Some species filter or suspension feed (e.g. *Metriduim* larvae) (Shanks 2001).
	Chemical sensitivity	1	In a study determining the effects of light crude oil on the scyphozoans *Pelagia noctiluca* and *Aurelia aurita* and the ctenophore *Mnemiopsis leidyi*, the authors found that *P. noctiluca* was highly sensitive to crude oil, while *A. aurita* and *M. leidyi* adults had a high tolerance compared to other zooplankton, the larval stages of gelatinous zooplankton were more sensitive to crude oil than adult stages, and some of the most toxic PAHs of crude oil can be bioaccumulated in gelatinous zooplankton (Almeda et al. 2013).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 64	MARINE INVERTEBRATES	Pelagic	Larvae	N/A	Worms
Example species: N/A					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	There may be patchiness or aggregations where a large number of larvae would be affected at once.
	Low mobility	1	Larvae have low mobility
	Sea surface interacting	1	Pelagic larvae likely to have regular interaction with the sea surface.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Many larvae in this subgroup have cilia for capturing food particles (Shanks 2001).
	Chemical sensitivity	1	During experimental exposure of the larvae of three annelid species (*Nereis vexilosa*, *Serpula vermicularis*, *Nereis branti*) to diesel WAF (0.5 %), all larvae died within 48 hours (Chia 1973).

Category	Criteria	Score	Justification
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 65	MARINE INVERTEBRATES	Pelagic	Larvae	N/A	Chordata
Example species: N/A					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	There may be patchiness or aggregations where a large number of larvae would be affected at once.
	Low mobility	1	Larvae have low mobility.
	Sea surface interacting	1	Pelagic larvae likely to have regular interaction with the sea surface.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	0	All ascidian larvae are lecithotrophic (Shanks 2001).
	Chemical sensitivity	1	During experimental exposure of tunicate (*Boltenia velosa*) larvae to diesel WAF (0.5 %), all larvae died within 5 hours (Chia 1973).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 66	MARINE INVERTEBRATES	Pelagic	Larvae	N/A	Arthropoda
Example species: N/A					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	There may be patchiness or aggregations where a large number of larvae would be affected at once.
	Low mobility	1	Larvae have low mobility.
	Sea surface interacting	1	Pelagic larvae likely to have regular interaction with the sea surface.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Many crustacean larvae feed using setae to gather particles (Shanks 2001).
	Chemical sensitivity	1	Larval mysids exposed to physically dispersed oil have low LC50 (96 h) values (0.15 to 83.1 mg TPH/L; high acute toxicity) (reviewed in NRC 2005). During experimental exposure of barnacle embryos to No. 2 fuel oil, early embryos were more sensitive than late embryos, and nauplii quickly died upon hatching at a concentration of 7.5 ppm (Donahue et al. 1977). During experimental exposure of Dungeness Crabs (*Cancer magister*) to sediment contaminated with crude oil (0, 1.2, 3.7, or 8.6 ul oil/g) the larvae produced were not as robust, as indicated by shorter survival times compared with control larvae (Karinen et al. 1985). Acute exposure to oil also reduced growth, feeding, and activity in larvae of shrimps as well as resulted in an increase in abnormal phenotypes (Arnberg et al. 2018 – Effects of oil and global environmental drivers on two keystone marine invertebrates).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 67	MARINE INVERTEBRATES	Pelagic	Larvae	N/A	Mollusca
Example species: N/A					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	There may be patchiness or aggregations where a large number of larvae would be affected at once.
	Low mobility	1	Larvae have low mobility.
	Sea surface interacting	1	Pelagic larvae likely to have regular interaction with the sea surface.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Many mollusc larvae feed using cilia to gather particles (Shanks 2001).
	Chemical sensitivity	1	LC50 values (96 h) reported for early-life stages of molluscs exposed to crude oil are in the low range (high acute toxicity) of 1.14 – 1.83 mg TPH/L (reviewed in NRC 2005).
Recovery	Reduced population status	1	Northern Abalone (Endangered - COSEWIC 2016); Olympia Oyster (Special Concern - COSEWIC 2016); Newcomb Periwinkle (*Algamorda subrotundata*)(Species of concern - US Federal Endangered Species Act (Gaydos and Gilardi 2003).
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 68	MARINE INVERTEBRATES	Pelagic	Larvae	N/A	Echinodermata
Example species: N/A					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	There may be patchiness or aggregations where a large number of larvae would be affected at once.
	Low mobility	1	Larvae have low mobility.

Category	Criteria	Score	Justification
	Sea surface interacting	1	Pelagic larvae likely to have regular interaction with the sea surface.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Planktotrophic echinoderm larvae use ciliated arms to gather food particles (Shanks 2001).
	Chemical sensitivity	1	In an experiment testing the effects of fresh crude oil from the Deepwater Horizon blowout, the WAFs of the fresh oil showed adverse effects on larval development of echinoderm larvae (*Strongylocentrotus purpuratus* and *Dendraster excentricus*)(Stefansson et al. 2016). Acute exposure to oil also reduced growth, feeding, and activity in larvae of sea urchins and resulted in increased mortality (Arnberg et al. 2018).
Recovery	Reduced population status	1	Seastar wasting disease has caused population declines (Hewson et al. 2014). The Sunflower Seastar (*Pycnopodia helianthoides*) is listed as critically endangered with a decreasing population trend on IUCN Red List (Gravem et al. 2020).
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 69	MARINE INVERTEBRATES	Pelagic	Larvae	N/A	Lophophorata
Example species: N/A					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1 *	There may be patchiness or aggregations where a large number of larvae would be affected at once.
	Low mobility	1	Larvae have low mobility.
	Sea surface interacting	1	Pelagic larvae likely to have regular interaction with the sea surface.
	Seafloor interacting	0	Pelagic larvae and adults are not expected to have regular contact with the seafloor and/or vegetation.
Sensitivity	Mechanical sensitivity	1	Lophophorate larvae use cilia to gather food particles (Shanks 2001).
	Chemical sensitivity	1 *	No studies found on the sensitivity of larvae in this group.

Category	Criteria	Score	Justification
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Relative to other biological groups, most invertebrates have high reproductive capacity.
	Endemism/Isolation	0	No evidence of endemism or isolation could be found.
	Association with unconsolidated substrates	0	Only infaunal subgroups and those that spend a significant portion of time in contact with unconsolidated substrate fulfill this criterion.

SG ID 70	MARINE FISHES	Estuarine	Transient	N/A	Cod (Gadidae)
Example species: Pacific Tomcod, Walleye Pollock (juveniles)					**Total Score: 1**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Aggregations in this group are not documented to occur in estuaries, though do elsewhere, e.g. Walleye Pollock spawn in aggregations and form very large schools (Love 2011); Pacific Cod aggregate in deep water for breeding (shelf break) (Neidetcher et al. 2014).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Adult cod are a deeper water species that live in the mid-water column or demersally and would not be expected to interact with the surface regularly (Love 2011).
	Seafloor interacting	0	Not expected to have regular interaction with the seabed in the estuary.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Evidence of exposure to PAHs from crude oil following the EVOS was found for Walleye Pollock at least one year after the spill. However, the biological effects of this exposure was not studied (Collier 1996). Evidence of exposure of Pollock was also found for at least one year following the EVOS; however, there was no evidence of an effect of the exposure on reproductive function (Collier 1993).
Recovery	Reduced population status	0	Pacific Cod biomass in Hecate Strait has been increasing (Forrest 2015). No evidence of decline elsewhere.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).

Category	Criteria	Score	Justification
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular and close interaction with unconsolidated substrates in the estuary.

SG ID 71	MARINE FISHES	Estuarine	Transient	N/A	Salmonids
Example species: juvenile and adult salmon, Steelhead					**Total Score: 8**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Adult salmon aggregate in estuaries in preparation for river spawning runs, schools of juveniles transit through estuaries in schools as they leave the rivers (Love 2011).
	Low mobility	1	When adult salmon are in estuaries they exhibit high site fidelity as they prepare for migration up rivers.
	Sea surface interacting	1	In estuaries, fishes in this subgroup are scored for regular surface interaction as they mill in dense aggregations at all depths in the water column in prep for seasonal spawning migrations.
	Seafloor interacting	1	Juveniles use eelgrass and other vegetation as rearing and feeding habitat, and adults dig redds in gravel. Eggs developing within gravel can suffer increased mortality in oiled areas (Bue et al. 1996).
Sensitivity	Mechanical sensitivity	1	Sockeye Salmon use gill rakers for filter feeding that could become clogged with oil (Tyler et al. 2001).
	Chemical sensitivity	1	Juvenile Pink Salmon experienced lower growth rates and likely lower survival rates in the year following exposure to EVOS. Reduced growth is largely attributed to the energetic cost of metabolizing oil (Rice 2010). Additionally, (Bue et al. 1996) demonstrated elevated embryo mortality in salmon incubating in intertidal habitats of oiled streams for several years following the Exxon Valdez oil spill. Acute toxic effects from crude oil exposure from the Exxon Valdez oil spill resulted in the mortality of billions of salmon and Herring eggs and consumption of the bulk oil from foraging juvenile Pink Salmon lead to reduced growth rates and associated effects on adult returns (Barron et al. 2020).The mechanical and chemical sensitivity rating are most applicable to alevins, fry and smolts and less so to mature fish.
Recovery	Reduced population status	1	Coho Salmon (Endangered (Interior Fraser River population) - COSEWIC); Sockeye Salmon (Endangered/Threatened (many populations) - COSEWIC); Chinook Salmon (Endangered/Threatened (many populations) - COSEWIC).
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).

Category	Criteria	Score	Justification
	Endemism/Isolation	1	Many populations of salmon in BC are endemic (DFO 2005).
	Association with unconsolidated substrates	0	Not expected to have regular and close interaction with unconsolidated substrates in the estuary.

SG ID 72	MARINE FISHES	Estuarine	Transient	N/A	Sturgeon
Example species: Green Sturgeon, White Sturgeon					Total Score: 7

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Green Sturgeon aggregate in non-natal estuaries (Lindley et al. 2011). They also aggregate near the Brooks Peninsula likely for overwintering (Lindley et al. 2008).
	Low mobility	0	Green Sturgeon are highly mobile and migratory (Lindley et al. 2008; Love 2011).
	Sea surface interacting	1	Green Sturgeon do not spawn in BC rivers and are, therefore, not expected to have regular surface interaction in estuaries. White sturgeon are expected to interact with the surface occasionally, as they spend time in estuaries as juveniles and many migrate in and out of rivers throughout their life.
	Seafloor interacting	1	White Sturgeon use their barbels in soft sediment in estuaries while feeding.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Evidence of exposure of white sturgeon to aromatic hydrocarbons from residual and industrial oil following a spill in the Columbia River was found after the spill (Krahn 1986). However, the biological effects of this exposure was not studied. An investigation indicated that diesel oil is toxic to sturgeon due to severe damage in gill epithelium which could result in hypoxia of tissue and death (Jahanbakhsi and Hedayati 2013).
Recovery	Reduced population status	1	Green Sturgeon (Schedule 1 - Special Concern - SARA); White Sturgeon have experienced severe population decline in BC (Lamb 2010; DFO 2014c).
	Low reproductive capacity	1	High fecundity, but late reproductive maturity. Green Sturgeon are mature at (8-18 years for males and 13-27 years for females) and females only spawn every 2-5 years (Love 2011).
	Endemism/Isolation	0	No endemism or isolation.

Category	Criteria	Score	Justification
	Association with unconsolidated substrates	1 *	Sturgeon live over sand and silt substrates. Their mouth is benthically oriented and their diet consists of benthic fishes and molluscs. Extensive association with unconsolidated substrates for feeding is likely.

SG ID 73	MARINE FISHES	Estuarine	Transient	N/A	Smelts
Example species: Eulachon					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Eulachon aggregate in estuaries/river mouths, for example in the Fraser River there is a bottleneck which aggregates both seaward bound and river bound fish/juveniles (Jamieson and Levesque 2014).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Fishes in this subgroup will have regular surface interaction as they aggregate in shallow estuarine waters for seasonal spawning migrations.
	Seafloor interacting	0	Not expected to have regular interaction with the seabed in the estuary.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1 *	No studies could be found explicitly for the effects of crude and refined oils on species in this subgroup.
Recovery	Reduced population status	1	Eulachon have been reported to have declined dramatically in the last two decades (Hay et al. 1997). Eulachon (*Thaleichthys pacificus*), SARA Status: Under consideration for listing. COSEWIC Status: Nass/Skeena Rivers population (Special Concern); Central Pacific Coast population (Endangered); Fraser River Population (Endangered).
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	1	There are several genetically isolated populations of eulachon in BC (COSEWIC 2013a).
	Association with unconsolidated substrates	0	Not expected to have regular and close interaction with unconsolidated substrates in the estuary.

SG ID 74	MARINE FISHES	Estuarine	Transient	N/A	Lampreys
Example species: River and Pacific Lamprey					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Lampreys are thought to aggregate in estuaries (for feeding) to coincide with salmon aggregating in estuaries (preparing head up river for spawning) as high lamprey attacks have been reported in some cases (Beamish 1980).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Not expected to have regular surface interaction in estuaries.
	Seafloor interacting	1	Lamprey are poor swimmers and rely on sucking onto rocks in a current (Love 1996).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	No studies could be found explicitly for the effects crude or refined oils on species in this subgroup.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Lamprey are poor swimmers and rely on sucking onto rocks in a current, so association with unconsolidated substrates is unlikely (Love 1996).

SG ID 75	MARINE FISHES	Estuarine	Transient	N/A	Sculpins (Cottidae)
Example species: Prickly Sculpin					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Not documented to aggregate in estuaries, e.g. the mainly freshwater Prickly Sculpin travels to estuaries for breeding (catadromous), but do not aggregate for spawning, they aggregate up river and move back and forth into the estuary for spawning (Morrow 1980).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Sculpins are not expected to have regular surface interaction, but larvae can occur in near surface waters (Love 2011).
	Seafloor interacting	1	Prickly Sculpin often rest on bottoms of fine materials, predominantly sand (Lee et al. 1980).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Longhorn Sculpins (*Myoxocephalus octodecemspinosus*) (a congeneric species to BC's Great Sculpin) exposed to crude oil contaminated sediments exhibited increased parasite loads, reduced levels of lymphocytes, hyperplasia in gill lamellae and increased mortality after cold stress (Khan 1991). Also, 1 year after the EVOS (Barber et al. 1995) found reduced densities of intertidal fishes (including sculpins) in intertidal surveys at sites that had been oiled compared to control sites.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Prickly Sculpin regularly rest on bottoms of fine materials, predominantly sand (Lee et al. 1980).

SG ID 76	MARINE FISHES	Estuarine	Transient	N/A	Sticklebacks
Example species: Threespine Stickleback					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Some populations are anadromous, spawning in rivers, but not in aggregations (Love 2011). Spend most of their lives in schools (Love 2011), and can form feeding aggregations, outside of estuaries (Froese and Pauly 2016).
	Low mobility	1	Sticklebacks have limited mobility due to their small size.
	Sea surface interacting	0	Threespine Sticklebacks can rise into surface waters at night (Love 2011) but this is not considered a regular interaction.
	Seafloor interacting	1	Excavate soft substrates to build nests (Love 2011).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1 *	Effects are uncertain in this group. Blenkinsopp et al. (1996) exposed three-spine stickleback to the water accommodated fraction (WAF) of weathered crude oil (Alberta sweet mixed blend) and burn residue obtained during the Newfoundland offshore burn experiment. The 96hLC50 was greater than 10,000 mg/L for both the unburned and burned crude WAF. Another study conducted on Threespine Stickleback determined that oil exposure on juvenile Threespine Stickleback has variable effects: exposure does not impact survival (Ireland and Milligan-Myhre 2020).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Build nests in soft substrates, but don't spend the majority of their time closely associated with unconsolidated substrates (Love 2011).

SG ID 77	MARINE FISHES	Estuarine	Transient	N/A	Flatfishes
Example species: Starry Flounder					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	English Sole and Starry Flounder reside in estuaries as juveniles (Castillo 1996; Love 2011); however, feeding aggregations are not described in the literature.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Not expected to interact with the surface regularly as they are benthic fish.
	Seafloor interacting	1	Flatfishes have a close interaction with the seafloor as they are bottom dwelling fish whose bodies are in frequently contact with the seabed (Love 2011).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Evidence of exposure to PAHs from crude oil following the EVOS was found for several flatfish species for 2 years after the spill (Collier 1996). English Sole chronically exposed to sediments contaminated with crude oil developed severe liver abnormalities (HLV), emaciation, morbidity, gill damage, fin necrosis and higher parasite loads (Haensly 1982; McCain 1978; Wolfe 1987). Juvenile Halibut, Yellow Sole and Rock Sole reared on sediment contaminated with crude oil had reduced growth, fin erosion and gill damage (Moles and Norcross 1998). Reduced recruitment and growth in flatfishes was observed following the Amoco Cadiz spill of crude oil (Conan 1982). However, no measureable differences in growth or condition were measured in juvenile sole a few months after the Erika spill of Bunker C oil in France (Gilliers 2006).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Flatfishes have a close interaction with unconsolidated substrates as they are bottom dwelling fish whose bodies are in frequently contact with the seabed (Love 2011).

SG ID 78	MARINE FISHES	Estuarine	Resident	N/A	Surfperches
Example species: Shiner Perch					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Surfperch species are schooling types, sometimes in large schools of many thousands (such as the Shiner Perch) (Love 2011). They form large aggregations for mating and giving birth during the spring and summer (Lane 2002).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Surfperch are present in the intertidal, and are expected to have regular interaction with the surface (Love 2011).
	Seafloor interacting	1	Surfperch don't interact with the seafloor regularly as they are continuously swimming in the water column. However, they are found in vegetated habitats where they interact with vegetation by picking food off fronds (Love 1996).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Surfperch species exposed to a petroleum seep (crude oil) in California exhibited lesions in gills, liver and kidneys that are expected to have an adverse effect (Spies 1996).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found; however, data is known to be lacking for these species (Lane 2002).
	Low reproductive capacity	1	Embiotocids exhibit viviparity and produce few young each year compared to other fish groups. This has the potential to limit their recovery potential (Lane 2002).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Surfperch are mainly found over unconsolidated substrates in estuaries, such as in eelgrass beds (Love 1996). However, they don't interact with the seafloor regularly as they are continuously swimming in the water column.

SG ID 79	MARINE FISHES	Estuarine	Resident	N/A	Sculpins
Example species: Staghorn Sculpin					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Do not aggregate for spawning in estuaries (Morrow 1980).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Sculpins are a benthic species and not expected to have regular surface interaction (Love 2011).
	Seafloor interacting	1	Staghorn Sculpins are most common in the sand or mud of bays and estuaries (Love 1996). They are frequently found buried in soft substrates.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Longhorn Sculpins (*Myoxocephalus octodecemspinosus*) (a congeneric species to BC's Great sculpin) exposed to crude oil contaminated sediments exhibited increased parasite loads, reduced levels of lymphocytes, hyperplasia in gill lamellae and increased mortality after cold stress (Khan 1991). Also, 1 year after the EVOS (Barber et al. 1995) found reduced densities of intertidal fishes (including sculpins) in intertidal surveys at sites that had been oiled compared to control sites.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Staghorn Sculpins are commonly found in the sand or mud of bays and estuaries (Love 1996). They are frequently found buried in soft substrates.

SG ID 80	MARINE FISHES	Estuarine	Resident	N/A	Salmonids
Example species: Cutthroat Trout, Dolly Varden					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Dolly Varden form small schools in estuaries (Love 2011), but there is no evidence of large aggregations in the literature.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Coastal Cutthroat Trout will have regular surface interactions as they feed on organisms at the water surface (Romero 2005; Schutz 1972).
	Seafloor interacting	1 *	Dolly Varden build nests for spawning in gravel, but this usually occurs in freshwater and likely not be impacted by a marine oil spill.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Juvenile Pink Salmon experienced lower growth rates and likely lower survival rates in the year following exposure to EVOS. Reduced growth is largely attributed to the energetic cost of metabolizing oil (Rice 2010). Additionally, (Bue et al. 1996) demonstrated elevated embryo mortality in salmon incubating in intertidal habitats of oiled streams for several years following the Exxon Valdez oil spill. Tagging studies of cutthroat trout and dolly varden have demonstrated significantly reduced growth and survival for fish that foraged in oil contaminated marine areas following the EVOS (Hepler 1994). (Woodward 1981) found that cutthroat trout exposed to crude oil in freshwater exhibited reduced survival and growth, fin erosion and lesions on the gills and eyes.
Recovery	Reduced population status	0	Most coastal populations of Dolly Varden are secure (Speciesatriskbc.ca). Coastal sea run Cutthroat Trout populations are also not considered at risk.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Though Dolly Varden build nests for spawning, this is in fresh water rather than marine habitats.

SG ID 81	MARINE FISHES	Intertidal	Non-benthic (pelagic and demersal)	N/A	Rockfishes (juvenile)
Example species: Black Rockfish, Copper Rockfish					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Juveniles school in the intertidal where many species rear, but usually do not occur at high enough densities to be considered aggregating.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Resident intertidal organisms are assumed to have regular surface interaction due to tidal movements. However, fish species in this group move in and out with the tides and so are less likely to have regular surface interaction.
	Seafloor interacting	1	These non-benthic species are generally not expected to have regular interaction with the seafloor, but do rest against and feed off vegetation.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Dead and dying demersal rockfishes were reported from several areas following the EVOS, including Yelloweye Rockfish and a Shortraker Rockfish (Marty et al. 2003). In addition to the initial mortality, exposure to spilled oil and increased incidences of liver lesions continued for 2 years after the spill (Hoffmann and Hansen 1994). Exposure to crude oil has also been shown to cause reduced immune function and increased mortality from fish disease in *Sebastes schlegeli* in Korea (Kim 2014; Kim 2013).
Recovery	Reduced population status	1	Populations of Copper Rockfish have declined (Love et al. 2002).
	Low reproductive capacity	1	Although fecundity can be high, only 50% of Copper Rockfish are mature by 4-6 years, and reproductive success is infrequent (Love 1996).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	These non-benthic groups are generally not expected to have regular interaction with unconsolidated substrates.

SG ID 82	MARINE FISHES	Intertidal	Non-benthic (pelagic and demersal)	N/A	Surfperch
Example species: Shiner Perch, Striped Perch, Pile Perch					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Surfperch species are schooling types, sometimes in large schools of many thousands (such as the Shiner Perch) (Love 2011). Shiner Perch form large aggregations for mating and giving birth during the spring and summer (Lane 2002). Many species aggregate under docks and pilings for shelter.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Resident intertidal organisms are assumed to have regular surface interaction due to tidal movements. However, fish species in this subgroup are less likely to interact with the surface regularly as they move in and out of intertidal areas with the tides.
	Seafloor interacting	1	Surfperch don't interact with the seafloor regularly as they are continuously swimming in the water column. However, they are found in vegetated habitats where they interact with vegetation by picking food off fronds
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Surfperch species exposed to a petroleum seep (crude oil) in California exhibited lesions in gills, liver and kidneys that are expected to have an adverse effect (Spies 1996).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found; however, data is known to be lacking for these species (Lane 2002).
	Low reproductive capacity	1	Embiotocids exhibit viviparity and produce few young each year compared to other fish groups. This has the potential to limit their recovery potential (Lane 2002).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	These non-benthic groups are generally not expected to have regular interaction with unconsolidated substrates.

SG ID 83	MARINE FISHES	Intertidal	Benthic	Associated with consolidated substrates (cobble, boulder, bedrock)	Snailfishes
Example species: Tidepool Snailfish					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Not expected to aggregate in the benthic intertidal for a specific purpose or in significantly large numbers.
	Low mobility	1	These small species that live in close association with rocks likely have a relatively limited home range.
	Sea surface interacting	1	Intertidal organisms are assumed to have regular surface interaction due to tidal movements. Surface interaction is very likely in this group because they will remain in the intertidal as the tide drops (Lamb and Edgell 2010).
	Seafloor interacting	1	Species in this subgroup have regular interactions with the seafloor.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	One year after the EVOS (Barber et al. 1995) found reduced densities of intertidal fishes (including Snailfishes) in intertidal surveys at sites that had been oiled compared to control sites.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular interaction with unconsolidated substrates.

SG ID 84	MARINE FISHES	Intertidal	Benthic	Associated with consolidated substrates (cobble, boulder, bedrock)	Clingfishes
Example species: Northern Clingfish					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Not expected to aggregate in the benthic intertidal for a specific purpose or in significantly large numbers.
	Low mobility	1	These small species that live in close association with rocks likely have a relatively limited home range.
	Sea surface interacting	1	Intertidal organisms are assumed to have regular surface interaction due to tidal movements. Regular surface interaction is likely in this group because they remain in the intertidal as the tide drops (Lamb and Edgell 2010).
	Seafloor interacting	1	Species in this subgroup have regular interactions with the seafloor.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Clingfish were among the three species found dead after a spill of No 2 diesel in Washington (Chia 1971).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular interaction with unconsolidated substrates.

SG ID 85	MARINE FISHES	Intertidal	Benthic	Associated with consolidated substrates (cobble, boulder, bedrock)	Blennies
Example species: Penpoint Gunnel, Crescent Gunnel, High Cockscomb					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Not expected to aggregate in the benthic intertidal for a specific purpose or in significantly large numbers.
	Low mobility	1	The home range of Pricklebacks has been shown to be less than 15 m (Barber et al. 1995).
	Sea surface interacting	1	Resident intertidal organisms are assumed to have regular surface interaction due to tidal movements. Surface interaction is likely in this group because they remain in the intertidal as the tide drops (Lamb and Edgell, 2010).
	Seafloor interacting	1	Species in this subgroup have regular interactions with the seafloor (Exxon Valdez Oil Spill Trustee Council 2009).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Pricklebacks and Crescent Gunnels exhibited hemosiderosis (a liver abnormality from toxic chemicals) following the EVOS (Jewett et al. 1995). Also, 1 year after the EVOS (Barber et al. 1995) found reduced densities of intertidal fishes (including Gunnels and Pricklebacks) in intertidal surveys at sites that had been oiled compared to control sites.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular interaction with unconsolidated substrates in the intertidal.

SG ID 86	MARINE FISHES	Intertidal	Benthic	Associated with unconsolidated substrates (Silt/Sand/Gravel) (including eelgrass environments)	Salmonids
Example species: Pink, Chum, Coho, Chinook Salmon					Total Score: 8

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Juveniles occur in high densities in intertidal areas including eelgrass beds (Groot and Margolis 1991; Love 2011).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Intertidal organisms are assumed to have regular surface interaction due to tidal movements. This is accurate in this group as juvenile salmon can school close to the surface and pick insects from the water/air interface (COSEWIC 2016).
	Seafloor interacting	1	Juvenile salmon will not have regular interaction with the seafloor, but do seek shelter and food in vegetated habitats.
Sensitivity	Mechanical sensitivity	1	Sockeye Salmon use gill rakers for feeding (Tyler et al. 2001).
	Chemical sensitivity	1	Juvenile Pink Salmon experienced lower growth rates and likely lower survival rates in the year following exposure to EVOS. Reduced growth is largely attributed to the energetic cost of metabolizing oil (Rice 2010). Additionally, (Bue et al. 1996) demonstrated elevated embryo mortality in salmon incubating in intertidal habitats of oiled streams for several years following the Exxon Valdez oil spill.
Recovery	Reduced population status	1	Coho Salmon (Endangered (Interior Fraser River population) - COSEWIC); Sockeye Salmon (Endangered/Threatened (many populations) - COSEWIC); Chinook Salmon (Endangered/Threatened (many populations) - COSEWIC).
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	1	Many populations of salmon in BC are endemic (DFO 2005).
	Association with unconsolidated substrates	1	Pink Salmon spawn intertidally near stream mouths in some locations (Bue et al. 1996)

SG ID 87	MARINE FISHES	Intertidal	Benthic	Associated with unconsolidated substrates (Silt/Sand/Gravel) (including eelgrass environments)	Herring
Example species: Pacific Herring					Total Score: 7

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Pacific Herring aggregate in significant numbers to spawn, there are multiple spawning locations that occur in BC, one of the most prominent being in the Southern Gulf Islands (Jamieson and Levesque 2014). Juveniles occur in dense schools in rearing habitats such as eelgrass beds.
	Low mobility	1	Most fish species are considered highly mobile relative to an oil spill; however, spawning adults will exhibit site fidelity at intertidal spawning grounds.
	Sea surface interacting	1	Intertidal organisms are assumed to have regular surface interaction due to tidal movements. For this subgroup, adults interact with the surface when spawning, and eggs would also interact with the surface when deposited in the intertidal (COSEWIC 2016).
	Seafloor interacting	1	Eggs deposited on vegetation and rocks will be in close association with the seafloor until they hatch, adult fish will be in close association while they are spawning.
Sensitivity	Mechanical sensitivity	1	Herring use gill rakers for feeding (Sanderson et al. 2001).
	Chemical sensitivity	1	A significantly higher rate of genetic defects were detected in larval Herring from oiled vs unoiled beaches following the Exxon Valdez oil spill (Hose and Brown 1998). These genetic effects were correlated with skeletal defects, such as absent jaws, and likely lead to reduced survival due to starvation. Significant mortality of exposed adult Herring was not observed following the spill (Carls 2001). Herring eggs deposited following a Bunker C spill in San Francisco harbour had very high levels of necrosis and mortality (Incardona 2012).
Recovery	Reduced population status	1	Herring stocks in Haida Gwaii, Prince Rupert, central coast and the west coast of Vancouver Island have declined for the past decade (Schweigert 2010). Valuable commercial fisheries have been closed in many of the recent years in 4 of 7 management areas (DFO 2015b) because of these declines.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals) - Pacific Herring in BC are mature by 3 years. Females produce up to 77,800 eggs (Love 2011).
	Endemism/Isolation	0	No endemism or isolation (Ware and Schweigert 2001).
	Association with unconsolidated substrates	0	The eggs are deposited on rocks and vegetation, not on unconsolidated intertidal substrates.

SG ID 88	MARINE FISHES	Intertidal	Benthic	Associated with unconsolidated substrates (Silt/Sand/Gravel) (including eelgrass environments)	Flatfishes- juvenile
Example species: English Sole, Starry Flounder					**Total Score: 3**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Not expected to aggregate in the benthic intertidal.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Intertidal organisms are assumed to have regular surface interaction due to tidal movements. However, fish species in this subgroup are less likely to interact with the surface regularly as they are benthic and move in and out of intertidal areas with the tides.
	Seafloor interacting	1	Flatfishes have a close interaction with unconsolidated substrates as they are bottom dwelling species whose bodies are in frequently contact with the seabed
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Evidence of exposure to PAHs from crude oil following the EVOS was found for several flatfish species for 2 years after the spill (Collier 1996). English Sole chronically exposed to sediments contaminated with crude oil developed severe liver abnormalities (HLV), emaciation, morbidity, gill damage, fin necrosis and higher parasite loads (Haensly 1982; McCain 1978; Wolfe 1987). Juvenile Halibut, Yellow Sole and Rock Sole reared on sediment contaminated with crude oil had reduced growth, fin erosion and gill damage (Moles and Norcross 1998). Reduced recruitment and growth in flatfishes was observed following the Amoco Cadiz spill of crude oil (Conan 1982). However, no measureable differences in growth or condition were measured in juvenile sole a few months after the Erika spill of Bunker C oil in France (Gilliers 2006).
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Flat fishes have a close interaction with unconsolidated intertidal substrates as they are bottom dwelling fish whose bodies are in frequent contact with the seabed.

SG ID 89	MARINE FISHES	Intertidal	Benthic	Associated with unconsolidated substrates (Silt/Sand/Gravel) (including eelgrass environments)	Pipefish
Example species: Bay Pipefish					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	No large aggregations for reproduction expected.
	Low mobility	1	Pipefish are not considered highly mobile as evidenced by low genetic connectivity between populations (De Graaf 2006).
	Sea surface interacting	0	Intertidal organisms are assumed to have regular surface interaction due to tidal movements. However, species in this subgroup (pipefish) move in and out of the intertidal with the tides. Pipefish may interact with the surface if oiled eelgrass leaves prevent them from leaving the intertidal as the tide drops (COSEWIC 2016).
	Seafloor interacting	1	Not expected to have regular interaction with the seafloor, but will be in close association with eelgrass.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Pipefishes were one of the predominant fish groups that were killed following the Amoco Cadiz crude oil spill (Conan 1982). A pipefish relative, the slender seahorse, experienced gill lesions after acute exposure to the water accommodated fraction (WAF) of diesel oil. These lesions were sufficient to impair oxygen uptake (Delunardo et al. 2020).
Recovery	Reduced population status	0	Bay Pipefish were assessed by the IUSN and determined to be of least concern (Graham and Pollom 2015).
	Low reproductive capacity	1	Pipefish have lower fecundity due to male brooding behavior.
	Endemism/Isolation	0	No endemism or isolation (De Graaf 2006).
	Association with unconsolidated substrates	0	Not expected to have regular interaction unconsolidated substrates in the intertidal.

SG ID 90	MARINE FISHES	Intertidal	Benthic	Associated with unconsolidated substrates (Silt/Sand/Gravel) (including eelgrass environments)	Smelts and sand lance
Example species: Pacific Sand Lance, Surf Smelt					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Pacific Sand Lance (*Ammodytes hexapterus*) aggregate to spawn in the intertidal. Adults migrate to sandy-gravel spawning beaches and wriggle into the sand to deposit eggs near the top of the beach on high tides (Robards et al. 1999). Female smelt deposit eggs on coarse sand beaches near the high tide line (Love 2011).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Intertidal organisms are assumed to have regular surface interaction due to tidal movements. Species in this subgroup would interact with the surface while spawning on the beach and as eggs.
	Seafloor interacting	1	The eggs and spawning adults will interact closely with the seafloor.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Toxicity tests on sand lance showed that dispersed crude oil droplets are highly toxic to them, while the water soluble fraction is also toxic, but to a lesser degree (Anderson et al. 1987). Sand lance populations declined after Exxon Valdez spill; however this cannot be explicitly attributed to the spill (Golet 2002). Finally, exposure to sediment contaminated with crude oil resulted in a significant increase in gill parasites for sand lance (Moles and Wade 2001).
Recovery	Reduced population status	1	There is some data to suggest that surf smelt populations are declining in BC (DFO 2002) and population declines have been documented in parts of Puget Sound (Greene 2015).
	Low reproductive capacity	0	Sand lance are highly fecund and mature after 1 year (Robards et al. 1999).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	The eggs and spawning adults will interact heavily with unconsolidated intertidal substrates. Pacific Sand Lance are generally in the water column by day and buried in sand at night and generally spend day and night buried in sand over the winter (Love 2011).

SG ID 91	MARINE FISHES	Intertidal	Benthic	Associated with unconsolidated substrates (Silt/Sand/Gravel) (including eelgrass environments)	Greenlings
Example species: Lingcod - juvenile					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Juveniles rear in sandy intertidal and eelgrass areas, often at high densities (Love 2011), but these are not large enough to be considered aggregating.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Intertidal organisms are assumed to have regular surface interaction due to tidal movements. However, fish species in this subgroup are less likely to interact with the surface regularly as they move in and out of intertidal areas with the tides.
	Seafloor interacting	1	All greenlings, including Lingcod live in association with the seafloor and vegetation as juveniles. Juvenile Lingcod typically associate with sandy bottoms (Love 2011).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Kelp Greenling exhibited hemosiderosis (a liver abnormality from toxic chemicals) following the EVOS (Khan 1991).
Recovery	Reduced population status	1	Lingcod are not listed by COSEWIC or SARA, but their abundance in the Strait of Georgia is low enough to warrant conservation concern (DFO 2015a; King 2001).
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	All greenlings, including Lingcod live in association with the seafloor. Juvenile lingcod associate with sandy intertidal bottoms (Love 2011).

SG ID 92	MARINE FISHES	Intertidal	Benthic	Associated with unconsolidated substrates (Silt/Sand/Gravel) (including eelgrass environments)	Other species (e.g. sculpins , gobies)
Example species: Staghorn Sculpin, Plainfin Midshipmen					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	No reports found to demonstrate that they aggregate.
	Low mobility	1	These species are not highly mobile, and nest site fidelity has been observed for midshipmen during breeding season as males guard clutches of eggs.
	Sea surface interacting	1	Resident intertidal organisms are assumed to have regular surface interaction due to tidal movements. Surface interaction is likely for some species in this group because they can remain in the intertidal as the tide drops.
	Seafloor interacting	1	Staghorn Sculpins bury themselves in soft substrates, as do Plainfin Midshipmen who spawn, guard eggs and rear young in soft substrates (Lamb and Edgell 2010).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Longhorn Sculpins (*Myoxocephalus octodecemspinosus*) (a congeneric species to BC's Great sculpin) exposed to crude oil contaminated sediments exhibited increased parasite loads, reduced levels of lymphocytes, hyperplasia in gill lamellae and increased mortality after cold stress (Khan 1991). Also, 1 year after the EVOS (Barber et al. 1995) found reduced densities of intertidal fishes (including sculpins) in intertidal surveys at sites that had been oiled compared to control sites.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Staghorn Sculpins bury themselves in soft intertidal substrates (Lamb and Edgell 2010).

SG ID 93	MARINE FISHES	Subtidal	Benthic	Associated with consolidated substrates (cobble, boulder, bedrock)	Wolf fish
Example species: Wolf Eel					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Species in this subgroup do not aggregate.
	Low mobility	1	Expected to exhibit site fidelity (as they live in rocky dens) (Parra et al. 2001).
	Sea surface interacting	0	Benthic organisms in the subtidal are generally considered not to have regular surface interaction. In this subgroup Wolf Eels tend to stay close to their benthic dens, and would not be expected to regularly interact with the surface.
	Seafloor interacting	1	Wolf Eels will regularly interact with rocky seafloors.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	No studies could be found explicitly for the effects of crude and refined oils on species in this subgroup.
Recovery	Reduced population status	0	No evidence of reduced or declining populations could be found.
	Low reproductive capacity	1	Reproductive maturity at 7 years (Love 1996).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Wolf Eels will regularly interact with rocky seafloors but not often with unconsolidated seafloors.

SG ID 94	MARINE FISHES	Subtidal	Benthic	Associated with consolidated substrates (cobble, boulder, bedrock)	Greenlings and Sculpins
Example species: Lingcod (adult), Cabezon					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Lingcod can be found at high densities where habitat conditions are good and fishing pressure is low, especially during spawning season, but not at a high enough density to be considered an aggregation. Adults are mostly found in the subtidal, but can be found in the low intertidal during spawning season (Love 2011).
	Low mobility	1	Nest site fidelity has been reported during breeding season as males guard clutches of eggs laid amongst rocks and often return to the same site in subsequent years (King and Withler 2005). (Reynolds 1997) documented residency and movements of lingcod in Alaska and noted high levels of site fidelity.
	Sea surface interacting	0	Benthic organisms in the subtidal are generally considered not to have regular surface interaction (COSEWIC 2016).
	Seafloor interacting	1	All greenlings, including Lingcod live in association with the seafloor and vegetation as juveniles. Juvenile Lingcod typically associate with sandy bottoms and adults with rocky relief and boulders (Love 2011).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Kelp Greenling exhibited hemosiderosis (a liver abnormality from toxic chemicals) following the EVOS (Peterson 2001).
Recovery	Reduced population status	1	Lingcod are not listed by COSEWIC or SARA, but their abundance in the Strait of Georgia is low enough to warrant conservation concern (DFO 2015a; King 2001).
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	All greenlings, including Lingcod live in association with the seafloor, but adults live mostly associated with rocky relief and boulders (Love 2011).

SG ID 95	MARINE FISHES	Subtidal	Benthic	Associated with consolidated substrates (cobble, boulder, bedrock)	Rockfishes
Example species: Quillback, Yelloweye, Tiger and China Rockfish					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Benthic rockfish species in the subtidal sometimes occur in schools, but are most often solitary (Loveet al. 2002).
	Low mobility	1	Some adult rockfish species are reported to have very limited home ranges (Black Rockfish, China Rockfish) (Love et al. 2002; Marliave 2013). Reynolds (2010) documented residency and movements of nearshore rockfishes in Alaska and noted high levels of site fidelity.
	Sea surface interacting	0	Benthic organisms in the subtidal are generally considered not to have regular surface interaction (COSEWIC 2016).
	Seafloor interacting	1	Rockfish species in rocky subtidal habitats often rest on the seafloor and hide in rocky crevices (Lamb and Edgell 2010).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Dead and dying demersal rockfishes were reported from several areas following the EVOS, including Yelloweye Rockfish and a Shortraker Rockfish (Marty et al. 2003).
Recovery	Reduced population status	1	Quillback Rockfish (Threatened - COSEWIC); Yelloweye Rockfish (Special Concern - SARA); Canary Rockfish (Threatened – COSEWIC); Rougheye Rockfish (Special Concern - SARA).
	Low reproductive capacity	1	Only 50% of Yelloweye Rockfish are mature at 19-22 years and for quillback rockfish, 50% are mature by 11 years. Also, many rockfish species have infrequent reproductive success (Love et al. 2002).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	-

SG ID 96	MARINE FISHES	Subtidal	Benthic	Associated with unconsolidated substrate (Silt/Sand/Gravel)	Flatfishes
Example species: English Sole, Starry Flounder, Pacific Halibut					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Some flatfishes aggregate to spawn in BC locations. For example, Dover Sole and Petrale Sole aggregate for spawning off the West Coast of Vancouver Island (Fargo 1998; Fargo 1999).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Benthic organisms in the subtidal are generally considered not to have regular surface interaction (COSEWIC 2016).
	Seafloor interacting	1	Expected to have regular interaction with the seafloor, as they are placed in this subgroup due to their association with unconsolidated substrate (silt/sand/gravel).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Evidence of exposure to PAHs from crude oil following the EVOS was found for several flatfish species for 2 years after the spill (Collier 1996). English Sole chronically exposed to sediments contaminated with crude oil developed severe liver abnormalities (HLV), emaciation, morbidity, gill damage, fin necrosis and higher parasite loads (Haensly 1982; McCain 1978; Wolfe 1987). Juvenile Halibut, Yellow Sole and Rock Sole reared on sediment contaminated with crude oil had reduced growth, fin erosion and gill damage (Moles and Norcross 1998). Reduced recruitment and growth in flatfishes was observed following the Amoco Cadiz spill of crude oil (Conan 1982). However, no measureable differences in growth or condition were measured in juvenile sole a few months after the Erika spill of Bunker C oil in France (Gilliers 2006).
Recovery	Reduced population status	0	Most species have not been assessed recently, but those that have show no current evidence of population decline (Arrowtooth Flounder (DFO 2015c); Rock sole (DFO 2014b); Halibut (Stewart and Hicks 2018)).
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Flatfishes have a close interaction with unconsolidated substrate as they are bottom dwelling fish whose bodies are in frequent contact with the seafloor.

SG ID 97	MARINE FISHES	Subtidal	Benthic	Associated with unconsolidated substrate (Silt/Sand/Gravel)	Elasmobranchs
Example species: Big Skate					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Egg cases of some species are deposited in aggregations (Hoff 2016; Love et al. 2008).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Benthic organisms in the subtidal are generally considered not to have regular surface interaction (COSEWIC 2016).
	Seafloor interacting	1	Expected to have regular interaction with seafloor, as they are placed in this category due to their association with unconsolidated substrate (silt/sand/gravel).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1 *	No studies could be found explicitly for the effects of crude or refined oils on species in this subgroup.
Recovery	Reduced population status	1	Big Skate (near threatened - IUCN); Longnose Skate (Least concern – IUCN).
	Low reproductive capacity	1	Big Skate reaches maturity at 6-8 years; Longnose Skate reaches maturity at 7-10 years (McFarlane and King 2006). Skate species also have relatively low fecundity (King 2015).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Have a close interaction with sediment, as they are bottom dwelling fish whose bodies are in frequent contact with unconsolidated substrate types (silt/sand/gravel) likely to retain oil.

SG ID 98	MARINE FISHES	Subtidal	Benthic	Associated with unconsolidated substrate (Silt/Sand/Gravel)	Hagfishes
Example species: Pacific Hagfish					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Hagfish are known to aggregate at food sources in the deep sea. A whale carcass can concentrate hagfishes from a 1-2 km2 sized area (Smith and Baco 2003).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Benthic organisms in the subtidal are generally considered not to have regular surface interaction (COSEWIC 2016).
	Seafloor interacting	1	Expected to have regular interaction with the seafloor based on their known preference for mud habitats (Love 1996).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1 *	No studies could be found explicitly for the effects crude or refined oils on species in this subgroup.
Recovery	Reduced population status	0	No evidence of declining populations could be found; however, data is known to be lacking (Black Hagfish: Data deficient - IUCN; Pacific Hagfish: Data deficient - IUCN).
	Low reproductive capacity	1	Hagfish fecundity is low with a female hagfish producing 20–30 eggs per reproductive cycle. (CalCoFI 2015).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Have a close interaction with unconsolidated substrates, as they are bottom dwelling fish whose bodies are in frequent contact with unconsolidated substrate types (silt/sand/gravel) likely to retain oil. Also, likely preference for mud mentioned in Love 1996.

SG ID 99	MARINE FISHES	Subtidal	Benthic	Associated with unconsolidated substrate (Silt/Sand/Gravel)	Rockfishes
Example species: Darkblotched Rockfish, Canary Rockfish					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	No mention of Darkblotched Rockfish aggregations in reference books (Love et al. 2002). When Canary Rockfish are found associated with the seafloor, they are not in aggregations.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Benthic organisms in the subtidal are generally considered not to have regular surface interaction (COSEWIC 2016).
	Seafloor interacting	1	Darkblotched Rockfish are typically found on mud near cobble or boulders (Love et al. 2002).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Dead and dying demersal rockfishes were reported from several areas following the EVOS, including Yelloweye Rockfish and a Shortraker Rockfish (Marty et al.2003). In addition to the initial mortality, exposure to spilled oil and increased incidences of liver lesions continued for 2 years after the crude oil spill (Hoffmann and Hansen 1994). Exposure to crude oil has also been shown to cause reduced immune function and increased mortality from fish disease in *Sebastes schlegeli* in Korea (Kim 2014; Kim 2013).
Recovery	Reduced population status	1	Darkblotched Rockfish (Special Concern - COSEWIC); Longspine Thornyhead (Special Concern – SARA).
	Low reproductive capacity	1	Darkblotched Rockfish mature from 4-8 years and many rockfish species have infrequent reproductive success (Love et al. 2002).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Darkblotched Rockfish are typically found on mud near cobble or boulders (Love et al. 2002).

SG ID 100	MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Rockfishes
Example species: Yellowtail, Blue, Widow Rockfishes, Bocaccio					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Widow Rockfish live in very large aggregations of 1000s -10 000s (Love 1996; Love 2011) as do many other species including blue rockfish and yellowtail rockfish.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Some species in this subgroup interact with the surface, as they have been observed feeding and tail flicking at the surface (Love et al. 2002).
	Seafloor interacting	0	Not expected to have regular interaction with the seafloor, as they are placed in the mid water/pelagic category (Levesque and Jamieson 2015).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1 *	No studies could be found explicitly for the effects of crude or refined oils on species in this subgroup.
Recovery	Reduced population status	1	Bocaccio Rockfish (Endangered COSEWIC); Yellowmouth Rockfish (Threatened - COSEWIC).
	Low reproductive capacity	1	50% of Yellowtail Rockfish are mature between 6 and 15 years (Love et al. 2002); Widow Rockfish mature at 8-9 years. Also, many rockfish species have infrequent reproductive success (Love et al. 2002).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular, close interaction with unconsolidated substrates, as they are placed in the non-benthic category.

SG ID 101	**MARINE FISHES**	**Subtidal**	**Non-benthic (pelagic, midwater and demersal)**	**N/A**	**Cod**
Example species: Pacific Cod, Hake, Pacific Tomcod, Walleye Pollock					**Total Score: 3**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Hake aggregate in the Juan de Fuca eddy area, presumably for feeding (Jamieson and Levesque 2014), and Pacific Cod are known to aggregate in deeper water for breeding (on the shelf break)(Neidetcher et al. 2014).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	Species in this subgroup are not reported to interact with the surface regularly (COSEWIC 2016).
	Seafloor interacting	1	Most cod species will live in close association with the seafloor in addition to schooling in the midwater.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Evidence of exposure to PAHs from crude oil following the EVOS was found for Walleye Pollock at least one year after the spill. However, the biological effects of this exposure was not studied (Collier 1996). Evidence of exposure of Pollock was also found for at least one year following the EVOS; however, there was no evidence of an effect of the exposure on reproductive function (Collier 1993).
Recovery	Reduced population status	0	No evidence of serious population decline in BC (DFO 2022; Forrest 2015).
	Low reproductive capacity	0	Pacific Cod mature at 2-4 years (Love 1996).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular, close interaction with unconsolidated substrates, as they are placed in the non-benthic category.

SG ID 102	MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Misc species
Example species: Sablefish, salmon, surfperch, Herring					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Salmon and Herring often occur in large schools, but not for feeding or breeding in this habitat. Aggregations of more than 500 Sablefish have been observed (Kreiger 1997), but they are more often found singly.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Not all species in this subgroup interact with the surface regularly, although salmon, Herring and perch can be observed in surface waters in the subtidal environment (Lamb and Edgell 2010).
	Seafloor interacting	0	Not expected to have regular interaction with the seafloor, as they are placed in the mid water/pelagic category.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Sablefish are relatively more sensitive to the water soluble fractions of crude oil than many other species, based on toxicity testing (McConville 2018). Juvenile Pink Salmon experienced lower growth rates and likely lower survival rates in the year following exposure to EVOS. Reduced growth is largely attributed to the energetic cost of metabolizing oil (Rice 2010). Additionally, (Bue et al. 1996) demonstrated elevated embryo mortality in salmon incubating in intertidal habitats of oiled streams for several years following the Exxon Valdez oil spill.
Recovery	Reduced population status	1	Many salmon stocks are listed as species at risk; Herring biomass has declined in many areas of BC (Schweigert 2010).
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular, close interaction with unconsolidated substrates, as they are placed in the non-benthic category.

SG ID 103	MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Elasmobranchs (filter feeder)
Example species: Basking Shark					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Basking Sharks used to be found in large aggregations in some parts of the province, but no longer due to severely depleted populations (Wallace and Gisborne 2006).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Expected to have regular surface interaction as they feed close to the surface (COSEWIC 2016).
	Seafloor interacting	0	Not expected to have regular interaction with the seafloor, as they are placed in the mid water/pelagic category.
Sensitivity	Mechanical sensitivity	1	Basking sharks feed using gill rakers that may become clogged by oil and inhibit filter feeding.
	Chemical sensitivity	1 *	No studies could be found explicitly for the effects of crude or refined oils on species in this subgroup.
Recovery	Reduced population status	1	Basking Shark (Endangered (Pacific population) - SARA).
	Low reproductive capacity	1	Very little is known about Basking Shark reproduction, but it is known that they give birth to live young and the gestation period may be 12-36 mos. (Saad et al. 2012).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular, close interaction with unconsolidated substrates, as they are placed in the non-benthic category.

SG ID 104	MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Elasmobranchs (other)
Example species: Spiny Dogfish, Sixgill Sharks					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Spiny Dogfish form very large aggregations (Love 2011). They are scored a 1 as they likely aggregate this way for feeding, and due to the particularly large extent of the schools, it is also expected that aggregations are related to reproduction, as pregnant females are found together (Tribuzio and Kruse 2012).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Satellite tagging indicates that sixgill sharks do occupy surface waters in summer; Spiny Dogfish have been observed at surface waters and smaller individuals can form nomadic schools at the surface (Love 2011); however, it is unclear if this is a 'regular' interaction.
	Seafloor interacting	0	Note expected to have regular interaction with the seafloor, as they are placed in the mid water/pelagic category.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1 *	Biochemical effects of the Deepwater Horizon oil spill on sharks were detected in the form of increased biotransformation enzyme activity (Leary 2015; Walker 2011). However, no population level effects on elasmobranchs were detected following this spill (Peterson et al. 2017).
Recovery	Reduced population status	1	Common Thresher Shark (Vulnerable (Eastern Central Pacific) - IUCN); Bluntnose Sixgill Shark (Special Concern - SARA); Broadnose Sevengill Shark (Data deficient - IUCN); Blue Shark (Near Threatened - IUCN); Pacific Sleeper Shark (Data deficient - IUCN); Spiny Dogfish (Special Concern - COSEWIC); Top shark (Special Concern – SARA).
	Low reproductive capacity	1	Life history features for Bluntnose Sixgill Shark such as longevity (estimated to be 80 years), late age at maturity (estimated at 18-35 years) and low fecundity (47-108) characterize them as vulnerable equilibrium life history strategists. As such, they have a low intrinsic rate of increase, and are unable to recover quickly after population reduction. Spiny Dogfish live longer (up to 80 years old) and mature later than any other shark species that has been studied. Females may gestate their eggs for 22 months. (Love 2011).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular, close interaction with unconsolidated substrates, as they are placed in the non-benthic category.

SG ID 105	MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Mackerels and Tunas
Example species: Pacific Chub Mackerel					**Total Score: 2**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Mackerel spawn over small, patchy areas, not in aggregations (Lo 2010).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	0	No evidence of regular surface interaction.
	Seafloor interacting	0	Not expected to have regular interaction with the seafloor, as they are placed in the mid water/pelagic category.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1 *	Pacific Chub Mackerel (*Scomber japonicas*) exhibit physiological stress in the form of significantly increased metabolic demand after exposure to the water soluble fraction of crude oil, presumably due to the energetics required to metabolize the contaminants (Klinger 2015). Effects of oil were shown to reduce Bluefin Tuna ventricular cardiomyocytes. Experimental findings provide cardiac-specific physiological defects which reinforces findings that crude oil has deleterious physiological impacts on fish hearts (Brett et. al. 2014).
Recovery	Reduced population status	1	The population of Pacific Mackerel started to decline in the mid 1980's and has since remained at low levels (Chrone 2015).
	Low reproductive capacity	0	Pacific Mackerel females are sexually mature after 2-3 yrs (Knaggs, 1973) and spawn in multiple batches of over 68,000 eggs (Dickerson 1992).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular, close interaction with unconsolidated substrates, as they are placed in the non-benthic category.

SG ID 106	MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Ocean sunfishes
Example species: Ocean Sunfish					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Found singly or in small groups off western North America (Love 1996).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Ocean Sunfish are expected to have regular surface interaction as they bask at the surface (Love 2011).
	Seafloor interacting	0	Not expected to have regular interaction with the seafloor, as they are placed in the mid water/pelagic category.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1 *	No studies could be found explicitly for the effects of crude or refined oils on species in this subgroup.
Recovery	Reduced population status	1	Ocean Sunfish (Vulnerable (suspected global decline) - IUCN)
	Low reproductive capacity	0	Little is known about time to reproductive maturity, but a single 4.5 foot female was found to contain 300 million eggs (Love 1996).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular, close interaction with unconsolidated substrates, as they are placed in the non-benthic category.

SG ID 107	MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Sand lance
Example species: Pacific Sand Lance					Total Score: 4

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Pacific Sand Lance (*Ammodytes hexapterus*) can form large schools in the subtidal but spawning aggregations occur in the intertidal, where they spawn on sandy beaches depositing eggs in the upper intertidal zone (Love 2011).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Pacific Sand Lance are expected to have regular surface interaction, as they have been reported to occur close to the surface regularly (COSEWIC 2016; Love 2011).
	Seafloor interacting	1	Although sand lance are a midwater schooling species, they also regularly spend time buried in sand and fine gravel (Love 2011).
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1	Toxicity test on sand lance showed that dispersed crude oil droplets are highly toxic to them, while the water soluble fraction is also toxic, but to a lesser degree (Anderson et al. 1987). Sand Lance populations declined after Exxon Valdez spill; however this cannot be explicitly attributed to the spill (Golet 2002). Finally, exposure to oiled (crude) sediment resulted in a significant increase in gill parasites for sand lance (Moles and Wade 2001).
Recovery	Reduced population status	0	No evidence of declining populations could be found.
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1	Sand lance are a midwater schooling species, but generally spend nights and winter buried in sand and fine gravel (Love 2011).

SG ID 108	MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Anchovy
Example species: Northern Anchovy					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Anchovy form large schools in the pelagic environment, presumably for feeding and spawning. They can also be found aggregated around docks and pilings (Love 2011).
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	Anchovy migrate to the surface at night, and are more commonly found in shallow, inshore water waters during the spring (Kucas 1986).
	Seafloor interacting	0	Not expected to have regular interaction with the seafloor, as they are placed in the mid water/pelagic category.
Sensitivity	Mechanical sensitivity	1	Anchovy filter feed using gill rakers (Lamb and Edgell 2010).
	Chemical sensitivity	1	Decreased growth and increased mortality have been reported for Bay Anchovy larvae from the Gulf of Mexico acutely exposed to crude oil PAHs (Duffy 2016; O'Shaughnessy 2018).
Recovery	Reduced population status	0	Recent research shows a population increase in southern BC (Duguid 2019).
	Low reproductive capacity	0	Most fish species have high fecundity and early reproductive maturity when compared with other animal groups (e.g. marine mammals).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	0	Not expected to have regular, close interaction with unconsolidated substrates, as they are placed in the non-benthic category.

SG ID 109	MARINE FISHES	Subtidal	Non-benthic (pelagic, midwater and demersal)	N/A	Ratfish
Example species: Spotted Ratfish					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Can occur in very large schools (King and McPhie 2015) but not reported to aggregate for reproduction or feeding.
	Low mobility	0	Most fish species are considered highly mobile relative to an oil spill.
	Sea surface interacting	1	They have been observed to undergo diel vertical migrations occupying surface waters at night (COSEWIC 2016).
	Seafloor interacting	1	Ratfish mostly swim above the seafloor, but do interact with unconsolidated substrates in order to feed.
Sensitivity	Mechanical sensitivity	0	Species in this subgroup are not prone to smothering and do not have filter-feeding appendages that could become clogged from oil.
	Chemical sensitivity	1 *	No studies could be found explicitly for the effects of crude or refined oils on species in this subgroup.
Recovery	Reduced population status	0	IUCN status is least concern. Justification for status stated that the population is stable or increasing.
	Low reproductive capacity	1	Males are estimated to mature at 12 years of age, females at 14 years of age. Females only produce 2 eggs at a time and spawn year-round. Eggs develop for 1 year in egg cases (King and McPhie 2015; Love 1996).
	Endemism/Isolation	0	No endemism or isolation.
	Association with unconsolidated substrates	1 *	Ratfish live over flat, muddy, or sandy substrates. Diet is mostly comprised of benthic and epibenthic species, including clams (Love 2011), so close association is a possibility depending on how extensively they forage into the substrate.

SG ID 110	MARINE REPTILES	Sea turtles			N/A
Example species: Leatherback Sea Turtle; Green Sea Turtle; Olive Ridley					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Migratory/Accidental in BC waters and not expected to aggregate (SARA 2006)
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Interact with the sea surface to breathe
	Seafloor interacting	0	Sea turtles can interact with the seafloor/vegetation when foraging (Seminoff et al. 2006). However, in BC they are accidental visitors and not likely to be actively foraging.
Sensitivity	Mechanical sensitivity	0	Sea turtles do not rely on fur for thermoregulation and do not have filter feeding structures.
	Chemical sensitivity	1 *	Precautionary scoring due to a lack of research on the toxic effects of oil on sea turtles.
Recovery	Reduced population status	1	The Pacific Leatherback population has collapsed by over 90% in the last generation (Endangered - (COSEWIC 2012a).
	Low reproductive capacity	1	Marine reptiles have low reproductive capacity relative to other groups in the assessment. Leatherbacks have large clutch sizes (50-170 eggs) and multiple nestings per season (4-10), but age at reproductive maturity and generation time is uncertain (COSEWIC 2012a)
	Endemism/Isolation	0	No evidence of endemic/isolated populations of species in this group in BC.
	Association with unconsolidated substrates	0	Some Sea turtles forage deeply within small particle substrate (Seminoff et al. 2006). However, in BC, Sea turtles are accidental visitors and are not likely to be actively foraging.

SG ID 111	MARINE MAMMALS	Cetaceans	Toothed	Discrete	N/A
Example species: Killer Whales: residents (Northern and Southern) and offshore populations; Pacific White-Sided Dolphin, Harbour Porpoise, False Killer Whale					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Resident Killer Whales (Southern Resident Killer Whale (SRKW) and Northern Resident Killer Whales (NRKW)) travel in large groups and can form large aggregations in specific areas relating to concentrations of spawning salmon runs (Ford et al. 2000). Offshore Killer Whales are have a small population (~500 coast wide, California to Aleutians) but travel in very large aggregations (100+) (Ford et al. 2000). Pacific White-Sided Dolphins most often travel in large groups of between 40-100 individuals (Best et al. 2015; Heise 1997) though they are widely distributed in inshore and offshore waters. Harbour Porpoises usually travel in groups (of <8 individuals) (Jarvela-Rosenberger et al. 2017), but do aggregate at times, and in the Salish Sea have been observed in groups of 250 (Butler et al. 2017; Calambokidis et al. 1997; COSEWIC 2003a).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. The relative amount of time spent at the surface varies based on life history. Species and ecotypes of this subgroup spend most of their time near the sea surface.
	Seafloor interacting	0 *	No evidence that marine mammals within this subgroup regularly forage in substrates below the seafloor surface. However, an asterisk (*) is added to note that Northern resident Killer Whales interact with hard seafloor substrates at rubbing beaches (Ford et al. 2000) but do not forage below seafloor substrate.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil for animals in this group is expected to be relatively low they lack feeding structures vulnerable to clogging and do not depend on fur for thermoregulation. They also have smooth skin that has low oil adherence (Engelhardt 1983; Helm et al. 2015; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	See specific entries by species/ecotype in this group.
Recovery	Reduced population status	1	The Southern Resident Killer Whale (SRKW) population is small and declining, and is designated Endangered (COSEWIC 2008). The Offshore Killer Whale population is very small and has Threatened status (COSEWIC 2008). The Harbour Porpoise has Special Concern status with uncertain population levels (COSEWIC 2003a). In contrast, the Pacific White-Sided Dolphin has a large stable population and Not at Risk status (Best et al. 2015). Harbour Porpoise has Special Concern status, as populations in Southern BC are suspected to have declined (COSEWIC 2003a; DFO 2009, 2018).
	Low reproductive capacity	1	Low reproductive capacity overall. Killer Whales are long-lived, slow reproducers: female longevity is 80 years and males 40-50 years, female sexual maturity at 12-17, calving interval five years, generation time is 26-29 years (COSEWIC 2008).This subgroup also contains the relatively shorter-lived Harbour Porpoise, which reproduces every 1-2 years (COSEWIC 2003a).

Category	Criteria	Score	Justification
	Endemism/Isolation	1	The NRKW and SRKW populations are distinct in the region, isolated from each other and other Killer Whale populations (COSEWIC 2008)
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas

SG ID 111a	MARINE MAMMALS	Cetaceans	Toothed	Discrete	N/A
Southern Resident Killer Whales (SRKW) (*Orcinus orca*)					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Southern Resident Killer Whales (SRKW) travel in family groups and can form large aggregations in specific areas relating to concentrations of spawning salmon runs (Ford et al. 2000).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe, SRKW spend most of the time near the sea surface (Jarvela-Rosenberger et al. 2017).
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.

Category	Criteria	Score	Justification
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low in SRKW as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and have smooth skin (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1	No studies found for demonstrated effects of oil (all types) on the SRKW ecotype specifically, but effects of oil exposure can reasonably be expected to be as observed in other resident Killer Whales in Alaska (severe acute and sub-lethal toxic impacts). Acute exposure to oil from the EVOS in Alaska resulted in numerous Killer Whale mortalities, reducing numbers in two groups (AB (residents) and AT1 (transients)) by 33% and 41%. The likely cause was inhalation of toxic fumes (Matkin et al. 2008), which can cause marine mammals to lose consciousness and drown (St. Aubin and Geraci 1994). Killer Whales exhale before surfacing so must inhale even if oil is present at the surface (Matkin et al. 1999) and fumes were noted to still be present several days after the EVOS occurred (Matkin et al. 2008). In addition, when stressed, mammals surface more frequently which can lead to greater exposure to volatile chemical inhalation. Prolonged inhalation of high vapours can cause death or nervous system damage (lesions in respiratory membranes, leading to lung disease, bacterial pneumonia, adrenal disease, etc) (Jarvela-Rosenberger et al. 2017). Long term population consequences to these Killer Whale populations have occurred due to these losses, the residents through population depression, still not recovering to pre spill number 16 years later, with population yearly increases half that of other resident populations. The transient population continued to decline, with further deaths and the loss of all potentially reproducing individuals (Matkin et al. 2008; Matkin et al. 2012; Williams et al. 2009). It is rare to have this level of knowledge on acute effects of oil exposure (see statement in group entry), but resident Killer Whales are regularly surveyed and can be identified by individual.
Recovery	Reduced population status	1	The Southern Resident Killer Whale (SRKW) population is small and declining, with Endangered status (COSEWIC 2008).
	Low reproductive capacity	1	Low reproductive capacity. Killer Whales are long-lived, slow reproducers: female longevity is 80 years and males 40-50 years, female sexual maturity at 12-17, calving interval 5 years, generation time is 26-29 years (COSEWIC 2008).
	Endemism/Isolation	1	SKRW are a specific ecotype of Killer Whales that do not interact with other Killer Whales socially and are distinct in terms of their culture, acoustics, and genetics (DFO 2017).
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 111b	MARINE MAMMALS	Cetaceans	Toothed	Discrete	N/A
Northern Resident Killer Whales (NRKW) (*Orcinus orca*)					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Northern Resident Killer Whales (NRKW) travel in large group sizes of 10-25 individuals (Ford et al. 2000), and groups can aggregate in specific areas relating to concentrations of spawning salmon runs (Ford et al. 2000).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. NRKW spend most of the time near the sea surface (Jarvela-Rosenberger et al. 2017).
	Seafloor interacting	0	Though NRKW interact with hard seafloor substrate when using rubbing beaches (Ford et al. 2000) this criterion specifically relates to foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low in NRKW as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and have smooth skin (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1	No studies found for effects of oil (all types) on the NRKW ecotype specifically, but effects of oil exposure can reasonably be expected to be as observed in other resident Killer Whales in Alaska (severe acute and sub-lethal toxic impacts). NRKWs were thought to have been exposed to an oil spill in 2007 when 10,000 litres of diesel was spilled in Johnstone strait, a Killer Whale sanctuary area, though no effects were described, up to 25% of the NRKW population were estimated to have potentially passed through the spill and inhaled toxic fumes (Jarvela-Rosenberger et al. 2017; Williams et al. 2009). *Refer to entry for SRKW for information on effects observed in Alaskan Killer Whales following exposure to oil from the EVOS.
Recovery	Reduced population status	1	The Northern Resident Killer Whale (NRKW) population is small, but not declining but rather slowly increasing. It has been designated Threatened (COSEWIC 2008).
	Low reproductive capacity	1	Low reproductive capacity. Killer Whales are long-lived, slow reproducers: female longevity is 80 years and males 40-50 years, female sexual maturity at 12-17, calving interval 5 years, generation time is 26-29 years (COSEWIC 2008).
	Endemism/Isolation	1	NKRW are a specific ecotype of Killer Whales that do not interact with other Killer Whales socially and are distinct in terms of their culture, acoustics, and genetics (DFO 2017).
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas

SG ID 111c	MARINE MAMMALS	Cetaceans	Toothed	Discrete	N/A
Offshore Killer Whale population (*Orcinus orca*)					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Offshore Killer Whales are have a small overall population (~500 coast wide, California to Aleutians) that travels in large groups (30-60, and sometimes up to 100 individuals) (Ford et al. 2000).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. Offshore Killer Whales spend much of the time near the sea surface (Jarvela-Rosenberger et al. 2017).
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low for Offshore Killer Whales as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and have smooth skin (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	No studies found for the effects of oil (all types) on the Offshore Killer Whale ecotype specifically, but effects of oil exposure expected to be similar to other Killer Whales observed in Alaska (severe acute and sub-lethal toxic impacts). An asterisk added to score as this is a different ecotype of Killer Whale (i.e. not a 'resident' or 'transient' ecotype). *Refer to entry for SRKW for information on effects observed in Alaskan Killer Whales following exposure to oil from the EVOS.
Recovery	Reduced population status	1	The Offshore Killer Whale population is small (~120 mature individuals in 2008) but stable, apparently not in decline, but designated as Threatened (COSEWIC 2008).
	Low reproductive capacity	1	Low reproductive capacity. Killer Whales are long-lived, slow reproducers: female longevity is 80 years and males 40-50 years, female sexual maturity at 12-17, calving interval 5 years, generation time is 26-29 years (COSEWIC 2008).
	Endemism/Isolation	1	Offshore Killer Whales are a specific ecotype of Killer Whales.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 111d	MARINE MAMMALS	Cetaceans	Toothed	Discrete	N/A
Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*)					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Pacific White-Sided Dolphins usually travel in large groups of between 40-100 individuals (Best et al. 2015; Heise 1997), but can travel in large groups of several thousand (Stacey and Baird 1981), they are widely distributed in inshore and offshore waters.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. Pacific White-Sided Dolphins spend most of the time near the sea surface (Jarvela-Rosenberger et al. 2017).
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface. They consume cephalopods and small schooling fishes (Stacey and Baird 1981).
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low for this species as it lacks feeding structures vulnerable to clogging, uses blubber not fur for thermoregulation and have smooth skin (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	No studies found for the effects of oil (all types) on the Pacific White-Sided Dolphin specifically, but effects expected to be similar to other delphinids, which when exposed to an oil spill would most likely suffer acute and sub-lethal exposure through inhalation of oil vapours (and indirectly from contaminated prey) (Helm et al. 2015). Coastal Bottlenose Dolphins exposed to the DWH crude oil spill developed adrenal gland disease and dysfunction (DWH Natural Resource Damage Assessment Trustees 2016). The leading hypothesis for adrenal gland cortex injury in the Gulf of Mexico Common Bottlenose Dolphins is exposure to contaminants from the DWH oil spill. Chemical inhalation injury is likely amplified in dolphins as they exchange 75–90% of deep lung air with each breath (Venn-Waston et al 2015). Longer term effects from exposure from the DWH spill in bottlenose dolphins included reduced calving rates (76% reduction in pregnant bottlenose dolphins producing viable young), a decline in adult survival (by 8-9%) and elevated levels of severe lung disease (Ackleh et al. 2017; Lane et al. 2015; Murawski et al. 2020).
Recovery	Reduced population status	0	There is a large and stable population of Pacific White-Sided Dolphins. Not at risk status (Best et al. 2015).
	Low reproductive capacity	1	Low reproductive capacity, longevity: estimated >40 years, sexual maturity 6-10 years, gestation 10-12 months, birth interval 3 years (Stacey and Baird 1981).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas

SG ID 111e	MARINE MAMMALS	Cetaceans	Toothed	Discrete	N/A
Harbour Porpoise (*Phocena phocena*)					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Harbour Porpoises usually travel in groups of <8 individuals (Jarvela-Rosenberger et al. 2017), but have also been reported to aggregate at times, and in the Salish Sea have been observed in groups of 250 (Butler et al. 2017; Calambokidis et al. 1997; COSEWIC 2003a).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. Harbour Porpoises spend most of the time near the sea surface (Jarvela-Rosenberger et al. 2017).
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low for Harbour Porpoises as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and have smooth skin (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	No studies found for the effects of oil (all types) on Harbour Porpoises specifically, but effects expected to be similar to other delphinids, which when exposed to an oil spill, i.e. they would suffer acute and sub-lethal exposure through inhalation of oil vapours (and indirectly from contaminated prey) (Helm et al. 2015). Harbour Porpoises have a very low detection rate for carcasses (<1%), making mortality estimates challenging (Moore and Read 2008) In: (Williams et al. 2011). A marine mammal carcass survey post Exxon Valdez found 5 Harbour Porpoises carcasses (Loughlin 2013). Refer to SRKW and Pacific white-Sided Dolphin entries for more details on effects on delphinids.
Recovery	Reduced population status	1	Harbour Porpoise has Special Concern status, as populations in Southern BC are suspected to have declined (COSEWIC 2003a; DFO 2009, 2018).
	Low reproductive capacity	1	Low reproductive capacity. Relatively shorter-lived within the marine mammals as they reproduce every 1-2 years (COSEWIC 2003a).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 111f	MARINE MAMMALS	Cetaceans	Toothed	Discrete	N/A
False Killer Whale (*Pseudorca crassidens*)					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	False Killer Whales can travel in larger groups of 20-100 (Ford 2014).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and have smooth skin (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	No studies found for toxic effects of oil (all types) for False Killer Whales specifically, but toxic effects of oil exposure expected to be as observed in other delphinids such as Killer Whales (refer to SRKW and White-sided dolphin entries).
Recovery	Reduced population status	0	Designated 'Not at Risk' in 1990 by COSEWIC, rare in Canadian waters.
	Low reproductive capacity	1	Low reproductive capacity. False Killer Whale gestation 15-16 months and lactation 18 months. Sexual maturity estimated at 8 years (IUCN 1991; Stacey et al. 1994).
	Endemism/Isolation	0	No evidence of endemic/isolated populations
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 112	MARINE MAMMALS	Cetaceans	Toothed	Dispersed	N/A
Example species: Sperm Whales, Killer Whales (W.Coast Transients), Beaked Whales (Baird's, Hubbs' and Stejneger's), Dall's Porpoise					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	The species and species ecotypes within this subgroup are generally dispersed in BC waters and do not form discrete aggregations, and may be transiting the region. For example, Dall's Porpoises usually occur in small groups of < 8 (Ford 2014; Jefferson 1987), West Coast Transient Killer Whales most often occur in small groups of 2-6 (DFO 2007). Baird's Beaked Whales whales can be gregarious but are usually found in groups of 2-7 (Ford 2014). Stejneger's Beaked Whales whales travel in small groups of 3-4. (Ford 2014).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. The relative amount of time spent at the surface varies based on life history. Some in this group (e.g., Sperm Whale) engage in long deep dives and so spend relatively less time on the surface, whereas others are more frequently at the sea surface (e.g., Dall's Porpoises).
	Seafloor interacting	0	There is no evidence that marine mammals within this subgroup regularly forage in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil for animals in this group is expected to be relatively low as they lack feeding structures vulnerable to clogging and do not depend on fur for thermoregulation. They also have smooth skin (skin has low oil adherence) (Engelhardt 1983; Helm et al. 2015; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	See specific entries by species/ecotype in this group
Recovery	Reduced population status	1	Transient Killer Whales have a small population that is Threatened (COSEWIC 2008) and critically imperiled (BC province). However, other species in this subgroup are considered not at risk (e.g., the species of Beaked Whales, Dall's Porpoise). Though sperm whale populations are still significantly reduced from commercial whaling (Taylor et al. 2008), they were designated 'Not at Risk' by COSEWIC in 1996.
	Low reproductive capacity	1	Low reproductive capacity overall for this subgroup. Killer Whales are long lived slow reproducers (COSEWIC 2008), Sperm Whales are also slow reproducers with long gestation times. Baird's Beaked Whales whales have a very long gestation time (17 months) (Ford 2014). However, this subgroup also contains relatively faster reproducing and shorter-lived species, such as the Dall's Porpoise. Relative to the other groups in the assessment, reproductive capacity Is low.
	Endemism/Isolation	1	There is no evidence of endemic/isolated populations for most of the species in this subgroup, with the exception of the west coast transient Killer Whale ecotype, which is a small population of approximately 250 animals (DFO 2007).

Category	Criteria	Score	Justification
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 112a	MARINE MAMMALS	Cetaceans	Toothed	Dispersed	N/A
Sperm Whale (*Physeter macrocephalus*)					**Total Score: 4**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Outside of BC waters, Sperm Whales are found in groups of adult females with calves and juveniles (20-40), or in groups of adult males (50) (BC Conservation Data Centre 2006). However, in BC waters, Sperm Whales are rare and dispersed.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. Sperm Whales engage in long deep dives and so may spend relatively less time on the surface than other marine mammals.
	Seafloor interacting	0	Sperm Whales primarily eat squid (Whitehead 2003), no evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low for Sperm Whales as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and have smooth skin with low oil adherence (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), which is similarly smooth, however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	No studies found for toxic effects of oil (all types) on the Pacific population of Sperm Whales specifically. There is some evidence that after the DWH oil spill, the density of the Gulf of Mexico Sperm Whales close to the blowout area decreased by a factor of 2 (Ackleh et al. 2012). The mean presence of Sperm Whales has declined overall over the longer term following the DWH spill but has not been explicitly linked to the spill (Murawski et al. 2020). A dead Sperm Whale was recovered following an oil well blowout in 1969 in California (Geraci and St.Aubin 1990) that could be presumed to have died as a result of exposure to the crude oil. It can be assumed that toxic effects in Sperm Whales might be similar to those seen in other cetaceans, where exposure usually occurs through inhalation of toxic vapours (see SRKW entry in the table). Sperm Whale populations lack study on acute and chronic population impacts of oil spills (Ackleh et al. 2017). A biopsy study after the DWH spill found elevated levels of genotoxic chromium and nickel in Sperm Whales linked to exposure to oil from the DWH spill, the presence of these contaminants can impair reproduction (Wise Jr et al. 2014). Oil exposure to Sperm Whales in the northern Gulf of Mexico from the DWH oil spill is projected to reduce survival and reproductive success and estimated to cause a decline of 26% by 2025 (Farmer et al. 2018).

Category	Criteria	Score	Justification
Recovery	Reduced population status	1 *	Though Sperm Whale populations are still significantly reduced due to commercial whaling (Taylor et al. 2008), they are designated ‘Not at Risk’ (in 1996 by COSEWIC). Their provincial designation is ‘Special concern’ (Klinkenberg 2019).
	Low reproductive capacity	1	Low reproductive capacity. Sperm Whale gestation is 14-15 months, calving interval 3-6 years with weaning takes up to 3.5 years. Female sexual maturity 7-11 years; males up to 25 years. Longevity 60-70 years (BC Conservation Data Centre 2006).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 112b	MARINE MAMMALS	Cetaceans	Toothed	Dispersed	N/A
Transient Killer Whales (West coast) (*Orcinus orca*)					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	West Coast Transient Killer Whales usually occur in small groups of 2-6 (DFO 2007).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low for Bigg’s Killer Whales as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and have smooth skin with low oil adherence (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1	No studies found for the effects of oil (all types) on the Transient (Bigg’s) Killer Whale ecotype specifically, but effects of oil exposure expected to be similar to other Killer Whales observed in Alaska (severe acute and toxic impacts), where impacts were found on resident and transient ecotypes. *Refer to SRKW entry for information on effects observed in resident and transient Alaskan Killer Whales following exposure to oil from the EVOS.

Category	Criteria	Score	Justification
Recovery	Reduced population status	1	Transient Killer Whales have a very small population (~122 individuals) designated 'Threatened' (COSEWIC 2008) and 'Critically imperiled' (BC province listing). However, the population is slowly increasing.
	Low reproductive capacity	1	Low reproductive capacity, Killer Whales are long lived slow reproducers (COSEWIC 2008).
	Endemism/Isolation	1	Transient Killer Whales are a specific ecotype with a small population of approximately 250 animals (DFO 2007).
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 112c	MARINE MAMMALS	Cetaceans	Toothed	Dispersed	N/A
Baird's Beaked Whale (*Berardius bairdii*)					**Total Score: 3**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Baird's Beaked Whales can be gregarious but are usually found in groups of 2-7 (Ford 2014), they are rare in BC waters.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. Beaked Whales are deep divers with longer foraging times than other marine mammals (Quick et al. 2020). Dives of 1000m are normal for Baird's Beaked Whales (Reeves and Mitchell 1992). Consequently, Beaked Whales are likely to spend relatively less time on the surface than other marine mammals.
	Seafloor interacting	0	They consume squid and deep-sea fishes (Reeves and Mitchell 1992) no evidence of regular foraging below the seafloor surface.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and presumed to have smooth, non-adherent skin. There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	No studies found for toxic effects of oil (all types) for the little studied Baird's Beaked Whales whales specifically, but acute and sub-lethal toxic effects of oil exposure may be comparable to those observed in other toothed cetaceans such as Killer Whales (refer to SRKW and White-Sided Dolphin entries).

Category	Criteria	Score	Justification
Recovery	Reduced population status	0	Designated 'Not at Risk' in 1992 by COSEWIC, provincially its status is unknown (BC Conservation Data Centre 1995).
	Low reproductive capacity	1	Low reproductive capacity. Gestation estimated at 17 months and lactation 1 year. Sexual maturity in males occurs at 6-10 years, females at 10-14 years. Longevity estimated at several decades (Reeves and Mitchell 1992). Relative to the other groups in the assessment, reproductive capacity Is low.
	Endemism/Isolation	0	No evidence of endemic/isolated populations, but little is known.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 112d	MARINE MAMMALS	Cetaceans	Toothed	Dispersed	N/A
Hubb's Beaked Whale (*Mesoplodon carlhubbsi*)					**Total Score: 3**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Little known about this species that is rare in Canadian waters.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. Beaked Whales are deep divers with longer foraging times than other marine mammals (Quick et al. 2020). Consequently, Beaked Whales are likely to spend relatively less time on the surface than other marine mammals.
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface, their diet consists primarily of squid (Mead et al. 1982).
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and presumed to have smooth, non-adherent skin. There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	No studies found for toxic effects of oil (all types) for the little studied Hubb's Beaked Whales specifically, but acute and sub-lethal toxic effects of oil exposure may be comparable to those observed in other toothed cetaceans such as Killer Whales (refer to SRKW and White-sided dolphin entries).

Category	Criteria	Score	Justification
Recovery	Reduced population status	0	Designated 'Not at Risk' in 1989 by COSEWIC.
	Low reproductive capacity	1	Low reproductive capacity, little known of this species.
	Endemism/Isolation	0	No evidence of endemic/isolated populations, but little is known.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 112e	MARINE MAMMALS	Cetaceans	Toothed	Dispersed	N/A
Stejneger's Beaked Whale (*Mesoplodon stejnegeri*)					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Stejneger's Beaked Whales whales travel in small groups of 3-4. (Ford 2014).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. Beaked Whales whales are deep divers with longer foraging times than other marine mammals (Quick et al. 2020). Consequently, Beaked Whales whales are likely to spend relatively less time on the surface than other marine mammals.
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface, stomach contents of stranded animals indicates they primarily eat squid in deep waters (Walker and Hanson 1999).
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and presumed to have smooth, non-adherent skin. There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	No studies found for toxic effects of oil (all types) for the little studied Stejneger's Beaked Whales whales specifically, but acute and sub-lethal toxic effects of oil exposure may be comparable to those observed in other toothed cetaceans such as Killer Whales (refer to SRKW and White-Sided Dolphin entries).

Category	Criteria	Score	Justification
Recovery	Reduced population status	0	Designated 'Not at Risk' in 1989 by COSEWIC.
	Low reproductive capacity	1	Low reproductive capacity, little known of this species.
	Endemism/Isolation	0	No evidence of endemic/isolated populations, but little is known.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 112f	MARINE MAMMALS	Cetaceans	Toothed	Dispersed	N/A
Dall's Porpoise (*Phocoenoides dalli*)					Total Score: 3

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Dall's Porpoises usually occur in small groups of < 8 (Ford 2014; Jefferson 1987).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil low as they lack feeding structures vulnerable to clogging, do not depend on fur for thermoregulation and have smooth skin (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). There is some evidence that oil can adere to the skin of dolphins (Dias et al. 2017), however adherance to external surfaces of large-bodied marine animals has not been shown to alter swimming, diving efficiency, or other aspects of mechanical performance.
	Chemical sensitivity	1 *	No studies found for toxic effects of oil (all types) for Dall's Porpoise specifically, but acute and sub-lethal toxic effects of oil exposure expected to be as observed in other delphinids such as Killer Whales (refer to SRKW and White-sided dolphin entries).
Recovery	Reduced population status	0	Designated 'Not at Risk' in 1989 by COSEWIC.
	Low reproductive capacity	1	Low reproductive capacity, little known of this species.
	Endemism/Isolation	0	No evidence of endemic/isolated populations, but little is known.

Category	Criteria	Score	Justification
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas. Eats squid and fish (Jefferson 1987).

SG ID 113	MARINE MAMMALS	Cetaceans	Baleen	Discrete	N/A
Example species: Humpback Whales; Grey Whales; Fin Whales					Total Score: 9

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Humpbacks aggregate for feeding in BC waters and travel in large, loose groups, with increasing populations in BC waters (Dalla Rosa et al. 2012). Grey Whales travel in small groups of 1-5 (Ford et al. 2013) during migration population is age class segregated with pregnant females in the lead (Wursig 1990). A Grey Whale population concentrates off Southern Vancouver island as (Pacific Coast Feeding group (Calambokidis et al. 2002; COSEWIC 2017). Fin Whales are common in large groups up to 20 individuals (Best et al. 2015; Ford 2014) in BC waters.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. The relative amount of time spent at the surface varies based on life history. Baleen whales spend much of their time at the sea surface.
	Seafloor interacting	1	In contrast to other baleen whales, Grey whales are primarily bottom feeders who forage in below seafloor surface substrates to consume benthic and epibenthic invertebrates filtered out of sediment (Ford 2014). No evidence that Pacific Humpbacks forage in sub-surface substrates, but in the Atlantic Humpbacks do bottom feed on northern sand lance (Hain et al. 1995; Ware et al. 2013). Both species have strong site fidelity to feeding areas (COSEWIC 2017).
Sensitivity	Mechanical sensitivity	1	Mechanical impairment of Humpback and Grey Whales relatively high, as both have filter feeding structures (baleen) that can become fouled by oil, reducing ability to feed (Wursig 1990) and both have rough skin surfaces (skin has medium oil adherence)(DFO 2010c, 2013). Oil adherence of less importance for categorization of mechanical sensitivity than filter feeding, since adherence alone would likely not alter swimming, diving, or other locomotory movements.
	Chemical sensitivity	1 *	See specific entries by species/ecotype in this group.

Category	Criteria	Score	Justification
Recovery	Reduced population status	1	Humpback and Grey Whale populations are still drastically reduced from historic levels due to commercial whaling. Humpback Whales are designated 'Special concern', having been reclassified from 'Threatened' in 2011 due to increased growth rates and abundance (COSEWIC 2011). Of the three Pacific Grey Whale populations, two are designated 'Endangered' while the third is designated 'not at risk) (COSEWIC 2017).
	Low reproductive capacity	1	Low reproductive capacity: Humpback and Grey Whales have long gestation and longevity, and calving intervals are 1-5 years for Humpback Whales and a minimum of 2 years for Grey Whales. Gestation is 11-12 months in Humpbacks and 13-14 months in Grey Whales. Longevity is at least 48 years in Humpbacks and at least 40 years in Grey Whales (COSEWIC 2011, 2017) Relative to the other groups in the assessment, reproductive capacity Is low.
	Endemism/Isolation	1	Grey Whales have a small (~243 individuals) and genetically distinct 'Pacific Coast Feeding Group' population which resides for the summer in the Pacific Northwest for feeding after migrating from Mexico, rather than continuing North (COSEWIC 2017). No evidence of endemic/isolated populations for Humpback Whales.
	Association with unconsolidated substrates	1	Grey Whales regularly forage in shallow subtidal or intertidal soft substrates, disturbing large areas of sediment (Anderson and Lovvorn 2008; COSEWIC 2017) (Nelson et al. 2006). No evidence that Humpback Whales regularly forage in unconsolidated substrates in intertidal area, though Atlantic Humpbacks bottom feed on Northern Sand Lance (Hain et al. 1995; Ware et al. 2013).

SG ID 113a	MARINE MAMMALS	Cetaceans	Baleen	Discrete	N/A
Humpback Whale (*Megaptera novaeangliae*)					**Total Score: 6**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Humpbacks aggregate for feeding in BC waters and travel in large, loose groups, with increasing populations in BC waters (Dalla Rosa et al. 2012).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. Humpback Whales spend much of their time at the sea surface in general and in addition much of their feeding occurs at the surface when lunge feeding, or for longer periods when 'trap-feeding', a technique recently observed in BC (McMillan et al. 2019).
	Seafloor interacting	0	No evidence that Pacific Humpbacks regularly forage in substrates below the seafloor surface, though Humpbacks in the Atlantic bottom feed on Northern Sand Lance (Hain et al. 1995; Ware et al. 2013).

Category	Criteria	Score	Justification
Sensitivity	Mechanical sensitivity	1	Mechanical impairment by oil relatively high as the filter feeding structures (baleen) of Humpback Whales could be clogged, reducing feeding ability (Wursig 1990). Humpback skin is also rough (due to tubercles) increasing oil adherence (skin has medium oil adherence) (DFO 2013) (Jarvela-Rosenberger et al. 2017). Oil adherence of less importance for categorization of mechanical sensitivity than filter feeding, since adherence alone would likely not alter swimming, diving, or other locomotory movements.
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil exposure on Humpback Whales have not been clearly demonstrated. Humpback Whale surveys after EVOS found no oiled whales or deaths (carcasses), and no evidence of movement of the population (Dalheim and von Ziegesar 1993). Humpback Whales were observed swimming in and feeding within a heavy oil slick in the N. Atlantic (composed of Bunker C and fuel oil) after a spill following a collision in 1979 (Geraci and St. Aubin 1988). Clear evidence for sub-lethal effects in Humpback Whales was not found, but may be similar to those seen in other cetaceans, where exposure usually occurs through inhalation of toxic vapours (refer to SRKW and White-Sided Dolphin entries).
Recovery	Reduced population status	1 *	Designated 'Special concern'. Conservation status was reclassified from 'Threatened' to 'Special Concern' in 2011 due to increased growth rates and abundance (COSEWIC 2011).
	Low reproductive capacity	1	Low reproductive capacity. Gestation 11-12 months, calving interval 1-5 years, sexual maturity reached after 5-9 years, and longevity at least 48 years (COSEWIC 2011).
	Endemism/Isolation	0	No evidence of endemic/isolated Pacific Humpback Whale populations, though it has been proposed that those in BC waters may be members of two different subpopulations (COSEWIC 2011).
	Association with unconsolidated substrates	0	No evidence of regular foraging by Pacific Humpback in unconsolidated substrates in intertidal areas, though Atlantic Humpbacks bottom feed on Northern Sand Lance (Hain et al. 1995; Ware et al. 2013).

SG ID 113b	MARINE MAMMALS	Cetaceans	Baleen	Discrete	N/A
Grey Whale (*Eschrichtius robustus*)					**Total Score: 9**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Grey Whales travel in small groups of 1-5 (Ford et al. 2013) during migration population is age class segregated with pregnant females in the lead (Wursig 1990).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe.

Category	Criteria	Score	Justification
	Seafloor interacting	1	Grey Whales interact with the seabed regularly as they are primarily bottom feeders that use coarse baleen plates to filter prey from sediment ingested while swimming and rolling on their sides. They consume benthic and epibenthic invertebrates from within the sediment (Ford 2014) and feed in shallow subtidal and intertidal areas disturbing large areas of soft sediments (Anderson and Lovvorn 2008).
Sensitivity	Mechanical sensitivity	1 *	Mechanical impairment by oil relatively high due to filter feeding structures (baleen) that could be clogged, reducing feeding ability (Wursig 1990). Grey whales have 130-180 baleen plates, each 5 to 25cm long (COSEWIC 2017). However, Grey Whale baleen is not likely to be exposed to floating oil as they are bottom feeders (hence precautionary *). Skin is rough due to barnacles (skin has medium oil adherence; DFO 2010c; Jarvela-Rosenberger et al. 2017). Oil adherence of less importance for categorization of mechanical sensitivity than filter feeding, since adherence alone would likely not alter swimming, diving, or other locomotory movements.
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil exposure on Grey Whales have not been clearly demonstrated. Acute effects were suspected following the EVOS when post EVOS surveys in 1989 found 26 Grey Whale carcasses (Loughlin 2013), a higher number than found than earlier years. However, the cause of these deaths has not been conclusively linked to the EVOS and may be due to increased survey effort. As Grey Whale migration was underway at the time of the EVOS, exposure by feeding was less likely, but as Grey Whales were observed swimming through oil (Moore and Clarke 2002) so exposure through skin contact and inhalation could have occurred. Sub-lethal effects in Grey Whales may be similar to those seen in other cetaceans, where exposure usually occurs through inhalation of toxic vapours (refer to SRKW and Pacific White-Sided Dolphin entries).
Recovery	Reduced population status	1	Three Pacific Grey Whale populations have been defined as of 2017: 1. Northern Pacific Migratory, designated 'Not at Risk'; 2. Pacific Coast Feeding Group designated 'Endangered'; and 3. Western Pacific population designated 'Endangered' (COSEWIC 2017). The 2017 assessment divided the population previously known as 'Eastern North Pacific' into populations 1 and 2 above.
	Low reproductive capacity	1	Low reproductive capacity. Gestation 13-14 months, and calving interval is a minimum of 2 years, age of sexual maturity is 8 years and longevity at least 40 years (COSEWIC 2017).
	Endemism/Isolation	1	The small (~243 individuals) and genetically distinct 'Pacific Coast Feeding Group' Grey Whale population which resides for the summer in the Pacific Northwest for feeding after migrating from Mexico, rather than continuing North (COSEWIC 2017). This population is also distinct from other Grey Whale populations in terms of foraging behaviour and habitat selection (COSEWIC 2017) populations like this that demonstrate 'behavioral plasticity' may be important for adapting to changing conditions (Pyenson and Lindberg 2011).
	Association with unconsolidated substrates	1	Unusual for baleen whales, Grey Whales regularly forage in shallow subtidal or intertidal soft substrates, disturbing large areas of sediment (Anderson and Lovvorn 2008; COSEWIC 2017; Nelson et al. 2006).

SG ID 113c	MARINE MAMMALS	Cetaceans	Baleen	Discrete	N/A
Fin Whale (*Balaenoptera physalus*)					Total Score: 6

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	In BC waters, Fin Whales aggregate in areas where their euphausiid prey concentrates such as canyons and troughs (COSEWIC 2019). Fin Whales are common in large groups up to 20 individuals (Best et al. 2015; Ford 2014) in BC waters.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. Baleen whales spend much of their time at the sea surface so may have relatively more surface interaction.
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	1	Mechanical impairment by oil relatively high due to filter feeding structures (baleen) that could be clogged, reducing feeding ability (Wursig 1990). Fin Whale skin is smooth (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017)
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil exposure on Fin Whales have not been clearly demonstrated. Though a single Fin Whale carcass was found in the marine mammal survey in 1989 following the EVOS (among the 37 found in total) (Loughlin 2013) it was not linked conclusively to the EVOS. Fin Whales were observed swimming in and feeding within a heavy oil slick in the N. Atlantic (composed of Bunker C and fuel oil) after a spill following a collision in 1979 (Geraci and St. Aubin 1988). No evidence found for sub-lethal effects but effects expected to be similar to those seen in other cetaceans, where exposure usually occurs through inhalation of toxic vapours (refer to SRKW and White-sided dolphin entries).
Recovery	Reduced population status	1	The Pacific Fin Whale population is designated 'Special concern' (COSEWIC 2019) changed from previously 'Threatened' status (COSEWIC 2005) as the population is showing recovery from commercial whaling depletions. Numbers in Canadian waters are estimated at less than 1000 mature individuals, but this estimate excludes the many individuals observed off the continental shelf and populations in nearby US waters (COSEWIC 2019).
	Low reproductive capacity	1	Low reproductive capacity: Sexual maturity at 6-8 years old, gestation time 11-12 months, generation time ~25 years, calving interval 2.24 years, longevity up to 100 years . Relative to other groups in the overall assessment, reproductive capacity is low.
	Endemism/Isolation	0	No confirmed endemic/isolated populations in the Pacific though photo-identification studies indicate Fin Whales can show site fidelity and individuals reside for extended periods in particular areas such as Caamaño Sound (COSEWIC 2019; Nichol et al. 2018)
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas. Fin Whales in the Pacific consume mostly euphausiids and copepods (COSEWIC 2019).

SG ID 114	MARINE MAMMALS	Cetaceans	Baleen	Dispersed	N/A
Example species: Sei Whale; Blue Whale; North Pacific Right Whale; Common Minke Whale					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	The species within this group are generally dispersed in BC waters and do not form discrete aggregations, or may be transiting the region. For example common minke whales are primarily seen alone or in similar areas yet independent of one another (Dorsey 1981).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. The relative amount of time spent at the surface varies based on life history. Baleen whales spend much of their time at the sea surface.
	Seafloor interacting	0	Marine mammals within this subgroup do not have regular interaction with seafloor or vegetation.
Sensitivity	Mechanical sensitivity	1	Mechanical impairment high relative to other groups due to filter feeding structures (baleen) that can become fouled by oil, reducing ability to feed (Wursig 1990). The group contains species with both smooth and rough skin (rough skin has medium oil adherence, smooth skin has low oil adherence) . Oil adherence of less importance for categorization of mechanical sensitivity than filter feeding, since adherence alone would likely not alter swimming, diving, or other locomotory movements.
	Chemical sensitivity	1 *	See specific entries by species/ecotype in this group.
Recovery	Reduced population status	1	Populations of many whale species are still drastically reduced due to commercial whaling. Blue Whales have a particularly greatly reduced population. Sei, Blue and North Pacific Right Whales are designated 'Endangered' status, all designations are due to population declines (COSEWIC 2004, b, 2013b; DFO 2017). In contrast, minke whales are considered 'Not at Risk' (COSEWIC 2006a).
	Low reproductive capacity	1	Low reproductive capacity: Sei whales are sexually mature at 5 - 15 years of age, have a 10-12 month gestation period, and live at least up to 60 years (COSEWIC 2013c). Blue whale females give birth every 2-3 years, with a long gestation period (10-12 months) (Gregr et al. 2006). Relative to other groups in the overall assessment, reproductive capacity is low.
	Endemism/Isolation	0	No evidence of endemic/isolated populations of species in this group.
	Association with unconsolidated substrates	0	The majority of baleen whales do not forage in unconsolidated sediment. No evidence of regular foraging in unconsolidated substrates in intertidal areas for species in this group.

SG ID 114a	MARINE MAMMALS	Cetaceans	Baleen	Dispersed	N/A
Sei Whale (*Balaenoptera borealis*)					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Very rare in BC waters (COSEWIC 2013c) and when present usually alone or in very small groups.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. Sei Whales feed at the surface (COSEWIC 2013c).
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	1	Mechanical impairment by oil relatively high due to filter feeding structures (baleen) that could be clogged, reducing feeding ability (Wursig 1990). Sei Whale skin is rough, due to parasitic copepods (skin has medium oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). Oil adherence of less importance for categorization of mechanical sensitivity than filter feeding, since adherence alone would likely not alter swimming, diving, or other locomotory movements.
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil exposure on sei whales have not been clearly demonstrated. A marine mammal carcass survey in 1989 after the EVOS did not locate any Sei Whale carcasses among the 37 found in total (Loughlin 2013) (Sei Whales are present in the area). No evidence found for sub-lethal effects but effects expected to be similar to those seen in other cetaceans, where exposure usually occurs through inhalation of toxic vapours (refer to SRKW and Pacific White-Sided Dolphin entries).
Recovery	Reduced population status	1 *	The Pacific Sei Whale population is designated ‘Endangered’. The population is still depleted from commercial whaling and numbers in Canadian waters are very low (<250 mature animals), based on observations (COSEWIC 2013c). However the population is not considered to be in decline.
	Low reproductive capacity	1	Low reproductive capacity: Sei Whales are sexually mature at 5 - 15 years of age, have a 10-12 month gestation period, and live at least up to 60 years (COSEWIC 2013c).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 114b	MARINE MAMMALS	Cetaceans	Baleen	Dispersed	N/A
Blue Whale (*Balaenoptera musculus*)					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Migrates in small herds (COSEWIC 2012b), can aggregate for feeding at continental shelf edge where kill concentrations occur due to upwelling (COSEWIC 2002, 2012b). However, as rare in BC, scored a 0.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. Blue Whales engage in dives of up to 20-36 minutes, so may have relatively less surface interaction than other baleen whales.
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	1	Mechanical impairment by oil relatively high due to filter feeding structures (baleen) that could be clogged, reducing feeding ability (Wursig 1990). Blue Whale skin is smooth (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017). Oil adherence of less importance for categorization of mechanical sensitivity than filter feeding, since adherence alone would likely not alter swimming, diving, or other locomotory movements.
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil exposure on blue whales have not been clearly demonstrated. No evidence found for sub-lethal effects but effects expected to be similar to those seen in other cetaceans, where exposure usually occurs through inhalation of toxic vapours (refer to SRKW and White-sided dolphin entries).
Recovery	Reduced population status	1	The Pacific Blue Whale population is still greatly depleted by commercial whaling in Canadian waters and numbers in Canadian waters are thought to be very low (<250 mature individuals) based on sightings. Designated 'Endangered' (COSEWIC 2012b).
	Low reproductive capacity	1	Low reproductive capacity: Blue Whale females give birth every 2-3 years, with a long gestation period (10-12 months) (Gregr et al. 2006), longevity 70-80 years (COSEWIC 2002).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas. Pacific Blue Whales consume mostly euphausiids.

SG ID 114c	MARINE MAMMALS	Cetaceans	Baleen	Dispersed	N/A
North Pacific Right Whale (*Eubalaena japonica*)					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	This species is so rarely seen in BC waters and population levels so low that aggregations unexpected.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. They are skim feeders and spend much of their time at the sea surface so may have relatively more surface interaction.
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	1	Right Whales tend to feed by skimming the surface (Geraci and St.Aubin 1990). Mechanical impairment by oil relatively high due to filter feeding structures (baleen) that could be clogged, reducing feeding ability (Wursig 1990). Skin is rough, due to callosities (skin has medium oil adherence) (DFO 2011; Jarvela-Rosenberger et al. 2017) and may impair body functions such as swimming. Oil adherence of less importance for categorization of mechanical sensitivity than filter feeding, since adherence alone would likely not alter swimming, diving, or other locomotory movements.
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil exposure on North Pacific Right Whales have not been clearly demonstrated. No evidence found for sub-lethal effects but expected to be similar to those seen in other cetaceans, where exposure usually occurs through inhalation of toxic vapour (refer to SRKW and Pacific White-Sided Dolphin entries).
Recovery	Reduced population status	1	The North Pacific Right Whale is designated 'Endangered' (COSEWIC 2004) as population numbers are extremely low, and sightings very rare. This species was almost extirpated by commercial whaling. (COSEWIC 2015).
	Low reproductive capacity	1	Low reproductive capacity: almost nothing is known about reproduction in this species (COSEWIC 2004).
	Endemism/Isolation	0	No evidence of endemic/isolated populations.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas. North Pacific Right Whales feed on zooplankton (COSEWIC 2004).

SG ID 114d	MARINE MAMMALS	Cetaceans	Baleen	Dispersed	N/A
Common Minke Whale - North Pacific subspecies (*Balaenoptera acutorostrata scammonii*)					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Generally solitary, or in very small groups of up to 3 animals. Can aggregate for feeding, no evidence in BC of this where they are rarely seen.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe baleen whales spend much of their time at the sea surface so may have relatively more surface interaction. Minke whales are not a highly active at the sea surface.
	Seafloor interacting	0	No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	1	Mechanical impairment by oil relatively high due to filter feeding structures (baleen) that could be clogged, reducing feeding ability (Wursig 1990). Minke Whale skin is smooth (skin has low oil adherence) (Engelhardt 1983; Jarvela-Rosenberger et al. 2017) and may impair body functions such as swimming. Oil adherence of less importance for categorization of mechanical sensitivity than filter feeding, since adherence alone would likely not alter swimming, diving, or other locomotory movements.
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil exposure on Minke Whales have not been clearly demonstrated. A marine mammal carcass survey in 1989 after the EVOS found 2 minke whale carcasses (among the 37 found in the survey) (Loughlin 2013) but these deaths were not explicitly linked to the spill. No evidence found for sub-lethal effects but expected to be similar to those seen in other cetaceans, where exposure usually occurs through inhalation of toxic vapour (refer to SRKW and Pacific White-Sided Dolphin entries).
Recovery	Reduced population status	1 *	The Common Minke Whale is designated 'Not at Risk', as the population is thought to be naturally small with potential for rescue from US waters that border Canadian waters (COSEWIC 2006a). However due to deficiency of knowledge and data they are scored a precautionary 1*.
	Low reproductive capacity	1	Low reproductive capacity: little is known, reproduction estimation to occur annually, gestation time of 10 months and calves are nursed for up to 6 months, sexual maturity around 7 years for males and 6 for females. Longevity potentially up to 60 years (Ford 2014).
	Endemism/Isolation	0	No evidence of endemic/isolated populations. This is a subspecies of Minke Whale specific to the North Pacific.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas. Consume small fish and zooplankton (Ford 2014).

SG ID 115	MARINE MAMMALS	Pinnipeds	Thermo-regulate with fur		N/A
Example species: Northern Fur Seal					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Females and sub-adult Northern Fur Seal males occur off the Canadian west coast (off shelf) during winter and spring, are rarely observed inshore. Not known to breed in Canada but did in the past (Newsome et al. 2007). Though Northern Fur Seals rarely haul out in BC waters, they have been seen to infrequently come ashore at sea lion haulouts such as Race Rocks. Consequently they do not tend to aggregate in BC waters (Bigg 1990; COSEWIC 2010; Ford 2014). However, they can occur in large numbers at times in offshore waters in BC year round (Baird and Hanson 1997).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. The relative amount of time spent at the surface varies based on life history. Northern Fur Seals are predominantly pelagic but are regular divers, usually dives are around 4 min in duration (COSEWIC 2010) so may spend relatively less time at the surface than other marine mammals.
	Seafloor interacting	0	Northern Fur Seals feed on schooling fishes and squid (Bigg 1990; COSEWIC 2010; Ford 2014). No evidence of regular foraging in substrates below the seafloor surface.
Sensitivity	Mechanical sensitivity	1	Mechanical impairment by oil relatively high as Northern Fur Seals rely on their fur for thermoregulation, oil can adhere to and foul fur, drastically reducing its insulative properties (skin has high oil adherence) (Geraci and St.Aubin 1990).
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil exposure on Northern Fur Seals have not been clearly demonstrated. There is evidence of acute effects on a different fur seal species from a crude oil spill in 1997 in Uruguay, where over 4000 young south American Fur Seals (2-3 months old) died when their rookery was oiled in 1997 (Mearns et al. 1999). However, this evidence may have limited applicability, as it is from a different fur seal species, and there are no fur seal rookeries in BC waters, and in this case, as the animals were on land, mortality was simple to establish. Additionally, in the Santa Barbara Channel spill, Northern Fur Seals were observed coated with beached oil but no significant mortality could be attributed to the coating (Englehart 1983). Sub-lethal effects – As Northern Fur Seals rely on their fur for insulation rather than blubber as in other pinnipeds, the sub-lethal effects from oiling of fur are expected to be similar to those found in Sea Otters, primarily hypothermia and toxic ingestion. Studies show that heat transfer doubles in oiled fur seal pelts compared to other pinnipeds where no change in heat transfer is found when oiled (Kooyman et al. 1977); In (Helm et al. 2015). Juvenile Northern Fur Seals with one third of their body coated in crude oil experienced a 50% increase in heat loss in water (Kooyman et al. 1976) In (Helm et al. 2015). Oiled pups may also not be recognisable to mothers, as the mother-pup bond in pinnipeds is thought be based on scent (Geraci and St. Aubin 1988) though they do not breed in BC. Following the Cosco Busan spill in California (bunker fuel), two dead oiled Northern Fur Seals were collected but necropsies determined oil was not the primary cause of death (Cosco Busan Oil Spill Trustees 2012).

Category	Criteria	Score	Justification
Recovery	Reduced population status	1	Northern Fur Seals winter in Canadian waters, their designation was strengthened from 'Not at Risk' in 1996 to 'Threatened' in 2006 due to the declining pup production (an index of population size) in major breeding colonies (outside BC waters), representing a 38% decline over 3 generations (COSEWIC 2010).
	Low reproductive capacity	1	Low reproductive capacity: Northern Fur Seals are sexually mature at 3-7 years, with a generation time of 10 years. Males have a short reproductive span averaging 1.5 seasons. Females can reproduce into their 20's with approximately 20 offspring in their lifetime (COSEWIC 2010). Relative to the other groups in the overall assessment, reproductive capacity Is low.
	Endemism/Isolation	0	At least 75% of the world's total Northern Fur Seal population is from the Pribilof Islands in Alaska, and most fur seals in BC waters are from this population, which migrate south in winter including along BC waters (COSEWIC 2010). This is the only species of fur seal in the temperate waters of the north Pacific ocean (Baird and Hanson 1997; COSEWIC 2006b).
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas. Their primary diet when in BC waters consists of Herring and squid (Baird and Hanson 1997).

SG ID 116	MARINE MAMMALS	Pinnipeds	Other pinnipeds	Discrete	N/A
Example species: Steller Sea Lion, Harbour Seal, California Sea Lion					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Species in this subgroup aggregate at haulout sites for resting and for some species also breeding in BC waters. Steller Sea Lions are non-migratory and have three types of haulouts: year round, breeding and winter (Bigg 1985; Ford 2014) and the Scott Islands in BC has the second largest breeding aggregation of Stellar Sea Lions in the world (DFO 2010b). California Sea Lions overwinter in BC, congregating at haul out sites such as Race Rocks (Ford 2014). California Sea Lions are gregarious at all times of the year, but only adult and sub-adult males winter in BC waters between September and May (Klinkenberg 2019) where they feed nocturnally and haul out during the day on rocky and sandy beaches often on islands (BC Conservation Data Centre 1996). Harbour Seals aggregate when hauled out for breeding, moulting, and resting in BC waters.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. The relative amount of time spent at the surface varies based on life history. California Sea Lions are deep divers (up to 274m, but usually dive 80m for less than 3min) (Feldkamp et al. 1989) so may spend relatively less time on the sea surface than other marine mammals.
	Seafloor interacting	1	Harbour Seals regularly forage in unconsolidated substrates and rest on the seafloor, and pups primarily feed on benthic crustaceans (Ford 2014). Steller Sea Lions mostly consume small schooling fish but also forage on the seafloor (Ford 2014; Pitcher 1981).

Category	Criteria	Score	Justification
Sensitivity	Mechanical sensitivity	0	Mechanical impairment by oil for animals in this group is expected to be minimal. They lack feeding structures vulnerable to clogging and do not depend on fur for thermoregulation.
	Chemical sensitivity	1 *	Pinnipeds, in contrast to cetaceans, must come ashore to breed on land or ice (Helm et al. 2015) and the way pinnipeds concentrate are tied to these sites at certain times means they can be exposed to oil and suffer acute and sub-lethal consequences in different ways to cetaceans. Another difference in that oil affects pinniped breeding sites on land, there may be a better understanding of effects. In general, exposure to oil in pinnipeds can have a range of sub-lethal effects. Oiling of breeding sites can result in a disruption of the mother-pup bond, which relies on scent (mothers unable to detect the scent of oiled pups). Exposure to oil can irritate the mucous membranes around the eyes affecting vision, and potentially resulting in permanent damage with long term exposure (St. Aubin 1990). See specific entries by species/ecotype in this group.
Recovery	Reduced population status	0	Though Steller Sea Lions are designated 'Special Concern' (COSEWIC 2003b, 2013a; Olesiuk 2018), this is due to the few breeding locations in BC, and being sensitive to human disturbance when on land rather than population decline. The Steller Sea Lion population in BC is increasing, to similar levels to before harvesting and predator control programs began in the 1900's.(COSEWIC 2013b). No evidence of population decline in Harbour Seals. Harbour Seals and California Sea Lions are both designated 'Not at risk' under COSEWIC.
	Low reproductive capacity	1	Low reproductive capacity: Steller Sea Lions are long-lived slow reproducing species, with only three breeding sites in BC (COSEWIC 2013b). Sexual maturity in females 3-6 years, for males 3-7 years but they usually only successful mate at 9-13 years. Breeding occurs annually, gestation takes 8-9 months, nursing is extended and can continue for up to 3 years (Ford 2014).
	Endemism/Isolation	0	No evidence of endemic/isolated populations of species in this group.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 116a	MARINE MAMMALS	Pinnipeds	Other pinnipeds	Discrete	N/A
Steller Sea Lion (*Eumetopias jubatus*)					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Aggregate at haulout sites for resting and breeding in BC waters. Steller Sea Lions are non-migratory and have three types of haulouts: year round, breeding and winter (Bigg 1985; Ford 2014) and the Scott Islands in BC has the second largest breeding aggregation of stellar sea lions in the world (DFO 2010b). Also aggregate in floating rafts in suitable feeding areas where no haulouts are available.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe.
	Seafloor interacting	1 *	Steller Sea Lions consume mostly small schooling fish, but have a very varied diet and are also forage on the seafloor (Pitcher 1981). It is uncertain if they regularly forage in substrates below the seafloor surface (hence *).
Sensitivity	Mechanical sensitivity	0	Steller Sea Lions lack fur or filter-feeding structures that can be fouled/clogged by oil.
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil on Steller Sea Lions have not been clearly demonstrated and were not well studied post EVOS (Peterson 2001). Though not conclusively linked to EVOS oil exposure, twelve dead Steller Sea Lions were recovered following the EVOS. Steller Sea Lions were undoubtedly exposed to oil from the EVOS, as they were observed swimming within spilled oil and occupying oiled rookeries and haulouts. Tissue samples from carcasses and living animals confirmed exposure (Calkins et al. 1994) but this study concluded a lack of evidence to indicate acute or sub-lethal damage to Steller Sea Lions from the toxic effects of oil (Calkins et al. 1994).
Recovery	Reduced population status	0	Though Steller Sea Lions are designated as a 'Special Concern' species (COSEWIC 2003b, 2013a; Olesiuk 2018), this is due to the few breeding locations in BC, and being sensitive to human disturbance when on land rather than population decline. The Steller Sea Lion population in BC is increasing, to similar levels to before harvesting and predator control programs began in the 1900's (COSEWIC 2013b).
	Low reproductive capacity	1	Low reproductive capacity. Females sexual maturity: 3-6 years, average breeding age (both sexes) is 10-11 years. Females reproduce annually giving birth to a single pup, nursing for around 1 year but up to 4 years. Longevity: ~22 years for females and 14 years for males (COSEWIC 2013b). Higher reproductive capacity than other marine mammals, but low relative to the overall assessment.
	Endemism/Isolation	0	No evidence of endemic/isolated populations of species in this group.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 116b	MARINE MAMMALS	Pinnipeds	Other pinnipeds	Discrete	N/A
Pacific Harbour Seal (*Phoca vitulina richardsi*)					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Aggregate at haulout sites for resting and breeding in BC waters. Harbour Seals aggregate when hauled out for breeding, moulting, and resting in BC waters.
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe.
	Seafloor interacting	1	Harbour Seals regularly forage in forage in substrates below the seafloor surface and rest on the seafloor, and pups primarily feed on benthic crustaceans (Ford 2014).
Sensitivity	Mechanical sensitivity	0	Harbour Seals lack thick fur or filter-feeding structures that can be fouled/clogged by oil
	Chemical sensitivity	1	It has been demonstrated in seals that they can absorb oil through the skin and gastrointestinal tract (Englehart 1983). Acute and sub-lethal effects of oil exposure on Harbour Seals have been clearly demonstrated. Harbour Seals suffered acute toxic effects after exposure to oil from the EVOS in Alaska, oil ingestion, inhalation and smothering resulted in recorded deaths of 300 Harbour Seals (Barron et al. 2020). Necropsies found brain lesions that were linked to hydrocarbon exposure (Matkin et al. 2008), which may connect to observations of oiled seals being disoriented (diesel) (Geraci and St.Aubin 1990) and lethargic (Peterson 2001). Reproductive impacts from the observed elevated PAH concentrations in milk may have contributed to fewer pups being observed in oiled areas for three years after the spill (Frost et al. 1999).A large proportion of seals were heavily oiled and remained that way months after the spill when observed at haul-outs (Matkin et al. 2008; Scheel et al. 2001). Blubber samples of the oiled seals indicated elevated polycyclic aromatic hydrocarbon levels, much higher than reference samples (Loughlin 1994). These elevated levels may have caused the lesions (typical of hydrocarbon toxicity) discovered in necropsies of seals who died months after the spill (Spraker et al. 1994), and suggest oiled seals suffered sub-lethal effects after the spill that could lead to later mortality. Reproduction was also impacted, as many haul out sites remained oiled when pupping season began 1 month after the EVOS leading to pups becoming oiled (St. Aubin 1990). This can result in a disruption of the mother-pup bond, which relies on scent (mothers unable to detect the scent of oiled pups) (St. Aubin 1990). Long term population effects from the effects of the spill were suspected, as the population had made little recovery 10 years after the spill (EVOSTC 2001) but the population is officially considered recovered at present. Harbour Seal haulouts were also oiled after the 2007 Cosco Busan spill in California, and a later observation of a deformed Harbour Seal pup with elevated PAH levels was reasonably assumed to be a result of maternal exposure to toxic oil, though the authors did note that they considered overall evidence was lacking to show reproductive impacts from exposure to oil from the spill (Cosco Busan Oil Spill Trustees 2012).

Category	Criteria	Score	Justification
Recovery	Reduced population status	0	Harbour Seals are designated 'Not at Risk' under COSEWIC (in 1999) as there is no evidence of population decline, population levels are similar to or higher than historic levels.
	Low reproductive capacity	1	Low reproductive capacity. Sexual maturity: 3-5 years (both sexes), annual reproduction (single pup), weaning lasts 2 weeks. Longevity: Females: 10 years (average), 26 years (maximum); Males:), 8 years (average), 20 years (maximum) (DFO 2010a). Higher reproductive capacity than other marine mammals, but low relative to the overall assessment.
	Endemism/Isolation	0	No evidence of endemic/isolated populations of species in this group.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 116c	MARINE MAMMALS	Pinnipeds	Other pinnipeds	Discrete	N/A
California Sea Lion (*Zalophus californianus*)					**Total Score: 5**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	California Sea Lions overwinter in BC, congregating at haul out sites such as Race Rocks (Ford 2014). California Sea Lions are gregarious at all times of the year, but only adult and sub-adult males winter in BC waters between September and May (Klinkenberg 2019) where they feed nocturnally and haul out during the day on rocky and sandy beaches often on islands (BC Conservation Data Centre 1996).
	Low mobility	0	Highly mobile
	Sea surface interacting	1	Regular sea surface interaction to breathe. This species is a deep diver (usual dives are 80m for <3min, but can be up to 274m) (Feldkamp et al. 1989) so may spend relatively less time on the sea surface than other marine mammals.
	Seafloor interacting	1 *	California Sea Lions feed on small schooling fish and squid, but also skates and flatfish so can have some interaction with the seabed. It is uncertain if they regularly forage in substrates below the seafloor surface (hence *).

Category	Criteria	Score	Justification
Sensitivity	Mechanical sensitivity	0	California Sea Lions lack fur or filter-feeding structures that can be fouled/clogged by oil.
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil exposure on California Sea Lions have not been clearly demonstrated. Three dead California Sea Lions were found following a crude oil spill from an oil platform blowout in California in 1969, but efforts to link these to the oil spill were not made. Later surveys of an oiled breeding colony found 76 oiled and dead pups, though the link to oiling was unclear as pup mortality is naturally high (Geraci and St.Aubin 1990). An unusual number of premature births and aborted pregnancies occurred in the California Sea Lion population following oil exposure (St. Aubin 1990) suggesting sub-lethal reproductive effects of oil exposure on pregnant sea lions, though in this case the authors again stated the link to be circumstantial, premature births in this species have been observed in other studies following exposure to contaminants (DeLong et al. 1973; Goldstein et al. 2009). Bunker fuel from the Cosco Busan spill in California in 2007 oiled many marine mammals, with California sea lions were observed to have particularly heavy oiling with tar (Cosco Busan Oil Spill Trustees 2012).
Recovery	Reduced population status	0	California Sea Lions are designated 'Not at Risk' by COSEWIC (in 1987). They winter in BC (only adult and sub-adult males) between September and May (Klinkenberg 2019).
	Low reproductive capacity	1	Low reproductive capacity. Sexual maturity 4-5 years (both sexes), though breeding age for males is 9-12 years old. Pups are nursed for around a year. Higher reproductive capacity than other marine mammals, but low relative to the overall assessment.
	Endemism/Isolation	0	No evidence of endemic/isolated populations of species in this group.
	Association with unconsolidated substrates	0	No evidence of regular foraging in unconsolidated substrates in intertidal areas.

SG ID 117	MARINE MAMMALS	Pinnipeds	Other pinnipeds	Dispersed	N/A
Example species: Northern Elephant Seal					Total Score: 5

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	0	Northern Elephant Seals spend the majority of their life on the high seas under the surface, when in BC waters they are generally dispersed and do not aggregate as the majority of breeding and calving occurs outside of BC. However, the establishment of a small Northern Elephant Seal breeding colony in BC (Race Rocks) in recent years (Ford 2014; Stewart and DeLong 1995) may eventually lead to a larger breeding population that could aggregate in BC waters.
	Low mobility	0	Highly mobile

Category	Criteria	Score	Justification
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. The relative amount of time spent at the surface varies based on life history. Northern Elephant Seals spend majority of life on the high seas under the sea surface (Ford 2014), so spend relatively less time at the surface than other marine mammals.
	Seafloor interacting	1 *	Bottom foragers (Peterson et al. 2003) generally consuming mainly pelagic/demersal fishes above the seabed. Have been observed foraging on the seabed for Hagfishes (Ford 2014). It is uncertain if they regularly forage in substrates below the seafloor surface (hence *).
Sensitivity	Mechanical sensitivity	0	Northern Elephant Seals do not have fur or filter feeding structures that can be fouled/clogged by oil.
	Chemical sensitivity	1 *	Acute and sub-lethal effects of oil to Northern Elephant Seals have not been clearly demonstrated in the evidence found. Little evidence was found, other than reports from a study of the effects of a crude oil spill in 1969 (oil well blowout in California) indicated the oiling of more than 100 weaned northern elephant seal pups when their breeding colony was oiled (St. Aubin 1990). Tagging studies of the oiled pups concluded that the crude oil coating these pups did not have notable deleterious effects, in the short- and long- (up to 15 months later) term. Four dead Elephant Seals were also observed in oil pools but not confirmed to be due to oil exposure (Le Boeuf 1971). However, it was noted that had the pups not been weaned by the time the spill occurred, the effects would have likely been much worse.
Recovery	Reduced population status	1 *	The overall Northern Elephant Seal population is not in decline, reflected in the 'Not at Risk' designation under COSEWIC. However, the establishment of the first, small breeding colony in BC in 2014 (Race Rocks) led to the BC breeding population being designated as 'Critically imperiled' provincially (BC provincial status S1B). The * reflects this difference in population status whether the BC breeding population or overall population is the focus.
	Low reproductive capacity	1	Low reproductive capacity. Sexually mature between 2-6 years and produce offspring most years (Reiter and LeBeouf 1991). Higher reproductive capacity than other marine mammals, but low relative to the overall assessment.
	Endemism/Isolation	0	This species has a single small breeding colony in BC isolated from the others, as it is the most northern breeding colony (at Race Rocks). Since the first pup was born in 2009, the same female has returned and as of 2014 had five pups there (E-Fauna BC 2018). However, it is not clear if this small new colony will persist and become a distinct breeding population.
	Association with unconsolidated substrates	0	Do not closely associate with unconsolidated substrates in intertidal areas.

SG ID 118	MARINE MAMMALS	Mustelids			N/A
Example species: Sea Otter (*Enhydra lutris*)					**Total Score: 9**

Category	Criteria	Score	Justification
Exposure	Concentration/Aggregation	1	Sea Otters regularly form large single sex aggregations (male, or female with pups) called rafts (DFO 2014a) where they spend a lot of time resting, rafting is known to occur in specific locations and each raft can contain up to 200 individuals (Nichol et al. 2015).
	Low mobility	1	Low mobility: Do not migrate and live within limited home ranges (DFO 2014a; Nichol et al. 2015).
	Sea surface interacting	1	Marine mammals interact regularly with the sea surface to breathe. The relative amount of time spent at the surface varies based on life history.
	Seafloor interacting	1	Sea Otters regularly forage in substrates below the seafloor surface as they forage for clams in soft bottom substrate, they also interact with vegetation as they rest in kelp beds (DFO 2014a; Kvitek et al. 1993).
Sensitivity	Mechanical sensitivity	1	Sea Otters rely on their fur for thermoregulation and fouling by oil severely reduces the insulative value of the fur it relies on for insulation, rather than subcutaneous fat as in other species (DFO 2014a; Ralls and Siniff 1990; Williams et al. 1988). Oiled fur also results in increased grooming leaving less time for other important activities such as foraging and the care of young (Ralls and Siniff 1990).
	Chemical sensitivity	1	There is abundant direct evidence available linking oil exposure to acute and chronic effects to Sea Otters. Sea Otters in Alaska suffered severe acute toxic effects from exposure to crude oil from the EVOS through ingestion and inhalation of oil, smothering, drowning and hypothermia, the death of 2800 Sea Otters was recorded (Barron et al. 2020). Sea Otters can suffer hypothermia when oiled, but also Sea Otter necropsies indicated that inhalation of oil vapour had caused the development of pulmonary emphysema that affected respiration in Sea Otters having acute effects (Peterson et al. 2003). Bunker C can be ingested through grooming of oil covered skin and was found to cause fatal haemorrhagic gastroenteropathy (Englehart 1983). There is also evidence for sub-lethal, long term effects. Sea Otter populations suffered long term effects, some of this due to the persistence of submerged oil in sediments (Ballachey et al. 2014). Sea Otters recovered from hypothermia were also noted to often have also suffered long-term organ damage as a result of the hypothermic period (Helm et al. 2015). Gastrointestinal injuries were also common due to the grooming behaviour of Sea Otters (Helm et al. 2015). Even longer term, 19 years after the spill Sea Otters in the oiled areas compared to less impacted areas had higher transcription of genes associated with the formation of tumours, cell death, heat shock and inflammation (MILES 2012).

Category	Criteria	Score	Justification
Recovery	Reduced population status	1	Sea Otters are designated as 'Special concern' (COSEWIC 2007; DFO 2014a). After reintroduction to BC from 1969-72, Sea Otters have repopulated up to 33% of their historic BC range, but the population not yet secure. A 2013 survey indicated there was population growth, varying by area, and slowing in areas where carrying capacity was being approached, overall annual growth in BC ~ 6.8% a year (2004 to 2008) and 7.2% a year (2009 to 2013) (Nichol et al. 2015).
	Low reproductive capacity	1	Low reproductive capacity. Sexual maturity 2-6 years (both sexes), reproduction usually annual , gestation 6 months, pup interval 12-13 months (Jameson and Johnson 1993; Riedman and Estes 1990). Higher reproductive capacity than other marine mammals, but low relative to the overall assessment.
	Endemism/Isolation	0	No evidence of endemic/isolated populations of species in this group.
	Association with unconsolidated substrates	1	Sea Otters regularly forage and excavate into unconsolidated substrates in the intertidal (Short et al. 2006), with an estimated 5-38% of all foraging occurring in the intertidal area (Bodkin et al. 2012). Examination of Sea Otter foraging pits (in areas previously exposed to the Exxon Valdez oil spill found that 44% contained lingering oil with levels above background concentrations (Bodkin et al. 2012). This indicates that through foraging, Sea Otters likely encounter lingering subsurface oil in previously oiled areas that may impact population recovery.

Scoring Table References

Ackleh, A.S., Ioup, G.E., Ioup, J.W., Ma, B., Newcomb, J.J., Pal, N., Sidorovskaia, N.A., and Tiemann, C. 2012. Assessing the deepwater horizon oil spill impact on marine mammal population through acoustics: Endangered sperm whales. The Journal of the Acoustical Society of America 131(3): 2306-2314.

Ackleh, A.S., Chiquet, R.A., Ma, B., Tang, T., Caswell, H., Veprauskas, A., and Sidorovskaia, N. 2017. Analysis of lethal and sublethal impacts of environmental disasters on sperm whales using stochastic modeling. Ecotoxicology 26(6): 820–830.

Saad, A., Ali, M., Saad, R.-R., and Capape, C. 2012. Occurrence of Basking Shark, Cetorhinus maximus (Elasmobranchii: Lamniformes: Cetorhinidae), off the Syrian Coast (Eastern Meterranean). Rapport Commerciale Internationale du Mer Mediterrane 41.

Alexander, S.K., and Webb Jr., J.W. 1985. Seasonal response of Spartina alterniflora to oil. In: Proceedings, Oil Spill Conference (Prevention, Behavior, Control, Cleanup) American Petroleum Institute 25–28 February 1985, Los Angeles, CA, pp. 355–357.

Almeda, R., Wambaugh, Z., Chai, C., Wang, Z., Liu, Z., and Buskey, E.J. 2013. Effects of crude oil exposure on bioaccumulation of polycyclic aromatic hydrocarbons and survival of adult and larval stages of gelatinous zooplankton. PLoS ONE 8(10): e74476. doi:10.1371/journal.pone.0074476

Anderson, J.W., Riley, R., Kiesser, S., and Gurtisen, J. 1987. Toxicity of dispersed and undispersed Prudhoe Bay crude oil fractions to shrimp and fish. International oil spill conference proceedings 1987(1):235-240.

Anderson, E.M., and Lovvorn, J.R. 2008. Gray whales may increase feeding opportunities for avian benthivores. Marine Ecology Progress Series 360: 291-296.

Antrim, L.D., Thom, R.M., Gardiner, W.W., Cullinan, V.I., Shreffler, D.K., and Bienert, R.W. 1995. Effects of petroleum products on bull kelp (*Nereocystis luetkeana*). Mar. Biol. 122: 23-31.

Arnberg, M., Calosi, P., Spicer, J.I., Taban, I.C., Bamber, SD., Westerlund, S., Vingen, S., Baussant, T., Bechmann, R.K. and Dupont, S. 2018. Effects of oil and global environmental drivers on two keystone marine invertebrates. Sci Rep 8, 17380.

Austin, W.C. 2000. Rare and endangered marine invertebrates in British Columbia. *In* Proceedings of a conference on the biology and management of species and habitats at risk, Kamloops, BC, 15 - 19 Feb.,1999. Volume One. 490 pg.

BC Conservation Data Centre. 1995. Species summary: *Berardius bairdii*. BC Ministry of Environment.

BC Conservation Data Centre. 1996. Species summary: *Zalophus californianus*. BC Ministry of the Environment.

BC Conservation Data Centre. 2006. Species summary: *Physeter macrocephalus*. BC Ministry of the Environment.

Baird, R.W., and Hanson, M.B. 1997. Status of the Northern fur seal, *Callorhinus urinsus*, in Canada. Canadian Field Naturalist 111(2): 263-269.

Ballachey, B.E., Bodkin, J.L., Esler, D., and Rice, S.D. 2014. Lessons from the 1989 *Exxon Valdez* oil spill: A biological perspective. *In* Impacts of Oil Spill Disasters on Marine Habitats and Fisheries in North America. *Edited by* J.B. Alford, M.S. Peterson, and C.C. Green. CRC Press Online. pp. 181-198.

Banks, P.D. and Brown, K.M. 2002. Hydrocarbon effects on fouling assemblages: the importance of taxonomic differences, seasonal, and tidal variation. Marine Environmental Research, Volume 53, Issue 3, Pages 311-326. ISSN 0141-1136.

Banning, J. 2010. The effects of diluted bitumen on marine intertidal vascular plants. Master's thesis: Simon Fraser University, British Columbia, Canada.

Barber, W.E., McDonald, L.L., Erickson, W.P. and Vallarino, M. 1995. Effect of the Exxon Valdez Oil Spill on Intertidal Fish: A Field Study. Transactions of the American Fisheries Society, 124: 461-476.

Barron, M.G., Vivian, D.N., Heintz, R.A., and Yim, U.H. 2020. Long-term ecological impacts from oil spills: Comparison of Exxon Valdez, Hebei Spirit, and Deepwater Horizon. Environ Sci Technol. 54(11):6456-6467.

Beamish, R.J. 1980. Adult biology of the river lamprey (*Lampetra ayresi*) and the Pacific lamprey (*Lampetra tridentate*) from the Pacific coast of Canada. Can. J. Fish. Aquat. Sci. 37: 1906-1923.

Best, B.D., Fox, C.H., Williams, R., Halpin, P.N., and Paquet, P.C. 2015. Updated marine mammal distribution and abundance estimates in British Columbia. J. Cetacean. Res. Manag. 15: 9-26.

Bigg, M.A. 1985. Status of the Steller sea lion (*Eumetopias jubatus*) and California sea lion (*Zalophus californianus*) in British Columbia. Can. Spec. Publ. Fish. Aquat. Sci. 77: 20.

Bigg, M.A. 1990. Migration of Northern fur seals (*Callorhinus ursinus*) off Western North America. Can. Spec. Publ. Fish. Aquat. Sci. 1764: 64.

Blake, J.A. 1975. The larval development of Polychaeta from the Northern California coast III: Eighteen species of Errantia. Ophelia 14: 23-84.

Blenkinsopp, S.A., Sergy, G., Doe, K., Wohlgeschaffen, G., Li, K. and Fingas, M. 1996. Toxicity of the weathered crude oil used at the Newfoundland offshore burn experiment (NOBE) and the resultant burn residue. Spill Science and Technology Bulletin 3(4):277-280.

Bodkin, J.L., Ballachey, B.E., Coletti, H.A., Esslinger, G.G., Kloecker, K.A., Rice, S.D., Reed, J.A., and Monson, D.H. 2012. Long-term effects of the 'Exxon Valdez'oil spill: Sea Otter foraging in the intertidal as a pathway of exposure to lingering oil. Marine Ecology Progress Series 447: 273-287.

Bonsdorff, E. and Nelson, W.G. 1981. Fate and effects of Ekofisk crude oil in the littoral of a Norwegian fjord. Sarsia 66: 231-240.

Brette, F., Machado, B., Cros, C., Incardona, J.P., Scholz, N.L., and Block, B.A. 2014. Crude Oil Impairs Cardiac Excitation-Contraction Coupling in Fish. Science 343(6172): 772-776.

Bue, B.G., Sharr, S., Moffit, S.D., and Craig, A.K. 1996. Effects of the *Exxon Valdez* oil spill on pink salmon embryos and pre-emergent fry. *In* Proceedings of the *Exxon Valdez* oil spill Symposium, Anchorage, Alaska, 2-5 February 1993. American Fisheries Society 18: 619-627.

Burke, R.D. 1986. Pheromones and the gregarious settlement of marine invertebrate larvae. Bull. Mar. Sci. 39(2): 323-331.

Butler, R.W., MacVicar, R.S., and Hollick-Kenyon, S. 2017. Observation of a super pod of Pacific harbor porpoises (*Phocoena phocoena vomerina*) in the Salish Sea. Northwestern Naturalist 98(2): 137-138.

Calambokidis, J., Osmek, S., and Laake, J.L. 1997. Aerial surveys for marine mammals in Washington and British Columbia inside waters. Cascadia Research, Olympia, WA. *In* Harbour Porpoise Pacific Ocean population. Canadian Wildlife Service (CWS) 2007.

Calambokidis, J., Darling, J.D., Deecke, V.B., Gearin, P., Gosho, M., Megill, W., Tombach, C.M., Goley, P.D., Toropova, C., and Gisborne, B. 2002. Abundance, range and movements of a feeding aggregation of gray whales from California to southeastern Alaska. Journal of Cetacean Research and Management 4: 267-276.

CalCOFI. 2015. Review selected California fisheries for 2014: Coastal pelagic finfish, market squid, groundfish, Pacific herring, Dungeness crab, ocean salmon, true smelts, hagfish, and deep water ROV surveys of MPAs and surrounding nearshore habitat. Fisheries Review. CalCOFI report., Vol 56, 2015.

Calkins, D.G., Becker, E., Spraker, T.R., and Loughlin, T.R. 1994. Chapter 7: Impacts on Steller Sea Lions. *In* Marine mammals and the *Exxon Valdez*. pp. 119.

Carls, M.G., Marty, G.D., and Hose, J.E. 2001. Synthesis of the toxicological and epidemiological impacts of the Exxon Valdez oil spill on Pacific Herring in Prince William Sound, Alaska. Exxon Valdez Oil Spill Restoration Project 99328 Final Report. 92 pp.

Castège, I., Milon, E., and Pautrizel, F. 2014. Response of benthic macrofauna to an oil pollution: Lessons from the "Prestige" oil spill on the rocky shore of Guéthary (south of the Bay of Biscay, France). Deep Sea Research Part II: Topical Studies in Oceanography 106: 192-197.

Castillo, G.C., Miller, T.W., Chapman, J.W., and Li, H.W. 1996. Non-indigenous species cause major shifts in the food-base of estuarine-dependent fishes. Fish Physiology 2: 101-109.

Chan, G. 1972. A study of the effects of the San Francisco Oil Spill on marine organisms-- Part L College of Marin, Kentfield, California.

Chan, G.L. 1973. A study of the effects of the San Francisco oil spill on marine organisms. Proceedings of the Joint Conference on Prevention and Control of Oil Spills: March 1983, Vol. 1973, 1. American Petroleum Institute, Washington, D.C., pp. 741–781.

Chan, G. 1975. A study of the effects of the San Francisco oil spill on marine life. Part II: recruitment. In Proceedings of 1975 Conference on Prevention and Control of Oil Pollution, 457-461. American Petroleum Institute, Washington, D.C.

Chia, F-S. 1971. Diesel oil spill at Anacortes. Marine Pollution Bulletin 2:105–106.

Chia, F.S. 1973. Killing of marine larvae by diesel oil. Marine Pollution Bulletin 4(2): 29-30.

Clark, R.C. JR., Finley, J.S., Patten, B.G., Stefani, D.F. and Denike, E.E. 1973. Interagency investigations of a persistent oil spill on the Washington coast. In Proceedings of Joint Conference on Prevention and Control of Oil Spills, 793-808. American Petroleum Institute, Washington, D.C.

Clark, R. C. Jr., Finley, J.S., Patten, B.G. andand Denike, E.E. 1975. Long-term chemical and biological effects of a persistent oil spill following the grounding of the General M. C. Meigs. In Proceedings of 1975 Conference on Prevention and Control of Oil Pollution, 479-487. American Petroleum Institute, Washington, D.C.

Clark, R.C. Jr., B.G. Patten, B.G., and Denike, E.E.. 1978. Observations of a cold-water intertidal community after 5 years of a low-level, persistent oil spill from the General M.C. Meigs. J. Fish. Res. Board Can. 35: 754-765.

Collier, T.K. Krahn, M.M., Krone, C.A., Johnson, L.L., Myers, M.S., Chan, S.L., and Varanasi, U. 1993. Oil exposure and effects in subtidal fish following the Exxon Valdez oil spill. International Oil Spill Conference Proceedings 1: 301–305.

Collier, T.K., Krone, C.A., Krahn, M.M., Stein, J.E., Chan, S.L., and Varanasi, U. 1996. Petroleum exposure and associated biochemical effects in subtidal fish after the Exxon Valdez oil spill. American Fisheries Society Symposium 18:671-683.

Conan G. 1982. The long-term effects of the Amoco Cadiz oil spill. Philosophical Transactions of the Royal Society of London B 297: 323–333.

Cosco Busan Oil Spill Trustees. 2012. Cosco Busan oil spill final damage assessment and restoration plan/environmental assessment. Prepared by California Department of Fish and Game, California State Lands Commission, National Oceanic and Atmospheric Administration, United States Fish and Wildlife Service, National Park Service, Bureau of Land Management.

COSEWIC. 1996. COSEWIC assessment and update status report on the Sperm Whale *Physeter macrocephalus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 38 pp.

COSEWIC. 2002. COSEWIC assessment and update status report on the Blue Whale *Balaenoptera musculus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 32 pp.

COSEWIC. 2003a. COSEWIC assessment and update status report on the harbour porpoise *Phocena phocena* (Pacific Ocean population) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa: 22.

COSEWIC. 2003b. COSEWIC assessment and update status report on the Steller sea lion *Eumetopias jubatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa: vii + 47.

COSEWIC. 2004. COSEWIC assessment and update status report on the north pacific right whale *Eubalaena japonica* in Canada. . Committee on the Status of Endangered Wildlife in Canada. Ottawa.: vi + 22.

COSEWIC. 2005. COSWEIC assessment and update status report on the fin whale *Balaenoptera physalus*, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa: 37.

COSEWIC. 2006a. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) annual report, 2006. 75.

COSEWIC. 2006b. COSEWIC assessment and update status report on the northern fur seal *Callorhinus ursinus* in Canada. Committee on the Status of Endangered Wildlife in Canada (COSEWIC). vii + 33 pp.

COSEWIC. 2007. COSEWIC assessment and updated status report on the sea otter *Enhydra lutris* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa: vii + 36pp.

COSEWIC. 2008. COSEWIC assessment and update status report on the killer whale *Orcinus Orca*, Southern Resident population, Northern Resident population, West Coast Transient population, Offshore population, and Northwest Atlantic/Eastern Arctic population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa: viii + 65.

COSEWIC. 2010. COSEWIC assessment and status report on the Northern fur seal *Callorhinus ursinus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa: x + 50.

COSEWIC. 2011. COSEWIC assessment and status report on the humpback whale *Megaptera novaeangliae* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa: 32.

COSEWIC. 2012a. COSEWIC assessment and status report on the Leatherback Sea Turtle *Dermochelys coriacea* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 58 pp.

COSEWIC. 2012b. COSEWIC status appraisal summary on the blue whale *Balaenoptera musculus*, Pacific population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

COSEWIC. 2013a. COSEWIC assessment and status report on the Eulachon, Nass/Skeena population, *Thaleichthys pacificus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 18 pp.

COSEWIC. 2013b. COSEWIC assessment and status report on the steller sea lion *Eumetopias jubatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa: 54.

COSEWIC. 2013c. COSEWIC status appraisal summary on the sei whale *Balaenoptera borealis*, Pacific population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

COSEWIC. 2015. COSEWIC status appraisal summary on the North Pacific Right Whale *Eubalaena japonica* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiii pp.

COSEWIC. 2016. Committee on the status of endangered wildlife in Canada. (Accessed February 8, 2017)

COSEWIC. 2017. COSEWIC assessment and status report on the Grey Whale *Eschrichtius robustus*, Northern Pacific Migratory population, Pacific Coast Feeding Group population and the Western Pacific population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.: xxi + 74pp.

COSEWIC. 2019. COSEWIC assessment and status report on the Fin Whale *Balaenoptera physalus,* Atlantic population and Pacific population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 72 pp.

Cowles, T.J. 1983. Effects of exposure to sublethal concentrations of crude oil on the copepod Centropages hamatus. II: Activity patterns. Marine Biology 78: 53-57.

Cowles, T.J. and Remillard, J.F. 1983. Effects of exposure to sublethal concentrations of crude oil on the copepod *Centropages hamatus*. Marine Biology 78: 45–51.

Culbertson, J.B., Valiela, I., Pickart, M., Peacock E.E., and Reddy, C.M. 2008. Long-term consequences of residual petroleum on salt marsh grass. J. Appl. Ecol. 45: 1284-1292.

Dalla Rosa, L., Ford, J.K.B., and Trites, A. 2012. Distribution and relative abundance of humpback whales in relation to environmental variables in coastal British Columbia and adjacent waters. Cont. Shelf. Res. 36: 89–104.

Dauvin, J.C. 1982. Impact of "Amoco Cadiz" oil spill on the muddy sand *Abra alba* and *Melinna palmata* community from the Bay of Morlaix. Estuarine, Coastal and Shelf Science 14, 517-531.

Dauvin, J.C. 1987. Evolution long terme (1978-1986) des populations d'amphipodes des sables fins de la Pierre Noire (Baie de Morlaix, Manche occidentale) apres la catastrophe de l'Amoco Cadiz. Marine Environmental Research 21, 247-273.

Dauvin, J.C. and Gentil, E. 1990. Conditions of the peracarid populations of subtidal communities in northern Brittany ten years after the "Amoco Cadiz" oil spill. Marine Pollution Bulletin 21, 123-130.

Davy, A.J., Bishop, G.F. and Costa, C.S. 2001. Salicornia L. (*Salicornia pusilla J. Woods, S. ramosissima J. Woods, S. europaea, L., S. obscura P.W. Ball and Tutin, S. nitens P.W. Ball and Tutin, S. fragilis P.W. Ball and Tutin and S. dolichostachya Moss*). J. Applied Ecology. 89: 681-707.

Dean, T.A., Stekoll, M.S. and Smith, R.O. 1996a. Kelps and oil: the effects of the "Exxon Valdez" oil spill on subtidal algae. American Fisheries Society Symposium 18, 412-423.

Dean, T. A., Jewett, S. C., Laur, D. R. and Smith, R. O. 1996b. Injury to epibenthic invertebrates resulting from the "Exxon Valdez" oil spill. *American Fisheries Society Symposium* 18, 424-439.

Dean, T. D., M. S. Stekoll, S. C. Jewett, R. O. Smith and J. E. Hoses. 1998. Eelgrass (*Zostera marina L.*) in Prince William Sound, Alaska: Effects of the Exxon Valdez oil spill. Mar. Poll. Bull. 36:201-210.

De Graaf, R.C. 2006. Fine-scale population genetic structure of the eastern Pacific Bay pipefish, *Sygnathus leptorhynchus*. M.Sc. thesis, Dept. Zoology, the University of British Columbia, Vancouver, BC

DeLong, R.L., Gilmartin, W.G., and Simpson, J.G. 1973. Premature births in California sea lions: association with high organochlorine pollutant residue levels. Science 181(4105): 1168-1170.

Delunardo, F.A.C., Paulino, M.G., Campos-Medeiros, L.C., Narciso-Fernandes, M., Scherer, R., and Chippari-Gomes, A.R. Morphological and histopathological changes in seahorse (*Hippocampus reidi*) gills after exposure to the water-accommodated fraction of diesel oil. Marine Pollution Bulletin 150: 110769.

Den Hartog, C.D., and Jacobs, R P.W.M. 1980. Effects of the “Amoco Cadiz” oil spill on an eelgrass community at Roscoff (France) with special reference to the mobile benthic fauna. Helgoländer Meeresuntersuchungen, 33(1), 182.

DFO. 2005. Canada’s Policy for Conservation of Wild Pacific Salmon.

DFO. 2007. Recovery Strategy for the Transient Killer Whale (*Orcinus orca*) in Canada.

DFO. 2009. Management Plan for the Pacific Harbour Porpoise (*Phocoena phocoena*) in Canada. *Species at Risk Act* Management Plan Series. Fisheries and Oceans Canada, Ottawa. v + 49 pp.

DFO. 2010a. Population Assessment Pacific Harbour Seal (*Phoca vitulina richardsi*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/011.

DFO. 2010b. Management Plan for the Steller Sea Lion (*Eumetopias jubatus*) in Canada [Final]. *Species at Risk Act* Management Plan Series. Fisheries and Oceans Canada, Ottawa: vi + 69.

DFO. 2010c. Management Plan for the Eastern Pacific Grey Whale (*Eschrichtius robustus*) in Canada [Final]. *Species at Risk Act* management plan series. Fisheries and Oceans Canada, Ottawa. v + 60pp.

DFO. 2011. Recovery strategy for the North Pacific right whale (*Eubalaena japonica*) in Pacific Canadian waters [Final]. Species at Risk Act recovery strategy series. Fisheries and Oceans Canada, Ottawa. v + 60pp.

DFO. 2013. Recovery Strategy for the North Pacific Humpback Whale (*Megaptera novaeangliae*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada; x+6.

DFO. 2014a. Management Plan for the Sea Otter (*Enhydra lutris*) in Canada. *Species at Risk Act* Management Plan Series, Fisheries and Oceans Canada, Ottawa: iv + 50.

DFO. 2014b. Stock Assessment and Harvest Advice for Rock Sole (*Lepidopsetta spp.*) in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/039.

DFO. 2014c. Recovery strategy for White Sturgeon (*Acipenser transmontanus*) in Canada [Final]. In *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. 252 pp.

DFO. 2015a. Stock assessment for Lingcod (*Ophiodon elongatus*) for the Strait of Georgia, British Columbia in 2014. DFO Can. Sci. Advis. Sec. Sci Advis. Rep. 2015/014.

DFO. 2015b. Stock Assessment and Management Advice for BC Pacific Herring: 2015 Status and 2016 Forecast. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/038

DFO. 2015c. Arrowtooth Flounder (*Atheresthes stomias*) stock assessment for the west coast of British Columbia. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/055.

DFO. 2017. Action plan for Blue, Fin, Sei and North Pacific Right Whales (*Balaenoptera musculus, B. physalus, B. borealis, and Eubalaena japonica*) in Canadian Pacific Waters. *Species at Risk Act* Action Plan Series. Fisheries and Oceans Canada, Ottawa. iv + 28 pp.

DFO. 2018. Report on the Progress of Management Plan Implementation for the Pacific Harbour Porpoise (*Phocoena phocoena vomerina*) in Canada for the Period 2010-2015. *Species at Risk Act* Management Plan Report Series. Fisheries and Oceans Canada, Ottawa. iv+ 38 pp.

DFO. 2022. Groundfish Integrated Fisheries Management Plan 2022/23. 22-2125.353 p.

Dias, L, Litz, J., Garrison, L., Martinez, A., Barry, K. and Speakman, T. 2017. Exposure of cetaceans to petroleum products following the Deepwater Horizon oil spill in the Gulf of Mexico. Endangered Species Research. 33: 119-125.

Dickerson, T.L., Macewicz, B.J., and Hunter, J.R. 1992. Spawning frequency and batch fecundity of Chub Mackerel, *Scomber japonicus*, during 1985. CalCoFI Rep. 33: 130-140.

Donahue, W.H., Wang, R.T., Welch, M., and Colin Nicol, J.A. 1977. Effects of water-soluble components of petroleum oils and aromatic hydrocarbons on Barnacle larvae. Environmental Pollution. Volume 13, Issue 3, Pages 187-202, ISSN 0013-9327

Dorsey, E.M. 1981. Exclusive adjoining ranges in individually identified minke whales (*Balaenoptera acutorostrata*) in Washington state. Can. J. Zool. 61: 174-181.

Duarte, C.M., Marba, N., Agawin, N., Cebrian, J., Enriquez, S., Fortes, M.D., Gallegos, M.E., Merino, M., Olesen, B., Sand-Jensen, K., Uri, J. and Vermaat, J. 1994. Reconstruction of seagrass dynamics: age determinations and associated tools for the seagrass ecologist. Marine Ecology Progress Series 107:195-209.

Duffy, T.A., Childress, W., Portier, R., and Chesney, E.J. 2016. Responses of bay anchovy (Anchoa mitchilli) larvae under lethal and sublethal scenarios of crude oil exposure. Ecotoxicology and Environmental Safety 134(1): 264-272.

Duguid, W.P., Boldt, J.L., Chalifour, L., Greene, C.M., Galbraith, M., Hay, D., Lowry, D., McKinnell, S., Neville, C.M., Qualley, J., Sandell, T., Thompson, M., Trudel, M., Young, K., Juanes, F. 2019. Historical fluctuations and recent observations of Northern Anchovy, *Engraulis mordax*, in the Salish Sea. Deep Sea Research Part II: Topical Studies in Oceanography 159: 22-41.

Dupuis, A., and Ucán-Marín, F. 2015. A literature review on the aquatic toxicology of petroleum oil: An overview of oil properties and effects to aquatic biota. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/007. vi + 52 p.

DWH Natural Resource Damage Assessment Trustees. 2016. Deepwater Horizon oil spill: Final rogrammatic damage assessment and restoration plan and final programmatic environmental impact statement.

Ecoscan Resource Data. 2015. Washington coastal kelp resources; Port Townsend to the Columbia River Summer 2014. Prepared for Washington Dept. Natural Resources, Nearshore Habitat Program. Washington.

E-Fauna BC. 2018. E-Fauna BC: Electronic atlas of the wildlife of British Columbia Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver.

Elmgren, R., Hansson, S., Larsson, U. , Sunderlin, B., and Boehm, P.D.I. 1983. The “Tsesis” oil spill: Acute and long-term impact on the benthos. Mar. Biol. 73: 51–65.

Engelhardt, F.R. 1983. Petroleum effects on marine mammals. Aquatic Toxicology 4: 199–217.

EVOSTC. 2001. Exxon Valdez Oil Spill Trustee Council. Status Report. Alaska Department of Fish and Game. Anchorage, AK. .

EVOSTC. 2009. Exxon Valdez Oil Spill Trustee Council - Legacy of an oil spill 20 years after the Exxon Valdez.

Fargo, J. 1998. Dover Sole West coast Vancouver Island (Areas 3C, D) to Queen Charlotte Islands (Areas 5A-E). DFO Sci. Stock Status Report A6-04.

Fargo, J. 1999. Petrale Sole British Columbia (Areas 3C-5D). DFO Sci. Stock Status Report A6-06.

Farmer, N. A., Noren, D. P., Fougères, E. M., Machernis, A., and Baker, K. 2018. Resilience of the endangered sperm whale *Physeter macrocephalus* to foraging disturbance in the Gulf of Mexico, USA: a bioenergetic approach. Marine Ecology Progress Series, 589, 241–261.

Feldkamp, S.D., DeLong, R.L., and Antonelis, G.A. 1989. Diving patterns of California sea lions, *Zalophus californianus*. Canadian Journal of Zoology 67(4): 872-883.

Fonseca, M.S., Piniak, G.A., and Cosentino-Manning, N. 2017. Susceptibility of seagrass to oil spills: A case study with eelgrass, *Zostera marina* in San Francisco Bay, USA. Marine pollution bulletin, 115(1): 29-38.

Ford, C.E. Jr. 1964. Reproduction in the aggregating sea anemone, *Anthopleura elegantissima*. Pacific Science 18: 138-145.

Ford, J.K.B. 2014. Marine mammals of British Columbia. Royal BC Museum handbook, British Columbia.

Ford, J.K.B., Durban, J.W., Ellis, G.M., Towers, J.R., Pilkington, J.F., Barrett-Lennard, L.G. and Andrews, R.D. 2013. New insights into the northward migration route of gray whales between Vancouver Island, British Columbia, and southeastern Alaska. Marine Mammal Science 29: 325-337.

Ford, J.K.B., Ellis, G.E., and Balcomb, K.C. 2000. Killer whales: the natural history and geneology of *Orcinus orca* in British Columbia and Washington State 2nd edition. UBC Press, Vancouver, BC

Forrest, R.E., Rutherford, K.L, Lacko, L., Kronlund, A.R., Starr, P.J., and McClelland, E.K. 2015. Assessment of Pacific Cod (Gadus macrocephalus) for Hecate Strait (5CD) and Queen Charlotte Sound (5AB) in 2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/052. xii + 197 p.

Forsythe, J., Kangas, N., and Hanlon, R.T. 2004. Does the California market squid (*Loligo opalescens*) spawn naturally during the day or at night? A note on the successful use of ROVs to obtain basic fisheries biology data. Fish. Bull. 102(2): 389-392.

Foster, M., NeushulL, M. and Zingmark, R. 1970. The Santa Barbara Oil Spill Part II. Initial effects on intertidal and kelp bed organisms. Wat. Pollut. Contr. Res. Series 15080 DZR, 2d ~. United States Dept. of Interior, Washington, D.C.

Foster, M., Neushul, M., and Zingmark, R. 1971. The Santa Barbara oil spill Part 2: Initial effects on intertidal and kelp bed organisms. Environ. Poll. 2: 115-134.

Froese, R. and Pauly, D. Editors. 2016. Fishbase. World Wide Web electronic publication. Version 10/2016.

Frost, K.J., Lowry, L.F., and Ver Hoef, J.M. 1999. Monitoring the trend of harbor seals in Prince William Sound, Alaska, after the Exxon Valdez oil spill. Marine Mammal Science 15(2): 494-506.

Frouin, H., Pellerin, J., Fournier, M., Pelletier, E., Richard, P., Pichaud, N., Rouleau, C., and Garnerot, F. 2007. Physiological effects of polycyclic aromatic hydrocarbons on soft-shell clam *Mya arenaria*. Aquat. Toxicol. 82: 120–134.

Gaydos, J.K., and Gilardi, K.V.K. 2003. Species of concern in the Georgia Basin/Puget Sound marine ecosystem: More support for a transboundary ecosystem approach to marine conservation. In Georgia Basin/Puget Sound Research Conference Proceedings, Vancouver, British Columbia, 31 March – 3 April, 2003.

Garrity, S.D. and Levings, S.C. 1990. Effects of an oil spill on the gastropods of a tropical intertidal reef flat. Marine Environmental Research, Volume 30, Issue 2, Pages 119-153. ISSN 0141-1136.

Geraci, J.R., and St. Aubin, D.J. 1988. Synthesis of effects of oil on marine mammals. Department of Interior, Minerals Management Service, Atlantic OCS Region, Contract No. 14-1 2-0001 -30293.

Geraci, J.R., and St.Aubin, D.J. 1990. Sea mammals and oil: confronting the risks, Academic Press, San Diego, California.

Gilliers, C., Le Pape, O., Desaunay, Y., Bergeron, J.P., Schreiber, N., Guerault, D., Amara, R. 2006. Growth and condition of juvenile sole (*Solea solea L.*) as indicators of habitat quality in coastal and estuarine nurseries in the Bay of Biscay with a focus on sites exposed to the Erika oil spill. Scientia Marina, 70(1), 183-192.

Girard, F., and Fisher, C.R. 2018. Long-term impact of the Deepwater Horizon oil spill on deep-sea corals detected after seven years of monitoring. Biological Conservation. Volume 225. Pages 117-127. ISSN 0006-3207.

Golet, G.H., Seiser, P.E., McGuire, A.D., Roby, D.D., Fischer, J.B., Kuletz, K.J., Irons, D.B., Dean, T.A., Jewett, S.C., and Newman, S.H. 2002. Long-term direct and indirect effects of the 'Exxon Valdez' oil spill on pigeon guillemots in Prince William Sound, Alaska. Marine Ecology Progress Series 241:287-304.

Goldstein, T., Zabka, T.S., DeLong, R.L., Wheeler, E.A., Ylitalo, G., Bargu, S., Silver, M., Leighfield, T., Dolah, F.V., Langlois, G., and Sidor, I. 2009. The role of domoic acid in abortion and premature parturition of California sea lions (*Zalophus californianus*) on San Miguel Island, California. Journal of wildlife diseases 45(1): 91-108.

Gordon Jr., D.C., Dale, J., and Keizer, P.D. 1978. Importance of sediment working by the deposit-feeding polychaete *Arenicola marina* on the weathering rate of sediment-bound oil. *J. Fish Res. Board Can.* 35:591-603.

Graham, C. and Pollom, R. 2015. *Syngnathus leptorhynchus*. The IUCN Red List of Threatened Species 2015: e.T65374916A67621840.

Haensly, W.E., Neff, J.M., Sharp, J.R., Morris, A.C., Bedgood, M.F. and Boem, P.D. 1982. Histopathology of *Pleuronectes platessa L.* from Aber Wrac'h and Aber Benoit, Brittany, France: long-term effects of the Amoco Cadiz crude oil spill. Journal of Fish Diseases 5: 365-391.

Gravem, S.A., Heady, W.N., Saccomanno, V.R., Alvstad, K.F., Gehman, A.L.M., Frierson, T. N. and Hamilton, S.L. 2020. *Pycnopodia helianthoides*. The IUCN Red List of Threatened Species 2020: e.T178290276A178341498.

Green, E.P., and Short, F.T. 2003. World atlas of seagrasses. University of California Press, Berkeley, California.

Greene, C., Kuehne, L., Rice, C., Fresh, K., and Penttila, D. 2015. Forty years of change in forage fish and jellyfish abundance across greater Puget Sound, Washington (USA): anthropogenic and climate associations. Marine Ecology Progress Series 525:153-170.

Gregr, E.J., Calambokidis, J., Convey, L., Ford, J.K.B., Perry, R.I., Spaven, L., and Zacharias, M. 2006. Recovery strategy for Blue, Fin, and Sei Whales (*Balaenoptera musculus, B. physalus, and B. borealis*) in Pacific Canadian Waters. *Species at Risk Act* Recovery Strategy Series. Vancouver: Fisheries and Oceans Canada: vii + 53.

Groot, C., and Margolis, L. 1991. Pacific salmon life histories. UBC Press, Vancouver, BC

Grundy, M., Moore, M., Howell, S., and Ratcliffe, N. 1996a. Phagocytic reduction and effects on lysosomal membranes by polycyclic aromatic hydrocarbons, in haemocytes of *Mytilus edulis*. Aquat. Toxicol. 34: 273–290.

Grundy, M., Ratcliffe, N., and Moore, M. 1996b. Immune inhibition in marine mussels by polycyclic aromatic hydrocarbons. Mar. Environ. Res. 42: 187–190.

Gundlach, E.R., Berne, S., D'Ozouville , L. and Topinka, J.A. 1981. Shoreline oil two years after *Amoco Cadiz:* new complications from *Tanio.* Pp. 525-540 *in* Proceedings of the 1981 Oil Spill Conference. American Petroleum Institute. Publ. No. 4334.

Hain, J.H.W., Ellis, S.L., Kenney, R.D., Clapham, P.J., Gray, B.K., Weinrich, M.T., and Babb, I.G. 1995. Apparent bottom feeding by humpback whales on Stellwagen bank. Marine Mammal Science 11(4): 464-479.

Hamner, W.M., Hamner, P.P., and Strand, S.W. 1994. Sun-compass migration by *Aurelia aurita* (Scyphozoa): population retention and reproduction in Saanich Inlet, British Columbia. Mar. Biol.119: 347.

Hampson, G.R., and Moul, E.T. 1978. No. 2 Fuel oil spill in Bourne, Massachusetts: Immediate assessment of the effects on marine invertebrates and a 3-year study of growth and recovery of a Salt Marsh. J. Fish. Res. Board. Can. 35: 731-744.

Hannam, M.L., Bamber, S.D., Moody, A.J., Galloway, T.S. and Jones, M.B. 2010. Immunotoxicity and oxidative stress in the Arctic scallop *Chlamys islandica*: Effects of acute oil exposure. Ecotoxicology and environmental safety, 73(6), pp.1440-1448.

Hansen, B.H., Altin, D., Olsen, A.J., and Nordtug, T. 2012. Acute toxicity of naturally and chemically dispersed oil on the filter-feeding copepod *Calanus finmarchicus*. Ecotoxicol. Environ. Saf. 86: 38–46.

Hashim, A.A. 2010. Effect of sublethal concentrations of fuel oil on the behavior and survival of larvae and adults of the barnacle *Balanus amphitrite amphitrite* (Darwin). Turkish Journal of Fisheries and Aquatic Sciences, 10, 499-503.

Hay, D.E., Boutillier, J., Joyce, M., and Langford, G. 1997. Eulachon (*Thaleichthys pacificus*) as an indicator species in the North Pacific. *In* Proceedings: Forage fishes in marine ecosystems. Alaska sea grant college program AK-SG-97-01, 1997. pp 509-530.

Heip, C.H.R. 1976. On the significance of aggregation in some benthic marine invertebrates. In IZWO Collected Reprints, 6: Chapter 14.

Heise, K. 1997. Life history and population parameters of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*). Rep. Int. Whal. Commn. 47(2): 817-825.

Helm, R.C., Costa, D.P., DeBruyn, T.D., O'Shea, T.J., Wells, R.S., and Williams, T.M. 2015. Overview of effects of oil spills on marine mammals. *In* Handbook of Oil Spill Science and Technology. Wiley Online Library. pp. 455-475.

Hepler, K.R., Hansen, P.A., and Bernard, D.R. 1994. Impact of oil spilled from the Exxon Valdez on survival and growth of dolly varden and cutthroat trout in Prince William Sound, Alaska. Fish/shellfish study number 5 (restoration study number 90). Exxon Valdez oil spill state/federal natural resource damage assessment final report. United States.

Hershner, C. and Moore, K., 1977. Effects of the Chesapeake Bay Oil Spill on salt marshes of the lower bay. In: Proceedings of the 1977 Oil Spill Conference. American Petroleum Institute, Washington, D.C, pp. 529–533.

Herunter, H.E., Nomura, M., Jackson, J.S., and Macdonald, J.S. 2017. A survey of literature on oil spill effects on marine organisms on the west coast of British Columbia, Canada with a focus on bitumen related products. Can. Tech. Rep. Fish. Aquat. Sci. 3219: iii + 435 p.

Hess, W.N. 1978. The *Amoco Cadiz* oil spill. NOAA/EPA Special Report. US Govt. Printing Office, Washington, DC.

Hewson, I., Button, J.B., Gudenkauf, B.M., Miner, B., Newton, A.L., Gaydos, J.K., Wynne, J., Groves, C.L., Hendler, G., Murray, M., Fradkin, S., Breitbart, M., Fahsbender, E., Lafferty, K.D., Kilpatrick, A.M., Miner, C.M., Raimondi, P., Lahner, L., Friedman, C.S., Daniels, S., Haulena, M., Marliave, J., Burge, C.A., Eisenlord, M.E., and Harvell, C.D. 2014. Densovirus associated with sea-star wasting disease and mass mortality. Pro. Nat. Acad. Sci. U.S.A. 111(48): 17278-17283.

Hoff, G.R. 2016. Identification of multiple nursery habitats of skates in the eastern Bering Sea. J. Fish. Biol. 88: 1746-1757.

Hoffmann, A.G. and Hansen, P.A., 1994. Injury to demersal rockfish and shallow reef habitats in Prince William Sound, 1989-1991. Exxon Valdez Oil Spill Trustee Council.

Hose, J.E. and Brown, E.D. 1998. Field applications of the piscine anaphase aberration test: lessons from the Exxon Valdez oil spill. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis 399(2): 167-178.

Houghton, J.P., Gilmour, R.H., Lees, D.C., Driskell, W.B., Lindstrom, S.C. and Mearns, A. 1997. Prince William Sound intertidal biota seven years later: Has it recovered? International Oil Spill Conference Proceedings, (1):679-686.

Houghton, J.E, Fukuyama, A. K., Lees, D.C., Teas, H., III, Cumberland, H.L., Harper, EM., Ebert, T.A. and Driskell, W.B. 1993. Evaluation of the 1991 condition of Prince William Sound shorelines following the "Exxon Valdez" oil spill and subsequent shoreline treatment: Volume II, 1991 biological monitoring survey. NOAA Technical Memorandum NOS ORCA 67. NOAA, Hazardous Materials Response and Assessment Division, Seattle, Washington.

Howard, S., Baker, J.M. and Hiscock, K. 1989. The effects of oil and dispersants on seagrasses in Milford Haven. In: Dicks, B., (Ed), Ecological Impacts of the Oil Industry. pp. 61-98, John Wiley and Sons Ltd, Chichester.

Incardona, J.P., Vines, C.A., Anulacion, B.F., Baldwin, D.H., Day, H.L., French, B.L., Labenia, J.S., Linbo, T.L., Myers, M.S., Olson, O.P., Sloan, C.A., Sol, S., Griffin, F.J., Menard, K., Morgan, S.G., West, J.E., Collier, T.K., Ylitalo, G.M., Cherr, G.N., and Scholz, N.L. 2011. Unexpectedly high mortality in Pacific herring embryos exposed to the 2007 Cosco Busan oil spill in San Francisco Bay. PNAS 109(2): E51-E58.

Ireland, K. and Milligan-Myhre, K. 2020. The effects of crude oil on juvenile threespine stickleback.

IUCN. 1991. Dolphins, porpoises and whales of the world: the IUCN Red Data Book. M. Klinowska (compiler). IUCN, Gland, Switzerland, and Cambridge, United Kingdom. viii + 429 pp.

Jacobs, R.P.W.M. 1980. Effects of the 'Amoco Cadiz' oil spill on the seagrass community at Roscoff with special reference to the benthic infauna. Marine Ecology Progress Series, 207-212.

Jahanbakhshi, A. and Hedayati, A. 2013. The effect of water-soluble fraction of crude oil on serum biochemical changes in the Great Sturgeon, *Huso huso*. Comp Clin Pathol 22:1099–1102.

Jameson, R.J., and Johnson, A.M. 1993. Reproductive characteristics of female sea otters. Mar. Mamm. Sci. 9(2): 156-167.

Jamieson, G.S., and Levesque, C. 2014. Identification of Ecologically and Biologically Significant Areas on the West Coast of Vancouver Island and the Strait of Georgia, and in some nearshore areas on the North Coast: Phase II – Designation of EBSAs. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/101. vii + 36 p.

Jarvela-Rosenberger, A.L., MacDuffee, M., Rosenberger, A.G.J., and Ross, P.S. 2017. Oil spills and marine mammals in British Columbia, Canada: development and application of a risk-based conceptual framework. Archives of Environmental Contamination and Toxicology 71(1): 131-153.

Jefferson, T.A. 1987. A study of the behaviour of Dall's porpoise (*Phocoenoides dalli*) in the Johnstone Strait, British Columbia. Can. J. Zool. 65: 736-744.

Jensen, G.C. 1989. Gregarious settlement by megalopae of the porcelain crabs *Petrolisthes cinctipes* (Randall) and *P. eriomerus* Stimpson. J. Exp. Mar. Biol. Ecol. 131(3): 223-231.

Jewett, S. C., Dean, T. A., Smith, R. O., Stekoll, M., Haldorson, L. J., Laur, D. R. and McDonald, L. 1995. The effects of the "Exxon Valdez" oil spill on shallow subtidal communities in Prince William Sound, Alaska 1989-93. "Exxon Valdez" Oil Spill Restoration Project Final Report (Project 93047: Subtidal Study Number 2A), Alaska Department of Fish and Game, Habitat and Restoration Division, Anchorage, Alaska.

Johansson, S., Larsson, U., and Boehm, P. 1980. The Tsesis oil spill impact on the pelagic ecosystem. Marine Pollution Bulletin.Volume 11, Issue 10, Pages 284-293. ISSN 0025-326X.

Juday, G.P., and Foster, N.R. 1990. A preliminary look at effects of the Exxon Valdez oil spill on Green Island Research natural area. Agroborealis-Alaska Agricultural and Forestry Experiment Station, University of Alaska-Fairbanks (USA).

Karinen, J.F., and Rice, S.D. 1974. Effects of Prudhoe Bay Crude Oil on molting Tanner Crabs, *Chionoecetes bairdi.* Marine Fishenes Review. Vol 36, No 7.

Karinen, J.F., Rice, S.D., and Babcock, M.M. 1985. Reproductive success in Dungeness Crab (*Cancer magister*) during long-term exposure to oil contaminated sediments. Final Report Outer Continental Shelf Environmental Assessment Program Research Unit 650 pp 435-461.

Karinen, J. F., Rice, S.D., and Babcock, M.M. 1990. Reproductive success in Dungeness crab (*Cancer magister*) during long-term exposures to oil-contaminated sediments. *Outer Continental Shelf Assessment Program, Final Reports of Principal Investigators 67*: 435-461.

Khan, R.A. 1991. Effect of oil-contaminated sediment on the longhorn sculpin (*Myoxocephalus octodecemspinosus*) following chronic exposure. Bulletin of Environmental Contamination and Toxicology 47:1.

Kim, H.N., Park, C.I., Chae, Y.S., Shim, W.J., Kim, M., Addison, R.F., and Jung, J.H. 2013. Acute toxic responses of the rockfish (*Sebastes schlegeli*) to Iranian heavy crude oil: Feeding disrupts the biotransformation and innate immune systems. Fish & Shellfish Immunology 35(2): 357-365.

Kim, H.N., Chae, Y.S., Shim, W.J. Park, C.I., Jung, J.H. 2014. Combined Effects of Iranian Heavy Crude Oil and Bacterial Challenge (*Streptococcus iniae*) on Biotransformation and Innate Immune Responses in Rockfish (*Sebastes schlegeli*). Bull. Environ. Contam. Toxicol. 93:199–203.

King, J.R. 2001. Assessment of Lingcod in the Strait of Georgia. Can. Sci. Advis. Sec. Res. Doc. 2001/132. 41 pp.

King, J.R., and Withler, R.E. 2005. Male nest site fidelity and female serial polyandry in lingcod (*Ophiodon elongatus*, Hexagrammidae). Mar. Ecol. 14: 653-660.

King, J.R., and McPhie, R.P. 2015. Preliminary age, growth and maturity estimates of spotted ratfish (*Hydrolagus colliei*) in British Columbia. Deep Sea Research Part II: Topical studies in Oceonography. 115: 55-63.

Kingston, E.E., Dixon, I.M.T., Hamilton, S. and Moore, D.C. 1995. The impact of the "Bract" oil spill on the macrobenthic infauna of the sediments off the Shetland Islands. Marine Pollution Bulletin 30, 445-459.

Klinger, D.H., Dale, J.J., Machado, B.E., Incardona, J.P., Farwell, C.J., and Block, B.A. 2015. Exposure to Deepwater Horizon weathered crude oil increases routine metabolic demand in Chub Mackerel, *Scomber japonicus*. Marine Pollution Bulletin 98(1–2): 259-266.

Klinkenberg, B.E. 2019. E-Fauna BC: Electronic atlas of the fauna of British Columbia [efauna.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver.

Knaggs, E.H. and Parrish, R.H. 1973. Maturation and growth of Pacific Mackerel, *Scomber japonicus* Houttuyn. California Department of Fish and Game Marine Resources Technical Report No. 3.

Kooyman, G.L., Gentry, R.L., and McAllister, W.B. 1976. Physiological impact of oil on pinnipeds. US Department of Commerce, National Oceanic and Atmospheric Administration(NOAA), National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Marine Mammal Division. .

Kooyman, G.L., Davis, R.W., and Castellini, M.A. 1977. Thermal conductance of immersed pinniped and sea otter pelts before and after oiling with Prudhoe Bay crude. *In* Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms. *Edited by* D.A. Wolfe. Pergamon Press, Oxford 151.

Korn, S., Moles, D.A. and Rice, S.D. 1979. Effects of temperature on the median tolerance limit of pink salmon and shrimp exposed to toluene, naphthalene, and cook inlet crude oil. Bull. Environ. Contam. Toxicol. 21, 521–525.

Krahn, M.M., Kittle, L.J., and MacLeod, W.D. 1986. Evidence for exposure of fish to oil spilled into the Columbia river. Marine Environmental Research 20(4): 291-298.

Krebs, C.T., and Burns, K.A. 1977. Long-term effects of an oil spill on populations of the salt-marsh crab *Uca pugnax. Science:* 197:484-487.

Krieger, K. J. 1997. Sablefish, *Anoplopoma fimbria*, observed from a manned submersible. In M. Wilkins & M. Saunders (Eds.), Biology and management of sablefish, *Anoplopoma fimbria*: Papers from the international symposium on the biology and management of sablefish (pp. 39– 43). Seattle, WA, 13–15 April 1993. U.S. Dept. Commer. NOAA Tech. Rep. 130.

Kubodera, T. 1991. Distribution and abundance of the early stages of octopus, *Octopus dofleini* Wulker, 1910, in the north Pacific. Bull. Mar. Sci. 49: 235-243.

Kucas, S.T. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) – Northern anchovy. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.50). U.S. Army Corps of Engineers, TR EL-82-4. 11pp.

Kushmaro, A., Henning, G., Hofmann, D.K., and Benayahu, Y. 1997. Metamorphosis of *Heteroxenia fuscescens* planulae (Cnidaria: octocorallia) is inhibited by crude oil: a novel short term toxicity bioassay. Marine Environmental Research, 43(4): 295-302.

Kvitek, R.G., Bowlby, C.E., and Staedler, M. 1993. Diet and foraging behaviour of sea otters in Southeast Alaska. Mar. Mamm. Sci. 9(2): 168-181.

Lamb, A., and Edgell, P. 2010. Coastal fishes of the Pacific Northwest. Harbour publishing, Madeira Park, BC

Lane, E.H., Wulff, W., McDiarmid, A., Hay, D.E., and Rusch, B. 2002. A review of the biology and fishery of the Embiotocids of British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/123. 61 p.

Lane, S.M., Smith, C.R., Mitchell, J., Balmer, BC, Barry, K.P., McDonald, T., Mori, C.S., Rosel, P.E., Rowles, T.K., and Speakman, T.R. 2015. Reproductive outcome and survival of common bottlenose dolphins sampled in Barataria Bay, Louisiana, USA, following the Deepwater Horizon oil spill. Proceedings of the Royal Society B: Biological Sciences 282(1818): 20151944.

Lavado, R., Janer, G., and Porte, C. 2006. Steroid levels and steroid metabolism in the mussel *Mytilus edulis*: the modulating effect of dispersed crude oil and alkylphenols. Aquat. Toxicol. 78 Suppl 1: S65–S72.

Le Boeuf, B.J. 1971. Oil contamination and elephant seal mortality: a 'negative'finding.

Lee, D.S., Gilbert, C.R., Hocutt, C.H., Jenkins, R.E., McAllister, D.E., and Stauffer, J.R. 1980. Atlas of North American freshwater fishes. North Carolina Museum of Natural History, Raleigh.

Levesque, C., and Jamieson, G.S. 2015. Identification of Ecologically and Biologically Significant Areas in the Strait of Georgia and off the West Coast of Vancouver Island: Phase I – Identification of Important Areas. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/100. viii + 68 p.

Lin, Q., Mendelssohn, I.A., Graham, S.A., Hou, A., Fleeger, J.W., and Deis, D.R. 2016. Response of salt marshes to oiling from the Deepwater Horizon spill: implications for plant growth, soil-surface erosion, and shoreline stability. Sci. Total Environ. 2016, 557−558, 369−377.

Linden, O., Elmgren, R. and Boehm, RD. 1979. The "Tsesis" oil spill - its impact on the coastal ecosystem of the Baltic Sea. Ambio 8, 244-253.

Lindholm, J., Kelly, M., Kline, D.E., and de Marignac, J. 2008. Patterns in the local distribution of the sea whip, *Halipteris willemoesi*, in an area impacted by mobile fishing gear. Mar. Tech. Soc. J. 42(4): 64-68.

Lindley, S.T., Moser, M.L., Erickson, D.L., Belchik, M., Welsh, S.W., and Rechisky, E.L. 2008. Marine migration of North American green sturgeon. Trans. Amer. Fish. Soc. 137: 182-194.

Lindley, S.T., Erickson, D.L., Moser, M.L., Williams, G., Langness, O.P., McCovey, B.W. Jr., Belchik, M., Vogel, D., Pinnix, W., Kelly, J.T., Heublein, J.C., and Klimley, A.P. 2011. Electronic tagging of Green Sturgeon reveals population structure and movement among estuaries. T. Am. Fish. Soc. 140(1): 108-122.

Lobban, C.S., and Harrison, P.J. 1994. Seaweed ecology and physiology. Cambridge University Press. New York.

Loughlin, T.R. 1994. Marine Mammals and the Exxon Valdez. Academic Press, San Diego, CA.

Loughlin, T.R. 2013. Marine mammals and the Exxon Valdez. Academic Press.

Love, M. 1996. Probably more than you want to know about the fishes of the Pacific coast. Really Big Press, Santa Barbara, California.

Love, M.S, Yoklavich, M., and Thornsteinson, L. 2002. The rockfishes of the northeast Pacific. University of California Press, Berkeley, California.

Love, M.S., Schroeder, D.M., Snook, L., York, A., and Cochrane, G. 2008. All their eggs in one basket: a rocky reef nursery for the longnose skate (*Raja rhina* Jordan and Gilbert, 1880) in the Southern California Bight. Fish. Bull. 106: 471-475.

Love, M.S. 2011. Certainly more than you want to know about the fishes of the Pacific coast. Really Big Press. Santa Barbara, California.

Luter, H.M., Whalan, S., Andreakis, N., Abdul Wahab, M., Botté, E.S., Negri, A.P., and Webster, N.S. 2019. The effects of crude oil and dispersant on the larval sponge holobiont. mSystems 4:e00743-19.

Macinnis-Ng, C.M. and Ralph, P.J. 2003. In situ impact of petrochemicals on the photosynthesis of the seagrass Zostera capricorni. Marine Pollution Bulletin, 46(11), 1395-1407.

Mackenzie, W.H., and Moran, J.R. 2004. Wetlands of British Columbia: A guide to identification. Res. Board, BC Ministry Forests, Victoria, BC Land Mgmt. Handb. No. 52

Mageau, C., Engelhardt, F.R., Gilfillan, E.S., and Boehm, P.D. 1987. Effects of short-term exposure to dispersed oil in Arctic invertebrates. *Arctic*, *40*, 162–171.

Marliave, J., Frid, A., Welch, D.W., and Porter, A.D. 2013. Home site fidelity in black rockfish, *Sebastes melanops*, reintroduced into a fjord environment. The Canadian field naturalist. 127: 255-261.

Marty, G.D., Hoffmann, A., Okihiro, M.S., Hepler, K., and Hanes, D. 2003. Retrospective analysis: bile hydrocarbons and histopathology of demersal rockfish in Prince William Sound, Alaska, after the Exxon Valdez oil spill. Marine Environmental Research 56(5): 569-584.

Matkin, C., Ellis, G., Saulitis, E., Barrett-Lennard, L., and Matkin, D. 1999. Killer whales of southern Alaska. North Gulf Oceanic Society, Homer, Alaska, pp.1-96.

Matkin, C., Saulitis, E., Ellis, G., Olesiuk, P., and Rice, S. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez'oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series 356: 269-281.

Matkin, C.O., Durban, J.W., Saulitis, E.L., Andrews, R.D., Straley, J.M., Matkin, D.R., and Ellis, G.M. 2012. Contrasting abundance and residency patterns of two sympatric populations of transient killer whales (*Orcinus orca*) in the northern Gulf of Alaska. Fishery Bulletin 110(2): 143-155.

McCain, B.B., Hodgins, H.O., Gronlund, W.D., Hawkes, J.W., Brown, D.W., Myers, M.S., and Vandermeulen, J.H. Bioavailability of Crude Oil from Experimentally Oiled Sediments to English Sole (*Parophrys vetulus*), and Pathological Consequences. Journal of the Fisheries Research Board of Canada. 35(5): 657-664.

McClintock, J.B. and Robnett, T.J. Jr. 1986. Size selective predation by the asteroid *Pisaster ochraceus* on the bivalve *Mytilus californianus*: A cost-benefit analysis. Mar. Ecol. 7(4): 321-332.

McConville, M.M., Roberts, J.P., Boulais, M., Woodall, B., Butler, J.D., Redman, A.D., Parkerton, T.F., Arnold, W.R., Guyomarch, J., LeFloch, S., Bytingsvik, J., Camus, L., Volety, A. and Brander, S.M. 2018. The sensitivity of a deep-sea fish species (*Anoplopoma fimbria*) to oil-associated aromatic compounds, dispersant, and Alaskan North Slope crude oil. Environ Toxicol Chem, 37: 2210-2221

McFarlane, G.A., and King, J.R. 2006. Age and growth of big skate (Raja binoculata) and longnose skate (Raja rhina) in British Columbia waters. Fish. Res. 78: 169-178.

McMillan, C.J., Towers, J.R., and Hildering, J. 2019. The innovation and diffusion of "trap-feeding," a novel humpback whale foraging strategy. Marine Mammal Science 35: 779-796.

Mead, J.G., Walker, W.A., and Houck, W.J. 1982. Biological Observations on *Mesoplodon carlhubbsi* (Cetacea: Ziphiidae). Smithsonian contributions to Zoology 344.

Mearns, A.J., Levine, E., Yender, R., Helton, D., and Loughlin, T. 1999. Protecting Fur Seals During Spill Response: Lessons from the San Jorge (Uruguay) Oil Spill. *In* International Oil Spill Conference Proceedings: March 1999. pp. 467-470.

Miles, A.K., Bowen, L., Ballachey, B.E., Bodkin, J.L., Murray, M., Estes, J.L., Keister, R.A., and Stott, J.L. 2012. Variation in transcript profiles in sea otters (*Enhydra lutris*) from Prince William Sound, Alaska and clinically normal reference otters: Marine Ecology Progress Series, v. 451, p. 201–212.

Moles, A. and Norcross, B.L. 1998. Effects of oil-laden sediments on growth and health of juvenile flatfishes. Canadian Journal of Fisheries and Aquatic Sciences. 55(3): 605-610.

Moles, A., and Wade, T. 2001. Parasitism and phagocytic function among Sand Lance, *Ammodytes hexapterus* Pallas, exposed to crude oil-laden sediments. Bull. Environ. Contam. Toxicol. 66, 528–535.

Mondragon, J. and Mondragon, J. 2003. Seaweeds of the Pacific Coast. Sea Challengers, California.

Moore, J.E., and Read, A.J. 2008. A bayesian uncertainty analysis of cetacean demography and bycatch mortality using age-at-death data. Ecological Applications 18: 1914-1931.

Moore, S.E., and Clarke, J.T. 2002. Potential impact of offshore human activities on gray whales (*Eschrichtius robustus*). Journal of Cetacean Research and Management 4(1): 19-25.

Morris, M. and Harper, J. 2006. Oil spill response techniques for BC coastal wetlands. Prepared by Archipelago Marine Research and Coastal and Ocean Resources Inc. for Environment Canada.

Morrow, J.E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Company, Anchorage, Alaska.

Murawski, S.A., Ainsworth, C.H., Gilbert, S., Hollander, D.J., Paris, C.B., Schlüter, M., and Wetzel, D.L. 2020. Deep Oil Spills: Facts, Fate, and Effects. Springer.

National Academies of Sciences Engineering and Medicine. 2016. Spills of diluted bitumen from pipelines: A comparative study of environmental fate, effects, and response. National Academies Press.

Neidetcher, S.K., Hurst, T.P., Ciannelli L. and Logerwell, E.A. 2014. Spawning phenology and geography of Aleutian Islands and eastern Bering Sea Pacific Cod (*Gadus microcephalus*). Deep Sea Res. Part II: Topical Studies in Oceanography. 109: 204-214.

Nelson, C.H., Johnson, K.R., and Barber, J.H.J. 2006. Gray whales and walrus feeding excavation on the Bering shelf, Alaska. J. Sed. Petrology 57(3): 419-430.

Nelson-Smith, A. 1972. Oil Pollution and Marine Ecology. Springer New York, NY. 260 p.

Newsome, S.D., Etnier, M.A., Kurle, C.A., and Koch, P.L. 2007. Historic decline in primary productivity in western Gulf of Alaska and eastern Bering Sea: Isotopic analysis of Northern fur seal teeth. Mar. Ecol. Prog. Ser. 332: 211-224.

Nichol, J. 1976. Mizushima Oil Spill-a tragedy for Japan and a lesson for Canada. Rep. No. EPS-8-EC-76-2. Environ. Can. Environ. Prot. Serv., Ottawa, Canada.

Nichol, L.M., Watson, J.C., Abernethy, R., Rechsteiner, E., and Towers, J. 2015. Trends in the abundance and distribution of sea otters (*Enhydra lutris*) in British Columbia updated with 2013 survey results. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/039: vii + 31 p.

Nichol, L.M., Abernethy, R.M., Wright, B.M., Heaslip, S., Spaven, L.D., Towers, J.R., Pilkington, J.F., Stredulinsky, E.H., and Ford, J.K.B. 2018. Distribution, movements and habitat fidelity patterns of Fin Whales (*Balaenoptera physalus*) in Canadian Pacific waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/004: vii + 52 p.

National Research Council (NRC). 2005. Understanding oil spill dispersants: efficacy and effects. The National Academies Press, Washington, D.C. 400 p.

North, W.J. 1967. Tampico, a study of destruction and restoration. Sea Frontiers 13(4): 212-217.

O'Brien, P.Y., and Dixon, P.S. 1976. The effects of oils and oil components on algae: a review. British Phycol. J. 11: 115-142.

O'Clair, C.E.and Rice, S.D. 1985. Depression of feeding and growth rates of the seastar *Evasterias troschelii* during long-term exposure to the water-soluble fraction of crude oil. Mar. Biol. 84, 331–340.

Olesiuk, P.F. 2018. Recent trends in Abundance of Steller Sea Lions (*Eumetopias jubatus*) in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/006. v + 67 p.

Ormond, R.F.G. and Caldwell, S. 1982. The effect of oil pollution on the reproduction and feeding behaviour of the sea anemone *Actinia equina*. Marine Pollution Bulletin, Volume 13, Issue 4, Pages 118-122. ISSN 0025-326X.

Ozhan, K., Parsons, M.L., and Bargu, S. 2014. How were phytoplankton affected by the Deepwater Horizon oil spill? BioScience. 64: 829-836.

O'Shaughnessy, K.A., Forth, H., Takeshita, R., and Chesney, E.J. 2018. Toxicity of weathered Deepwater Horizon oil to Bay Anchovy (*Anchoa mitchilli*) embryos. Ecotoxicology and Environmental Safety 148: 473-479.

Paine, R.T. 1979. Disaster, catastrophe, and local persistence of the sea palm *Postelsia palmaeformis*. Science. 205: 695-687.

Palazzi, D., Goodwin, L., Bradbury, A., Sizemore, B., Espy, L., Sturges, S., Ladenburg, C., and Sabottke, B. 2001. Supplemental Environment Impact Statement (S.E.I.S.) for the Puget Sound commercial geoduck fishery, Washington State Department of Natural Resources and Washington State Department of Fish and Wildlife. 135 pg.

Parra, T.R., Palsson, W.A., and Pacunski, R.E. 2001. Abundance, mate and den fidelity of wolf-eel (*Anarrhichthys ocellatus*) in Puget Sound, Washington. Puget Sound Research. pp 7.

Payne, J., and Driskell, W. 2003. The importance of distinguishing dissolved-dersus oil-droplet phases in assessing the fate, transport, and toxic effects of marine oil pollution. *In* Proceedings of the International Oil Spill Conference, Washington, D.C., pp.1993–2000.

Pechenik, J.A. 2005. Biology of the invertebrates, 5th Ed. McGraw-Hill, New York, NY. 590 pg.

Pecko, P., Levings, S.C., and Garrity, S.D. 1990. Kelp responses following the World Prodigy oil spill. Mar. Poll. Bull. 21: 473-476.

Perry, D. 1980. Factors influencing aggregation patterns in the sand crab *Emerita analoga* (Crustacea: Hippidae). Oecologia. 45(3): 379-384.

Peterson, C.H. 2001. The Exxon Valdez oil spill in Alaska: Acute, indirect and chronic effects to the ecosystem. *In* Advances in Marine Biology, Volume 39. *Edited by* A.J. Southward and P.A. Tyler and C.M. Young and L.A. Fuiman. Academic Press Ltd.

Peterson, C.H., Rice, S.D., Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E., and Irons, D.B. 2003. Long-term ecosystem response to the Exxon Valdez oil spill. Science 302(5653): 2082-2086.

Peterson, C.T., Grubbs, D. R., and Mickle, A. 2017. An investigation of effects of the deepwater horizon oil spill on coastal fishes in the Florida Big Bend using fishery-independent surveys and stable isotope analysis. Southeastern Naturalist. 16(1):G93-G108.

Pezeshki, S.R., Hester, M.W., Lin Q., and Nyman, J.A. 2000. The effects of oil spill and clean-up on dominant US Gulf coast marsh macrophytes: a review. Environ. Poll. 108 : 129-139.

Phillips, R.C., Grant, W.S., and McRoy, C.P. 1983. Reproductive strategies of eelgrass *(Zostera marina L.*). Aquat. Bot. 16: 1-2.

Pitcher, K.W. 1981. Prey of the Steller sea lion, *Eumetopias jubatus*, in the Gulf of Alaska. Fish. Bull. Seattle 79(3): 467-472.

Pyenson, N.D., and Lindberg, D.R. 2011. What happened to gray whales during the Pleistocene? The ecological impact of sea-level changes on benthic feeding areas in the North Pacific Ocean. PLOS ONE 6(7): e21295.

Quick, N.J., Cioffi, W.R., Shearer, J.M., Fahlman, A., and Read, A.J. 2020. Extreme diving in mammals: first estimates of behavioural aerobic dive limits in Cuvier's beaked whales. Journal of Experimental Biology 225: 1-6.

Rabalais, N.N. and Turner, R.E. 2016. Effects of the Deepwater Horizon oil spill on coastal marshes and associated organisms. Oceanography, 29 (3), 150–159.

Ralls, K., and Siniff, D.B. 1990. Sea otters and oil: ecologic perspectives. *In* Sea mammals and oil: confronting the risks. Academic Press, Inc. pp. 199-210.

Reed, D.C., Laur, D.R. and Ebeling, A.W. 1988. Variation in algal dispersal and recruitment: the importance of episodic events. Ecological Monographs. 58(4): 321-335.

Reeves, R.R., and Mitchell, E. 1992. Status report on the Baird's beaked whale *Berardius bairdii* in Canada. Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 35 pp.

Reiter, J., and LeBeouf, B.J. 1991. Life history consequences of variation in age at primiparity in Northern elephant seals. Behav. Ecol. Sociobiol. 28: 153-160.

Reynolds, J.B. 1997. Ecology of overwintering fishes in Alaskan freshwaters. *In* Freshwaters of Alaska: ecological syntheses. *Edited by* A.M. Milner and M.W. Oswood. Springer-Verlag, New York. pp. 281-302.

Reynolds, B.F., Powers, S.P., and Bishop, M.A. 2010. Application of acoustic telemetry to assess residency and movements of rockfish and lingcod at created and natural habitats in Prince William Sound. PLoS ONE 5(8): e12130.

Riedman, M.L. and Estes, J.A. 1990. The Sea Otter (*Enhydra lutris*): Behavior, Ecology, and Natural History. United States Fish and Wildlife Service, Biological Report.

Blanc, A.M., Holland, L.G., Rice, S.D., Kennedy, C.J. 2010. Anthropogenically sourced low concentration PAHS: In situ bioavailability to juvenile Pacific salmon. Ecotoxicology and Environmental Safety 73(5):849-857.

Robards, M.D., Piatt, J.F., and Rose, G.A. 1999. Maturation, fecundity and intertidal spawning of Pacific sand lance in the Northern Gulf of Alaska. J. Fish Biol. 54: 1050-1068.

Romero, N., Gresswell, R.E., and Li, J.L. 2005. Changing patterns in coastal cutthroat trout (*Oncorhynchus clarki clarki*) diet and prey in a gradient of deciduous canopies. Canadian Journal of Fisheries and Aquatic Sciences 62(8): 1797-1807.

Rossi, S.S., Anderson, J.W. and Ward, G.S., 1976. Toxicity of water-soluble fractions of four test oils for the polychaetous annelids, *Neanthes arenaceodentata* and *Capitella capitata*. Environmental Pollution (1970), 10(1), pp.9-18.

Rudy, P. Jr., and Rudy, L.H. 1983. Oregon estuarine invertebrates: An illustrated guide to the common and important invertebrate animals. National Coastal Ecosystems Team, U.S. Fish and Wildlife Service. Contract No 79-111.

Runcie, J., Macinnis-Ng, C,. and Ralph, P. 2004. The toxic effects of petrochemicals on seagrasses. Literature review. Prepared for the Australian Maritime Safety Authority.

Sanderson, S.L., Cheer, A.Y., Goodrich, J.S., Graziano, J.D., and Callan, W.T. 2001. Crossflow filtration in suspension-feeding fishes. Nature 412: 439–441.

SARA (Pacific Leatherback Turtle Recovery Team). 2006. Recovery strategy for leatherback turtles (*Dermochelys coriacea*) in Pacific Canadian waters. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Vancouver, v + 41 pp.

SARA. 2016. *Species at Risk Act*.

Sastry, A. 1979. Pelecypoda (Excluding Ostreidae). In Reproduction of Marine Invertebrates, Vol. V. Edited by A. Giese and J. Pearse, eds. Plenum Press, New York. pp. 113-292.

Scheel, D., Matkin, C.O., and Saulitis, E.L. 2001. Distribution of killer whale pods in Prince William Sound, Alaska over a thirteen-year period, 1984–1996. Marine Mammal Science 17: 555-569.

Schutz, D.C. and Northcote, T.G. 1972. An experimental study of feeding behavior and interaction of coastal Cutthroat Trout (*Salmo clarki clarki*) and Dolly Varden (*Salvelinus malma*). Journal of the Fisheries Research Board of Canada 29(5): 555-565.

Schweigert, J.F., Boldt, J.L., Flostrand, L., and Cleary, J.S. 2010. A review of factors limiting recovery of Pacific Herring stocks in Canada. ICES Journal of Marine Science 67(9): 1903–1913.

Seminoff, J.A., Jones, T., and Marshall, G.J. 2006. Underwater behaviour of green turtles monitored with video-time-depth recorders: what's missing from dive profiles? Mar. Ecol. Prog. Ser. 322: 269- 280.

Shanks, A.L. 2001. An identification guide to the larval marine invertebrates of the Pacific Northwest. Oregon State University Press, Corvallis, Oregon.

Short, J.W., Maselko, J.K., Lindeberg, M.R., Harris, P.M., and Rice, S.D. 2006. Vertical distribution and probability of encountering intertidal Exxon Valdez Oil on shorelines of three embayments within Prince William Sound, Alaska. Enviro. Sci. and Tech. 40(12): 3723-3729.

Southward, A.J. 1982. An ecologists view of the implications ofthe observed physiological and biochemical effects of petroleumcompounds on marine organisms and ecosystems. Phil. Trans. R.Soc. B. 297: 241–255.

Spangenberg, D.B. 1987. Effects of energy-related contamination on ephyra development in Aurelia. In J. V. Dorigan and F. L. Harrison (eds.), Physiological responses of marine organisms to environmental stresses, pp. 423-427. U.S. Department of Energy Publication DOE ER-0317.

Spies, R.B., Stegeman, J.J., Hinton, D.E., Woodin, B., Smolowitz, R., Okihiro, M., and Shea, D. 1996. Biomarkers of hydrocarbon exposure and sublethal effects in embiotocid fishes from a natural petroleum seep in the Santa Barbara Channel. Aquatic Toxicology 34(3): 195-219.Spight, T.M. 1974. Sizes of populations of a marine snail. Ecology. 55: 712–729.

Spraker, T.R., Lowry, L.F., and Frost, K.J. 1994. Gross necropsy and histopathological lesions found in harbor seals. *In* Marine mammals and the ‘Exxon Valdez’. *Edited by* T.R. Loughlin. Academic Press, San Diego, CA. pp. 281-312.

St. Aubin, D.J. 1990. Chapter 4: Physiologic and toxic effects on pinnipeds. *In* Sea mammals and oil: confronting the risks. Academic Press Inc. pp. 103-123.

St. Aubin, D.J., and Geraci, J.R. 1994. Summary and conclusions. *In* Marine mammals and the 'Exxon Valdez'. *Edited by* T.R. Loughlin. Academic Press, San Diego, CA. pp. 381-386.

Stacey, P.J., and Baird, R. 1981. Status of the Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, in Canada. Canadian Field Naturalist 105(2): 219-232.

Stacey, P.J., Leatherwood, S., and Baird, R.W. 1994. *Pseudorca crassidens*. Am. Soc. Mamm. Mammalian Species No. 456:1-6.

Stefansson, E.S., Langdon, C.J., Pargee, S.M., Blunt, S.M., Gage, S.J. and Stubblefield, W.A. 2016. Acute effects of non-weathered and weathered crude oil and dispersant associated with the Deepwater Horizon incident on the development of marine bivalve and echinoderm larvae. Environ Toxicol Chem, 35: 2016-2028.

Stekoll, M.S., Deysher, L. and Dean, T.A. 1993. Seaweeds and the "Exxon Valdez" Oil Spill. Proc. In "1993 International Oil Spill Conference (Prevention, Preparedness, Response)", pp. 135-140. American Petroleum Institute Publication 4580, Washington, DC.

Stekoll, M.S. and Deysher, L. 1996. Recolonization and restoration of upper intertidal *Fucus gardneri* (Fucales, Phaeophyta) following the *Exxon Valdez* oil spill. Hydrobiologia. 326/327:311-316.

Stewart, I., and Hicks, A. 2018. Assessment of the Pacific halibut (*Hippoglossus stenolepis*) stock at the end of 2017. IPHC-2018-AM094-10. 25 p.Stevens, B.G., Donaldson, W.E., and Haaga, J.A. 1992. First observations of podding behavior for the Pacific lyre crab *Hyas lyratus* (Decapoda: Majidae). J. Crust. Biol. 12(2): 193-195.

Stevens, B.G., Haaga, J.A., and Donaldson, W.E. 1994. Aggregative mating of tanner crabs, *Chionoecetes bairdi*. Can. J. Fish. Aquat. Sci. 51: 1273-1280.

Stewart, B.S. and DeLong, R.L. 1995. Double migrations of the Northern elephant seal, *Mirounga angustirostris*. J. Mammol. 76: 196-205.

Suchanek, T. 1993. Oil Impacts on Marine Invertebrate Populations and Communities. American Zoologist, 33(6): 510–523.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P., and Pitman, R.L. 2008. *Physeter macrocephalus*. The IUCN Red List of Threatened Species 2008.

Thom, R.M., Judd, C., Buenau, K.E., and Cullinan, V.I. 2011. Eelgrass (*Zostera marina L.*) stressors in Puget Sound. Prepared for Washington State Dept. Natural Resources.

Thomas, M.L.H. 1973. Effects of Bunker C Oil on Intertidal and Lagoonal Biota in Chedabucto Bay, Nova Scotia. Journal of the Fisheries Research Board of Canada. 30(1): 83-90.

Tribuzio, C.A., and Kruse, G.H. 2012. Life history characteristics of a lightly exploited stock of *Squalus suckleyi*. J. Fish. Biol. 80: 1159-1180.

Tyler, A.V., Swanston, C.O., and McIntosh, BC 2001. Feeding ecology of maturing sockeye salmon (*Oncorhynchus nerka*) in nearshore waters of the Kodiak archipelago. Final Report. OCS Study MMS 2001-059.

Vad, J., Dunnett, F., Liu, F., Montagner, C.C., Roberts, J.M., and Henry, T.B. 2020. Soaking up the oil: Biological impacts of dispersants and crude oil on the sponge *Halichondria panicea*. Chemosphere 257: 127109.

Vadas, R.L., Elner, R.W., and Garwood, P.E. 1986. Experimental evaluation of aggregation behavior in the sea urchin *Strongylocentrotus droebachiensis*. Mar. Biol. 90: 433-448.

Vasquez, H.E., Hashimoto, K., Yoshida, A., Hara, K., and Imai, C.C. 2013. A glycoprotein in shells of conspecifics induces larval settlement of the Pacific oyster *Crassostrea gigas*. PLoS ONE. 8(12): e82358.

Venn-Watson, S., Colegrove, K.M., Litz, J., Kinsel, M., Terio, K., Saliki, J., Fire, S., Carmichael, R., Chevis, C., Hatchett, W., Pitchford, J., Tumlin, M., Field, C., Smith, S., Ewing, R., Fauquier, D., Lovewell, G., Whitehead, H., Rotstein, D., McFee, W., Fougeres, E., and Rowles, T. 2015. Adrenal gland and lung lesions in Gulf of Mexico Common Bottlenose Dolphins (*Tursiops truncatus*) found dead following the Deepwater Horizon Oil Spill. PLoS ONE 10(5): e0126538.

Vermaat, J. E., Agawin, N. S. R., Fortes, M. D., Uri, J., Duarte, C. M., Marba, N., and Van Vierssen, W. 1997. The capacity of seagrasses to survive increased turbidity and siltation: the significance of growth form and light use. Ambio, 26(8): 499-504.

Walker, C.J. 2011. Assessing the effects of pollutant exposure on sharks: A biomarker approach. UNF Graduate Theses and Dissertations 141.

Walker, W.A., and Hanson, M.B. 1999. Biological observations on Stejneger's beaked whale, *Mesoplodon stejnegeri*, from strandings on Adak island, Alaska. Marine Mammal Science 15(4): 1314-1329.

Wallace, S. and Gisborne B. 2006. Basking sharks: the slaughter of BC's gentle giants. New Star Books, Vancouver, BC

Ware, D. and Schweigert, J. 2001. Metapopulation structure and dynamics of British Columbia Herring. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/127. 27 p.

Ware, C., Wiley, D.N., Friedlaender, A.S., Weinrich, M., Hazen, E.L., Bocconcelli, A., Parks, S.E., Stimpert, A.K., Thompson, M.A., and Abernathy, K. 2013. Bottom side roll feeding by humpback whales (*Megaptera novaeangliae*) in the Southern Gulf of Maine, U.S.A. Mar. Mamm. Sci. 30: 494-511.

Whalen, M.A., Millard-Martin B.R., Cox, K.D., Lemay, M.A., and Paulay, G. 2020. Poleward range expansion of invasive bopyrid isopod, *Orthione griffenis* Markham, 2004, confirmed by establishment in Central British Columbia, Canada. BioInvasions Records 9(3): 538– 548,

Whitehead, H. 2003. Sperm whales: social evolution in the ocean University of Chicago press.

Williams, R., Lusseau, D., and Hammond, P.S. 2009. The role of social aggregations and protected areas in killer whale conservation: The mixed blessing of critical habitat. Biological Conservation 142(4): 709-719.

Williams, R., Gero, S., Bejder, L., Calambokidis, J., Kraus, S.D., Lusseau, D., Read, A.J., and Robbins, J. 2011. Underestimating the damage: interpreting cetacean carcass recoveries in the context of the Deepwater Horizon/BP incident. Conservation Letters 4(3): 228-233.

Williams, T.M., Kastelein, R.A., Davis, R.W., and Thomas, J.A. 1988. The effects of oil contamination and cleaning on sea otters (*Enhydra lutris*). Thermoregulatory implications based on pelt studies. Can. J. Zool. 66: 2776-2781.

Willner, G.B. 2006. The potential impacts of the commercial Geoduck (*Panope generosa*) hydraulic harvest method on organisms in the sediment and at the water-dediment interface in Puget Sound. M.E.S. thesis, The Evergreen State College, Olympia, Washington.

Wise Jr, J.P., Wise, J.T., Wise, C.F., Wise, S.S., Gianios Jr, C., Xie, H., Thompson, W.D., Perkins, C., Falank, C., and Wise Sr, J.P. 2014. Concentrations of the genotoxic metals, chromium and nickel, in whales, tar balls, oil slicks, and released oil from the gulf of Mexico in the immediate aftermath of the deepwater horizon oil crisis: is genotoxic metal exposure part of the deepwater horizon legacy? WisEnvironmental science and technology 48(5): 2997-3006.

Wolfe, D.A. 1987. Interactions of spilled oil with suspended materials and sediments in aquatic systems. In: Fate and Effects of Sediment-bound Chemicals in Aquatic Systems., Ed. Dickson, K. L., Maki, A. W. and Brungs, W. A. August 12-17, 299–316. Proceedings of the 6th Pellston Workshop. pp. In: [eds.]1984. Florissant, Colorado. Pergamon Press, Oxford, England.

Woodward, D.F., Mehrle, P.M., Jr. and Mauck, W.L. 1981. Accumulation and sublethal effects of a Wyoming crude oil in Cutthroat Trout. Transactions of the American Fisheries Society, 110: 437-445.

Wursig, B. 1990. Cetaceans and oil: Ecological perspectives. In: Sea mammals and oil: confronting the risks. Academic Press, San Diego, California.

Zahn, R.K., Zahn-Daimler, G., Müller, W.E.G., Michaelis, M.L., Kurelec, B., Rijavec, M., Batel, R., and Bihari, N., 1983. DNA damage by PAH and repair in a marine sponge. Sci. Total Environ. 26, 137e156.

Zieman, J.C., Orth, R.J., Phillips, R.C., Thayer, G., and Thorhaug, A. 1984. The effects of oil on seagrass ecosystems. In Restoration of habitats impacted by oil spills. Edited by J. Cairns and L. Buikema. Butterworth Publishers. Pp 37-64.

This Report is Available from the:

Centre for Science Advice (CSA)
Pacific Region
Fisheries and Oceans Canada
3190 Hammond Bay Road
Nanaimo BC V9T 6N7

E-Mail: DFO.PacificCSA-CASPacifique.MPO@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-3769
ISBN 978-0-660-47862-3 Cat. No. (Fs70-7/2023-016E-PDF)
© His Majesty the King in Right of Canada, as represented by the Minister of the Department of Fisheries and Oceans, 2023

Correct Citation for this Publication:

DFO. 2023. 2022 Update to the application of a framework to assess the vulnerability of biological components to ship-source oil spills in the marine environment in the Pacific region. DFO Can. Sci. Advis. Sec. Sci. Resp. 2023/016.

Aussi disponible en français :

MPO. 2023. 2022 Mise à jour sur l'application d'un cadre d'évaluation de la vulnérabilité des composantes biologiques du milieu marin de la région du Pacifique aux déversements d'hydrocarbures provenant de navires. Secr. can. des avis sci. du MPO. Rép. des Sci. 2023/016.