## Aquaculture

### AC: Finfish Farms

Finfish aquaculture is associated with the following impacts on the marine environment: chemical pollution; organic and genetic pollution; and introduction of parasites and diseases to the wild populations. Aquaculture can affect, not only wild fish populations, but also benthic communities, especially if located in semi-enclosed water areas. It also requires some coastal infrastructure and an increased level of shipping to maintain and transport the product.

*Example:* salmon, trout and cod aquaculture in Norway, Iceland, Faroe Islands, and the Russian Kola Peninsula

#### Assessment findings:

*Marine mammals.* Source of *notable* concern for most areas: farms should not be located in semi-enclosed areas and away from areas of regular animal aggregation. Source of significant concern when situated near well-defined, spatially restricted stable habitats like haul out sites, key beluga or narwhal habitats, and sea otter habitats.

*Seabirds.* Source of *notable* concern for most areas: farms should not be in the vicinity of seabird colonies or areas where there are stable and regular bird concentrations, especially, of diving birds.

*Fish.* Source of *significant* concern and non-mitigable risks in the important habitats of Atlantic salmon and White-sea cod. Source of notable concern requiring limitations on scale and robust monitoring in some important habitats of other species like Least cisco, Inconnu, Arctic charr, Taranetz's charr, Atlantic capelin, etc. and in the estuarine brackish-water fish complex distribution areas. Minor concern in other areas if comprehensively adhering to existing environmental standards and best practices.

*Benthos. Not applicable* for most of the benthic features. Source of *notable* concern and requiring limitation of scale in the kelp-associated conservation feature areas.

*Coastal features. Significant* concern if located in estuaries as it can affect the conservation value of semi-enclosed water bodies. Source of *significant* concern for salt marshes due to sensitivity of the habitats. *Notable* concern for intertidal zones: requires limitations on scale and robust monitoring.

#### Assumptions:

We assumed that finfish farms are located within 45 km (1.5 planning units) of the shoreline in waters with depths less than 1000 m and only in waters that are ice-free year-round.

#### Data sources (by country):

· Norway – EMODnet – Human Activities (2023).

· Russia – manually added information based on the company's report: Inarctica (2022), and website: Russian Salmon (2023).

· USA (Alaska) - no finfish farms within ArcNet area.

· Canada - no finfish farms within ArcNet area.

· Greenland - no finfish farms within ArcNet area.

· Iceland – MAST (2023) was used to add information on farm locations manually.

*Dataset produced:* August 2023.

### AM: Shellfish Farms

This type of aquaculture is associated with organic pollution when farms are densely concentrated. Shellfish farms can also change the pH of the surrounding waters. They also require some coastal infrastructure and an increased level of shipping to maintain and transport the product.

*Example:* Icelandic and Norwegian Blue Mussel Farms.

#### Assessment findings:

*Marine mammals.* Source of *notable* concern for most of the important marine mammal habitats: farms should be of limited scale with robust monitoring and with all environmental requirements met for the industry. Source of *significant* concern for the important feeding areas for grey whales and walruses; bowhead whale concentration areas; and some others.

*Seabirds.* Source of *significant* concern for the well-defined sites used by benthos-feeding species, i.e., moulting, wintering, or migration stopover sites of the sea ducks. *Minor* concern for other habitats.

*Fish. Significant* concern for the important habitats of White-sea cod. *Notable* concern with restrictions on scale and under robust monitoring for some important habitats of other species like least cisco, Inconnu, Arctic charr, Taranetz's charr, Atlantic capelin, etc. and in the estuarine brackish-water fish complex distribution areas. *Minor* concern for other areas.

*Benthos. Not applicable* for most of the benthic features. Source of *notable* concern and requires limitation of scale in the kelp-associated conservation feature areas.

*Coastal features.* Source of *notable* concern: can take place at limited scale, but only with robust monitoring and with all environmental requirements met for the industry.

#### Assumptions:

We assumed that shellfish farms are located within 45 km (1.5 planning units) of the shoreline in waters with depths not exceeding 1000 m and only in waters that are ice-free year-round.

#### Data sources (by country):

· USA (Alaska) – State of Alaska (2023). There are just two farm permits within ArcNet Area - one grows kelp. There was one more aquaculture farm permit issued in 2023 to Trident Seafoods in Alaska, but their intentions could not be identified, and thus it does not appear on the map.

· Canada – no shellfish farms within the ArcNet Area according to Licensed fish processors and aquaculture sites (2021).

· Norway – a few farms in Norway according to the EMODnet Human Activities, Aquaculture, Shellfish (2022).

· Greenland – no information about shellfish farms is available.

· Iceland – only an experimental site in Skötufjörður (Northlight Seafood, 2023). Plans for some other sites as well according to MAST (2023).

· Russia – no shellfish farms within the ArcNet Area.

*Dataset produced:* August 2023.

### AS: Seaweed Farming

This type of aquaculture is associated with fewer impacts compared to the other farming types, but it still leads to the alteration of the seascape and increased ship traffic for maintenance and harvesting.

*Example:* There are plans for seaweed farming in the White Sea.

#### Assessment findings:

*Marine mammals. Notable* concern for most of the important marine mammal habitats: should be undertaken at limited scale with robust monitoring and adherence to existing environmental standards and best practices. Source of *significant* concern for the important feeding areas for grey whales and walruses; bowhead whale concentration areas; and some others.

*Seabirds.* Source of *notable* concern but only for areas where there are stable or regular eider concentrations, i.e., at their moulting, wintering, or migration stopover sites. *Minor* concern for other areas.

*Fish.* Source of *significant* concern for the important habitats of White-sea cod. *Notable* concern with restrictions on scale and with robust monitoring for some important habitats of species like Least cisco, Inconnu, Arctic charr, Taranetz's charr, Atlantic capelin, etc. and in the estuarine brackish-water fish complex distribution areas. Source of *minor* concern in other areas.

*Benthos.* Source of *significant* concern for kelp and seagrass habitats due to their sensitivity to impacts of this activity. Not-applicable for most of the benthic features.

*Coastal features.* Source of *notable* concern for intertidal zones and estuaries: should be limited in scale, with robust monitoring implemented and all environmental requirements met for the industry. Source of *significant* concern for salt marshes due to their sensitivity.

#### Assumptions:

We assumed that seaweed farms are located within 45 km (1.5 planning units) of the shoreline in waters with depths less than 20 m, and only active in waters that are ice-free at least seasonally.

#### Data sources (by country):

· USA (Alaska) – one farm (Aquaculture, 2023). More about the farm: KUCB (2019).

· Russia – no seaweed farming at the moment.

· Norway, Greenland and Iceland - EMODnet – Human Activities (2023). No seaweed aquaculture in Iceland.

· Canada - no seaweed farming in the Arctic.

*Dataset produced:* August 2023.

## Fisheries

### FBD: Dredge Fishing

Dredge fishing is used in the scallop fishery primarily in shallow and coastal waters of the Barents Sea. Sometimes it is also used in the Bering Sea. It destroys benthic communities in a way similar to bottom trawling. It is also responsible for incidental catch and direct mortality of a wide range of organisms. In addition to industry-specific impacts, those impacts associated with shipping are also relevant.

*Examples:* Scallop fishing in Iceland and Norway

#### Assessment findings:

*Marine mammals. Significant* concern for benthic feeders like walrus or bearded seal, or for compact, well-known, and critically important habitats like whelping habitats for seals or core summer habitats beluga or narwhal. Source of *minor* concern for most of the pelagic habitats during months that animals are not present, but a source of notable concern during the season(s) they are in the area. Related risks require mitigation: observers are needed on board to prevent animal entanglement and disturbance.

*Seabirds.* Similar to marine mammals, dredging is a source of *significant* concern for benthic feeders, e.g. all the eiders and ducks.

*Fish.* Source of *minor* concern for most of the CFs except for Siberian sturgeon, least cisco, Inconnu (*significant* concern).

*Benthos.* Source of *significant* concern for all distinctive benthic features.

*Coastal features. Not applicable* for most of the coastal features.

#### Assumptions:

We assumed that there are no limitations regarding distance to the shoreline and that dredge fishing can take place at depths under than 200 m and only during the ice-free season.

#### Data sources:

We used the Global Fishing Watch (GFW) data field “dredge\_fishing” for January 2020 – January 2023 (Global Fishing Watch, 2022). Datasets were downloaded for each of the three years (2020, 2021, 2022) and separately for each EEZ. After being merged geographically, mean fishing effort values were calculated for each 30 x 30 km Geranium planning unit.

*Dataset produced:* September 2023.

### FBG: Bottom Gillnet Fishing

Gillnets consist of a panel of netting that is suspended vertically in the water column with floats at the top and weights at the bottom. The netting is designed to entangle fish by catching them behind the gills, preventing them from escaping. Bottom gillnets are usually set on the seafloor and are anchored using weights or anchors to keep them in place.

Gillnets can be very dangerous if lost as they are not degradable and can continue ghost fishing for a long time. They are also cause bycatch of seabirds, small marine mammals, and non-target fish species.

*Examples:* In the Arctic, bottom gillnets are used primarily in coastal areas for fishing Arctic charr, salmon, lumpfish, and grenadier in ice-free areas and within 50 m of the surface.

#### Assessment findings:

*Marine mammals:* A source of significant concern for some CFs, including ringed seal of the Spitsbergen population summer habitats, sea otter and Steller sea lion habitats, key summer habitats for the majority of cetacean species. Notable concern for the majority of seal habitats if measures are taken to prevent seal entanglement.

*Seabirds:* This activity should keep away from the diving seabird breeding colonies. It is a source of significant concern for the majority of seabird habitats during the seasons these habitats are used.

*Fish:* Source of minor concern for most of the CFs.

*Benthos:* Source of minor concern for most of the CFs.

*Coastal features:* Not applicable for most of the coastal features.

#### Assumptions:

We assumed that bottom gillnet fishing can take place in coastal areas not further than 150 km (5 planning units) offshore and at depths less than 50 m during the ice-free season only.

#### Data sources:

We used the Global Fishing Watch (GFW) data field “set\_gillnets” for January 2020 – January 2023 (Global Fishing Watch, 2022). GFW does not distinguish between surface/pelagic and bottom gillnets. However, the assessment of impacts for FBG sets such limits as: depth no more than 50 m and a distance from the shoreline is no more than 5 planning units (150 km). Therefore, the potential conflict assessment should consider areas within these limits only.

Datasets were downloaded for each of the three years (2020, 2021, 2022) and separately for each EEZ. After being merged geographically, mean fishing effort values were calculated for each 30 x 30 km Geranium planning unit.

*Dataset produced:* September 2023.

### FBT: Bottom Trawling

Bottom trawling is considered among the most destructive types of fisheries and is associated with following impacts: direct physical destruction of the seafloor (trenches up to 40-60 cm depth) and associated benthic communities especially on solid substrates (corals, sponges, etc.), and siltation. Bycatch can include rays and other benthic species as this method of fishing is non-selective. These specific impacts are complemented by the general impacts of shipping such as underwater noise, chemical and plastic pollution, etc.

*Example:* Bottom trawling is used year-round in cod and haddock fishing in the Barents Sea. Areas under the highest pressure are located along the northern Norwegian coast and southern slopes of Bear Island. Other species caught with this method in the Arctic include halibut and shrimp.

#### Assessment findings:

The assessment for bottom trawling largely follows that for bottom dredging with the same risks and recommendations for their minimisation.

*Marine mammals. Significant* concern for benthic feeders like walrus or bearded seal, or for compact, well-known, and critically important habitats like whelping habitats for seals or core summer habitats beluga or narwhal. Source of *minor* concern for most of the pelagic habitats during months that animals are not present, but a source of *notable* concern during the season they are in the area. Related risks require mitigation: observers are needed on board to prevent animal entanglement and disturbance.

*Seabirds*. Similar to marine mammals, dredging is a source of *significant* concern for benthic feeders, e.g. all the eiders and ducks.

*Fish.* Source of minor concern for most of the CFs except for Siberian sturgeon, least cisco, Inconnu (*significant* concern).

*Benthos.* Source of *significant* concern for all distinctive benthic features.

*Coastal features.* *Not applicable* for most of the coastal features.

#### Assumptions:

We assumed that there are no limitations regarding distance to the shoreline and that bottom trawling can take place at depths less than 500 m and only during the ice-free season.

#### Data sources:

We used the Global Fishing Watch (GFW) data field “trawlers” for January 2020 – January 2023 (Global Fishing Watch, 2022). GFW does not distinguish between bottom and pelagic trawling. Conservatively, we considered the trawling hours distribution map as representing both bottom and pelagic trawling, noting that further research or other data sources are required to distinguish between these two gear types.

Datasets were downloaded for each of the three years (2020, 2021, 2022) and separately for each EEZ. After being merged geographically, mean fishing effort values were calculated for each 30 x 30 km Geranium planning unit.

*Dataset produced:* September 2023.

### FCT: Pot and Trap Fishing

Pots and traps can be used in the winter (ice) season and at depths of 150-1000 m. If regulated, they have little negative impact apart from when fish-eating marine mammals get caught by the traps, especially when traps are lost or abandoned (so-called ghost fishing), and there is also evidence of bowhead whale entanglements in the trap lines.

*Examples:* Crab traps are used in the Arctic for fishing for shrimp, king and snow crab, and buccinum mostly in the Bering and the Barents Seas. Traps are also used to fish for cod sablefish in the Alaskan waters.

#### Assessment findings:

*Marine mammals:* *Significant* concern for benthic feeders in the key areas of bowhead whales. *Minor* or *notable* concern for most other seal and cetacean species, but ships should keep away from areas where animals concentrate.

*Seabirds:* Source of *minor* concern for all CFs, where applicable.

*Fish:* Source of *significant* concern for Atlantic cod and capelin during spawning season. Source of *minor* concern for other CFs.

*Benthos:* Source of *minor* concern for all CFs, where applicable.

*Coastal features.* *Not applicable* for most coastal features.

#### Assumptions:

We assumed that there are no limitations regarding distance to the shoreline and that pot and trap fishing can take place at depths less than 1000 m and is not restricted by sea ice cover.

#### Data sources:

We used the Global Fishing Watch (GFW) data field “pots\_and\_traps” for January 2020 – January 2023 (Global Fishing Watch, 2022). Datasets were downloaded for each of the three years (2020, 2021, 2022) and separately for each EEZ. After being merged geographically, meaning fishing effort values were calculated for each 30 x 30 km Geranium planning unit.

*Dataset produced:* September 2023.

### FDN: Drift Net Fishing

Drift nets, also known as driftnets or drift gillnets, are a type of fishing gear that is used to catch fish that swim close to the surface of the water. They are unique in their construction and operation compared to other fishing gear types. Drift nets consist of a panel of netting that is suspended vertically in the water column with floats at the top and weights at the bottom. Unlike gillnets, drift nets are not anchored to the seafloor but are allowed to drift with the current, hence their name. One of the advantages of drift nets is that they can cover large areas of water and are highly efficient at catching large quantities of fish.

Driftnets are highly unselective and are associated with high bycatch levels. Non-target fish species as well as seabirds and marine mammals are often caught in driftnets. These nets often get lost and continue ghost fishing. As they can be very large (i.e., many kilometres long), the damage they inflict can be significant.

Driftnets are used only in the ice-free areas/season.

*Examples:* In the Arctic area they are used in the USA for salmon fishery (outside of the ArcNet Area). It is banned in the Russian part of the Bering Sea.

#### Assessment findings:

*Marine mammals:* Source of *significant* concern for almost all marine mammal CFs.

*Seabirds:* Source of *significant* concern for a number of CFs. Source of *notable* concern, requiring avoidance of regular bird aggregation areas.

*Fish:* Source of *minor* concern for all fish CFs where applicable.

*Benthos:* Source of *minor* concern for all fish CFs where applicable.

*Coastal features: Not applicable* for coastal CFs.

#### Assumptions:

We assumed that drift net fishing can take place at any distance from the shoreline with no limitation on depth but only during the ice-free season.

#### Data sources:

No drift net fishing takes place in the ArcNet Area as of 2024 according to Global Fishing Watch (2022).

### FFR: Pole and Line Fishing

Specific negative impacts include bycatch of non-target species and littering; however, the scale of these impacts is relatively small. If such a fishery is regulated it can be used in some protected areas and in adjacent seas.

*Examples:* Poles and lines are used for halibut, salmon, cod, and squid fishing in the Arctic. It is used in the Bering and the Barents Seas and in the North Atlantic and is also used in Norway to catch mackerel. Rods are used for methods of fishing called jigging and trolling.

#### Assessment findings:

*Marine mammals:* Source of *minor* concern for most CFs, but *notable* concern for key seasons in key habitats for some species with recommendations to keep the scale of the activity limited and avoid regular animal concentrations. Source of *significant* concern for a few CFs, including Steller sea lion critical habitats among others.

*Seabirds:* Source of *minor* concern for all CFs, where applicable.

*Fish:* Source of *minor* concern for all CFs, where applicable.

*Benthos:* Source of *minor* concern for all CFs, where applicable.

*Coastal features: Not applicable* for most CFs, except were a source of *notable* concern for estuaries where it is recommended to limit the scale of the activity.

#### Assumptions:

We assumed that pole and line fishing can take place no further than 150 km (5 planning units) from the shoreline, at any depth, and only during the ice-free season.

#### Data sources:

We used the Global Fishing Watch (GFW) data “pole\_and\_line” for January 2020 – January 2023 (Global Fishing Watch, 2022). Datasets were downloaded for each of the three years (2020, 2021, 2022) and separately for each EEZ. After being merged geographically, mean fishing effort values were calculated for each 30 x 30 km Geranium planning unit.

*Dataset produced:* September 2023.

### FIC: Invertebrate Collection by Divers

Invertebrate (e.g., scallops and sea urchins) collection by divers is probably the least impactful as it is selective, can be very well-regulated, and does not destroy benthic communities. It is an expensive way to harvest invertebrates and it is restricted to 20-25 m depth. These factors limit the use of this method of harvest on a commercial scale. However, it still can be considered a potential activity in or near a protected area. Apart from scallops and sea urchin, divers also mow seaweed in some areas in the White Sea.

*Examples:* There are currently no examples of invertebrate collection by divers at commercial scale in the ArcNet Area.

#### Assessment findings:

*Marine mammals:* Source of *minor* concern for most CFs. *Notable* concern for some seasonal habitats with the recommendation to keep a distance from areas regularly used by animals. *Significant* concern for a few critical habitats.

Seabirds: Source of *notable* concern for a significant number of CFs with the recommendation to keep a distance from areas regularly used by animals.

*Fish: Minor* concern for most CFs.

*Benthos:* Source of *notable* concern for areas of high benthic biomass where the activity can only occur on a limited scale.

*Coastal features:* Source of *notable* concern for coastal CFs where the activity can only occur on a limited scale.

#### Assumptions:

We assume that harvesting by divers can take place no further than 45 km (1.5 planning units) from the shoreline, at depths no greater than 20 m, and only during the ice-free season.

### FLF: Longline Fishing

Impacts associated with longline fishing are significantly lower than the impacts of trawling, with almost no impact on the seafloor. However, there is a high level of seabird bycatch associated with this activity. It is estimated that there are more than 60 species of birds in the world that are affected by longline fishing gear. Among the species threatened by this type of fishery in the Arctic are cormorants, auks, skuas, shearwaters, albatrosses, and gulls. There are several approaches to reduce seabird mortality from longline fishing including:

· setting lines at night: Seabirds are primarily diurnal, and setting lines at night when they are less active can reduce interactions with fishing gear;

· using weighted lines: Using weighted lines that sink quickly can reduce the amount of time that baited hooks are available to seabirds;

· using bird-scaring lines: Bird-scaring lines (BSLs) are colourful streamers that are attached to the main fishing line to deter seabirds from approaching the hooks. When deployed correctly, BSLs can be effective in reducing seabird interactions;

· setting lines deeper: Seabirds are less likely to dive to depths greater than 10 metres, so setting lines deeper can reduce the risk of interactions with fishing gear;

· choosing fishing locations: Avoiding areas where seabirds are known to congregate can reduce interactions with fishing gear. Fishing in areas with lower seabird populations or during times when seabirds are less active can also be effective; and

· monitoring and reporting: Monitoring seabird interactions with fishing gear and reporting any incidents can help identify problem areas and inform future conservation efforts.

It is important to note that no single approach is 100% effective in reducing seabird mortality from longline fishing, and a combination of approaches is often necessary to achieve significant reductions.

*Examples:* Longline fishing is used for fishing cod, haddock, halibuts, and grenadiers mostly in the Barents and the Bering Seas. In the Barents Sea the number of Russian longline fishing vessels is 10-15 times lower than the number of trawlers; however, this type of fishery is more common in Norway, where longline fishing vessels make up a third of the number of trawlers.

#### Assessment findings:

*Marine mammals*: Source of *significant* concern for smaller marine mammals, and a source of *notable* concern for other important habits where the scale of the activity should be very limited. Source of *minor* concern during seasons when animals are not present in the area.

*Seabirds:* Source of *minor* concern for most CFs, and a source of *significant* concern for spectacled eiders.

*Fish*: Source of *minor* concern for most CFs, and a source of *significant* concern for capelin during the spawning season.

*Benthos:* Source of *minor* concern for most CFs, and a source of *notable* concern for benthic biomass hotspot areas.

*Coastal features:* *Not applicable* for coastal CFs.

#### Assumptions:

We assumed that there are no limitations regarding distance to the shoreline and that longline fishing can take place at depths less than 1000 m and is not restricted by sea ice cover.

#### Data sources:

We used the Global Fishing Watch (GFW) data field “longlines” for January 2020 – January 2023 (Global Fishing Watch, 2022). Datasets were downloaded for each of the three years (2020, 2021, 2022) and separately for each EEZ. After being merged geographically, mean fishing effort values were calculated for each 30 x 30 km Geranium planning unit.

*Dataset produced:* September 2023.

### FPS: Purse Seine Fishing

Purse seine fishing is a method of fishing that uses a large net, known as a purse seine, that encircles schools of fish, closing at the bottom to trap them.

While purse seine fishing can be an efficient way to catch large quantities of fish, it is also non-selective, causing high bycatch especially of small fish species. Sometimes marine mammals also get caught by a purse seine.

*Examples:* Purse seines are used for fishing for salmon in the North Pacific and for herring and mackerel in the North Atlantic. In the Arctic, they are mostly used in the Bering and Barents Seas and in ice free areas only. It is a very important fishing method in Norway.

#### Assessment findings:

*Marine mammals:* Source of *minor* concern for the majority of seal CFs except for the ringed seal Spitsbergen population, harbour seal, eared seals, and sea otter habitats where it is a source of *significant* concern. Source of *notable* concern for key habitats of many cetaceans with the recommendation to keep away from regular animal aggregations and keep the activity to a very limited scale. Source of *significant* concern for some critical habitats of cetaceans.

*Seabirds:* Source of *minor* concern for the majority of CFs. Source of *notable* concern for little auk, Atlantic puffin, thick-billed murre, common murre, and horned puffin.

*Fish:* Source of *minor* concern for most CFs and a source of *significant* concern for capelin during the spawning season.

*Benthos*: Source of *minor* concern for all CFs where applicable.

*Coastal features:* Source of *minor* concern for most CFs and a source of *significant* concern for estuaries.

#### Assumptions:

We assumed that purse seine fishing is not limited by the distance to the shoreline or depth and can only take place during the ice-free season.

#### Data sources:

We used the Global Fishing Watch (GFW) data fields “other\_purse\_seines” and “tuna\_purse\_seines” for January 2020 – January 2023 (Global Fishing Watch, 2022). Since there is no tuna fishing in the Arctic, we considered the GFW “tuna purse seine” field to mean purse seine fishing. Datasets were downloaded for each of the three years (2020, 2021, 2022) and separately for each EEZ. After being merged geographically, mean fishing effort values were calculated for each 30 x 30 km Geranium planning unit.

*Dataset produced:* September 2023.

### FPT: Pelagic Trawling

Pelagic trawling is associated with specific impacts such as a high rate of bycatch, including juvenile specimens of fished species and small cetaceans, as well as the more general impacts of shipping. In Russia, pelagic trawl gear is sometimes used for bottom trawling, and due to their much larger size, leads to all the associated impacts of bottom trawling, but on an even larger scale. This practice is illegal.

*Examples:* Pelagic trawling is the most common type of fishery in the Arctic waters, accounting for more than 90% of overall catch. It is used for catching walleye pollock, squid, herring, mackerel, capelin, and other species in the Bering and Chukchi Seas, and Greenlandic waters.

#### Assessment findings:

*Marine mammals*: Pelagic trawling is a source of *significant* concern for many CFs, including seal habitats as well as critical, well-defined habitats for smaller cetaceans. Source of *notable* concern for many other marine mammal habitats where risks can be minimised with strict limitations on scale, keeping away from cetacean concentration areas, and having observers on board ships.

*Seabirds:* Source of *notable* concern for many seabird CFs where the activity should only take place at depths of more than 40 m to minimise risks. *Significant* concern for spectacled eider.

*Fish:* Source of *significant* concern for a number of CFs, including key spawning areas and other critical habitats for several species.

*Benthos:* Source of *minor* concern for all applicable CFs.

*Coastal features:* Source of *significant* concern for kelp CFs.

#### Assumptions:

We assumed that there are no limitations regarding distance to the shoreline, that pelagic trawling occurs at depths less than 600 m and can only happen during the ice-free season.

#### Data sources:

We used the Global Fishing Watch (GFW) data field “trawlers” for January 2020 – January 2023 (Global Fishing Watch, 2022). GFW does not distinguish between bottom and pelagic trawling. As for bottom trawling, we considered the trawling hours distribution map as representing both bottom and pelagic trawling, noting that further investigation is required to distinguish between these two gear types.

Datasets were downloaded for each of the three years (2020, 2021, 2022) and separately for each EEZ. After being merged geographically, mean fishing effort values were calculated for each 30 x 30 km Geranium planning unit.

*Dataset produced:* September 2023.

### FSE: Seine and Stationary Seine Fishing

This type of fishing poses relatively low risk for biodiversity. However, stationary seines can cause bycatch or entanglement of marine mammals (seals, beluga whales, and even bowhead whales).

*Examples:* This type of fishing method is used in the Atlantic and in the Pacific sectors of the Arctic – in the Bering, Chukchi, White and Barents Seas. It is used to catch salmon, saffron cod, and herring. It is used in shallow, coastal areas and is often installed for the short season when anadromous fish are coming into the rivers.

#### Assessment findings:

*Marine mammals:* Source of *notable* concern for the majority of CFs where measures to prevent seal entanglement and pingers to keep away smaller cetaceans (like porpoises) should be implemented. Source of *significant* concern in critical habitats.

*Seabirds:* Source of *significant* or *notable* concern for most CFs and seabird colonies and known regular bird aggregation areas should be avoided.

*Fish:* Source of *minor* concern for the majority of CFs.

*Benthos:* Source of *minor* concern for benthic features where applicable.

*Coastal features:* source of *significant* concern for kelp CFs, and intertidal zones. Source of *notable* concern for estuaries where the activity can take place at a limited scale only.

#### Assumptions:

We assumed that seine and stationary seine fishing can only take place in the coastal waters not more than 45 km (1.5 planning unit) from shore and with depths less than 20 m during the ice-free seasons.

#### Data sources:

The dataset represents areas where stationary seine gear was used for fishing based on Marchenko et al (2021) by VNIRO (Russia).

*Dataset produced:* September 2023.

### FSM: Seaweed Mowing

Seaweed mowing destroys kelp forests, leaving only rhizoids behind making it difficult for kelp forests to recover.

*Examples:* Seaweed mowing is being practised in the White Sea, Iceland, and Greenland.

*Assessment findings:*

*Marine mammals:* Source of *minor* concern for the majority of species. *Notable* concern under the condition that animal aggregations for some cetacean CFs are avoided. *Significant* concern for critical, well-defined habitats for some species including sea otter, Steller sea lion, beluga, and narwhal.

*Seabirds:* Source of *significant* concern for coastal birds.

*Fish:* Source of *minor* concern for most CFs except for capelin spawning grounds where it is a source of *significant* concern.

*Benthos:* Source of *significant* concern for benthic biomass hotspots. Source of *minor* concern for other CFs.

*Coastal features:* Source of *significant* concern for most of the coastal CFs.

#### Assumptions:

We assumed that there are no limitations regarding distance to the shoreline, that seaweed mowing can take place at depths less than 50 m and can only happen during the ice-free season.

#### Data Sources:

The dataset was created manually based on the following publicly available sources:

· Arctic - Blue Bioeconomy in the Arctic Region, Björnsdóttir et al. (2021).

· Iceland - Kennedy (2023), Thorvin (2014), Thorverk (2023), NODPA (2023), Shop Icelandic (2023), Icelandic Kelp (2023).

· Russia - Solovetsky Islands (Wild Karelia, 2023; TASS, 2022).

· Greenland – Wegeberg & Geertz-Hansen (2020).

· Norway, Canada, Alaska - all harvesting sites are located to the south of the ArcNet Area.

*Dataset produced:* September 2023.

### FSN: Snurrevad Fishing

Snurrevad fishing is associated with impacts similar to those of bottom trawling, including destruction of benthic communities and high level of unselective bycatch. Snurrevad gear is often lost in the process of fishing. Impacts of shipping should also be considered when assessing the environmental impact of this type of fishery.

*Example:* Snurrevad is used for fishing of pollock and benthic fish species such as cod, flounder, saffron cod, gobies, and shrimp. In the ArcNet area it is used in the Bering and Barents Seas for shelf fishing, normally at depths below 150 m.

#### Assessment findings:

The assessment for snurrevad fishing largely follows that for bottom dredging with the same risks and recommendations for their minimisation.

*Marine mammals.* *Significant* concern for benthic feeders like walrus or bearded seal, or for compact, well-known, and critically important habitats like whelping habitats for seals or core summer habitats beluga or narwhal. Source of *minor* concern for most of the pelagic habitats during months that animals are not present, but a source of *notable* concern during the season they are in the area. Related risks require mitigation: observers are needed on board to prevent animal entanglement and disturbance.

*Seabirds.* Similar to marine mammals, dredging is a source of *significant* concern for benthic feeders, e.g. all the eiders and ducks.

*Fish.* Source of *minor* concern for most of the CFs except for Siberian sturgeon, least cisco, Inconnu.

*Benthos.* Source of *significant* concern for all distinctive benthic features.

*Coastal features. Not applicable* for most of the coastal features.

#### Assumptions:

We assumed that there are no limitations for snurrevad fishing regarding distance to the shoreline and that it takes place at depths less than 150 m. It can only happen during ice-free season.

#### Data sources:

We used the Global Fishing Watch (GFW) data field “other\_seines” for January 2020 – January 2023 (Global Fishing Watch, 2022). Datasets were downloaded for each of the three years (2020, 2021, 2022) and separately for each EEZ. After being merged geographically, mean fishing effort values were calculated for each 30 x 30 km Geranium planning unit.

*Dataset produced:* September 2023.

## Infrastructure

### ICI: Coastal Infrastructure

Here, we considered peers, ports, passenger and cargo terminals, search and rescue stations, recreation facilities, human settlements, and other infrastructure objects located in the coastal zone, excluding oil terminals and other oil and gas infrastructure. The construction of this infrastructure is associated with the removal or alteration of coastal habitats, disturbance, and destruction of benthic and coastal habitats, as well as increased levels of noise and other pollution, including petrochemical pollution since ports usually maintain a small supply of fuel. The operation of such infrastructure is associated with increased human presence, and marine and air traffic together with all the relevant impacts.

*Example:* Ports across the Arctic.

#### Assessment findings:

*Marine mammals.* Several key habitats of marine mammals are subject to *significant* concern from the construction of coastal infrastructure. While more detailed distribution studies are required at the local or regional level to identify regular animal concentration areas, construction sites must avoid such locations, but could be situated outside of the core areas under the condition that shipping to and from the infrastructure projects is limited and restricted appropriately (including routing, seasonality, speed, and fuel) and no waste discharge is allowed. In case of cetacean habitats, construction works should be kept away from whale aggregations where construction impulse noise levels will be less than 160 dB re 1 mPa peak-to-peak. Robust monitoring is mandatory, and ships should keep 5 km away from the aggregations. For habitats located far offshore concern for this activity was considered *not applicable.*

*Seabirds.* Infrastructure construction is a source of *significant* concern in the vicinity of seabird colonies and similar spatially restricted and well-defined habitats like moulting sites or migration stopovers. It is a source of *notable* concern for some other less spatially restricted habitats; however, additional surveys must be conducted to identify locations of high bird concentration that should then be avoided; and strict and robust monitoring must be implemented. Limitations will depend on particular development plans.

*Fish.* *Minor* concern and no specific restrictions for fish CFs apart from existing environmental standards and best practices. For some specific spawning areas, the scale of a project should be limited, and stricter monitoring requirements introduced.

*Benthos.* *Not applicable* for most CFs. *Significant* concern for areas along the kelp forest habitats.

*Coastal features.*  Source of significant concern for most CFs. *Notable* concern for estuaries were infrastructure and its construction can be built only at a limited scale and under robust environmental monitoring.

#### Assumptions:

We counted the coastal zone as the area between 60 km (2 planning units) inshore and 45 km (1.5 planning units) offshore. We assumed it is located between 50 m altitude and 500 m depth and that its location is not restricted by ice cover presence.

#### Data sources:

This commercial activity is mainly represented by the distribution of ports and is based on the WWF Sight dataset of “Arctic Ports” (WWF Sight, 2023). It was complemented manually based on information obtained from the public sources for Pavlovskoe (Bezymyannaya Bay) (Arctic Russia, 2023), Bukhta Sever (Taymyr) (PortNews, 2023b), and Cape Nagleyyin (Chaun Bay, Baimskoe) (PortNews, 2023a).

*Dataset produced:* August 2023.

### ID: Dredging

Dredging is the deepening of the seafloor, typically for shipping channels. It is often associated with development of coastal infrastructure and leads to increased shipping traffic in the area. Dredging causes the destruction and elimination of benthic habitats, increases water turbidity, and can dramatically change the hydrology of an area. The impacts of dredging are often complemented by those of petrochemical, noise, and light pollution as well as the physical presence of the dredgers.

*Example:* the substantial dredging in the Gulf of Ob’ where the hydrological regime of the gulf has been changed because of the large scale and regularly repeated events of deep dredging.

#### Assessment findings:

*Marine mammals.* For most of the walrus habitats, dredging poses non-mitigable risks as it affects shallow-water and benthic habitats on which they are highly dependent and thus is a source of *significant* concern. For seal ice habitats, dredging is a source of *notable* concern where it should not be allowed to lead to traffic increase in the winter/ice season, and robust monitoring should be established. Also, dredging should not be carried out in areas of regular seal concentration. For cetaceans, dredging poses non-mitigable risks in the spatially restricted and well-defined coastal habitats, but can be a source of *notable* concern for less spatially restricted habitats where it should be undertaken only at limited scale in areas identified as less important at the local or regional scale after dedicated and up-to-date studies. Dredging activities are *not applicable* in deeper waters and offshore habitats.

*Seabirds.* Most vulnerable are benthic-feeders (sea ducks) or active under-water hunters like divers (loons) or guillemots (Uria spp.). Dredging is a source of *significant* concern in the vicinity of breeding colonies and, especially, at moulting, wintering, and stopover sites of diving seabirds. Source of a *notable* concern when dredging is only undertaken during the off-season or when birds are present in areas that are considered not in regular use at the regional or local scale.

*Fish.* Source of *notable* concern for most CFs where dredging can only take place on a limited scale, when the hydrology of the area is not altered, and robust monitoring is implemented.

Benthos. Source of *significant* concern associated with non-mitigable risks in the areas where it is applicable.

*Coastal features.* Source of *significant* concern associated with non-mitigable risks in the areas where it is applicable.

#### Assumptions:

We assumed that dredging takes place in the coastal waters not further than 90 km (3 planning units) from the shoreline and in shallow water areas with depths less than 20 m. Sea ice cover does not limit where dredging can take place.

#### Data sources:

Dredging data are based on:

· Norway and Iceland: OSPAR (2021), dataset “[Dredging locations 20220915](https://odims.ospar.org/en/submissions/ospar_dumping_at_sea_2019_01/)”

· Russia:

o The Ob' channel (Gladysh et al, 2017, Logvina et al, 2012).

o The Chaun Bay - added based on publicly available sources - future port and floating nuclear power stations for Baimskaya (PortNews, 2023a, HydroTeh, 2023).

o Nayba (Yakutia) to be built in 2028 (see the map for 2030 Epoch) - PortNews (2021).

o Sever Bukhta (Taymyr) - PortNews (2023b).

o Dikson, Enisey Seaport – PortNews (2023c), Yenisey Seaport (2024).

o Summary for Russia: Portnews (2023d).

· US Arctic:

o Deep draft port in Nome, the only deep draft port in the Arctic Alaska. Based on City of Nome, Alaska (2023), Hovey, 2022, Thiessen, 2023.

o Dredging site in Unalaska – Hrvacevic, 2022.

· Canada and Greenland: no information on dredging was found.

*Dataset produced:* August 2023.

### IOP: Underwater Oil & Gas Pipelines

Underwater pipelines are used for oil and gas transportation between production sites and consumers, storage facilities, and terminals. Sometimes they are relatively short (a few kilometres) and connect an offshore facility with the coast. Sometimes they can be thousands of kilometres long, crossing oceans.

Pipelines are associated with localised disturbance and destruction of benthic habitats, noise, and physical disturbance during the construction phase as well as risks of leakages and accidental spills.

*Example:* Existing oil and gas pipelines in the Arctic region are short and connect production sites with export terminals (Varandey, Russia) or connect two coasts of a bay (Baydaratskaya Bay, Russia).

#### Assessment findings:

*Marine mammals:* Consensus is that pipelines cause *significant* concern for key habitats due to the risks of large-scale damage in the case of a spill. Pipelines can be located in some habitats where animals are less abundant, and their densities are lower, such as whelping or feeding areas for ringed or bearded seals or areas used by polar bears. The general rules are for construction to: avoid seasons when animals use the habitat; avoid regular or dense animal concentration areas; and to have marine mammal observers on board construction vessels to make sure work is paused in case marine mammals approach the construction site (in the case of whales, a 5 km exclusion zone is recommended).

*Seabirds:* A similar approach is used as for marine mammals. Pipelines are a source of *significant* concern if located in the vicinity of breeding colonies and other well-defined, high concentration areas (e.g., moulting and wintering sites or migration stopovers). They are a source of *notable* concern for other habitats and thus can be constructed only if animal concentrations are avoided and strict and robust monitoring of installed pipes is implemented.

*Fish:* The general approach is that pipelines can be laid in areas important for fish if the strictest environmental requirements and precautionary measures are taken during the construction and a robust monitoring system is installed during the exploitation. Construction works will be a source of significant concern if carried out during spawning seasons for some fish species, such as capelin, herring, or cod, which should be avoided.

*Benthos:* Pipelines is a source of *significant* concern for benthic features, and risks are considered non-mitigatable through activity-specific and/or habitat / biotope-specific considerations if pipelines are laid in the areas where key benthic features are to be conserved.

*Coastal features:* Pipelines related risks are non-mitigatable through activity-specific and/or habitat / biotope-specific considerations for the areas where key coastal features are to be conserved.

#### Assumptions:

We assumed no limitations of depth, ice conditions, or the distance from the shoreline. We considered underwater oil and gas pipelines to be located offshore and below the surface.

#### Data sources:

WWF Sight data (WWF Sight, 2023) was used as a base (only one pipeline in Norway). For other pipelines: oil (Global Energy Monitor, 2023a), gas (Global Energy Monitor, 2023b).

*Dataset produced:* August 2023.

### IOT: Coastal Oil Terminals

In addition to the impacts associated with other coastal infrastructure listed in the respective paragraph, oil terminals and other petrochemical storing facilities are sources of minor operational leakages and potential major spills as a greatest possible impact.

*Example:* Lukoil terminal in Varandey, Pechora Sea.

#### Assessment findings:

*Marine mammals.* The assessment for marine mammals follows the approach for non-oil and gas coastal infrastructure but with even more habitats being of *significant* concern. Fewer features were considered *not applicable* since the effects of major spills are widespread and can even affect offshore habitats.

*Seabirds.* Seabirds are among the most vulnerable wildlife in relation to the acute impacts of oil spills. The assessment for seabirds followed the approach for non-oil and gas coastal infrastructure. When 100 km buffer zones are established around seabird colonies or seabird moulting, stopover and wintering sites, this activity is of *significant* concern since the impacts of potential spills and associated oil spill response operations can affect larger areas. A source of *notable* concern with risks requiring mitigation through activity-specific and/or habitat/ biotope-specific considerations assigned to other habitats and with robust environmental monitoring.

*Fish.* There are no specific restrictions for most of the fish habitats except for the feeding/nursery areas of Siberian sturgeon where oil and gas terminals are a source of significant concern. Restrictions are proposed on works during the spawning season in spawning areas of cod, herring, and capelin as well as limitations on the scale of potential infrastructure in these locations.

*Benthos.* The installation of oil and gas terminals is a source of *significant* concern and can cause irreversible damage to benthic CFs and can cause extreme damage in a catastrophic scenario. For habitats located far offshore this activity was considered *not applicable*.

*Coastal features.* Oil and gas terminals are a source of *significant* concern as their installation causes significant and irreversible damage to benthic conservation features and can cause extreme damage in the case of an oil spill.

#### Assumptions:

We assumed that terminals are located in the coastal zone between 45 km (1.5 planning units) inshore and 60 km (2 planning units) offshore. We assumed no restrictions on depth or sea ice cover, and we only looked at onshore locations below 50 m elevation.

#### Data sources:

Location of terminals in Norway were based on information from the WWF Sight “Arctic Facilities” layer (WWF Sight, 2023). Coastal oil facilities were considered. Oil terminals in the Russian Arctic including Prirazlomnaya, Varandey, Vorota Arktiki, and Bukhta Sever (under construction, beginning operations in 2024) were added based on the following sources: Spiridonov et al. (2020), PortNews (2023b).

Coastal LNG/gas terminals and infrastructure are included in the MCM (Coastal Mining Layer) map.

*Dataset produced:* August 2023.

### IUC: Submarine Communication Cables

This activity includes the laying and maintenance of submarine communication cables. In the Arctic, this human use of the ocean is currently limited, but plans to develop cable communication are ambitious and progress over recent years has been fast.

Associated impacts are minor, limited in space and time, but include noise and light pollution from laying and service ships, risks of fuel leaks, and physical disturbance of seafloor communities and habitats. Once a cable is laid, its impact on biodiversity is minor.

Specific requirements for this human use are applied primarily during the installation phase. They include avoiding areas of critical importance and often of high seasonal animal concentration (e.g., whale feeding grounds, seabird moulting sites, and fish spawning areas) and keeping a distance from marine mammal and seabird aggregations, which are dynamic and therefore require active observation. To avoid areas of critical year-round importance, such as benthic and coastal features, more detailed surveys, mapping and planning are needed at local or a regional scale.

Submarine communication cables are highly valued by the corporations responsible for their implementation and operation, but also by national governments. Accordingly, the Australian Communications and Media Authority (ACMA) has created protection zones that restrict activities that could potentially damage cables linking Australia to the rest of the world. The ACMA also regulates all projects to install new submarine cables.

*Example:* Submarine communication cables in the Arctic include the Svalbard Undersea Cable System (since 2004), the Greenland Connect system connecting Greenland, Canada, and Iceland (since 2009) and many others. There are plans for more cables in the Arctic including the 12,000 km Polar Express that aims to connect Russian Arctic settlements to the south by 2026 (see TeleGeography, 2023). Similarly, Canada is planning the Kattittuq Nunavut Fibre Link connecting Newfoundland to Iqaluit by 2025. These plans along with others can be explored as potential opportunities for conservation and monitoring.

#### Assessment findings:

*Marine mammals.* Installation works can be a source of *significant* concern for small, spatially restricted, stable, and well-defined habitats such as core summer habitats for species like beluga and narwhal during the seasons they use these habitats. Works are of *notable* concern for other important marine mammal habitats with specific consideration such as having marine mammal observers on board and keeping at least 10 km distance from aggregations of beluga whales and 5 km from aggregations of other cetaceans, stopping work if they approach. While there is no recommended buffer distance for seals and walruses, it is important to note that where cables are laid in walrus habitats, they should be laid deep enough not to be damaged by feeding walruses.

*Seabirds.* In general, there is a requirement to avoid areas of seasonal bird concentrations and areas regularly used by birds while installing the cables. Works can be a source of *significant* concern for specific critical habitats (such as moulting sites and migration stopovers or in close proximity to breeding colonies) during the time of their use. Cables should avoid critical habitats of benthic feeding sea ducks such as moulting sites or migration stopovers.

*Fish.* Most conservation features representing diversity of fishes are presented at a coarse scale and, therefore, no specific restrictions on development of submarine cable networks have been proposed. However, in some spatially restricted spawning areas of commercially important species, such as Atlantic capelin and Atlantic herring, a ban on any works is proposed during the spawning season. There are also year-round restrictions proposed on the works in important semi-enclosed water bodies such as river estuaries.

*Benthos.* The assessment concludes that submarine cable related works can be a source of *notable* concern on benthic features and, therefore, should be undertaken at limited scale and under the condition that precise planning ensures that the most important parts of the features are avoided.

*Coastal features.* Works related to submarine communication cable laying and maintenance is a source of *notable* concern for coastal features and, therefore, should proceed only at limited scale while avoiding the most important coastal features. This is best accomplished via planning at the local and regional levels.

#### Assumptions:

We assumed that cables are or can be located beyond the shoreline with no restrictions on how far or how deep they can extend offshore and considered them to be below the ocean surface.

#### Data sources:

[Greg's Cable Map](https://www.cablemap.info/) (2023) was used as a base shapefile. It was manually edited and updated based on the information from TeleGeography (2023).

*Dataset produced:* August 2023.

### IW: Offshore Wind Farms

Offshore wind farms are seen as a green and renewable energy source and a sustainable alternative to fossil fuel. They are also getting increasingly efficient and economically viable and thus are likely to be used more widely in the future. However, they are associated with the impacts like significant noise pollution, risk of seabirds being struck by blades, and altering the behaviour of fishes, birds, and marine mammals (with attraction or avoidance for different species). Among the important impacts of wind farms is the unintentional provision of a new habitat that can be rapidly colonised by hard substrate benthic species, including alien and invasive species. The turbine installation process is associated with high level of underwater noise, light pollution, alteration of benthic habitats (in case it is a fixed turbine), and all the impacts from service ships, which can include potential petrochemical pollution. More about environmental impacts of offshore wind parks:<https://tethys.pnnl.gov/wind-energy>.

Fixed wind farms are usually installed at depths less than 40-50 metres. There are also floating wind farms with turbines mounted on floating platforms, which can be installed at depths ranging from ca. 100 to 500 m. This technology is still in its [infancy](https://emodnet.ec.europa.eu/en/checkpoint/arctic/challenges/windfarm-siting#:~:text=Offshore%20wind%20parks%20had%20not,wind%20turbines%20do%20not%20allow.) and not many such turbines are in operation.

Offshore wind parks have not yet been built in Arctic or sub-Arctic waters where sea ice and icebergs may occur. Technically, it is possible to build wind turbines strong enough to withstand the forces of sea ice; however, at a significantly increased cost.

*Example:* there are as yet no wind farms in the Arctic. A case of The Wind Farm Siting challenge for the Norwegian seas can be found in EMODNet (2023).

#### Assessment findings:

*Marine mammals.* Effects of wind parks on seal behaviour and health are not yet known. Surveys have shown that harbour seals avoid areas within 40 km of a turbine under construction. Also, there are concerns that turbines can have a long-term impact on seals’ hearing. It has been proposed that wind parks should not be constructed in small, spatially restricted, stable, and well-defined habitats such as coastal haul outs or sea otter coastal habitats (*significant* concern). For most of the other CFs, it is suggested that the parks can be constructed in appropriate locations once detailed surveys have identified areas regularly used by seals (*notable* concern). Avoiding these areas, works should also avoid seasons when seals use local habitats since related risks are non-mitigatable through activity-specific and/or habitat / biotope-specific considerations. Once turbines are installed a robust monitoring system should be implemented to assess long-term consequences on health and distribution of animals. The same approach is required in the case of walrus and cetaceans, restricting potential construction sites to areas away from whale aggregations where impulse noise levels are maintained below 160 dB re 1 mPa peak-to-peak and where service ships can keep a minimum separation of 5 km. For some cetacean habitats located far offshore, this activity was declared not applicable.

Since studies have shown that polar bears can adapt to windmills relatively easily, no restrictions were placed on this activity with respect to bear habitats (*minor* concern). However, it is a source of significant concern for the sensitive polar bear denning sites.

*Seabirds.* Wind parks are of *notable* concern and should not be constructed near seabird colonies nor in buffer zones surrounding them or in the areas of well-defined moulting sites or migration stopovers. In other habitats, wind parks can only take place where areas of regular bird concentration are avoided, and strict and robust monitoring is organised after construction.

*Fish.* Most of the CFs representing diversity of fishes are presented at a coarse scale and, therefore, no specific restrictions on wind park construction are proposed. However, in some spatially restricted spawning areas of mass, commercially important species, such as Atlantic capelin and Atlantic herring, a ban on any works during the spawning season is suggested. There are also year-round restrictions in the feeding/nursery area of the Siberian sturgeon) and in semi-enclosed areas like river estuaries.

*Benthos.* Wind parks are a source of *significant* concern for the areas important for conservation of benthic features except for the deep-sea and far offshore features such as vents where the assessment status is considered not applicable.

*Coastal features.* Risks related to wind park construction are considered non-mitigatable through activity-specific and/or habitat / biotope-specific considerations (*significant* concern) in the areas important for conservation of coastal features except for the glacial termini features where the assessment status is *not applicable*.

#### Assumptions:

We assumed that wind parks can be located offshore at depths between 0 and 500 metres and with no limitations on the distance to the shoreline. Also, their location does not depend on ice cover.

#### Data Sources:

At the moment no data is available for offshore wind parks in the ArcNet Area.

## Mining

We broadly define mining as the extraction of any non-renewable resource from the surface of the Earth, including ores as well as oil, natural gas, sand, etc.

Offshore hydrocarbon production starts with engineering, geological and seismic surveys at the first stage and continues with well drilling, platforms installation at the next stage. Once the production is established the infrastructure requires maintenance and hydrocarbons need to be stored, shipped, and transported. In the case of LNG, it also needs to be processed on site before shipment. Each stage is associated with various impacts of different scale and magnitude. The entire complex of the industry-associated impacts for each CF was assessed.

### MCM: Coastal Onshore Mining

Onshore mining directly impacts coastal and marine ecosystems through pollution by drains, leaks, and discharges. Also, coastal mining leads to development of coastal infrastructure (ports and terminals) that destroys coastal habitats. Their construction leads to an increase in ship and air traffic with all their associated impacts similar to the impacts of offshore mining, including light and noise pollution, oil and other petrochemical pollution, plastic pollution, habitat degradation, etc.

For the purposes of Geranium assessment, we considered on-shore gas production here under coastal on-shore mining.

*Example:* LNG in Yamal, Russia; Syrodasayskaya Coal Deposit, Taimyr, Russia.

#### Assessment findings:

*Marine mammals.* For most CFs, related risks of this activity require mitigation through specific considerations in areas where animals do not aggregate regularly. Risks are non-mitigable in coastal, well-defined, and spatially restricted habitats such as beluga whale or narwhal summer aggregation areas or in the important polar bear denning sites.

*Seabirds.* Source of significant concern in the vicinity of breeding colonies. Here, related risks require mitigation through specific considerations such as limiting scale and comprehensively adhering to existing environmental standards and best practices. Implementing robust monitoring in most other habitats is required, not because they are less sensitive to potential impacts, but because they need to be defined more precisely at regional and local scales through dedicated studies. This activity is also of significant concern for areas of mass or regular bird concentrations.

*Fish*. Source of notable concern for fish: should take place on a limited scale, adhering to existing environmental standards and best practices and monitoring for most CFs.

Benthos. Source of significant concern due to sensitivity of the habitats and the scale of potential harm.

*Coastal features.* Source of significant concern due to sensitivity of the habitats and the scale of potential harm.

#### Assumptions:

We included all mining taking place within 90 km (3 planning units) inshore and 45 km (1.5 planning units) offshore. We assumed that the activity could take place within 50 m elevation and 20 m depth and with no ice-associated restrictions.

#### Data sources:

The dataset for coastal on-shore mining was developed based on the Global-scale mining polygons (Version 2) map (Maus et al. 2022) with the following additions:

· Information on the Pavlovskaya (Novaya Zemlya), Bolshevik (Severnaya Zemlya) mining sites was added to the map manually. Locations are approximate, polygon boundaries are drawn based on the OpenStreetMap data (red polygons in known mining locations). The information about these mining sites was taken from the publicly available media publications (Volkov, 2020; Arctic Russia, 2023).

· Information on Mary River Mine (Canada) was also added to the map (Mining Data Solutions, 2023, Government of Canada, 2023).

· Information on gas producing locations is taken from the Global Energy Monitor tracker map (Global Energy Monitor, 2023c) and Rystad Energy (2023).

*Dataset produced:* August 2023.

### MGP: Offshore Gas Production

Engineering and geological surveys typically include drilling of exploratory boreholes, sampling of various geological materials and geophysical surveys (continuous seismic-acoustic profiling, side-scan sonar, etc.). These surveys are associated with the following impacts: noise pollution (from ships and from seismic surveys), petrochemical pollution (leaks from ships and equipment), light pollution (from ships and drilling platforms), physical disturbance, destruction of benthic habitats, and short-term changes in water turbidity levels.

Next stages of gas production are associated with the same risks and impacts as the production of oil: petrochemical pollution, physical disturbance, and destruction of habitats caused by installation of platforms and shipping, underwater and air noise pollution (from helicopters), changes in the ice cover, and light pollution. While there is no risk of catastrophic oil spills, there are risks of LNG and other chemical leaks and water warming in case it is used as a cooling agent in the production process.

#### Assessment findings:

*Marine mammals.* Geranium’sassessment of gas production follows that of oil production with fewer restrictions for some CFs. It can be a source of *notable* concern if it takes place on a limited scale, with adherence to existing environmental standards and best practices, with appropriate monitoring, and not closer than 10 km from any regular aggregation area for some cetaceans.

*Seabirds.* This activity is a source of *significant* concern when in the vicinity of breeding colonies and *notable* concern in most other CFs: it can take place on a limited scale with adherence to existing environmental standards and best practices and with appropriate monitoring, not because they are less sensitive to potential impacts, but because they need to be defined more precisely at regional and local scales. Source of significant concern for the areas of mass or regular bird concentrations.

*Fish.* Source of *notable* concern for most CFs: it should take place on a limited scale with adherence to existing environmental standards and best practices and appropriate monitoring.

*Benthos.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

*Coastal features.* Source of *significant* impact due to habitat sensitivity and scale of potential harm.

#### Assumptions:

We assumed that offshore gas production can physically take place at any distance from shore and in areas with depths up to 2000 m. There are no restrictions related to the ice cover presence.

#### Data sources:

There is no offshore gas production in the Arctic at the moment. For gas-condensate production, see the *MOP: Oil & Gas-Condensate Production (offshore)* dataset.

*Dataset produced:* August 2023.

### MOM: Other Offshore Mining

Sand is already being mined from the seafloor in some areas of the World Ocean. There are plans for deep seabed mining for ferromanganese nodules and rare-earth metals in the Norwegian EEZ. Associated impacts from such off-shore mining will be similar to the ones described for off-shore gas production, including engineering and geological surveys and associated ship work: noise pollution, petrochemical pollution (leaks from ships and equipment), light pollution, and physical disturbance.

Additionally, this activity will lead to significant impact on benthic habitats, including their complete destruction, long-term changes in the water turbidity levels and local hydrological characteristics.

Example: Proposal for deep seabed mining in the Norwegian EEZ.

#### Assessment findings:

*Marine mammals.* The assessment largely follows that for oil production but with more restrictions for some coastal seal habitats. For cetaceans, the assessment follows that for gas production with conditions that some risks can be mitigable for some features at limited scale and with all the environmental requirements observed and monitoring installed. Ships should not operate in areas closer than 5 km to any whales.

*Seabirds.* Source of *significant* concern: the activity should not take place in the vicinity of breeding colonies. A source of *notable* concern for most other habitats: the activity can only take place on a limited scale and with adherence to existing environmental standards and best practices and appropriate monitoring, not because they are less sensitive to potential impacts, but because they need to be defined more precisely at regional and local scales. A source of *significant* concern for areas of mass or regular bird concentrations.

*Fish.* Source of *notable* concern for most CFs: the activity should take place on a limited scale and with adherence to existing environmental standards and best practices and appropriate monitoring.

*Benthos.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

*Coastal features.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

#### Assumptions:

We assumed that offshore mining can physically take place at any distance from shoreline and with no restrictions on depth. There are no restrictions related to the ice cover presence.

#### Data sources:

This is an exploratory deep seabed mining area - Norwegian plans for exploration were digitised from Alberts (2023), Olje – Og Energidepartementet (2022).

Even though mining does not occur in this area currently, there are concrete plans to start in the near future and, therefore, it was included in the dataset.

*Dataset produced:* August 2023.

### MOP: Offshore Oil & Gas-condensate Production

Engineering and geological surveys typically include drilling of exploratory boreholes, sampling of various geological sediments; geophysical surveys (continuous seismic-acoustic profiling, side-scan sonar, etc.). These surveys are associated with the following impacts: air and underwater noise pollution (from ships, drilling and from seismic surveys), petrochemical pollution (leaks from ships and equipment), light pollution from ships and drilling platforms, physical disturbance, risks of strikes with vessels, destruction of benthic habitats, and short-term increase of the water turbidity.

The next stages of oil production are associated with high risk of oil and other petrochemical pollution, including accidental spills, physical disturbance and destruction of habitats caused by installation of platforms and shipping, noise pollution both underwater and in the air (from helicopters), disturbance of the ice cover, and light pollution. We consider gas-condensate production in the same category as oil production because from the conservation concern and environmental impact perspective they are more similar to each other compared to the gas production.

*Example:* Prirazlomnaya oil platform in the Pechora Sea, Russia; shelf production in Norway and Alaska.

#### Assessment findings:

*Marine mammals.* Source of *significant* concern for marine mammals in most of the important habitats. Source of *notable* concern in some less spatially restricted areas where it can only be undertaken on a limited scale, when regular animal concentration areas are avoided, and robust monitoring is installed.

*Seabirds*. Seabirds are among the most vulnerable wildlife in relation to acute impacts of oil spills. This activity is a source of *significant* concern if takes place within 100 km of seabird colonies or in areas of mass or regular bird concentrations like moulting, stopover, and wintering sites, as the impacts of potential spills and associated oil spill response operations can affect larger areas. It is a source of *notable* concern in other habitats where all environmental requirements are observed and robust monitoring is installed. Importantly, these habitats are also sensitive to potential impacts, but they need to be delineated more precisely at regional and local scales through dedicated studies.

*Fish.* Source of *notable* concern for most CFs where it can take place on a limited scale, adhering to existing environmental standards and best practices, and with appropriate monitoring. Source of *significant* concern for some well-defined and spatially limited habitats such as local forms of the White-Sea herring or estuarine anadromous fish complexes.

*Benthos.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

*Coastal features.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

#### Assumptions:

We assumed that offshore oil and gas-condensate production can physically take place at any distance from shore and in areas with depths up to 2000 m. There are no restrictions related to the ice cover presence.

#### Data sources (by country):

· Norway: EMODnet – Human Activities (2023) (OG offshore installations dataset).

· Russia and the USA: Global Energy Monitor (2023c).

· Information on the Nikaitchuq oil field (Offshore Technology, 2024) in the USA was manually added using the Open Street Map Information to locate the site.

· All countries: Rystad Energy oil and gas-condensate fields data as obtained by WWF Global Arctic Programme (Rystad Energy, 2023).

*Dataset produced:* August 2023, updated January 2024.

## Shipping

All ships have similar impacts on the marine environment: underwater noise pollution, physical disturbance, biological pollution (transportation of invasive species), risks of collisions with birds and mammals, waste pollution, light pollution, and ice cover destruction (especially in the port areas where permanent ice-free channels are maintained). The dredging of shipping channels can also have several associated consequences as discussed above. Apart from these, the impacts from shipping to a large extent depend on the ship’s fuel type and the cargo it carries. For example, a vessel carrying oil or petrochemicals or one using HFO (Heavy Fuel Oil) has a much larger potential impact than a container ship running on LNG. Thus, we divided shipping into the 5 categories: cargo/passenger vessels using HFO, LFO, LNG, or nuclear as a source of power and tankers (i.e., ships carrying oil and petrochemicals).

More about difference between different vessel fuel types and their impact on marine environment is here:<https://www.hfofreearctic.org/en/front-page/>

### SHF: Cargo Vessels - Heavy Fuel Oil

HFO or marine fuel oil is still the most common type of fuel for ships, used in 75% of vessels in the Arctic. It is considered the dirtiest and cheapest type of fossil fuel. HFO degrades very slowly in cold water, and it is impossible to recover in case of an oil spill. Also, the use of HFO causes significant sulphur oxide and black soot emissions. It is already prohibited in the Antarctic, and it will be banned in the Arctic after 2029 (The Polar Code, 2023).

#### Assessment findings:

*Marine mammals.* Source of *significant* or *notable* concern for most CFs. Most restrictions are seasonal and dependent on the animals’ presence. Ships should keep 2 nm away from walrus haul outs during the season when animals are out on land. These vessels should avoid locations of known regular animal concentrations, which in most cases are yet to be identified at the local or regional scale. For cetaceans, the distance to known concentrations should keep noise levels below 120 dB per 1 mPa. Often marine mammal observers on board and the introduction of speed limits will be required.

*Seabirds.* Source of n*otable* concern for most habitats where the importance of bird areas should be considered in oil spill contingency plans and ships should be double hulled. Can be a source of *significant* concern for core habitats (moulting sites, wintering areas, migration stopovers) of eiders.

*Fish.* Source of *minor* concern for many fish habitats.

*Benthos.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

*Coastal features.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

#### Assumptions:

#### We assumed that there are no limitations on distance to the shoreline and depths for shipping as well as there are no ice-associated limitations.

#### Data sources:

Arctic Ship Traffic Data System (2023). Data for 2021-2022 and first 9 months of 2023, filtered and cleared by WWF. The following fields were used to define SHF: fuelquality = "6" AND astdcat = "Chemical tankers", "Gas tankers", "Bulk carriers", "General cargo ships", "Container ships", "Ro-Ro cargo ships", "Refrigerated cargo ships", "Other activities". Mean monthly values were calculated for each PU.

*Dataset produced:* February 2024.

### SLF: Cargo Vessels – Light Fuel Oil

Light Fuel Oil or marine gasoil is a ship fuel with a lower amount of sulphur oxide, and accordingly, ships using this fuel emit less pollutants. In the event of a spill, light fuel covers the surface with a film, evaporating and dissolving much faster than marine fuel oil.

#### Assessment findings:

*Marine mammals.* Source of *significant* or *notable* concern for most CFs. Most restrictions are seasonal and dependent on animal presence. Ships should keep 2 nm away from walrus haul outs during the season when animals are present on land. These vessels should avoid known regular animal concentrations, which in most cases are yet to be identified at local or regional scale. For cetaceans, the distance to known concentrations should keep noise levels below 120 dB per 1 mPa. Often marine mammal observers on board and the introduction of speed limits will be required.

*Seabirds.* Source of *notable* concern for most of the habitats where the importance of bird areas should be considered in oil spill contingency plans, and ships should be double hulled. Can be a source of *significant* concern for the core habitats (moulting sites, wintering areas, migration stopovers) of eiders.

*Fish.* Source of *minor* concern for many fish habitats.

*Benthos.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

*Coastal features.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

#### Assumptions:

#### We assumed that there are no limitations on distance to the shoreline and depths for shipping as well as there are no ice-associated limitations.

#### Data sources:

Arctic Ship Traffic Data System (2023). Data for 2021-2022 and first 9 months of 2023, filtered and cleared by WWF. The following fields were used to define SLF: fuelquality = "0" AND astdcat = "Chemical tankers", "Gas tankers", "Bulk carriers", "General cargo ships", "Container ships", "Ro-Ro cargo ships", "Refrigerated cargo ships”, “Other activities". Mean monthly values were calculated for each PU.

*Dataset produced:* February 2024.

### SLN: Cargo LNG-powered Vessels

Liquified Natural Gas (LNG) is considered to be a relatively ecologically-friendly alternative fuel. Its sulphur oxide level is 95% lower than in HFO. In case of leakage, the gas warms and evaporates and does not pollute the marine environment.

#### Assessment findings:

*Marine mammals.* Source of *notable* or *minor* concern for most CFs. Most restrictions are seasonal and dependent on animal presence. Ships should keep 2 nm away from walrus haul outs during the season when animals are on land. These vessels should avoid known regular animal concentrations, which in most cases are yet to be identified at the local or regional scale. For cetaceans, the distance to known concentrations should keep noise levels below 120 dB per 1 mPa). Often marine mammal observers on board and the introduction of speed limits will be required.

*Seabirds.* Source of *notable* concern for most habitats. Can be a source of *significant* concern for core habitats (moulting sites, wintering areas, migration stopovers) of eiders.

*Fish.* Source of *minor* concern for many fish habitats.

*Benthos*. Source of *minor* concern. Related risks, if any, are mitigatable through the comprehensive adherence to existing environmental standards and best practices.

*Coastal features.* Source of *minor* concern. Related risks, if any, are mitigatable through the comprehensive adherence to existing environmental standards and best practices.

#### Assumptions:

#### We assumed that there are no limitations on distance to the shoreline and depths for shipping as well as there are no ice-associated limitations.

#### Data sources:

Arctic Ship Traffic Data System (2023). Data for 2021-2022 and first 9 months of 2023, filtered and cleared by WWF. The following fields were used to define SLN: fuelquality = "4" AND astdcat = "Chemical tankers", "Gas tankers", "Bulk carriers", "General cargo ships", "Container ships", "Ro-Ro cargo ships", "Refrigerated cargo ships", "Other activities". Mean monthly values were calculated for each PU.

*Dataset produced:* February 2024.

### SN: Nuclear-powered Vessels

Nuclear-powered vessels do not emit any pollutants in the atmosphere or water under operational scenarios. In the case of an accident, a vessel can be a source of radioactive pollution for the marine environment. However, during the decades of operation of such vessels, no such accidents or pollution emission have occurred. On the other hand, operation of nuclear-powered vessels is associated with other impacts like destruction of sea ice and disturbance of ice habitats, light pollution, risks of strikes with marine mammals and even with seabirds under certain conditions, i.e., in polynyas.

#### Assessment findings:

*Marine mammals.* Most restrictions are seasonal and dependent on animal presence. Ships should keep 2 nm away from walrus haul outs during the season when animals are on land. Should avoid known regular animal concentrations, which in most cases are yet to be identified at the local or regional scale. For cetaceans, the distance to known concentrations should keep noise levels below 120 dB per 1 mPa. Often marine mammal observers on board and the introduction of speed limits will be required.

*Seabirds.* Source of a *notable* concern for most habitats. Should observe and avoid seabird concentrations in ice habitats, especially, in polynyas and leads. In some areas (e.g. along the migration routes in the Chukchi and Bering Sea), black outs on vessels might be needed to avoid bird strikes during nighttime.

*Fish.* Source of *minor* concern. Related risks, if any, are mitigatable through comprehensively adhering to existing environmental standards and best practices.

*Benthos*. Source of *minor* concern. Related risks, if any, are mitigatable through the comprehensive adherence to existing environmental standards and best practices.

*Coastal features.* Source of *minor* concern. Related risks, if any, are mitigatable through the comprehensive adherence to existing environmental standards and best practices.

#### Assumptions:

We assumed that there are no limitations on distance to the shoreline and depths for shipping as well as there are no ice-associated limitations.

#### Data sources:

ASTD database available for WWF does not include information on nuclear-powered vessel tracks, therefore, there is no dataset for nuclear-powered vessel distribution in Geranium now.

### ST: Tankers carrying oil and other petrochemicals

If a ship carries oil and other petrochemicals as its cargo, the fuel it uses is irrelevant for the concern assessment since, in the case of an emergency, it is the cargo that threatens ecological disaster.

*Example:* tankers carrying oil from Varandey, the Pechora Sea across the Barents Sea, tankers carrying oil along coasts of Alaska.

#### Assessment findings:

*Marine mammals.* Source of *significant* concern for most important habitats during the season when they are in use by animals. Concern level can be reduced to *notable* if double-hulled tankers are used, during the off-season, with certain restrictions on speed limit, and with marine mammal observers on board to initiate maneuvers away from animal concentrations if they occur.

*Seabirds.* Source of *notable* concern for most of the habitats where the importance of bird areas should be considered in any oil spill contingency plans, and tankers should be double hulled. Can be a source of *significant* concern for the core habitats (moulting sites, wintering areas, migration stopovers) of eiders.

*Fish.* Source of *minor* concern for many fish habitats. Restrictions depend on scale and intensity of operations for some areas. This is in case only when double-hulled tankers are used in the area.

*Benthos.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

*Coastal features.* Source of *significant* concern due to habitat sensitivity and scale of potential harm.

#### Assumptions:

We assumed that there are no limitations on distance to the shoreline and depths for shipping as well as there are no ice-associated limitations.

#### Data sources:

Arctic Ship Traffic Data System (2023). Data for 2021-2022 and first 9 months of 2023, filtered and cleared by WWF. The following fields were used to define ST: astdcat = "Crude Oil Tankers", "Oil Product Tankers". Mean monthly values were calculated for each PU.

*Dataset produced:* February 2024.

## Tourism

Tourism is a growing industry in the Arctic. When undertaken responsibly, it is usually considered as a positive way to make conservation profitable. However, overtourism is a common problem around the world, and in the Arctic, it can be especially harmful as ecosystems here are fragile and slow to recover.

For the Geranium assessment, tourism was divided into 2 categories: ecotourism and mass tourism.

### TET: Ecotourism

Ecotourism is defined as the “responsible travel to natural areas that conserves the environment, sustains the wellbeing of local people and involves interpretation and education” (International Ecotourism Society, 2015) and includes small-ship expedition cruises and other small-scale tourism activities. It is characterized by a relatively small number of visitors, and the dependence of little or no permanent infrastructure. Expedition ships generally do not land more than 100 passengers at a time at a site and follow industry-specific guidelines, e.g., those developed by the Association of Arctic Expedition Cruise Operators ([AECO](https://www.aeco.no/)).

On the one hand, the impact on biodiversity and ecosystems from ecotourism is minimal because of its scale and the regulations it follows; however, on the other hand, ecotourism tends to provide access to the most valuable and vulnerable areas and wildlife such as seabird colonies, walrus and seal haul outs, whale aggregations, etc. Many examples exist that show a rise in the number of visitors can easily overcome an ecosystem’s capacity unless carefully regulated. Therefore, by definition, ecotourism is not necessarily compatible with conservation goals of ArcNet. Regulation should not be outsourced to industry associations like AECO, but rather should be undertaken by a conservation community in partnership with other stakeholders.

Restrictions, in addition to existing environmental standards and best practices, include using light fuel oil (LFO) instead of heavy fuel oil (HFO), site-specific visiting and wildlife observation guidelines and site management plans, restricted seasons when visitors are not allowed access, restriction on use of motorboats, etc.

Associated impacts: disturbance of animals, physical disturbance of habitats, pollution (including biological pollution - introduction of invasive species, pathogens, and diseases); in case of ship-based tourism all ship-associated impacts, including underwater noise, light pollution, disturbance of ice habitats (ice breaking), risks of ship strike for mammals and birds.

*Example:* expedition cruises by AECO tourist operators.

The ecotourism industry is among the most obvious ally and partner in conservation and thus should be actively involved in conservation planning and decision making.

#### Assessment findings:

*Marine mammals:* Marine mammal CFs are quite diverse and include small, locally restricted, stable, and very well-defined habitats, i.e., coastal haul out sites for walruses and eared seals and seasonal aggregation core areas for some philopatric cetaceans like beluga whales and narwhal. However, the majority of CFs are more widespread and dynamic though quite restricted in space such as seasonal key habitats like summer feeding areas, whelping and moulting patches. For some species or populations these habitats are not well-studied or defined, e.g. for the Barents-Kara-Laptev beluga whale stock.

Depending on the status of a habitat’s scale, importance, and sensitivity, concern levels for marine mammals vary from *significant* for polar bear denning sites, steller sea lion haul outs, and sea otter breeding sites to *notable* for the majority of the habitats and *minor* concern for the remaining CFs.

As most habitats are seasonal, restrictions are also temporary and seasonal. Restrictions include wildlife watching guidelines, speed limitations for ships in mammal aggregation areas, marine mammal observers on board, and specific site guidelines. these restrictions are best set at the regional and a local scale.

*Seabirds: S*eabird CFs in ArcNet can be divided into three types: bird colonies and their buffer zones (feeding areas), breeding grounds, and non-breeding bird habitats with moulting, migrating, and wintering aggregations. All these habitats are used seasonally, with birds present only for certain months of their annual cycle. Ecotourism is also a seasonal activity in that it does not require permanent, year-round infrastructure and, by definition, is organised in a way to not leave a lasting impact. Therefore, concern levels vary for seasons when birds are present in a habitat and when they are not.

The seasonal activity of ecotourism mostly overlaps with seasonal use of habitats seabird. Thus, for almost all habitats, ecotourism impact requires mitigation through activity-specific and/or habitat/ biotope-specific considerations if the activity takes place when birds are present and is assessed as a *minor* concern when birds are not using the habitat.

Regulations should include wildlife watching guidelines and site-specific guidelines that identify no-go zones and areas where visits are allowed. Developing site management plans is best undertaken at a local scale. In some areas (e.g. migrating birds concentration areas in the Chukchi and Bering Sea), black outs on the vessels might be needed to avoid bird strikes during nighttime.

*Fish:* As the impacts of ecotourism are relatively minor and of small scale and since CFs representing diversity of fishes are, in contrast, presented at a coarse scale, there are no specific fish-related regulations and recommendations for ecotourism other than existing environmental standards and best practices.[TJ2]

*Benthos:* Benthic CFs in the assessment are represented by distinctive deep-sea objects like vents, cold corals, rifts, underwater mountains, and areas of increased benthic biomass. These objects currently and in the foreseeable future are accessible only for occasional visits undertaken predominantly by scientists and not by tourists. Therefore, they were considered *not applicable* for the purposes of the assessment. However, some benthic CFs include shallow water and coastal elements like kelp forests and seagrass meadows. Ecotourism in these areas is of *notable* concern, and related risks require mitigation through activity-specific and/or habitat/ biotope-specific considerations to ensure kelp communities and seagrasses are not damaged. Limited use of motorboats, speed limits, and specific site guidelines directing boat traffic out from the most valuable and dense parts of the meadows and kelp forests may be required. The development of site management plans is best undertaken at a local scale.

*Coastal features*: Ecotourism causes *notable* concern for the areas where coastal CFs such as estuaries, salt marshes and intertidal zones are to be conserved. Certain restrictions should be applied to ensure the conservation of these features. Specific site guidelines, caps on the number of visitors, may be required.

There are no specific restrictions for ecotourism in the vicinity of glacial termini apart from existing environmental standards for the industry and safety measures. However, seabird and mammals feeding aggregation at glacier fronts should be addressed.

#### Assumptions:

We assumed that there are no limitations on distance to the shoreline and depths for ecotourism as well as there are no ice-associated limitations.

#### Data sources:

Arctic Ship Traffic Data System (2023). Data for 2021-2022 and first 9 months of 2023, filtered and cleared by WWF. The following fields were used to define TET: "astd\_cat"='Cruise ships' AND "sizegroup\_gt" = '10000 - 24999' OR "astd\_cat"='Cruise ships' AND "sizegroup\_gt" = '5000 - 9999 GT' OR "astd\_cat"='Cruise ships' AND "sizegroup\_gt" = '1000 - 4999 GT' OR "astd\_cat"='Cruise ships' AND "flagname" = 'France'. This complicated formula was used as there is no clear distinction between ecotourism and mass tourism in the database, and some of the expedition cruise vessels having capacity less than 200 passengers have high gross tonnage, whether some of the mass tourism cruise ships taking 600 and more less passengers have low tonnage.

*Dataset produced:* February 2024

### TMT: Mass Tourism

Mass tourism is characterised by large-scale and developed infrastructure, including roads and pathways, guest houses, peers, parking lots, cafes, souvenir shops, etc. Sometimes mass tourism is responsible for large numbers of poorly regulated visitors in an area. Vessel-based mass tourism can use large cruise ships (over 400 passengers) as well as numerous small boats in coastal areas.

Mass tourism can be destructive; however, it can take place in some areas where key CFs are less exposed to its impacts due to their biological characteristics, or seasonal/spatial mismatch. Additional requirements and conditions can be introduced besides general environmental requirements to the industry. Example regulations include speed restrictions for vessels and vehicles, onboard marine mammal observers, and use of electric engines or Light Fuel Oil (LFO) for ships.

Associated impacts: those associated with shipping and coastal infrastructure (see above), animal disturbance, physical disturbance of the habitats, and pollution, including noise and light, waste, and biological pollution (alien species, pathogens, and diseases).

*Examples:* polar bear watching tourism in the Churchill area, Canadian Arctic, and the cruise industry in waters of Alaska or Norway.

#### Assessment findings:

*Marine mammals:* Almost all marine mammal habitats considered for the assessment are seasonal. Therefore, the level of concern may vary by season except for avoiding the construction of permanent infrastructure in key mammal habitats. Mass tourism causes *significant* concern in small, locally restricted, stable, and very well-defined habitats especially during the seasons when animals are present and *notable* concern for other seasons. Under any circumstance, mass tourism should leave no trace.

Other restrictions for when animals are present can include: a heavy fuel oil (HFO) ban, speed limits, marine mammal observers on board, shipping routes planning, zoning, etc.

*Seabirds:* Seabird CFs in ArcNet can be divided into three types: bird colonies and the buffer zones around them (feeding areas), breeding grounds, and non-breeding bird habitats with aggregations during moulting, migrating, and wintering aggregations. All these habitats are used seasonally, with birds present only for certain months of their annual cycle. Therefore, the concern level may vary by season with the exception of avoiding the construction of permanent infrastructure in key bird habitats. Restrictions may include the introduction of site-specific guidelines and blackouts for cruise ships in migrating bird concentration areas at night to prevent bird strikes, etc.

Note that the assessment of concern level was undertaken at a coarse global scale and, in some cases, it will be appropriate to reconsider once finer scale data is available. For example, mass tourism is a source of *notable* concern for the CF yellow-billed loon Atlantic wintering grounds but where regular bird concentration areas must be identified and avoided. This means that upon finer scale assessment, *significant* concern will apply for these regular/known bird concentration areas while *notable* or *minor* concern will apply for areas at a distance from concentration areas. This applies to many seabird conservation features, which is highlighted in the comments section.

*Fish:* CFs representing diversity of fishes are presented at a coarse scale, and there are no specific fish-related regulations [TJ3] and restrictions for tourism other than existing environmental standards and best practices, such as measures to prevent oil spills, introduction of invasive species, minimising waste pollution, etc.

*Benthos:* Benthic CFs in the assessment are represented by distinctive deep-sea objects like vents, cold corals, rifts, underwater mountains, and areas of increased benthic biomass. It is not expected that mass tours to visit these objects will be organised in the foreseeable future. However, these areas should be considered as special areas where all measures to avoid any pollution from passing ships to be taken. Some benthic CFs include shallow water and coastal elements like kelp forests and seagrass meadows. Mass tourism in kelp forest areas requires mitigation through activity-specific and/or habitat/ biotope-specific considerations. Limiting the scale of potential activities, avoiding permanent infrastructure, limiting the use of motorboats, speed limits, and specific site guidelines to direct boat traffic away from the most valuable and dense parts of kelp forests maybe required. Mass tourism has a *significant* concern level for seagrass meadow areas because of the high sensitivity of this habitat. Related risks are assessed as non-mitigatable through activity-specific and/or habitat / biotope-specific considerations.

*Coastal features:* Mass tourism is a source of *significant* concern for the salt marsh areas and intertidal zones due to their sensitivity. It is a source of *notable* concern and should be conducted on a limited scale in other coastal areas. Recommendations include allowing no permanent infrastructure construction and the development of individual site guidelines to direct traffic and outline no-go zones. More specific restrictions and guidelines should be introduced at the regional and local scale.

#### Assumptions:

We assumed that mass tourism can physically take place in the areas with any depth and at any distance from the shore. It is also not restricted by sea ice. We did not consider terrestrial areas further than 3 planning units (pixels, 90 km) from the shoreline for the assessment as well as areas located higher than 50 m above the shoreline.

#### Data sources:

The database shows the area of mass marine ecosystem-related tourism activities concentrated around the Arctic. The areas were identified based on the following sources:

· Nome - City of Nome, Alaska (2023), Thiessen (2023).

· Sisimiut, Qaqortoq, Ilulissat, Nuuk – personal communication by Mette Frost.

· Lofoten Islands, Tromso area, Is fjord (Longyearbyen, Barentsburg), Husavik, Reykjavik, Murmansk, Solovki Islands, Teriberka, Churchill – Boris Solovyev.

Each dot represents the approximate position of an area 20-30 km in diameter.

This dataset is complemented by a dataset representing main shipping routes for the large cruise ships based on AIS data from Arctic Ship Traffic Data System ([ASTD](https://pame.is/index.php/projects/arctic-marine-shipping/astd)). Data for 2021-2022 and first 9 months of 2023, filtered and cleared by WWF. The following fields were used to define TMT "astd\_cat" = 'Cruise ships' AND "sizegroup\_gt" = '25000 - 49999' AND NOT "flagname" = 'France’ OR "astd\_cat" = 'Cruise ships' AND "sizegroup\_gt" = '50000-99999' OR "astd\_cat" = 'Cruise ships' AND "sizegroup\_gt" = '>=100000'. This complicated formula was used as there is no clear distinction between ecotourism and mass tourism in the database, and some of the expedition cruise vessels having capacity less than 200 passengers have high gross tonnage, whether some of the mass tourism cruise ships taking 600 and more less passengers have low tonnage.

*Dataset produced:* February 2024.