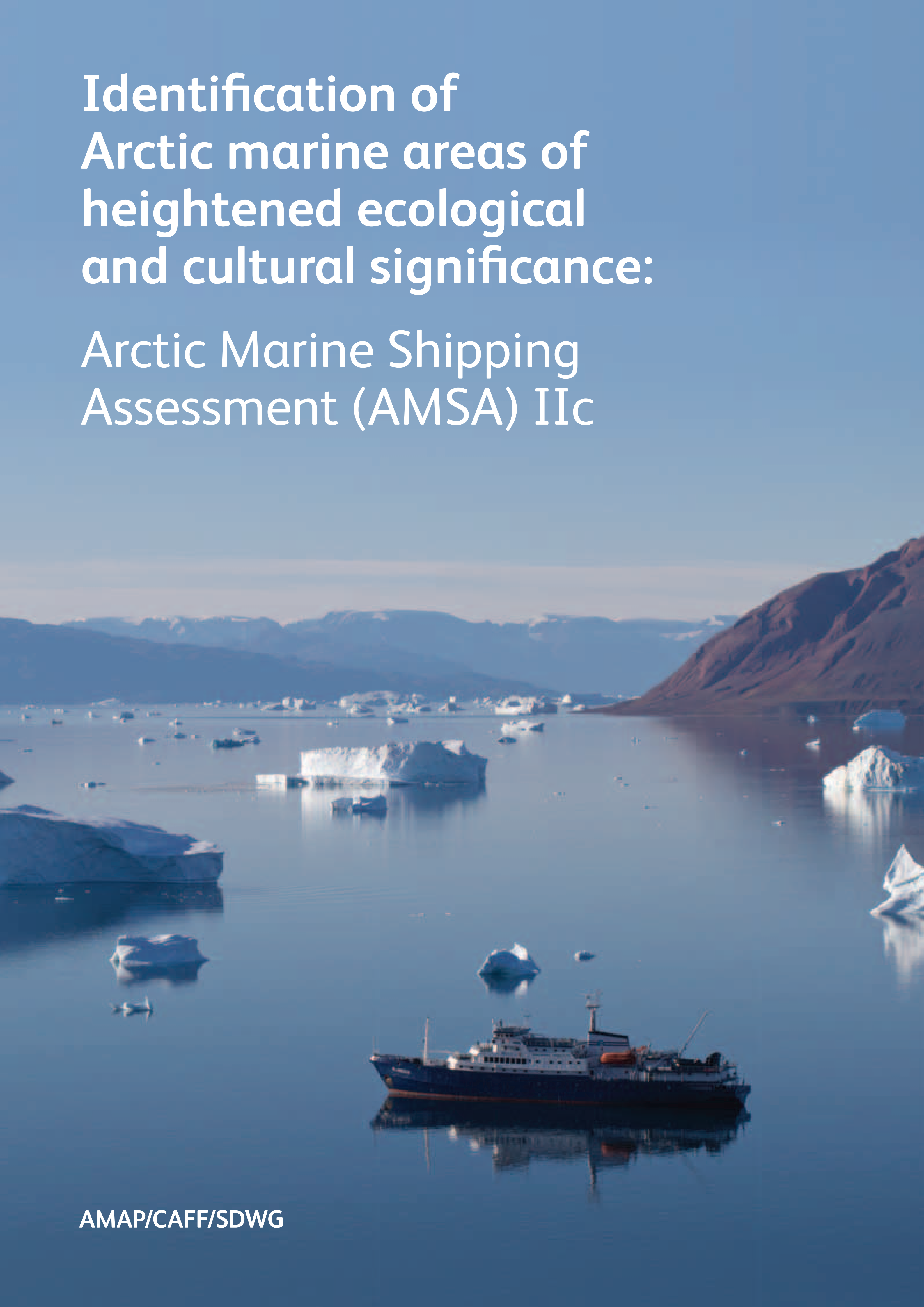
Identification of Arctic marine areas of heightened ecological and cultural significance:

Arctic Marine Shipping Assessment (AMSA) IIc



AMAP/CAFF/SDWG

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Preface

The Arctic Council's 2009 Arctic Marine Shipping Assessment (AMSA)[1] identified a number of recommendations to guide future action by the Arctic Council, Arctic States and others on current and future Arctic marine activity. Recommendation II C under the theme *Protecting Arctic People and the Environment* recommended:

> *"That the Arctic states should identify areas of heightened ecological and cultural significance in light of changing climate conditions and increasing multiple marine use and, where appropriate, should encourage implementation of measures to protect these areas from the impacts of Arctic marine shipping, in coordination with all stakeholders and consistent with international law."*

As a follow-up to the AMSA, the Arctic Council's Arctic Monitoring and Assessment Programme (AMAP) and Conservation of Arctic Flora and Fauna (CAFF) working groups undertook to identify areas of heightened ecological significance, and the Sustainable Development Working Group (SDWG) undertook to identify areas of heightened cultural significance.

The work to identify areas of heightened ecological significance builds on work conducted during the preparation of the AMAP (2007) Arctic Oil and Gas Assessment[2]. Although it was initially intended that the identification of areas of heightened ecological and cultural significance would be addressed in a similar fashion, this proved difficult. The information available on areas of heightened cultural significance was inconsistent across the Arctic and contained gaps in data quality and coverage which could not be addressed within the framework of this assessment. The areas of heightened cultural significance are therefore addressed within a separate section of the report (Part B) and are not integrated with the information on areas of heightened ecological significance (Part A). In addition, Part B should be seen as instructive in that it illustrates where additional data collection and integration efforts are required, and therefore helps inform future efforts on identification of areas of heightened cultural significance.

The results of this work provide the scientific basis for consideration of protective measures by Arctic states in accordance with AMSA recommendation IIc, including the need for specially designated Arctic marine areas as follow-up to AMSA recommendation IId.

The AMAP, CAFF and SDWG working groups would like to thank the following individuals for their contributions to the preparation of this report:

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1 Arctic Council Arctic Marine Shipping Assessment 2009 Report. www.pame.is/images/stories/PDF_Files/AMSA_2009_Report_2nd_print.pdf

2 www.amap.no/oil-and-gas-assessment-oga

Executive Summary

The Arctic Marine Shipping Assessment (AMSA) 2009 Report reviewed environmental impacts and threats from current and future Arctic marine shipping activities. AMSA Recommendation IIC called for the Arctic States to identify areas of heightened ecological and cultural significance in light of changing climate conditions and increasing multiple marine uses, and where appropriate, to encourage the implementation of measures to protect these areas from the impacts of Arctic marine shipping. An AMSA IIC project was established with Norway, Canada, Denmark/Greenland, and the USA as lead countries, and with assistance from AMAP, CAFF (the Arctic Council working group on the Conservation of Arctic Flora and Fauna) and SDWG (the Arctic Council Sustainable Development Working Group). A group of core-drafters were selected to carry out the work of identifying and describing the areas of heightened ecological significance. Part A of this report describes the areas identified as being of heightened ecological significance, while Part B describes the areas identified as being of heightened cultural significance (the work associated with Part B was undertaken by SDWG).

Areas of heightened ecological significance have been identified for each of the 16 Large Marine Ecosystems (LMEs) within the Arctic area. Three different approaches were used to identify such areas. (1) Areas identified as vulnerable areas in the AMAP Assessment of Oil and Gas Activities in the Arctic were used as the basis for 'AMSA IIC' areas in 11 LMEs (located in the Northeast Atlantic sector, in the Russian Arctic, Bering and Chukchi Seas, and the Central Arctic Ocean). (2 and 3) Canada and Denmark/Greenland had separate national processes to identify areas of heightened ecological significance for their waters (five LMEs, from the Beaufort Sea to the Greenland Sea).

The AMSA report identified oil spills as the most significant threat associated with Arctic marine shipping. Other potential impacts include ship strikes on marine mammals, disruption of migratory patterns, noise disturbance, and introduction of alien species. Aggregations of fish, birds and mammals, for purposes such as migration, staging, breeding, feeding, and resting, are to varying degrees sensitive and potentially vulnerable to oil spills and disturbances. Such areas would also generally be considered ecologically important and thus of heightened ecological significance. While an area can be ecologically important without necessarily being particularly sensitive or vulnerable, there is a broad correspondence between ecological importance and sensitivity (and potential vulnerability) for areas used by aggregations of animals. Areas with high production (such as polynyas) or rich benthic communities could be considered ecologically important in their own right. However, such areas would generally also be used for feeding by aggregations of birds and mammals and would therefore be identified as ecologically important from that perspective.

A total of about 97 areas of heightened ecological significance have been identified within the Arctic LMEs. The areas were identified primarily on the basis of their ecological importance to fish, birds and/or mammals, as these species are the most widely studied Arctic groups. The majority of areas identified are used by birds (85) and marine mammals (81), with a lower number used by fish (40, most of them spawning areas). About 70 areas are used both by birds and mammals, and only two of the areas identified are used only by fish.

The areas of heightened ecological significance comprise a total area of about 12 million km^2, or more than half the total area of the ice-covered part of the marine Arctic. The areas are generally not homogenous but comprise subareas used by fish, birds or mammals. Based on the approach used, subareas were identified separately for fish, birds, and mammals, or information on the use of the larger areas by these groups was summarized. The subareas often overlap and are also often used by two or more species of birds or mammals, such as for breeding in seabird colonies or for staging by waterfowl and shorebirds. Information on species present and the times and purposes of use are given in summary tables for each LME. Thus, while the areas identified as being of heightened ecological significance cover a large total area, this is the aggregate area used over all seasons throughout the year. The area used at any one time is lower due to the strong seasonal pattern in the annual migratory cycles of fish, birds and mammals.

The areas are essentially stationary habitats (even if they feature a current flowing through them) and the uses of the areas by aggregations of animals provide close links between species and habitats in a functional ecological sense. This is important in relation to use of the information in the context of the ecosystem approach to management.

This report builds on the large amount of information used in identifying and evaluating the areas of heightened ecological significance. This includes detailed information on species and populations and their seasonal migratory and ecological behavior in each LME. Such information may be necessary for assessing the vulnerability of areas to specific shipping activities and for evaluating the need for protective measures in relation to future Arctic marine shipping.

The Arctic has extensive, valuable cultural sites and practices along nearly its entire coastline. Readily available information makes the extent of this cultural legacy clear, but details are lacking. It is important to fill in gaps in knowledge so that important sites or activities are not neglected through ignorance. Priorities should be in areas where vessel and other activity is already occurring or expected soon. The Arctic has much potential for resource development and for shipping, but there is also a wealth of cultural legacy and current practice equally deserving of attention, recognition, and protection.

Background

The Arctic Marine Shipping Assessment 2009 Report (often referred to as 'the AMSA Report'; PAME, 2009) was approved at the Arctic Council's ministerial meeting in Tromsø in 2009. The AMSA Report focused on current and future Arctic marine activity and included a number of recommendations under three broad themes to guide future action by the Arctic Council, Arctic States and others.

Under Theme II, "Protecting Arctic People and the Environment", recommendation C concerned "Areas of Heightened Ecological and Cultural Significance" and stated:

That the Arctic states should identify areas of heightened ecological and cultural significance in light of changing climate conditions and increasing multiple marine use and, where appropriate, should encourage implementation of measures to protect these areas from the impacts of Arctic marine shipping, in coordination with all stakeholders and consistent with international law.

An AMSA IIC project was established with Canada, Denmark/Greenland, Norway, and the United States of America as lead countries. PAME requested assistance from AMAP, CAFF and SDWG in responding to the AMSA IIC recommendation, and the work was over-seen by a group of co-leads from the lead countries. A group of core-drafters were selected to carry out the work of identifying and describing the areas of heightened significance.

Part A of this report deals with the identification and description of areas of heightened ecological significance. The areas of heightened cultural significance are addressed in Part B of this report. The areas of heightened ecological significance identified here were primarily sites where large numbers of individuals of one or several species concentrate during particular times of the year, such as for breeding (i.e., colonies, rookeries, spawning areas), feeding, staging or during migrations. The report focuses on birds, marine mammals and fish species in situations and habitats where they are potentially vulnerable to the effects of vessel activity, such as oil spills, noise and physical disturbance. It provides summary information on areas of heightened ecological significance based on existing and published information.

This report addresses only the first part of AMSA Recommendation IIC; the *identification of* areas of heightened ecological and cultural significance. It documents Arctic marine areas that would be vulnerable or sensitive to activities associated with shipping, notably oil spills and physical disturbance including noise and ship strikes (collisions). The report compares these areas to criteria established by the International Maritime Organization (IMO) for determining Particularly Sensitive Sea Areas (PSSAs), as a guidance tool for PAME, Arctic State experts and Permanent Participants to use in the discussion, formulation, and conduct of follow-up projects, particularly in relation to AMSA Recommendation IID concerning Specially Designated Arctic Marine Areas. The present report has been reviewed by experts from the eight Arctic nations and the Permanent Participants (the indigenous peoples' organizations) and the three Arctic Council Working Groups (AMAP, CAFF, SDWG).

The AMSA Report (PAME, 2009) used a break-down of the Arctic area into Large Marine Ecosystems (LMEs) to summarize shipping activities and to evaluate their environmental impacts. These LMEs are also used as geographical units underlying the areas of heightened significance identified in the present report. The Arctic area as referred to here includes sub-Arctic, open-water areas south of the ice-covered areas. In the Pacific sector it extends south to include the Aleutian Islands and the east coast of Kamchatka. In the Atlantic the area extends south to the northern coast of Labrador in the west and to the Faroe Isles and the boundary to the North Sea at 62° N in the east.

Part A

Areas of Heightened Ecological Significance

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Environmental impacts and ecological sensitivity

Environmental impacts from shipping

The various types of environmental impacts from shipping in the Arctic were reviewed and summarized in the AMSA Report (PAME, 2009), with more extensive and detailed information provided in the scientific assessment document underpinning the AMSA Report (Skjoldal et al., 2009). With Arctic sea ice melting at an unprecedented rate in recent years, resulting in longer periods of open water in summer, more Arctic areas are likely to be open to shipping. The two main types of environmental effects from shipping considered in this report are (1) pollution from discharges and emissions and (2) disturbance from ships and shipping activity (Table A.1). The AMSA Report also acknowledged the introduction of alien invasive species as a serious problem that could lead to loss of native biodiversity through a wide range of specific effects. However, the pervasive nature of the introduction of invasive species does not readily lend itself to the identification of sensitive and ecologically important areas.

Table A.1. Overview of environmental impacts associated with Arctic marine shipping. Source: based on PAME (2009).

Category	Activities/pressures	Impacts
Pollution	Accidental discharge of oil and toxic chemicals	Physical oiling and death of birds and fur-bearing mammals due to impaired thermal insulation Toxicological effects
	Regular discharges to water (including garbage and illegal discharges)	Oiling (primarily from illegal discharges) Entanglement of whales and other wildlife (ropes, nets and other garbage) Ingestion of plastics by birds and mammals
	Emissions to air	Climate change (carbon dioxide and other greenhouse gases) Ozone and haze (nitrogen oxides) Decrease in local air quality Deterioration in ice conditions (black carbon; 'soot')
Disturbance	Sound and noise disturbance	Disruption of feeding, breeding or other vital activities for birds and mammals Interference with communication among whales
	Ice breakers and disturbance	Effects on behavior and communication between mammals Disturbance of wintering, migrating or staging birds and mammals in leads and polynyas Disruption of migration routes for terrestrial mammals crossing sea ice (e.g., caribou) Ice entrapment of whales in artificial leads
	Vessel strikes	Injury and death of whales by collision
	Light disturbance	Injury and death of birds attracted to lighted ships
Introductions	Introduction of invasive species through ballast water, hull fouling and cargo	Various biological and ecological effects including detrimental changes to food webs and displacement and potential loss of native species. Impacts on breeding birds by introduced predators, notably 'rat spills' associated with ship accidents on islands

The AMSA Report recognized that oil spills, either from accidents or illegal discharges, were the most significant threat to Arctic marine ecosystems. Ship strikes of whales were noted as being of concern in areas where shipping routes coincide with seasonal migration and areas of aggregation. Migration corridors through systems of leads and polynyas used by mammals and birds on their northward migration in spring from wintering areas were noted as particularly important features, with their location broadly corresponding to the current main shipping routes and travel through geographic chokepoints. Areas of heightened ecological significance at risk from current and/or increased shipping identified in the AMSA Report included the Bering Strait, Hudson Strait, Lancaster Sound and Pechora Sea. The report recognized that with a longer shipping season in the future, there is an increased possibility of interaction between migrating (and calving) species and ships.

Ecological sensitivity and use of areas by fish, birds and mammals

The ecological sensitivity of an area is reflected in the way and extent by which it is used by animals or animal populations. The present report distinguishes between the use of areas by fish, birds, and mammals. The various uses of areas by these three groups of organisms are summarized in Table A.2 along with an indicated sensitivity to the two main impact factors associated with marine shipping – accidental oil spills and disturbances, including vessel strikes of whales (see Table A.1). The estimated sensitivity builds on the outcome of the AMAP Oil and Gas Assessment (AMAP, 2007; Macdonald et al., 2010; Skjoldal et al., 2010, in prep.) and the AMSA Report (PAME, 2009; Skjoldal et al., 2009).

Fish spawning areas can be sensitive to oil spills. This is the case for small cod fishes that spawn their eggs under the ice in winter where they incubate for a long period before hatching in spring. Polar cod (*Boreogadus saida:* called 'Arctic Cod' in North America) in particular is a key species in Arctic food webs and ecosystems, and negative impacts on this species could have large ecological implications. Other species, such as capelin (*Mallotus villosus*) and herring, spawn their eggs at the seafloor. Their spawning beds could be impacted by sinking oil. Populations of Pacific herring (*Clupea pallasii*) and capelin which spawn in shallow waters and on beaches could be particularly sensitive to stranding of drifting oil (as was demonstrated in the *Exxon Valdez* accident in Prince William Sound, Alaska). Pelagic spawners are considered to be less sensitive to oil spills. However, the main spawning areas for major fish populations, such as Atlantic cod (*Gadus morhua*) in the Barents Sea and around Iceland and walleye pollock (*Theragra chalcogramma*) in the Bering Sea, are still considered potentially vulnerable in light of the great ecological importance of these stocks in marine ecosystems. Spawning aggregations of fish are considered to be less sensitive to disturbance from shipping activities in general due to the limited scope of such disturbances.

Seabirds and seaducks like eiders migrate to their northern breeding areas in spring when they may use leads and polynyas as staging areas before moving onto their breeding grounds as they begin to clear of snow and ice. The birds have spent much energy on the long migrations and are critically dependent on feeding to replenish their depleted energy stores and to accumulate energy for reproduction. Concentrations of spring staging birds in openings in the ice where there is access to food are very sensitive both to oil spills and disturbances. Other birds that may use openings in the ice to feed in spring are species of divers or loons and swimming phalaropes among the shorebirds.

Table A.2. Ecological use of areas by groups and/or species of fish, birds and mammals, and the associated sensitivity to oil spills and disturbance from shipping activities. Sensitivity is given in a relative and qualitative sense: 'Low' indicates possible effects on individuals (but not enough to be significant at the population level), 'High' indicates possible effects at the population level, while 'Moderate' indicates possible but generally limited effects at the population level.

Area type	Group/species	Sensitivity	
		Oil spill	Disturbance
Fish			
Spawning	Small cods spawning in winter under ice (Arctic cod, polar cod, navaga, saffron cod)	High	Low
	Demersal spawners (capelin, Atlantic and Pacific herring, Pacific cod)	Moderate to High	Low
	Pelagic spawners (Atlantic cod, walleye pollock, Greenland halibut)	Moderate to Low	Low
Nursery	Pacific salmons, eulachon, coregonid whitefishes	Moderate	Low
Migration	Arctic char	Low	Low
Wintering	Pacific herring, capelin	Moderate/Low	Low
Birds			
Spring staging	Seabirds (thick-billed and common murres, little auk, black guillemot, glaucous gull, ivory gull)	High	High
	Seaducks (common, king, spectacled and Steller's eiders, long-tailed duck, scoters)	High	High
	Divers or loons (red-throated, Arctic, Pacific, great northern, white-billed)	High	High
	Shorebirds (red-necked and red phalaropes)	High	High

Area type	Group/species	Sensitivity	
		Oil spill	Disturbance
Breeding	Seabirds (colonial breeders, including thick-billed and common murres, little auk, least, crested and parakeet auklets, black-legged kittiwake, northern fulmar, and others)	High	High to Moderate
	Seaducks (common eider)	High	High to Moderate
	Shorebirds (spoon-billed sandpiper)	High	High to Moderate
Feeding	Seabirds (non-breeding and post-breeding concentrations, including thick-billed and common murres, little auk, least, crested and parakeet auklets, black-legged kittiwake, short-tailed shearwater, short-tailed albatross)	High	Moderate to Low
	Seaducks	High	Moderate to Low
	Divers or loons	High	Moderate to Low
Molting	Seabirds (thick-billed and common murres)	High	High
	Seaducks (common, king, spectacled and Steller's eiders, long-tailed duck, scoters)	High	High
	Geese (brent, barnacle, emperor, cackling, white-fronted, pink-footed, snow)	High to Moderate/ Low	High to Moderate/Low
Autumn staging	Seabirds (thick-billed and common murres, others)	High	High
	Seaducks (common, king, spectacled and Steller's eiders, long-tailed duck, scoters)	High	High
	Geese (brent, barnacle, emperor, cackling, white-fronted, pink-footed, snow)	High	High
	Shorebirds (red-necked and red phalaropes, others)	High	High
Wintering	Seabirds	Moderate to Low	Moderate to Low
	Seaducks	High to Low	High to Low
	Geese	Moderate to Low	Moderate to Low
Mammals			
Migration	Bowhead, beluga, narwhal, walrus (spring migration)	High	High
	Seals (spotted, ribbon, harp)	Moderate/Low	Moderate/Low
	Polar bear	High	Moderate/Low
	Baleen whales (blue, fin, sei, humpback)	Low	Moderate/Low
Breeding	Bowhead, beluga, walrus (spring migration)	High	High
	Seals (ice-breeding species - harp, hooded, spotted, ribbon)	High	High
	Ringed seal	Moderate	Moderate/High
	Seals (harbor, gray)	Moderate	Moderate/Low
Feeding	Bowhead, beluga, narwhal, walrus	Moderate/Low	High/Moderate
	Polar bear	High	Moderate/Low
	Right whales (Atlantic and Pacific)	Moderate/High	High
	Baleen whales (blue, fin, sei, humpback)	Low	Moderate/Low
Resting	Walrus (haul-outs on ice and land)	Moderate	High/Moderate
	Seals (harp, hooded, spotted, ribbon, harbor, gray)	Moderate	Moderate/Low
Wintering	Bowhead, beluga, narwhal, walrus	High	High
	Seals (ice-associated - harp, hooded, spotted, ribbon)	Moderate	Moderate

Seabird breeding colonies can be huge aggregations of birds that feed and rest on the sea adjacent to the colonies. The foraging range out from the colonies varies by species, from a few tens of kilometers for small auks (such as least auklet *Aethia pusilla* and little auk *Alle alle*) to a hundred kilometers or more for species such as northern fulmar (*Fulmarus glacialis)*. A range of 50 km is used here to indicate sensitive zones around seabird colonies. Seabird colonies with foraging zones around them are considered to be highly sensitive to oil spills and may also be sensitive to disturbances in their vicinity. In addition to feeding around colonies, there may also be areas with feeding aggregations of seabirds and seaducks associated with features such as oceanographic fronts, productive zones, and schooling fish. Such areas may be used by non-breeding birds (immatures and failed breeders) during the breeding season in summer and by adults and juveniles in late summer and autumn after the breeding season. Areas with feeding aggregations of birds would generally have high sensitivity to oil spills but may have lower sensitivity to disturbances due to the more dynamic and shifting characteristics of such areas.

Seaducks and many auks among the seabirds molt their flight feathers in late summer or autumn when they are flightless for a period of about four weeks. Eiders and other seaducks (such as longtailed duck *Clangula hyemalis* and scoters) aggregate at favorable sites where they are protected and have access to food at diving range during the molt period. In this situation they are highly sensitive to oil spills and also to disturbances. Common (*Uria aalgae*) and thick-billed (*U. lomvia*) murres among the auks perform a swimming migration during the molt period when the young chicks are accompanied by their fathers. During this time they are potentially vulnerable to oil spills and disturbances. Geese also molt their flight feathers and remain flightless when they aggregate at molt sites often close to water. The association with marine coastal habitats varies among species and therefore the sensitivity also varies in relation to marine oil spills and activities. The circumpolar brent (or brant) goose (*Branta bernicla*) is the most marine of the geese, along with the emperor goose (*Chen canagica*) which is found in the Pacific sector of the Arctic.

Prior to the autumn migration to wintering areas often far south of the Arctic, many birds will aggregate at favorable autumn staging areas where they feed and fatten for the long southbound journey. This is the case for many seabirds such as common and thick-billed murres, eiders and other seaducks, geese, and many species of shorebird. Aggregations of staging birds at coastal and marine areas may be highly sensitive to oil spills and disturbances that disrupt their foraging and may negatively affect their energy balance prior to migration. There are also important stop-over and staging areas that are used by birds during the autumn migration. Prime examples are the Yukon-Kuskokwim Delta and lagoons along the northern side of the Alaska Peninsula in the Bering Sea, and coastal habitats in southwestern Hudson Bay and James Bay.

Several Arctic seabirds and seaducks move south to spend the winter in the marginal ice zone or in open sub-Arctic waters south of the ice. This is the case for ivory gull (*Pagophila eburnea*), and common and thick-billed murres among the seabirds, and common (*Somateria mollissima*) and king (*S. spectabilis*) eiders among the seaducks. Areas where seabirds and seaducks aggregate during winter may be sensitive to oil spills and also to disturbances dependent on the specific situations. One particular case is the wintering area of spectacled eider (*S. fischeri*) where the total world population is concentrated in a relatively small area in the marginal ice zone south of St. Lawrence Island in the northern Bering Sea. This is probably one of the most sensitive areas in terms both of oil spills and disturbances.

Among the marine mammals, whales, walrus (*Odobenus rosmarus*) and adult seals are considered to have low sensitivity to oiling from oil spills, whereas seal pups with lanugo fur, polar bear (*Ursus maritimus*), sea otter (*Enhydra lutris*), and northern fur seals (*Callorhinus ursinus*) have high sensitivity. However, in the AMAP Oil and Gas Assessment it was considered that whales and walrus that migrated and used openings in ice-covered waters were potentially sensitive to oil spills as well as to disturbances (AMAP, 2007; Skjoldal et al., in prep). Bowhead whale (*Balaena mysticetus*), beluga (*Delphinapterus leucas*), narwhal (*Monodon monoceros*) and walrus spend the winter in drifting pack ice or in polynyas. In spring they migrate north through systems of leads to their summer feeding grounds in the Arctic. During this time (late winter or spring) they reproduce by giving birth to their calves and mating. When they are in ice, these species are considered to have high sensitivity to oils spills and disturbances. As the ice clears from their feeding areas in late summer and autumn their sensitivity is reduced. With the slow-moving bowhead whale, vessel strike (collision) is a particular issue which tends to make them vulnerable also in open water. Walrus are wary animals and may have high sensitivity to disturbances when they are feeding off coasts or from the ice. This is also the case when they are hauling-out and resting on land or on ice floes between feeding bouts.

Ice-breeding seals typically give birth in dense breeding aggregations on drifting sea ice. This is the case for harp (*Phoca groenlandica*) and hooded (*Cystophora cristata*) seals in the Atlantic sector and spotted (*Phoca largha*) and ribbon (*Histriophoca fasciata*) seals in the Pacific. The pups are borne with lanugo wool to keep them warm until they develop sufficient layers of blubber, and at this stage they are very sensitive to oiling from oil spills. Breeding aggregations of seals are also sensitive to disturbances. Ringed seals (*Pusa hispida*) have a more scattered distribution during breeding and are usually to be found within the fast ice zone although they may also breed on drifting pack. As a result, they are generally less sensitive and vulnerable to oil spills and disturbances. Breaking of ice and waves generated by ships may, however, cause flushing of their dens and death of the exposed ringed seal pups. Ice-associated seals winter in the marginal ice zone and move north with the receding ice in summer; they tend to occur dispersed in smaller groups and in relatively open pack ice. They are therefore considered to have moderate or moderate to low sensitivity to oil spills and disturbances outside the breeding season in late winter or spring.

Polar bears are sensitive to oiling from oil spills. They tend to occur dispersed but may be more concentrated in some areas during migration from breeding and wintering areas to summer feeding areas and also in favorable feeding areas such as along leads and polynyas where prey may be more abundant than elsewhere.

The large baleen whales (including blue *Balaenoptera musculus*, fin *B. physalus*, sei *B. borealis* and humpback *Megaptera novaeangliae*) spend the winter at lower latitudes and move north in spring to feed in boreal and sub-Arctic waters during summer. These whales are considered to have low sensitivity to oil spills and moderate to low sensitivity to disturbances. Atlantic (*Eubalaena glacialis*) and Pacific (*E. japonica*) right whales are listed as Endangered species by the IUCN, each occurring with global populations of 400 to 500 individuals. They may move north in summer to feed in sub-Arctic waters off southern Greenland and in the Bering Sea. Due to their low numbers and slow swimming, they are considered sensitive to ship strikes, where the loss of even a few individuals may be significant at the population and species levels.

Identification of ecologically important areas

Ecological importance versus ecological sensitivity and vulnerability

Areas of heightened ecological significance are taken to mean that the areas are ecologically important. All areas of Nature have some ecological function for the animals, plants and microbes that occupy or use the areas, either permanently or seasonally. 'Heightened ecological significance' and 'ecologically important' are understood in a relative sense, as areas that are more important than other areas. This does not mean that those other areas are not ecologically significant or ecologically unimportant, only that they are less significant and less important than the identified 'important' areas.

Ecological sensitivity of an area is not strictly the same as ecological importance. An area may be ecologically important without necessarily being ecologically sensitive. However, the two aspects of sensitivity and ecological importance are often related in reality. This is particularly the case where the ecological sensitivity is reflected in the use of areas by animals for biological or ecological purposes such as breeding, feeding, migration, wintering, etc. This is illustrated in Table A.2 where the sensitivity to oil spills and disturbances from shipping activities is related to the various ecological uses of areas by fish, birds and marine mammals. Aggregations of fish, birds or mammals at particular geographical locations will often convey an ecological significance to those locations in that they may serve as important or critical habitats during the annual or life cycles of the animals.

Vulnerability is related to sensitivity but the two are not the same. Vulnerability relates to specific pressures or threats. If there are no activities or threats, an area may be considered sensitive but not vulnerable. The properties of sensitivity and vulnerability of areas may be seen as comprising three levels. The first level relates to the intrinsic properties of organisms or habitat features that reflect whether they are sensitive or fragile to external disturbances. Animal species may be sensitive to disturbances through changes in behavior or other biological effects, and may be slow to recover should they be impacted due to low rates of reproduction. Habitat features may be physically fragile and easily impacted by physical stress, for example, cold-water corals being impacted by bottom trawling. The second level relates to the ecological setting. An area where many sensitive organisms or habitat features are concentrated is more sensitive or fragile than a comparable area where they are more scarce and dispersed. The third level relates to the presence of pressures and impacts from human activities. Whether an area identified as sensitive should also be considered vulnerable depends on whether there are direct or potential threats.

Aggregations of seabirds at sea may be very sensitive to oiling, and such areas of aggregations may have high vulnerability to oil spills which could reach the sites from far away (1000 km or more). The aggregations may also be sensitive to disturbances from human activities, but the spatial range of such factors would be much smaller than in the case of an oil spill. Activities would generally have to be carried out fairly close to the animal aggregations in order to cause disturbance. If there are no activities and none are planned, an ecologically important area might be considered not to be vulnerable and no protective measures would be required, at least in the short term. However, protective measures may also be put in place on a precautionary basis, to prevent future activities and threats developing. Thus vulnerability can be considered both in a specific context of threats from existing or planned activities, and in a more proactive and hypothetical context of potential vulnerability should activities occur in the future. Such potential vulnerability is particularly relevant in the case of oil spills (from marine shipping or other activities) which could travel long distances between where an accident took place and where impacts could potentially occur.

The close relationship between sensitivity or vulnerability and ecological importance is reflected in sets of criteria for identification of sensitive and ecologically important areas, as described in the following section.

Criteria for identifying sensitive and ecologically important areas

There are several sets of criteria for identifying sensitive and ecologically important areas. Of particular relevance in the present case are the IMO criteria for Particularly Sensitive Sea Areas (PSSA) (IMO, 2002), which are mentioned as an appropriate tool in AMSA Recommendation IID (PAME, 2009). Another set of criteria has been adopted by the UN Convention on Biological Diversity for identifying Ecologically and Biologically Significant Areas (EBSAs). The International Union for the Conservation of Nature (IUCN) has also proposed criteria for selecting Marine Protected Areas (MPAs).

This report uses the IMO PSSA criteria (Particularly Sensitive Sea Areas) to evaluate the importance of the areas identified as being of heightened ecological significance. The PSSA criteria are part of the revised guidelines for the identification and designation of Particularly Sensitive Sea Areas adopted in December 2005 (Resolution A.982(24) (IMO, 2005). The guidelines consist of a set of eleven criteria, three socio-economic criteria, and three scientific criteria. The ecological criteria are listed in Annex 1.

A comparison of the various sets of criteria shows that they are broadly similar (Table A.3; Skjoldal and Tolopova, 2010). One reason for the high degree of similarity is that the set of IUCN criteria for MPAs, published in 1992, has been used as the basis for the development of the other two sets. The fact that the criteria are similar for identifying 'sensitive areas' and 'ecologically significant areas' reflects the coincidence of these features; areas are considered sensitive because they support aggregations of wildlife or other features which also are ecologically significant.

Use of the IMO PSSA criteria

The PSSA criterion (4.4.1) on **uniqueness or rarity** relates to areas or habitats that are 'the only one of its kind' or that occur only in a few locations. They may be habitats of rare or threatened species, or habitats used for feeding or breeding. Use of this criterion is scale dependent. An area may be unique or rare at the scale of the whole Arctic. Since the Arctic itself is globally unique, this would generally mean that an area would be unique or rare also at the global scale. Within the Arctic, an area may be unique or rare at a smaller scale, for example, nationally, or regionally in a biogeographic sense. At this scale, unique or rare may reflect two very different aspects. It may be that a species (or ecological feature) is unique or rare in a country or region because its occurrence there represents the periphery of the distributional area of the species. It may thus be common or abundant in other Arctic regions or countries. In the opposite case, a species (or feature) may be genuinely unique or rare, occurring only (or mainly) in that region or country. In this situation the significance of unique or rare becomes much greater than in the former case. To this picture must be added the fact that many common Arctic species of birds and mammals with circumpolar distribution are not homogenous but occur with different populations and subspecies in different parts of the Arctic (e.g., between the Atlantic and Pacific sectors, or between the Eurasian and North American sides).

In using the 'uniqueness or rarity' criterion, this study has generally scored this according to the overall pan-Arctic scale. However, in several cases weight has also been given to the occurrence of different subspecies or clearly defined migratory populations. For example, the migration route of bowhead whales and beluga up though the lead system along northwestern Alaska has been considered a unique ecological feature. The main spawning area for Atlantic cod in the Lofoten area is an example of an area considered unique due to the great ecological (and economic) importance of this cod stock

Table A.3. Comparison of criteria for identifying Ecologically and Biologically Significant Areas (EBSAs), Marine Protected Areas (MPAs) and Particularly Sensitive Sea Areas (PSSAs). Source: Skjoldal and Toropova (2010).

CBD EBSA	IUCN MPA	IMO PSSA
Uniqueness or rarity · Species, populations, communities · Habitats or ecosystems · Geomorphological or oceanographic features	Rare biogeographic qualities Unique or unusual geological features Rare or unique habitat	Uniqueness or rarity
Special importance for lifehistory stages of species · Breeding grounds, spawning areas, nursery areas, juvenile habitat, etc. · Habitats of migratory species	Presence of nursery or juvenile areas Presence of feeding, breeding or rest areas	Spawning, breeding and nursery grounds Migratory routes Critical habitat for the survival, function, or recovery of fish stocks
Importance for threatened, endangered or declining species and/or habitats	Presence of habitat for rare or endangered species Rare or unique habitat for any species	Critical habitat for rare or endangered marine species
Vulnerability, fragility, sensitivity, or slow recovery · Sensitive habitats, biotopes or species that are functionally fragile or with slow recovery		Fragility
Biological productivity	Ecological processes or life-support systems	Productivity
Biological diversity · Ecosystems, habitats, communities · Species · Genetic diversity	The variety of habitats Degree of genetic diversity within species	Diversity
Naturalness	Naturalness	Naturalness
	Integrity	Integrity
		Dependency
	Representative of a biogeographic "type" or types	Representativity - Bio-geographic importance, representative of a biogeographic "type" or types

in the Barents Sea ecosystem. In addition, the major polynyas (North Water, North-East Water, Great Siberian, St. Lawrence Island) are considered unique features of great ecological importance.

The criterion (4.4.2) on **critical habitat** relates to areas that 'may be essential for the survival, function, or recovery of fish stocks or rare or endangered marine species, or for the support of large marine ecosystems'. In this study the criterion is taken not only to relate to fish stocks and rare or endangered species, but also to apply to areas that are essential for marine mammals and marine and coastal birds. As many areas have been identified as ecologically important because they are used by fish, birds and mammals for various purposes (such as staging, migration, breeding, and feeding) during their life or annual migratory cycles, most of the areas qualify on this criterion.

There is considerable overlap between the criterion on critical habitat (4.4.2) and Criterion 4.4.7 on **spawning or breeding grounds**. The latter specifies that it may apply to areas that are critical spawning or breeding grounds or nursery areas for marine species, and also areas that are recognized as migratory routes for fish, birds, mammals, or invertebrates. Thus this criterion has a broader applicability than just spawning or breeding grounds. This study has included staging areas that are used by birds in preparation for breeding or migration as relevant for this criterion. Most of the identified areas of heightened ecological significance that score on the 'critical habitat' criterion have also been scored on the criterion on 'spawning or breeding grounds'.

The criterion (4.4.3) on **dependency** is specified to apply to areas where ecological processes are highly dependent on biotically structured systems such as coral reefs and kelp forests. It also includes migratory routes of fish, birds, mammals, and invertebrates. In this study this criterion has also been interpreted to apply to areas where there is a dependency on sea ice. This includes polynyas and ice-edge habitats, as well as whelping areas for seals on sea ice and spawning areas for polar cod under ice. Breeding colonies of seabirds have not been included under this criterion although in many cases there is dependency on cliffs that offer the combination of safe breeding conditions (from terrestrial predators) and access to food in nearby sea areas.

The criterion (4.4.4) on **representativeness** applies to areas that are outstanding and illustrative examples of specific biodiversity features in a broad sense (including ecological processes, habitats, etc). This criterion has been used to very limited extent in this study. It would require careful and detailed analysis to choose areas that would comprise a representative selection among all the areas that would be outstanding and representative examples of specific biodiversity features in the Arctic. The criterion could also have been applied more liberally in that many or most of the identified areas of heightened ecological significance could also be seen as good examples of Arctic biodiversity features.

The criterion (4.4.5) on **diversity** specifies areas that 'may have an exceptional variety of species or genetic diversity or includes highly varied ecosystems, habitats, and communities'. This criterion has been used to limited extent in this study. The Arctic is generally thought of as poor in species numbers compared to other biomes. This notion may not be entirely correct as suggested by fairly large number of benthic invertebrates. However, it applies to many groups such as fish, where the species number declines from the sub-Arctic into the High Arctic (Mecklenburg et al., 2011). Higher number of species in some areas may reflect biogeographical transition zones where for example, boreal and Arctic species overlap in the peripheries of their distributions. The diversity criterion has been used in a few cases where there is particular richness of species or diversity of ecological features such as in the Aleutian Islands and in the Bering Strait region.

The criterion (4.4.6) on **productivity** applies to areas that have a particularly high rate of natural biological production as a net result of biological and physical processes. Examples that are given are oceanic fronts and upwelling areas. In this study the criterion has been used where the rate or magnitude of basic primary production is enhanced such as in polynyas and in the Bering Strait region. It has also been used for spawning areas for fish that provide a food source for consumers such as seabirds and seals. Large seabird breeding colonies are often located near spawning areas or drift routes for fish larvae and juveniles or where there is an abundant supply of zooplankton due to the physical regime (such as currents or fronts). Feeding areas for polar bears and seals in the marginal ice zone are characterized by concentrated occurrence of prey and are considered to qualify for the productivity criterion.

The criterion (4.4.8) on **naturalness** has been used for nearly all the identified areas of heightened ecological significance. The Arctic in general and the identified areas in particular have relatively low levels of human presence, activities and disturbances. This study has not considered the general pollution situation, which may be serious in some cases (e.g., with persistent organic pollutants; AMAP, 2010a), or climate change to represent a significant deviation from naturalness. The Arctic environment is clearly not pristine with respect to contaminants and adverse health effects on Arctic top predators such as polar bears have been documented with potential effects at animal population level (AMAP, 2009). Climate change is likely to be ongoing (in addition to natural climate variability) but it is as yet difficult to ascribe observed changes to climate change rather than as expressions of the effects of natural climate and ecosystem variability. Climate change clearly represents a future threat. Fisheries and hunting are other activities that have effects on sub-Arctic and Arctic ecosystems. Fisheries have clear effects on the targeted stocks and are likely to have indirect effects through food-web interactions on other dependent parts of the marine ecosystems. Nevertheless, in this study the ecosystems are considered to be operating in a natural mode and manner, even if there are disturbances from fisheries and other exploitation.

The criterion on naturalness relates to the criterion on fragility (4.4.10), where the issues of stress from natural and anthropogenic causes are considered. This includes in a general sense the stresses from pollution, climate change and fisheries.

The criterion (4.4.9) on **integrity** applies to an area that constitutes a biologically functional unit, or 'an effective, self-sustaining ecological entity'. In this study, few areas have been identified as qualifying according to this criterion. The majority of areas are habitats used by fish, birds, and/or mammals at some stage during the life or annual migratory cycles. These areas would generally not be considered as 'self-sustaining ecological entities' in isolation, but rather as habitat entities that contribute to the integrity of the larger ecosystem of which they are functionally important parts.

The criterion (4.4.10) on **fragility** applies to areas that are highly susceptible to degradation by natural events or by the activities of people. This is an important criterion that relates to the relationship between ecological importance and sensitivity or vulnerability discussed in a previous section. The criterion recognizes the cumulative effects or stresses from natural variation and events and those resulting from human activities. In the explanation of the criterion, it is stated that "an area already subject to stress from natural and/or human factors may be in need of special protection from further stress, including that arising from international shipping activities".

The fragility criterion reflects the intrinsic properties of species or habitats and the specific ecological setting which determines whether sensitive or fragile species or habitats occur concentrated in a given area. It also reflects the potential vulnerability in relation to oil spills and disturbances from shipping activities, should such activities take place in or near an area. It is not vulnerability as would be reflected in the outcome of a risk analysis. The IMO PSSA guidelines contain a set of criteria (under Section 5 - Vulnerability to Impacts from International Shipping) that are to be applied to analyze the risk posed by international shipping activities for a given area that qualifies according to the ecological criteria considered here. The criteria for the vulnerability assessment include vessel traffic characteristics and natural (hydrographical, meteorological, and oceanographic) factors.

Nearly all the areas of heightened ecological significance identified in this study score on the fragility criterion. This is due to the nature of the areas, being habitats used by fish, birds and/or mammals during critical or important stages in their life or migratory cycles. As previously discussed, there is a close relationship between ecological importance and sensitivity to oil spills and disturbances, and therefore also between the scores on the criteria on critical habitats (4.4.2) and spawning or breeding grounds (including seasonal migrations) (4.4.7) and on the fragility criterion.

The criterion (4.4.11) on **bio-geographic importance** applies to areas that either contain rare biogeographic qualities, or are representative of biogeographic types, or contain unique or unusual features (biological, chemical, physical or geological). In this study the criterion has been used in a restricted sense for areas that are important for endangered species or contain some special features. For example, this includes areas that are important for the Critically Endangered Spitsbergen stock of bowhead whale in the Greenland Sea, areas used by the Laptev walrus, some of the High Arctic breeding areas for birds (e.g., on Severnaya Zemlya), and the spring migration corridor for bowhead whales and beluga along northwestern Alaska. The criterion has also been used for areas that are important staging areas for migratory birds (e.g., on Iceland) and for ecologically dominant species (e.g., spawning areas for major fish stocks that play particularly important roles in the ecosystems).

Approaches for identification of areas

The ecologically important areas have been identified by three different routes or approaches. (1) For many areas the information compiled and used to assess vulnerable areas in the AMAP Oil and Gas Assessment (AMAP, 2007, 2010b,c; Skjoldal et al., in prep) has been used. This is the case for 11 of the Arctic LMEs which have been used as geographical units for the identification of ecologically important areas. (2 and 3) Canada and Denmark/Greenland have had separate national processes whereby they have identified ecologically important areas for their waters. For Canada these have been areas identified as 'Ecologically and Biologically Significant Areas' (EBSAs). The three approaches are described in more detail in the following sections. While there are some differences among the approaches, the outcome is broadly comparable. In all three cases, the emphasis has been on the use of areas by fish, birds and marine mammals.

AMAP Assessment of Oil and Gas Activities in the Arctic

The AMAP Assessment of Oil and Gas Activities in the Arctic (AMAP 2007, 2010b, c) has been a major activity and product under the Arctic Council. The summary report, *Arctic Oil and Gas 2007*, was published in 2007 (AMAP, 2007). Work on the fully-referenced and peer-reviewed scientific report has continued since then. The first two volumes were published in 2010: Volume 1 addressed past, current and likely future oil and gas activities in the Arctic, plus the social and economic effects of these activities (AMAP, 2010b), while Volume 2 addressed the sources, inputs and concentrations of contaminants associated with Arctic oil and gas activities, plus the effects of these oil and gas activities on the environment and human health (AMAP, 2010c). The third volume, which will address the status and vulnerability of Arctic ecosystems in relation to Arctic oil and gas activities, is expected to be published in 2013. A draft version of Volume 3 is available via the AMAP website (www.amap.no/oga).

The AMAP Oil and Gas Assessment (AMAP, 2007, 2010b,c) identified oil spills as the greatest threat to the Arctic marine environment and recognized a number of potential effects from disturbances associated with oil and gas activities including ship traffic. The outcome of the assessment in terms of effects and areas identified as vulnerable to oil spills and disturbances was used as a source of information for the environment section of the AMSA Report. Due to the similarity of environmental threats and impacts from oil and gas activities and from shipping, with oil spills recognized as a major threat in both cases, the outcome of the AMAP Oil and Gas Assessment is particularly relevant to the AMSA IIC project work.

The AMAP Oil and Gas Assessment, and particularly the information compiled for soon-to-be-published Volume 3, was a major source of information for the identification of areas of heightened ecological significance in the present report. The report has also benefited from new information provided by various Arctic States.

Volume 3 of the AMAP Oil and Gas Assessment (specifically Chapter 6 – Skjoldal, in prep) summarizes information on species (and subspecies and populations where relevant) both at the pan-Arctic scale and for each of 17 Arctic LMEs. The information on use by species of fish, mammals and birds of areas for purposes such as wintering, migration, staging, breeding, feeding, molting, and resting was used to identify areas that were ecologically important and assessed to be vulnerable to oil spills and disturbances from activities associated with oil and gas development.

Chapter 6 (Skjoldal, in prep) contains four linked elements for each of the Arctic LMEs:

- A *description* of the LME with emphasis on species of fish, birds, and mammals. This part is fully referenced to the sources of the compiled and used information.
- An assessment with *identification of vulnerable areas* based on ecologically important aggregations of species considered sensitive to oil spills and disturbances.
- A *summary table* of the identified vulnerable areas with information on dominant species and time of year when the areas are used (and therefore are vulnerable).
- One or more *maps* showing the geographical locations of vulnerable areas for fish, mammals and birds.

The tables and maps of vulnerable areas in Chapter 6 (Skjoldal, in prep) have been used as the basis for identifying areas of heightened ecological significance in the present work. Overlapping and/or adjacent 'OGA areas' have been combined into larger areas but reference to the 'OGA areas' has been included in the tables. To keep the present report relatively short, basic information on species or the assessments leading to the identification of the ecologically significant areas has not been repeated. Instead short descriptions of each area have been provided that give the justification as to why the area is considered to be of heightened ecological significance. Further documentation and references to sources of basic information are available via Skjoldal (in prep).

Other sources of information have also been used where relevant and available.

Identification of areas of heightened ecological significance for Canadian waters

A scientific advisory process was held in June 2011 to peer-review existing information in order to identify marine 'Ecologically and Biologically Significant Areas' (EBSAs) in the Canadian Arctic. This advisory process included 32 experts from Canadian federal departments, academia, Inuit organizations, and environmental non-governmental organizations with a wide range of expertise (e.g., cetaceans, pinnipeds, polar bears, seabirds, corals and sponges, zooplankton, etc.). EBSAs were identified based on the National Framework for the Identification of Ecologically and Biologically Significant Areas (DFO, 2004), which uses criteria very similar to those used for identifying EBSAs in marine areas as defined in Annex I of Decision IX/20 of the Ninth Meeting of the Conference of the Parties to the Convention on Biological Diversity.

The scientific peer-review process produced a report entitled *Identification of Ecologically and Biologically Significant Areas in the Canadian Arctic* (DFO, 2011) as well as a primary background paper (Cobb, 2011) that considered an extensive list of reference material to support the conclusions. Similar scientific peer-reviews were previously conducted exclusively for the Beaufort Sea (Paulic et al., 2009) and northern Foxe Basin (DFO, 2010). The Canadian submission to the AMSA IIC exercise is based primarily on these four documents (and the references therein) and represents the scientific advice on the identification of marine EBSAs in the Canadian Arctic.

The EBSAs presented here are not meant to represent a general strategy for protecting all the habitats and marine communities identified. Rather, they are intended to call attention to areas with particularly high ecological or biological significance in order to facilitate provision of a higher degree of risk aversion in management actions, where and when appropriate. A threat assessment for identified Canadian Arctic marine EBSAs has not yet been conducted so vulnerability cannot yet be confidently reported. A scientific process to determine threats will be carried out by Canada and will be the primary source for input into decisions in Canadian waters. Such a process would take AMSA IIC into account.

Traditional Ecological Knowledge (TEK) was considered where available. Through a series of formal consultation processes, the EBSAs identified have been formally communicated to Inuit representatives and their input solicited (Newton et al., 2012).

Identification of areas of heightened ecological significance for Greenlandic waters

The sites presented in this report have been identified and delineated on the basis of the best available information. Over the past decade considerable effort has been invested in identifying marine areas and coastlines vulnerable to oil spills as well as key habitats, migration routes, and the population size and ecology of sensitive species and resources in Greenland, resulting in a number of strategic environmental impact assessments (SEIAs) for hydrocarbon exploration and exploitation activities. The SEIAs are conducted for the Greenland Bureau of Minerals and Petroleum by scientific environmental institutions (Danish Center for Environment and Energy, Århus University (formerly the Danish National Environmental Research Institute, NERI) and the Greenland Institute of Natural Resources). The SEIAs build on peer-reviewed scientific literature and supplementary scientific studies. Each SEIA states the sources to primary literature. In early 2011, the Danish Ministry of the Environment requested the Danish Center for Environment and Energy to compile a technical report identifying ecologically valuable and sensitive marine areas in relation to increased shipping activities in Greenlandic waters (Christensen et al., 2012). This report to a large extent builds on the SEIAs mentioned above, and identifies areas of heightened ecological significance in Greenlandic waters.

The areas of heightened ecological significance proposed for the Greenlandic waters are presented for two LMEs: the Greenland Sea LME and the Baffin Bay-Davis Strait LME. For each area, a brief description of the ecological significance is given, focusing on key areas for fish, seabirds and marine mammals, as these are the taxa most likely to be directly affected by shipping-related activities.

Use of references

A large body of primary scientific literature has been used in the processes to identify and document the areas of heightened ecological significance. Chapter 6 of the Arctic Oil and Gas Assessment (Skjoldal, in prep) provides the detailed information for the identified areas in 11 LMEs and should be consulted for primary references. For the Canadian areas the main references are the background document and report from the scientific peer-review process in June 2011 (Cobb, 2011; DFO, 2011), which provides a lead to the more detailed information. For the Greenland areas, references to the information have been included. In many cases this is to SEIAs which provide the primary literature for the information.

The basic sources of information should be consulted for further details when considering the need for and types of protective measures for the identified areas. The tracking of such information has been facilitated by the provision of references to systems of indexes which provide links to sections of the basic documents where more information can be found (see also page 19; Areas of heightened ecological significance).

Key features and species of Arctic marine ecosystems

Physical constraints for marine life

The physical environmental conditions set the stage for marine life in the Arctic. The freezing point of seawater (-1.8 °C) requires that cold-blooded animals (invertebrates and fish) have physiological mechanisms that enable their survival, for example, anti-freeze substances in their body fluids. For those that have such adaptations, temperature is not a major challenge. In contrast to seawater, which typically does not fall below -1.8 °C, air temperatures may be considerably lower and warm-blooded animals (mammals and birds) need insulation in the form of blubber, fur or feathers to survive. The biggest challenge to marine life is sea ice which may block access to air for breathing (marine mammals) or to food (mammals and birds).

Within the marine environment, there is large seasonality between winter and summer in terms of the physical conditions and the levels of primary production. Sea ice (particularly if covered by snow) limits the amount of light available for primary production by algae. When the sea ice begins to melt in spring, there is a burst of primary production by phytoplankton in the water column and by ice algae in and on the underside of ice. This fuels reproduction and growth of zooplankton, which in turn provides food for small fish, many seabirds, and large baleen whales. In areas with seasonal sea-ice cover, there is often an ice edge phytoplankton bloom that follows the northward retreat of the ice as it melts. In the central parts of the Arctic Ocean with multi-year pack ice, ice algae play a greater role relative to phytoplankton. The productive period may last up to six months (April to September) in the southern areas of seasonal ice cover, while being much shorter (two to three months) in the High Arctic. Ice-edge blooms are important not only for the zooplankton and other life within the water column but also for benthos since much of the organic matter associated with the blooms sinks down through the water column ungrazed to become a source of food and energy for the bottom communities on Arctic shelves.

Polynyas

Polynyas are areas of open seawater in the ice. Some remain open throughout winter while others open or increase in extent in late winter and spring (ACIA, 2005; AMAP, 2012). Polynyas are of two main types. (1) Mechanical or ‘latent heat’ polynyas are driven by persistent winds that carry ice away and thus keep the water open. Such polynyas occur on the lee side of islands, peninsulas, ice-bridges or landfast ice. (2) ‘Sensible heat’ polynyas are kept open by transport of warm water (i.e., water at temperatures above the freezing point). The energy flux from open water in polynyas under Arctic winter conditions can be formidable with rates of about 1 kW/m^2. This flux goes to generate ice (downstream in sensible heat polynyas) and the cumulative ice formation per unit area may be up to 30 m or more during a winter season. Through such mechanisms, polynyas greatly influence the formation and melting of sea ice. They are termed ‘factories of ice’, highlighting the fact that up to 70 % of the total volume of sea ice developing in the Arctic seas may be produced in polynyas. In contrast to this role in winter, the open waters of polynyas accumulate heat and become centers of seasonal sea-ice decay in spring and summer. Polynyas also influence the hydrography of Arctic waters by causing an increase in the salinity of surface water when ice forms, leading to the development of convection within the underlying waters.

Polynyas play important ecological roles (Stirling and Cleator, 1981; Stirling, 1997). They are associated with earlier and higher levels of plankton production which attracts plankton-feeding fish (e.g., polar cod (*Boreogadus saida*)) and other predators, including marine mammals and seabirds. They may have a particular importance for the recruitment of polar cod which is a key food item for most of the top predators in the High Arctic ecosystems. Benthic communities in polynya areas are also characterized by increased biomass and species diversity due to enrichment of near bottom water layers and sediments with organic matter. Polynyas may serve as wintering areas for marine mammals and birds. They also have an important role as stop-over sites for seabirds and seaducks during spring migration when they feed in the polynyas prior to breeding (Figure A.1). The largest seabird colonies in the High Arctic are typically associated with polynyas.

Shorelead systems or flaw leads open up along the edge of landfast ice where wind blows the drifting pack ice offshore. Landfast ice as a 'rule-of-thumb' extends out to about the 20-m isobath, but this may vary depending on the presence of islands, skerries (i.e., rocky islands or reefs) and other topographic features. Shorelead systems may be extensive and provide migration corridors for the Arctic whales and walrus, and stop-over and feeding sites for seabirds, seaducks and phalaropes.

The indigenous Arctic peoples have for millennia used recurring polynyas for their open water in winter and their abundance of seabirds and marine mammals. This was also the case for the first polar explorers in more recent centuries. The sites of ancient and contemporary indigenous settlements and the routes of early exploratory expeditions correspond well to the distribution of polynyas (Schledermann, 1980).

Productivity

Ice limits production in Arctic waters. It restricts the light needed for photosynthesis and limits the length of the season for production. When ice melts, a surface layer of relatively less dense water of lower salinity is formed which effectively restricts the transport of nutrient-rich water into the surface layers from deeper waters. Levels of phytoplankton primary production vary by two orders of magnitude across the Arctic Ocean. The highest levels occur in the northern Bering Sea and southern Chukchi Sea where annual production may exceed 500 gC/m^2. At the other end of the spectrum, annual production in the central Arctic Ocean with dense pack ice may be less than 5 gC/m^2 (Sakshaug, 2003).

The North Pacific is more nutrient-rich than the North Atlantic. Therefore productivity in the Pacific sector of the Arctic is considerably higher than in the Atlantic sector. In the slope waters of the Bering Sea annual primary production is of the order of 200–300 gC/m^2 compared to 100–150 gC/m^2 per year in the sub-Arctic waters of the North Atlantic (Springer et al., 1996; Sakshaug, 2003). This high primary production is the basis for the very rich animal life in this area with large populations of plankton-feeding seabirds and benthic-feeding mammals. In contrast, the productivity of the wide Siberian shelves and the Canadian Archipelago is typically much lower, in the range of 20–50 gC/m^2 per year (Sakshaug, 2003).

Arctic species

More than 250 species of fish inhabit Arctic and sub-Arctic marine ecosystems. There are 35 species of marine mammals that occur within the Arctic area, with most found in the southern sub-Arctic parts where many occur as seasonal visitors from lower

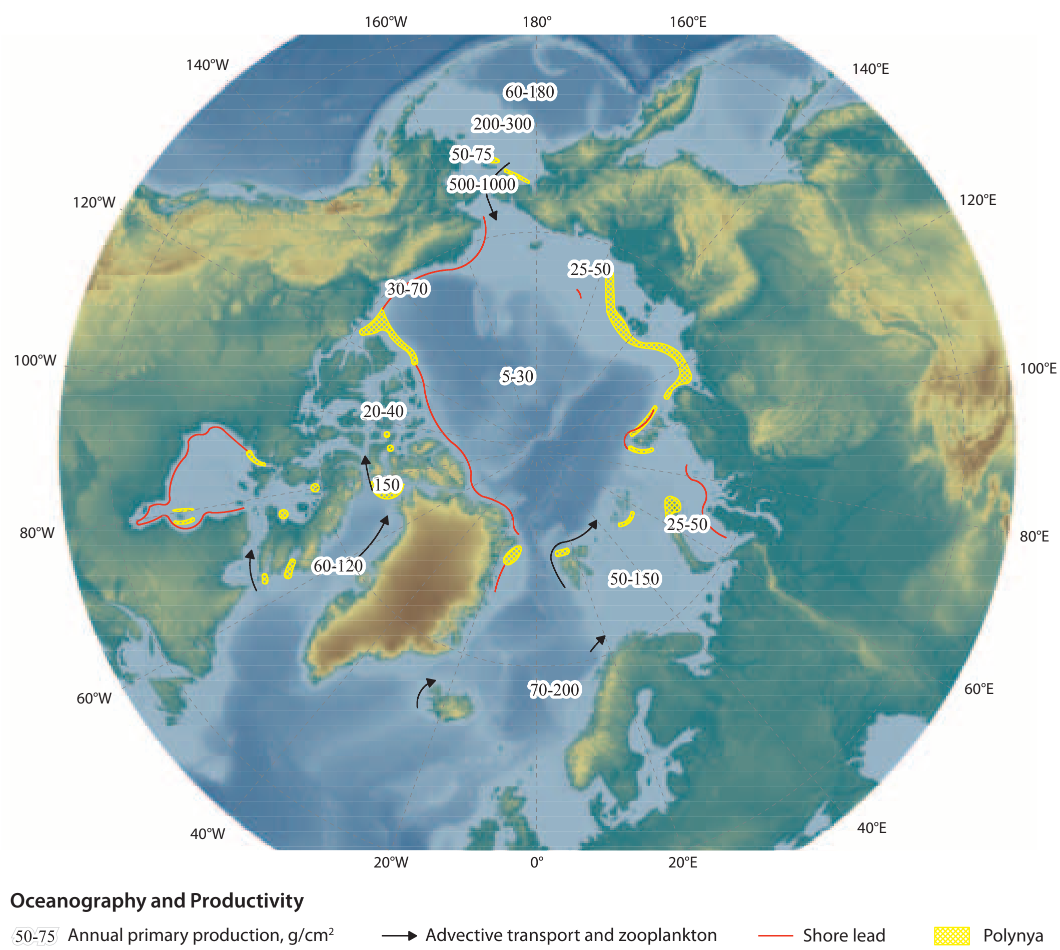


Figure A.1. Location of polynyas and leads and levels of annual primary production in the Arctic Ocean area.

latitudes. The mammals include nine species of baleen whales, 13 species of toothed whales, and 11 species of seals including walrus. Two species classified as terrestrial carnivores are also important Arctic species: polar bear and sea otter.

About 200 species of birds regularly occur in marine and coastal areas in the Arctic. There are about 70 species of seabirds (i.e., auks, gulls, terns, skuas, cormorants, storm-petrels, petrels and shearwaters, and albatrosses), most of them (about 50 species) restricted to the sub-Arctic region in the southern parts of the Arctic area (south of areas with sea ice and tundra). There are about 50 species of waterfowl (ducks, geese and swans) in the Arctic area, around 20 breeding in the High and Low Arctic. A total of about 70 species of shorebirds or waders occur within the Arctic area, with almost 40 breeding in the true Arctic.

More information on important Arctic species is given in Annex 2.

Species of marine mammals and birds in the Arctic area that are globally listed on the IUCN Red List of Threatened Species (IUCN, 2012) are shown in Tables A.4 and A.5.

Table A.4. Marine mammals in the Arctic area on the IUCN Red List of Threatened Species. The Red List evaluation is undertaken at the species level, that is, for the total global population of the species. For a given species, the conservation status may differ among specific populations or subpopulations. Source: IUCN (2012).

Category of 'Threatened'	Species	Latin name
Endangered	North Atlantic right whale	*Eubalaena glacialis*
	North Pacific right whale	*Eubalaena japonica*
	Blue whale	*Balaenoptera musculus*
	Fin whale	*Balaenoptera physalus*
	Sei whale	*Balaenoptera borealis*
	Sea otter	*Enhydra lutris*
Vulnerable	Sperm whale	*Physeter macrocephalus*
	Hooded seal	*Cystophora cristata*
	Northern fur seal	*Callorhinus ursinus*
	Polar bear	*Ursus maritimus*
Near Threatened	Beluga	*Delphinapterus leucas*
	Steller sea lion	*Eumetopias jubatus*
	Narwhal	*Monodon monoceros*

Table A.5. Arctic or Arctic-breeding seabirds, waterfowl and shorebirds on the IUCN Red List of Threatened Species. The Red List evaluation is undertaken at the species level, that is, for the total global population of the species. For a given species, the conservation status may differ among specific populations, subpopulations or subspecies. Source: IUCN (2012).

Category of 'Threatened'	Species	Latin name
Critically Endangered	Eskimo curlew[1]	*Numenius borealis*
	Kittlitz's murrelet	*Brachyramphus brevirostris*
	Spoon-billed sandpiper	*Eurynorhynchus pygmeus*
Endangered	Marbled murrelet	*Brachyramphus marmoratus*
	Red-breasted goose	*Branta ruficollis*
Vulnerable	Short-tailed albatross	*Phoebastria albatrus*
	Black-footed albatross	*Phoebastria nigripes*
	Pink-footed shearwater	*Puffinus creatopus*
	Red-legged kittiwake	*Rissa brevirostris*
	Lesser white-fronted goose	*Anser erythropus*
	Steller's eider	*Polysticta stelleri*
	Bristle-thighed curlew	*Numenius tahitiensis*
Near Threatened	Sooty shearwater	*Puffinus griseus*
	Ivory gull	*Pagophila eburnea*
	Laysan albatross	*Phoebastria immutabilis*
	Long-billed murrelet	*Brachyramphus perdix*
	Emperor goose	*Anser canagicus*
	Yellow-billed loon	*Gavia adamsii*
	Great snipe	*Gallinago media*
	Black-tailed godwit	*Limosa limosa*
	Buff-breasted sandpiper	*Tryngites subruficollis*

[1] Possibly extinct.

Areas of heightened ecological significance

In this assessment, areas of heightened ecological significance have been identified using three approaches. One approach is based on the areas identified in the AMAP assessment of oil and gas activities in the Arctic (the 'OGA approach'), while the other two approaches were the national processes used by Canada and Greenland/Denmark to identify such areas for their waters. The areas identified are briefly described in the following sections, organized by Arctic LME[1] (see also Figure A.2). Each area is characterized by a brief text that highlights why the area is important and the results are summarized in a set of tables and shown in a series of maps, one for each of the Arctic LMEs.

The areas identified as being of heightened ecological significance are in many cases composed of area components or subareas. Through the 'OGA approach' it was possible to separately identify areas that are used by fish, birds, and marine mammals. Overlapping or adjacent areas for fish, birds and mammals were grouped into larger areas. These are numbered consecutively (1, 2, 3, etc.) for each LME, and the numbers are used to identify areas on the maps and in the accompanying tables. In some cases, the specific areas do not fill the space of the larger areas, but are grouped nevertheless for convenience and comparability in the maps and tables.

The subareas within each area are shown on the maps with different symbols for different use categories (e.g., breeding area, migration corridor, etc) as explained in the legends. These subareas are numbered in three series: F for fish, B for birds, and M for marine mammals. The subarea numbers (e.g., F1, B1, M1, etc.) are shown on the maps and included in the accompanying tables. The subarea numbers correspond to the

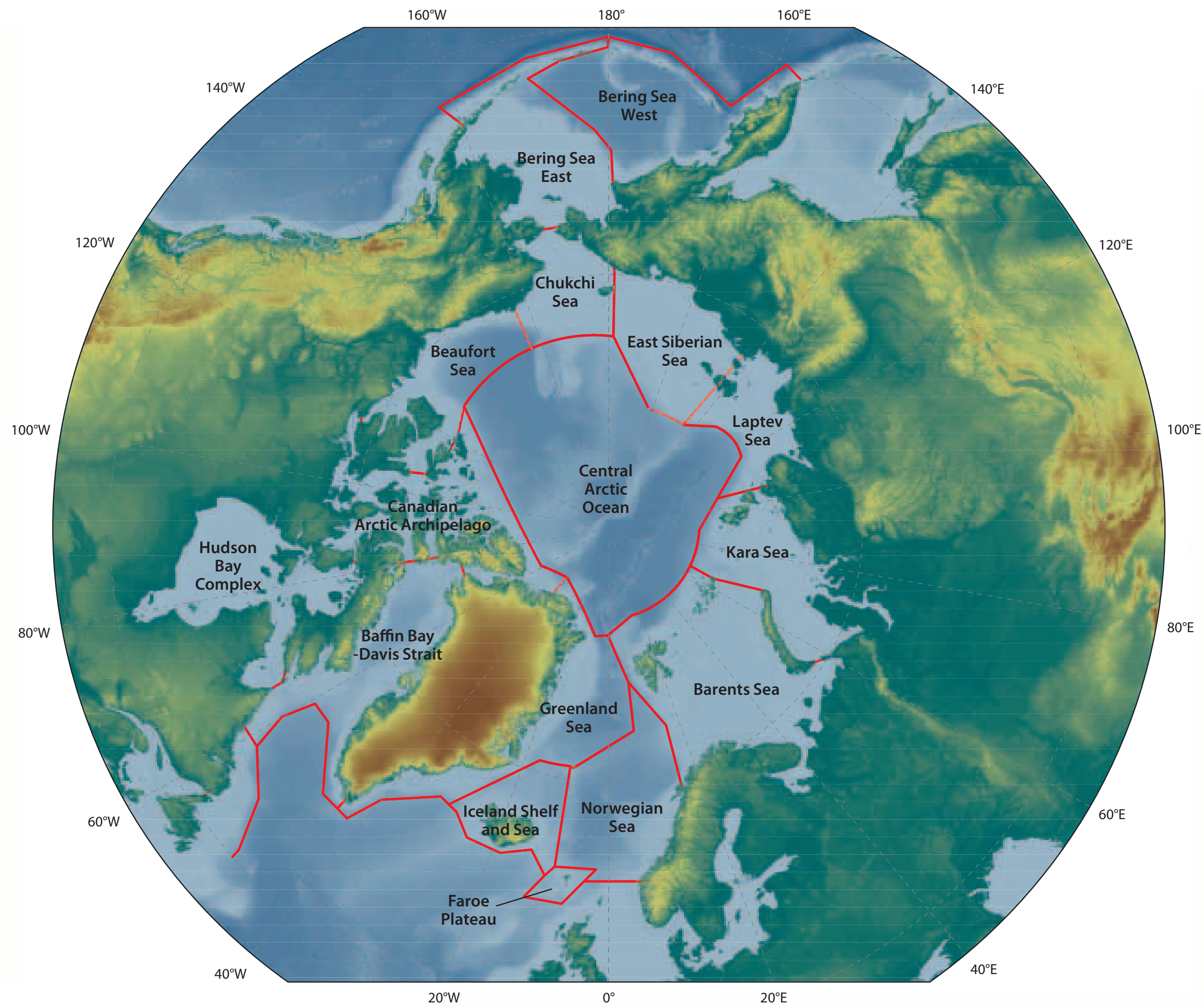


Figure A.2. Map of sixteen large marine ecosystems in the Arctic. Note: these are the LME boundaries prior to the revision agreed in May 2013 (PAME, 2013).

1 Although LMEs are used in this report for consistency across the entire Arctic, Canada, through a peer-review process, has selected similar, but not identical, biogeographic units as the basis of identifying its EBSAs and for planning and management in domestic waters. Canada will continue to use its own domestic system for domestic activities and in fulfilling commitments under the Arctic Council and other international fora.

index numbers used in Chapter 6 of the soon-to-be-published Volume 3 of the AMAP Oil and Gas Assessment (Skjoldal et al., in prep) and are identified in the tables under the column heading 'OGA No.'. This provides cross-reference to the Chapter 6 tables and texts that provide more information on the major species of fish, mammals and birds and the time of year when the areas are used.

The 'OGA approach' was used for the following LMEs: Iceland Shelf and Sea, Faroe Plateau, Norwegian Sea, Barents Sea, Kara Sea, Laptev Sea, East Siberian Sea, Chukchi Sea, East and West Bering Sea, and the Alaska portion of the Beaufort Sea LME.

The areas identified in the Canadian waters are EBSAs. They were grouped or linked into larger areas and numbered consecutively for each of the Canadian LMEs, in a manner similar to that used with the 'OGA approach'. The individual EBSAs that make up the larger areas are shown separately on the maps and listed in the tables with a numbering system for each area (1.1, 1.2, 2.1, 2.2, etc.). The original index numbers used to identify the EBSAs in Canada (e.g., B-3.14) are included in the tables for easy cross-reference to the information in source documents. Separate subareas or area components within each EBSA have not been identified. However, information on the use of the EBSAs by fish, birds and marine mammals, similar to that for the 'OGA areas', has been included in the tables for the Canadian areas.

The Canadian waters include the Canadian Arctic Archipelago LME, the Hudson Bay Complex LME, and the Canadian parts of the Beaufort Sea and Baffin Bay-Davis Strait LMEs.

For Greenland's waters, the areas identified have been numbered in an A series for areas in East Greenland (within the Greenland Sea LME) and in B and C series in West Greenland in the Baffin Bay-Davis Strait LME. The B areas are located along the coast on the inner shelf, while C areas are located (or include) offshore areas on the outer shelf and slope. The identified areas are shown on maps for the Greenland Sea and Baffin Bay-Davis Strait LMEs and listed in the accompanying tables for those LMEs. Separate subareas for fish, birds and mammals have not been identified but information on the use of the areas by these groups is provided in the text and tables for Greenland's waters. In addition, core areas have been identified within the larger areas and shown on the maps. The core areas are areas of highest importance within the larger areas, which all are considered to be of heightened ecological significance.

The Baffin Bay-Davis Strait LME includes Canadian and Greenlandic waters and the identified areas are somewhat different according to the two approaches used to identify and document them. Nevertheless, the information is comparable as illustrated by the entries in the table (see Table A.20) that provide details on the use of the areas by various groups of animals.

Iceland Shelf and Sea LME

Areas of heightened ecological significance in the Iceland Shelf and Sea LME are shown in Figure A.3, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.6.

Area 1 – Southwest/West Iceland

Coastal banks

Capelin and herring have demersal spawning areas on sandy bottoms along the southwestern and western coasts of Iceland, in the area southeast of the Reykjanes Peninsula to Vestmannaeyjar and in Faxaflói Bay between the Reykjanes and Snæfellness peninsulas. Capelin forms a large migratory population that feeds in the Iceland Sea north of Iceland in summer and is a key component of the marine ecosystem around Iceland. Herring of the Iceland summer spawning stock is also important both ecologically and commercially. This area also contains the main pelagic spawning grounds for cod of the large migratory Iceland cod stock.

Vestmannaeyjar

There are several important seabird breeding colonies on these islands off the coast of southwestern Iceland. Species include common murre, razorbill (*Alca torda*) and Atlantic puffin (*Fratercula arctica*).

Reykjanes Peninsula

There are several seabird colonies along the southern and western side of the Reykjanes Peninsula (that extends southwest from Reykjavik). These colonies are of moderate size and contain various species of seabird including auks and gulls.

Snæfellness Peninsula

This peninsula (between Faxaflói Bay and Breidafjördur) in western Iceland holds several smaller and moderate sized colonies of seabirds on its western end.

Faxaflói Bay

This wide bay between Reykjanes and Snæfellness along western Iceland contains large shallow areas in the inner part with many islets and skerries. This is an important breeding, feeding, molting, and wintering area for common eider. The area also contains large intertidal flats that are used as feeding and staging areas for shorebirds, including stop-over sites for migratory species such as red knot (*Calidris canutus,* ssp. *islandica*), dunlin (*Calidris alpina,* ssp. *arctica*), and common ringed plover (*Charadrius hiaticula*, ssp. *psammodroma*) between breeding areas in Greenland and wintering areas in western Europe and Africa. Important areas for shorebirds include Alftanes-Akrar, Alftanes-Skoganes, Hvalfjordur, Instavogsnes-Grunnafjördur, and Longafjördur.

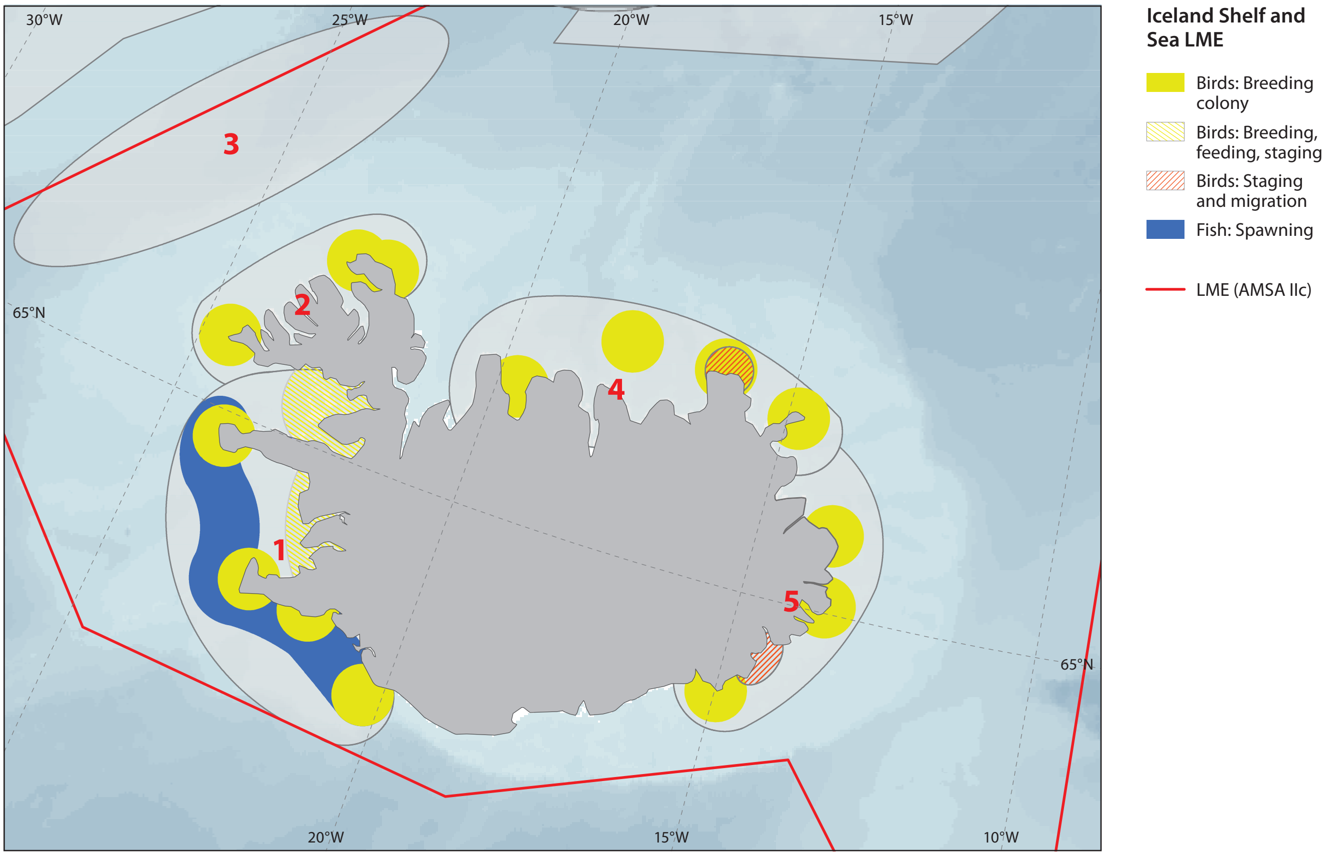


Figure A.3. Areas of heightened ecological significance in the Iceland Shelf and Sea LME.

Breidafjördur

This broad bay north of Snæfellness also contains large shallow areas with many islands and islets in the inner part. This area provides very important breeding, feeding, molting and wintering habitat for common eider in Iceland.

Area 2 – Northwest Iceland

Latrabjarg

Latrabjarg is located on Bjargtangar on the westernmost point in Iceland and holds one of the largest seabird colonies here. Both common and thick-billed murres breed in large numbers at this colony and use the adjacent sea areas for feeding and resting during the breeding season.

Hornbjarg and Hælavikubjarg

These are two large seabird colonies located on the northernmost part of the peninsula north of Isafjördur. Hornbjarg holds the largest numbers of breeding common and thick-billed murres in Iceland

Area 3 – Denmark Strait

Offshore waters

Denmark Strait is a migration corridor for seabirds such as thick-billed murre and ivory gull between breeding areas further north in the northeastern Atlantic sector and wintering areas along southern Greenland, Labrador and Newfoundland. The area is also part of the wintering area for seabirds such as ivory gull. The Endangered North Atlantic right whale which is found mainly along the US east coast may extend its summer feeding range north to Denmark Strait. The Denmark Strait area is also part of the feeding area for hooded seals of the population that breeds on sea ice in the Greenland Sea and that has declined markedly over recent decades.

Area 4 – North Iceland

Drangey, Grimsey, Langanes

There are several large seabird colonies in northern Iceland. Drangey is located in Skagafjördur in the western part and holds moderate numbers of common and thick-billed murres. Grimsey is an island off the coast on the shelf and holds the largest seabird colony in northern Iceland with a relatively large number of thick-billed murres. Langanes is located on the easternmost peninsula in northern Iceland.

Melrakkasletta

Melrakkasletta is the northernmost peninsula in Iceland and along its northern end there are intertidal areas that are important feeding and staging areas for many shorebirds. It is used as a stop-over area for migratory populations of red knot (*C. c. islandica*) and ruddy turnstone (*Arenaria interpres*) that breed in northern Greenland and the northeasternmost part of Canada.

Table A.6. Areas of heightened ecological significance within the Iceland Shelf and Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		Ecological function	PSSA Criteria										
No	Location		Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Coastal banks	Fish spawning areas; capelin, herring, cod	×	×				×	×	×		×	×
	Vestmannaeyjar	Seabird breeding colonies, summer feeding areas		×				×	×	×		×	
	Reykjanes Peninsula	Seabird breeding colonies, summer feeding areas		×				×	×	×		×	
	Snæfellness Peninsula	Seabird breeding colonies, summer feeding areas		×				×	×	×		×	
	Faxaflói Bay	Waterfowl breeding, feeding, molting and wintering; common eider. Shorebird feeding and staging areas	×	×	×		×	×	×	×		×	×
	Breidafjördur	Waterfowl breeding, feeding, molting and wintering; common eider. Shorebird feeding and staging areas	×	×	×		×	×	×	×		×	×
2	Latrabjarg	Seabird breeding colonies, summer feeding areas	×	×				×	×	×		×	×
	Hornbjarg and Hælavikubjarg	Seabird breeding colonies, summer feeding areas	×	×				×	×	×		×	×
3	Offshore waters	Seabird migration and wintering; ivory gull, thick-billed murre. Summer feeding, North Atlantic right whale. Feeding area, hooded seal		×	×		×	×		×		×	
4	Drangey, Grimsey, Langanes	Seabird breeding colonies, summer feeding areas		×				×	×	×		×	
	Melrakkasletta	Shorebird feeding and staging areas	×	×						×		×	×
5	Skrudur	Seabird breeding colonies, summer feeding areas		×					×	×		×	
	Skardsfjördur	Shorebird feeding and staging areas		×					×	×		×	×

Area 5 – East Iceland

Skrudur

Skrudur is located at the island Papey off the east coast of Iceland. This is the largest seabird colony in East Iceland. There are also several smaller colonies located along the coast north of Skrudur and to the south at Stokksnes east of Höfn.

Skardsfjördur

Intertidal areas in Skardsfjördur are used as feeding and staging areas for shorebirds. Migratory dunlin from breeding areas at Iceland and Greenland use this site for stop-over and staging.

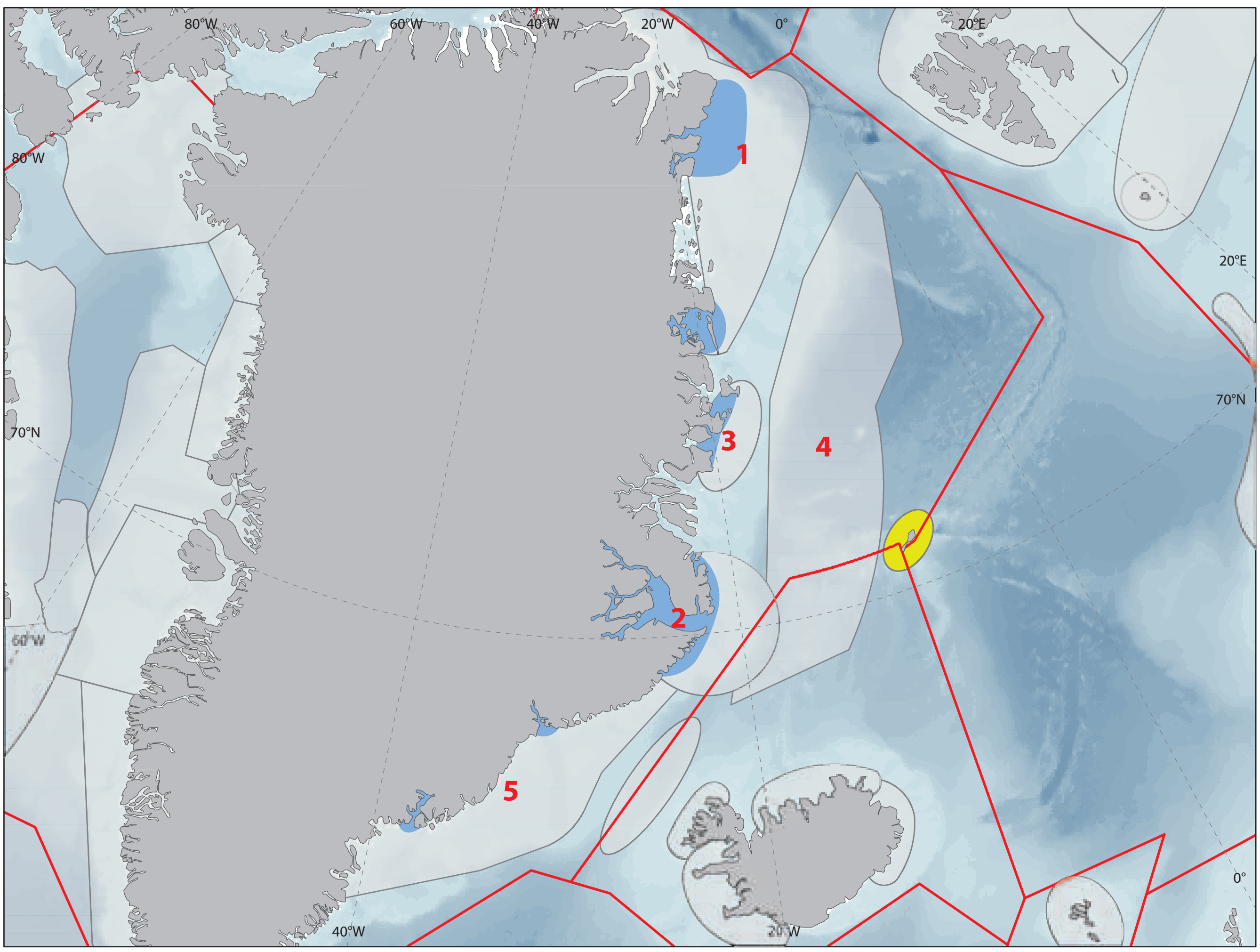
Greenland Sea LME

Areas of heightened ecological significance in the Greenland Sea LME are shown in Figure A.4, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.7.

Area 1 – Northeast Water polynya area and Peary Land

The very large (~45 000 km^2) and remote Northeast Water polynya is located off the northeastern corner of Greenland. The polynya is kept more or less open for a major part of the year by the southward current from Fram Strait forming a large local gyre (latent heat polynya). The ice edges and currents contribute to an early primary production important for several species. The coastlines and fjords north and south of the polynya contain important areas for seabirds and marine mammals:

- The northernmost breeding colonies, albeit small, of black-legged kittiwake (*Rissa tridactyla*) and northern fulmar are found along the coastline of the polynya (Christensen et al., 2012).
- The biggest known breeding colony of ivory gull (about 300 birds) in Greenland is found on Henrik Krøyer Holme. Other ivory gull colonies are found on Kronprins Christians Land and Peary Land (Boertmann and Mosbech, 2011b).
- Ross's gull (*Rhodostethia rosea*; in low numbers), Sabine's gull (*Xema sabini*) and Arctic tern (*Sterna paradisaea*) breed on Henrik Krøyer Holme. Sabine's gull and Arctic tern also breed in relatively large numbers along the coastline of Kilen (Boertmann and Mosbech, 2011b).
- The northern part is used as staging and foraging area by Ross's gull in July – September (Falk et al., 1997; Meltofte et al., 1981).
- The polynya is a pre-breeding staging area for seaducks and also serves as a feeding area during the breeding period. The banks in the northern part of the polynya (off Kilen) are especially important spring staging areas for king and common eiders (Boertmann and Mosbech, 2011b).
- New observations indicate that relatively large numbers of bowhead whales from the Critically Endangered Spitsbergen stock reside in the area in the summer months (Boertmann et al., 2009b).



Greenland Sea LME

Core area — Jan Mayen: bird breeding colony — LME (AMSA IIc)

Figure A.4. Areas of heightened ecological significance in the Greenland Sea LME.

Table A.7. Areas of heightened ecological significance within the Greenland Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		Ecological function	PSSA criteria										
No.	Location		Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Northeast Water polynya area and Peary Land	Important walrus and polar bear habitat	×	×	×		×	×	×	×	×	×	
		Pre-breeding staging area for seaducks and feeding area during the breeding period for seabirds and seaducks.											
2	Scoresby Sund fjord and adjacent fjord areas on Blosseville Coast	Narwhal of the Northeast Atlantic stock (or stocks) have summering areas. Foraging area for the Critically Endangered Spitsbergen stock of bowhead whale.	×	×	×	×	×	×	×	×	×	×	×
		Molting and staging area for seabirds											
3	Sirius Water/ Young Sund Polynya	Feeding grounds for walrus, polar bears and bowhead whale		×	×				×	×		×	
		Staging area for spring migrating water birds											
4	Sea ice in the western Greenland Sea	Whelping area for harp and hooded seals from the 'West Ice' populations and polar bear habitat	×	×	×				×	×		×	
		Seabirds migration corridor in late summer and autumn											
5	Southeastern Greenland and Denmark Strait	Narwhal summering area, walrus wintering area, hooded seal molting area		×	×				×	×		×	
		Staging, breeding and molting area for seabirds											
		Migration corridor for seabirds											

- Narwhal is common especially in the southern part of the area (Merkel et al., 2010).
- The Northeast Water polynya is a very important walrus habitat: the majority of the females of the NE Greenland stock occur here all year round and most of the calves are born and raised here. The area is also a very important winter habitat and males from the entire NE Greenland population migrate to the area. The number of animals in the Northeast Water polynya was estimated at 873 animals (on the ice) in 2009; the whole population was estimated to be 1500 animals (Born et al., 2009a).
- A significant proportion of the global polar bear population is utilizing the entire NE Greenland region, including the Northeast Water polynya and the pack ice between Greenland and Svalbard, although with shifting core areas over the year. Data from satellite telemetry indicate that denning areas occur along the coastlines of the Northeast Water polynya.

Area 2 – Scoresby Sund fjord and adjacent fjord areas on Blosseville Coast

- The fjords and the surrounding sea areas in the Scoresby Sund area are very important to several species. A polynya with a well defined ice edge occurs close to the mouth of the fjord. Also a shear zone may occur (with open cracks and leads) between the landfast ice and the drift ice. In summer the adjacent fjords and coastlines, including the Blosseville Coast, are important for some species.
- Narwhal of the Northeast Atlantic stock (or stocks) have summering areas in fjords in the Scoresby Sund area and further south along the Blosseville Coast. The population in the southern part of East Greenland (Scoresby Sund, Kangerlussuaq and Tasiilaq) was estimated at 6444

animals (Heide-Jørgensen et al., 2010) in 2008. Narwhal are numerous at the ice edge at the mouth of Scoresby Sund in spring until the fjord opens.

- The water east of Scoresby Sund is probably an important foraging area for the Critically Endangered Spitsbergen stock of bowhead whale (Gilg and Born, 2005).
- Polar bear frequently occur in the polynya at the entrance to Scoresby Sund and the Blosseville Coast, and the inner parts of the Scoresby Sund fjord complex are regularly used for maternity denning (Boertmann and Mosbech, 2011b).
- The polynya at the mouth of Scoresby Sund is an important seabird habitat where high concentrations of seabirds may be found in spring and summer, including common and king eiders and millions of little auks. The polynya is also important staging habitat for migrant waterfowl (some of which breed inland) in spring. The largest concentrations of breeding colonial seabirds in East Greenland are found on the coasts of the Scoresby Sund polynya, where an estimated 3.5 million little auks breed in a large number of colonies, several thousand thick-billed murres breed in two colonies (the only colonies in East Greenland), and a few thousand black-legged kittiwakes also breed in this area (Boertmann and Mosbech, 2011b).
- Ivory gull breeds in small numbers on nunataks at the Blosseville Coast (Christensen et al., 2012).
- The coastline along the Blosseville Coast is an important molting and staging area for common and king eiders (Merkel et al., 2010).

Area 3 – Sirius Water/Young Sund Polynya

This relatively small polynya is located further north from Scoresby Sund in Northeast Greenland. It creates conditions for a relatively diverse and productive ecosystem and the area is an important breeding and staging area for many species:

- The polynya is important as staging area for spring migrating waterbirds with common eider as the most important species; about 14 000 common eiders, 200 king eiders and 1500 long-tailed ducks were counted here during a survey in spring 2008. It is also important for breeding seabirds with Arctic tern, Sabine's gull, kittiwake and common eider as the most important (Boertmann et al., 2009a). About 3000 pairs of common eider breed in this area (Boertmann and Mosbech, 2011b).
- Sabine's gull concentrations occur along the coast, including one of the largest colonies in Greenland (about 300 birds) together with Arctic tern in Young Sund (Christensen et al., 2012).
- High numbers of ivory gulls migrate through the area in spring and autumn (Christensen et al., 2012).
- The coastal waters and banks in this area are important feeding grounds for walrus. The East Greenland stock (about 1500 animals) use several haul-outs along the coast during the summer season, north from about 75° N (Born et al., 2009a; NAMMCO, 2009).
- The coast serves as a denning area for polar bears which also occur in the ice-covered waters off the coast.
- Bowhead whales from the Critically Endangered Spitsbergen population occur regularly (Boertmann and Mosbech, 2011b).

Area 4 – Sea ice in the western Greenland Sea

The drift ice zone in the general areas northwest and west of Jan Mayen contains early spring foraging conditions for migrant seabirds and mammals. The area is significant because:

- Harp and hooded seals from the 'West Ice' populations assemble in a common whelping area in March and April. About 600 000 to 700 000 adult harp seal (and about 100 000 pups) and 70 000 adult hooded seal (and about 15 000 pups) are dependent on the ice here. The female seals remain with their pups on the ice for a period of about 12 and four days, respectively, before the pups are left alone. The seals aggregate some months later to molt on the pack ice to the north of the whelping areas (Aastrup and Boertmann, 2009).
- The western Greenland Sea is a wide migration corridor in late summer and autumn for large numbers of seabirds from breeding areas in the Barents Sea on their way to winter quarters in Davis Strait and the northern Labrador Sea. These birds include thick-billed murres (more than 1.5 million adults and several hundred thousand flightless chicks) and little auks (more than one million); the major part of the global population of ivory gulls follows this route. The first weeks of the migration is for the murres a swimming migration, when the adult birds are flightless due to molt and the chicks are not yet able to fly (Boertmann and Mosbech, 2011b).
- The entire drift ice zone is an important polar bear habitat. Densities vary across the area and over the year, largely governed by fluctuations in the distribution and density of ice and prey (Boertmann and Mosbech, 2011b).

Area 5 – Southeastern Greenland and Denmark Strait

The East Greenland Current carries cold and low salinity polar surface water and the polar pack ice southward along the East Greenland coast which is strongly influenced by the drift ice ('storis') during spring and summer. A branch of the warmer North Atlantic Current turns west and southward toward Greenland, flowing parallel to the East Greenland Current. Here a relatively productive area occurs around Dohrn Bank. The area contains:

- In the central parts of Denmark Strait (Dohrn Bank etc.) the Critically Endangered North Atlantic right whale has been observed several times and the area is regarded as a critical habitat for this species (Boertmann and Mosbech, 2011b).
- The Iceland-East Greenland-Jan Mayen capelin stock undertakes extensive feeding migrations into the Denmark Strait during summer. Also Greenland halibut (*Reinhardtius*

hippoglossoides) as well as Atlantic cod (trawling) fishing grounds occur in the area (Boertmann and Mosbech, 2011b).

- Large numbers of summering narwhal are known to occur in some of the fjords, particularly Kangerlussuaq (Boertmann and Mosbech, 2011b).
- Other toothed whales (primarily sperm whale *Physeter macrocephalus* and northern bottlenose whale *Hyperoodon ampullatus*) are known to occur in the eastern part of the area, and the baleen whales blue-, fin- and sei whales are also frequent (Boertmann and Mosbech, 2011b).
- The area is part of the general wintering range for walrus (Boertmann and Mosbech, 2011b).
- The pack ice along the entire southeastern Greenland coast is an important molting area for hooded seal in June – September (Andersen et al., 2009).
- The area around Kangerlussuaq holds polar bear maternity dens (Laidre et al., 2010a).
- The coastline and ice edge along southern Greenland are important for ivory gull. During the summer months the Blosseville Coast (including the northern part of this area) is used by foraging breeders, whereas the same area is used for staging of migrating birds from the northeastern Greenland and Svalbard breeding populations. The southern part of the area is an important winter quarter (Gilg et al., 2010).
- The entire coastline (and further south to Cape Farewell) is used by common eider in spring and summer (more than 18 000 birds have been recorded): staging and molting birds occur in small flocks with the highest concentrations in the fjords of the Blosseville Coast. Some may be from the Icelandic breeding population. Also a local breeding population (about 3200 pairs) is dispersed in many colonies along the coast (Merkel et al., 2010).
- The little auks breeding in Scoresby Sund and Svalbard (millions) and thick-billed murres from Svalbard, Jan Mayen and Iceland use the Irminger current through this area during their migration to wintering grounds in West Greenland and eastern Canada (Boertmann and Mosbech, 2011b).
- From August to November (most in August immediately after the breeding season) a proportion of the black-legged kittiwakes in the North East Atlantic occur in the eastern part of this area between Iceland and Greenland (Christensen et al., 2012).

Faroe Plateau LME

Areas of heightened ecological significance in the Faroe Plateau LME are shown in Figure A.5, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.8.

Area 1 – Faroe Islands

The waters around the Faroe Islands are important areas for birds that breed and visit this area. The Faroe Islands are home to about 1.7 million breeding pairs of seabirds with northern fulmar, Atlantic puffin (*Fratercula arctica*), European storm-petrel (*Hydrobates pelagicus*), black-legged kittiwake and common murre as the most numerous species. There are 18 major breeding colonies, all of them of international importance. The waters around the archipelago are used as foraging areas for the breeding birds as well as by large numbers of non-breeding birds. Common eider breeds at the Faroe Islands with a separate and endemic subspecies (*S. m. faeroeensis*) which is resident around the islands year-round. The sensitivity to oil spills and disturbances is greatest during the breeding season in summer, but the waters around the Faroe Islands hold large numbers of seabirds also outside the breeding season, including wintering birds from breeding colonies further north.

Table A.8. Area of heightened ecological significance within the Faroe Plateau LME, the ecological function, and the extent to which the area meets the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		OGA No.	Ecological function	PSSA criteria										
No.	Location			Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Faroe Islands	1	Seabirds breeding and feeding areas	×	×	×		×	×	×	×	×	×	×

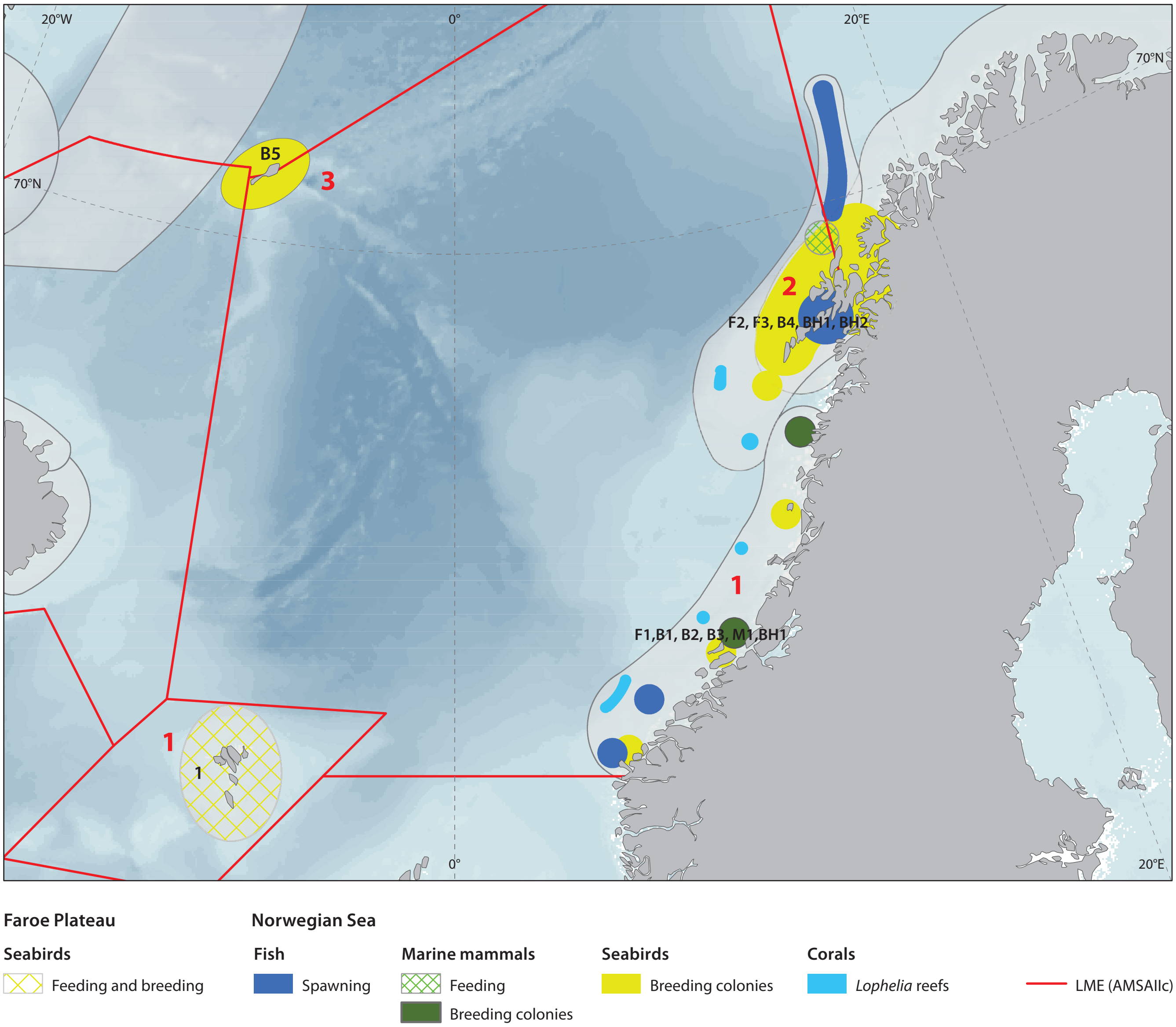


Figure A.5. Areas of heightened ecological significance in the Faroe Plateau LME and the Norwegian Sea LME.

Norwegian Sea LME

Areas of heightened ecological significance in the Norwegian Sea LME are shown in Figure A.5, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.9.

Area 1 – Norwegian coast and shelf – Møre-Helgeland

The main spawning grounds for the large Norwegian spring spawning herring stock are on coastal banks off the county of Møre adjacent to the southeastern Norwegian Sea (F1). This is an area where the shelf is relatively narrow with a steep slope to the deep-water. There are large seabird colonies in this area, notably on the island of Runde just off the coast (B1). There are also important seabird colonies further north on archipelagoes at the coasts of Trøndelag and Helgeland (B2, B3). Atlantic puffin is a major species along with gulls, cormorants and others. There are also many common eider along this coast.

Harbor (*Phoca vitulina*) and gray (*Halichoerus grypus*) seals occur along the coast with larger colonies at the Froan archipelago in Trøndelag and at the coast of Helgeland further north (M1).

There are several large reefs or reef complexes of the cold water coral *Lophelia* on the shelf along the eastern Norwegian Sea (BH1).

Area 2 – Lofoten area

Lofoten is the main spawning area for the large stock of Atlantic cod in the Barents Sea. Spawning takes place both on the inner side of the Lofoten archipelago in Vestfjorden and on the shelf outside in Vesteraalen (F2). Greenland halibut of the Barents Sea stock spawns along the steep slope in this area (F3).

Table A.9. Areas of heightened ecological significance within the Norwegian Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		OGA No.	Ecological function	Month/ Season	PSSA criteria										
No.	Location				Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Norwegian coast and shelf – Møre-Helgeland	F1	Herring spawning area	II-III	×	×	×				×	×		×	×
		B1-3	Seabird breeding colonies		×	×	×			×	×	×		×	×
		M1	Seal colonies			×					×	×		×	
		BH1	Cold-water *Lophelia* reefs	I-XII	×	×	×	×	×	×			×	×	×
2	Lofoten area	F2	Spawning area for Barents Sea cod	II-IV	×	×	×			×	×	×		×	×
		F3	Spawning area Greenland halibut	Winter		×					×	×			
		B4	Seabird breeding colonies	Summer	×	×	×			×	×	×		×	×
		BH1	Cold-water *Lophelia* reefs	I-XII		×	×		×	×			×	×	
		BH2	Canyon (Bleiksdjupet)	Spring-Summer	×	×	×					×			
3	Jan Mayen	B5	Seabird breeding colonies		×	×	×			×	×	×	×	×	×

The Lofoten area is important for seabirds, particularly in the outermost part of the Lofoten archipelago where there are large colonies at the island of Røst (B4). Atlantic puffin is particularly abundant here along with many other species of seabirds.

The largest known *Lophelia* reef (Røst-revet) lies at the shelf edge west of Røst (BH1). Further north where the shelf is very narrow off Andøya, there is a pronounced canyon (Bleiksdjupet) running down the continental slope (BH2). This area is an important feeding area for whales, notably sperm whales that dive to feed on deep-water squid and fish.

Area 3 – Jan Mayen

Important habitats of conservation concern for seabirds in this LME include the seabird breeding areas on the island of Jan Mayen (B5), the most remote island in the Arctic in terms of distance to other land.

Barents Sea LME

Areas of heightened ecological significance in the Barents Sea LME are shown in Figure A.6, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.10.

Area 1 – Pechora Sea

Polar cod (*Boreogadus saida*) is widely distributed in the cold water masses of the northern and eastern Barents Sea and

Kara Sea. The main polar cod stock has its spawning area in the Pechora Sea where the fish aggregate to spawn under the ice in winter (mainly in January–February) (F1). Herring of the Chesh-Pechora stock spawn demersal eggs in shallow waters in Cheskaya Bay (F3).

The shallow waters from Cheskaya Bay east of the Kanin Peninsula and along the southern shore of the Pechora Sea have fast ice in winter and are an important breeding area for ringed seals from the eastern Barents Sea as well as from the western Kara Sea (M4). The pack ice in the southeastern Barents Sea is presumably important for young ringed seals that aggregate to feed on the polar cod that spawn under the ice in this area.

The main wintering areas for walrus of the 'Kara Sea-southern Barents Sea-Novaya Zemlya' stock and for beluga of the large Karskaya stock are in the pack ice in the Pechora Sea region (M8).

Some walrus remain in this area during summer with main haul-outs on Vaigach and Dolgy islands and adjacent small islands (M9).

The coastal lowlands and intertidal zone along the southern shore of the Pechora Sea contain important molting and staging areas for geese (dark-bellied brent goose *Branta bernicla bernicla*, barnacle goose *Branta leucopsis*, and others) and many shorebirds (B10). The shallow waters along these coasts are also molting and staging areas for seaducks including king eider and scoters (*Melanitta* spp.), and staging area for thick-billed murre for birds from a wider breeding area further east and north (B11). Rich benthos communities support the abundant seaducks and walruses in these waters.

Pechora Bay is an important feeding area for several species of coregonid whitefish, and the coastal waters including Pechora Bay are important for large migratory populations of wild Atlantic salmon (*Salmo salar*).

Area 2 – Norwegian and Murman coasts

The Barents Sea capelin stock has its spawning grounds on coastal banks along the coast of northern Norway (Troms and Finnmark counties) and the Murman coast (F2).

The coasts of northern Norway and Murman hold large breeding colonies of seabirds including Atlantic puffins, razorbills, common and thick-billed murres, black-legged kittiwakes, great cormorants (*Phalacrocorax carbo*), European shags (*P. aristotelis*), and common eiders (B6, B7). These coasts which are largely ice-free are also wintering areas for some seabirds and seaducks, notably common and king eiders, long-tailed duck, and also the western population of the 'Vulnerable' Steller's eider (*Polysticta stelleri*) (B12).

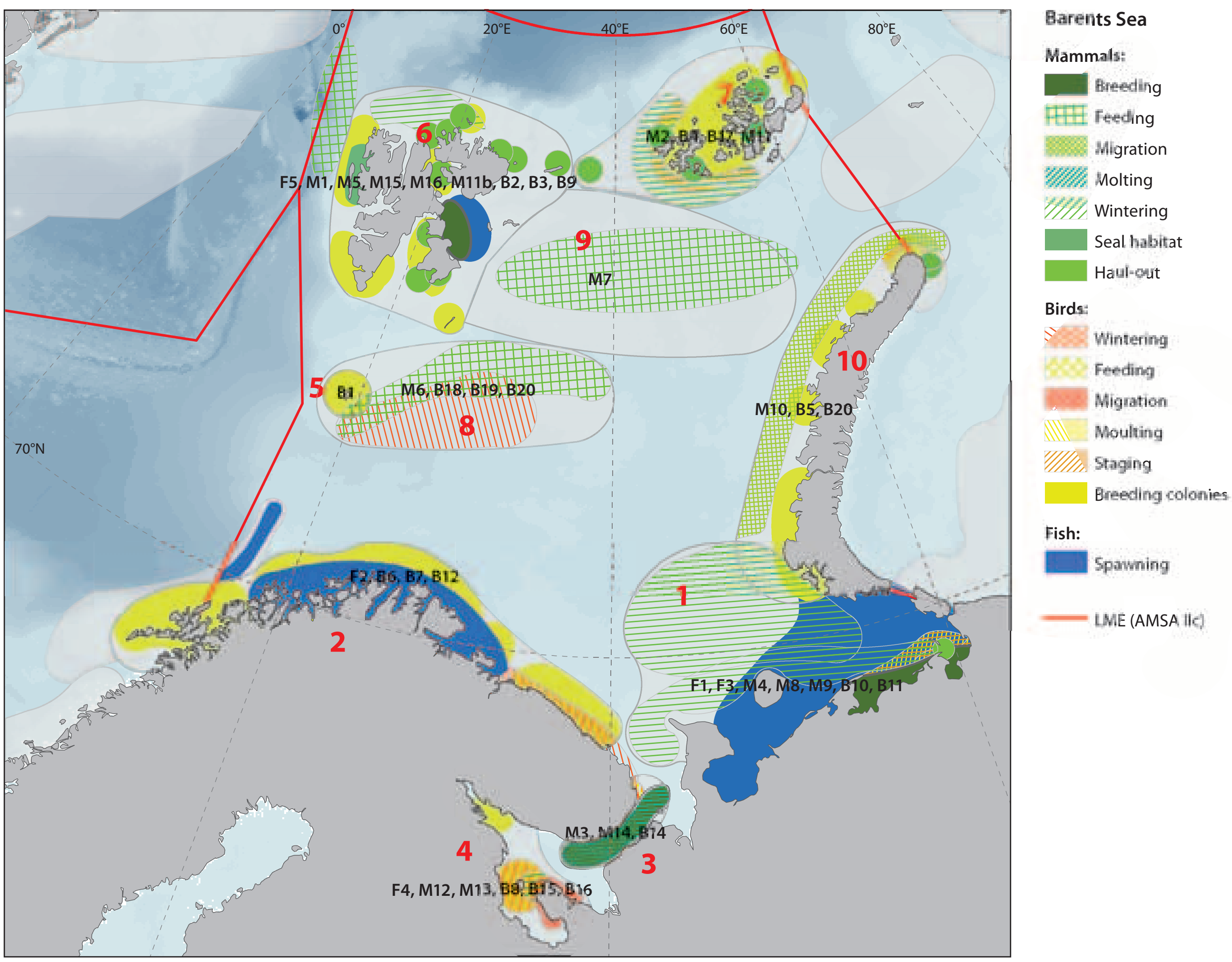


Figure A.6. Areas of heightened ecological significance in the Barents Sea LME.

Table A.10. Areas of heightened ecological significance within the Barents Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		OGA No.	Ecological function	Month/ Season	PSSA criteria										
No.	Location				Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Pechora Sea		Beluga wintering area	Winter		×					×	×		×	
		F1	Spawning area polar cod	I-II	×	×	×				×	×		×	×
		F3	Spawning area herring			×	×				×	×		×	
		M4	Ringed seal breeding area	Winter		×	×				×	×		×	
		M8	Walrus wintering area	Winter		×	×				×	×		×	
		M9	Walrus feeding and haul-out	Summer		×	×			×		×		×	
		B10	Molting and staging areas for waterfowl		×	×	×			×	×	×		×	×
		B11	Molting and staging area for seaducks, staging area for auks		×	×	×				×	×		×	×
2	Norwegian and Murman coasts	F2	Spawning area capelin	II-IV	×	×	×			×	×	×		×	×
		B6	Seabird breeding colonies			×					×	×		×	
		B7	Seabird breeding colonies			×					×	×		×	
		B12	Wintering area seaducks	Winter		×					×	×		×	
3	Entrance and northern White Sea	M3	Harp seal whelping and molting areas	Late winter	×	×	×				×	×		×	×
		M14	Beluga wintering area	Winter		×					×	×		×	
		B14	Seaducks molting and wintering area			×					×	×		×	
4	White Sea (Kandalaksha, Onega, Dvina bays)	F4	Spawning area herring			×	×				×	×		×	×
		M12	Beluga wintering area	Winter		×	×				×	×		×	×
		M13	Beluga summering area	Summer	×	×					×	×		×	×
		B8	Breeding colonies seabirds and eiders			×			×		×	×		×	
		B15	Seaducks molting and wintering area			×	×				×	×		×	
		B16	Ducks, geese and swans - staging area during spring and autumn migration	Spring		×	×				×	×		×	×
5	Bear Island	B1	Seabirds breeding colonies			×					×	×		×	
6	Svalbard Archipelago	F5	Spawning area for polar cod	Winter		×	×				×	×		×	
		M1	Potential wintering area narwhal and bowhead	Winter	×	×	×				×	×		×	×
		M5	Harbor seal habitat year-round		×	×				×	×	×		×	×
		M11b	Walrus feeding and haul-out			×	×			×	×	×		×	
		M15	Ringed seal breeding area	Winter		×	×			×	×	×		×	
		M16	Feeding area for bowhead, blue whale, minke whale		×	×	×			×	×	×		×	×
		B2 a,b,c	Seabird breeding colonies	Summer		×				×	×	×		×	
		B3 a,b,c	Seabird breeding colonies	Summer	×	×				×	×	×		×	×
		B9	Molting areas seaducks and geese	Late summer		×	×			×		×		×	
7	Franz Josef Land	M2	Wintering area bowhead and walrus	Winter	×	×	×				×	×		×	×
		B4	Seabird breeding colonies		×	×	×				×	×		×	×
		M11	Walrus feeding and haul-out			×				×		×		×	
		B17	Staging area for seabirds	Spring		×	×				×	×		×	×

Area No.	Area Location	OGA No.	Ecological function	Month/ Season	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
8	Western and central Barents Sea	M6	Feeding area - polar bear and harp seal	Spring-early Summer		×	×			×		×		×	
		B18	Feeding area for seabirds	Summer		×	×			×		×		×	
		B19	Seabird wintering area	Winter	×	×					×	×		×	
		B20	Molting area and swimming migration auks	Late summer		×					×	×		×	
9	Northern Barents Sea - marginal ice zone	M7	Polar bear feeding area	Summer-Autumn		×	×				×	×		×	
10	Western Novaya Zemlya	M10	Spring migration corridor for beluga and possibly walrus			×					×	×		×	
		B5	Seabird breeding colonies			×					×	×		×	
		B20	Swimming migration auks	Late summer		×					×	×		×	

Area 3 – Entrance and northern White Sea

Harp seal has its whelping and molting areas on the pack ice in late winter (February–April) at the entrance region (Funnel) and further into the northern White Sea (M3). Here the whole adult population of the large Barents Sea/White Sea stock occurs concentrated at this time of the year. The seals aggregate later in spring to molt on the ice north of the main breeding areas.

The White Sea beluga population has its wintering area in the Voronka and Gorlo ('Funnel' and 'Throat') area at the entrance to the White Sea (M14). In spring the beluga migrate into the White Sea to feed during summer when they occur most frequently in the Dvina and Onega Bays (M13). The spring migration route before ice clearance could be a vulnerable area as could some of the summer feeding areas with concentrations of beluga.

The inshore waters of the Tersky coast (along the eastern Kola Peninsula) are a molting and wintering area for seaducks including all three species of eider (common, king and Steller's) (B14).

Area 4 – White Sea (Kandalaksha, Onega and Dvina bays)

Herring of the White Sea stock (Pacific herring) has its main spawning area in the northern part of Onega Bay (F4).

Beluga in the White Sea may belong to three or more stocks with distinct summer feeding areas in Dvina and Onega bays (M13). Beluga may also winter in leads and polynyas in northern Onega Bay (M12).

There are breeding colonies of common eider, herring and lesser black-backed gull (*Larus fuscus*), Arctic tern and other species in Kandalaksha and Onega bays (B8). Onega Bay is an important molting and wintering area for common eider (B15). Onega and Dvina bays provide important staging habitat for ducks, geese and swans using the White Sea-Baltic branch of the East-Atlantic Flyway during spring and autumn migrations (B16).

Area 5 – Bear Island

Bear Island (Bjørnøya), which is the southernmost island of Svalbard, is an important area for seabirds with large mixed breeding colonies of thick-billed and common murres and black-legged kittiwake (B1). Razorbill, little auk, northern fulmar and glaucous gull (*Larus hyperboreus*) also breed on this island. Barnacle geese and light-bellied brent geese (*Branta bernicla hrota*) stage on Bear Island before they continue their southward migration in the autumn.

Area 6 – Svalbard Archipelago

There is a separate stock or stock component of polar cod (*Boreogadus saida*) in the Svalbard area. The location of the spawning area is not well known but is likely to be east of Svalbard in the area between Nordaustlandet, Kong Karls Land and Edgeøya (F5).

The Whalers Bay Polynya north of Svalbard is a potential wintering area for narwhal and bowhead whale of the Critically Endangered Spitsbergen stock (M1). Walrus winter in leads and polynyas along northern and eastern Svalbard, and beluga also winter in the Svalbard area. The northern and eastern parts of Svalbard contain important haul-outs and summer feeding areas for walrus (M11b).

The waters off northwestern Spitsbergen used to be a major early season feeding area for the large Spitsbergen stock of bowhead whales that was hunted to near extinction. The area is still important for this stock which is now very low and Critically Endangered. The area is also used as a summer feeding area by the Endangered blue whale (M16).

The eastern part of Svalbard including Kong Karls Land is an important denning area for polar bear.

Harbor seal occurs with a resident population in western Svalbard, mainly on Prins Karls Forland (M5). This population numbers about 1000 animals and is the northernmost occurrence of harbor seal (to about 80˚ N).

Ringed seal breeds in fast ice in many fjords around the Svalbard archipelago. The largest area of fast ice is in eastern Svalbard between Nordautslandet, Kong Karls Land and the Barents Island. This is in the same general area as the assumed location of the spawning area for the Svalbard polar cod stock component and is possibly an important breeding habitat for ringed seal (M15).

Svalbard holds large numbers of seabirds in the summer season. The largest breeding aggregations of seabirds are found in the northwestern (B3a) and southwestern and southeastern parts of the archipelago (B2a). There are also seabird breeding aggregations along western and southern Edgeøya (B2b), at Hopen (B2c), in the Hinlopenstredet (B3b) and north of Nordaustlandet (B3c). Major species in these colonies are dovekie (*Alle alle*), thick-billed murre, northern fulmar, Atlantic puffin, and black-legged kittiwake.

Seaducks and geese molt at several locations along the coasts of Svalbard mainly on the western and southern sides (B9). Important molting areas for common eider are found at the outer part of the west coast, at Prins Karls Forland and south of the Isfjord. King eider males aggregate and migrate after breeding to molting areas along the southwest coast between Hornsund and Sørkapp.

Area 7 – Franz Josef Land

Polynyas at Franz Josef Land, particularly on the southwest side, constitute wintering habitat for walrus of the Svalbard-Franz Josef Land stock and bowhead whale of the Critically Endangered Spitsbergen stock (M2). Narwhal may also possibly winter in this area. They are commonly seen at Franz Josef Land during the summer season with most observations in the deep water of Cambridge Channel. Franz Josef Land is an important part of the feeding area for walrus, particularly for females and young animals, and there are many haul-outs on land used by walrus in late summer and autumn (M11). Victoria Island to the west of Franz Josef Land is another major haul-out for Atlantic walrus.

There are many seabird colonies on this archipelago, with dovekie (ssp. *polaris*), thick-billed murre and black-legged kittiwake as the major species (B4). The Franz Josef Land polynyas are used as spring staging areas for seabirds prior to breeding (B17). There are important breeding colonies of the rare ivory gull on the islands, the largest in the Barents Sea.

Area 8 – Western and central Barents Sea

The polar front and ice edge in spring largely coincide in the western and central Barents Sea. This general area is also the wintering location for the Barents Sea capelin stock which provides an important food resource for harp seals and other consumers in the ecosystem.

Polar bears occur concentrated in the marginal ice zone during spring and early summer when they migrate east and north with the receding ice (M6).

The polar front and ice edge zone is an important feeding area in summer for seabirds that breed at Bear Island and southern Svalbard as well as for non-breeding birds (B18). This region is also an important wintering area for seabirds, particularly thick-billed murre that feed on wintering capelin (B19). The area is also likely to be part of the swimming migration route of thick-billed murre (males and juveniles) on their way from northern breeding colonies toward wintering areas (B20).

Area 9 – Northern Barents Sea – marginal ice zone

The sea ice in the marginal ice zone in the northern and northeastern Barents Sea is a feeding area for polar bears in late summer and autumn (M7). The marginal ice zone is also used by seals and seabirds. The location of this area can vary among years depending on climatic and ice conditions.

Area 10 – Western Novaya Zemlya

The system of shore leads and drift ice up along the west coast of Novaya Zemlya is supposed to constitute a spring migration route for beluga of the Karskaya stock and possibly also for walrus (M10).

Western Novaya Zemlya holds many fairly large seabird colonies with thick-billed murre and black-legged kittiwake as the major species (B5). Thick-billed murres perform a swimming migration south along Novaya Zemlya toward the Pechora Sea region (B20).

Kara Sea LME

Areas of heightened ecological significance in the Kara Sea LME are shown in Figure A.7, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.11.

Area 1 – Baydaratskaya Inlet – Western Yamal

Baydaratskaya Inlet is a spawning area for the codfish navaga (*Eleginus navaga*) that spawns in winter under the ice (F1). The fast ice zone in the southwestern Kara Sea is possible spawning area for polar cod (*Boreogadus saida*) (F2). Herring (of the Pechora herring type) also spawn on shallow sandy bottoms during May–July in the coastal waters of the southwestern Kara Sea (F3).

The fast ice zone is breeding habitat for ringed seal (M4). Leads and polynyas in the southwestern Kara Sea form a migration area for walrus ('Kara Sea-southern Barents Sea-Novaya Zemlya' stock) and beluga (Karskaya population) on their way from wintering areas in the Pechora Sea region to summer feeding areas in the Kara Sea (M2). Walrus has important feeding areas in the shallow productive waters up along western Yamal with rich benthos communities (M7).

The leads and polynyas in this area also form spring migration and staging habitat for seaducks, notably king eider and long-tailed duck (B3). In late summer and autumn the productive shallows west of Yamal constitute an important staging area for seaducks on their way from breeding areas in western Siberia to wintering areas further west and south (B12).

Area 2 – Northeastern Novaya Zemlya

Seabirds breed in colonies along the northern tip of Novaya Zemlya (B8). Black-legged kittiwake is the major species but some thick-billed murres also breed here. Polynyas off northern Novaya Zemlya are important spring staging areas for seabirds prior to breeding (B1).

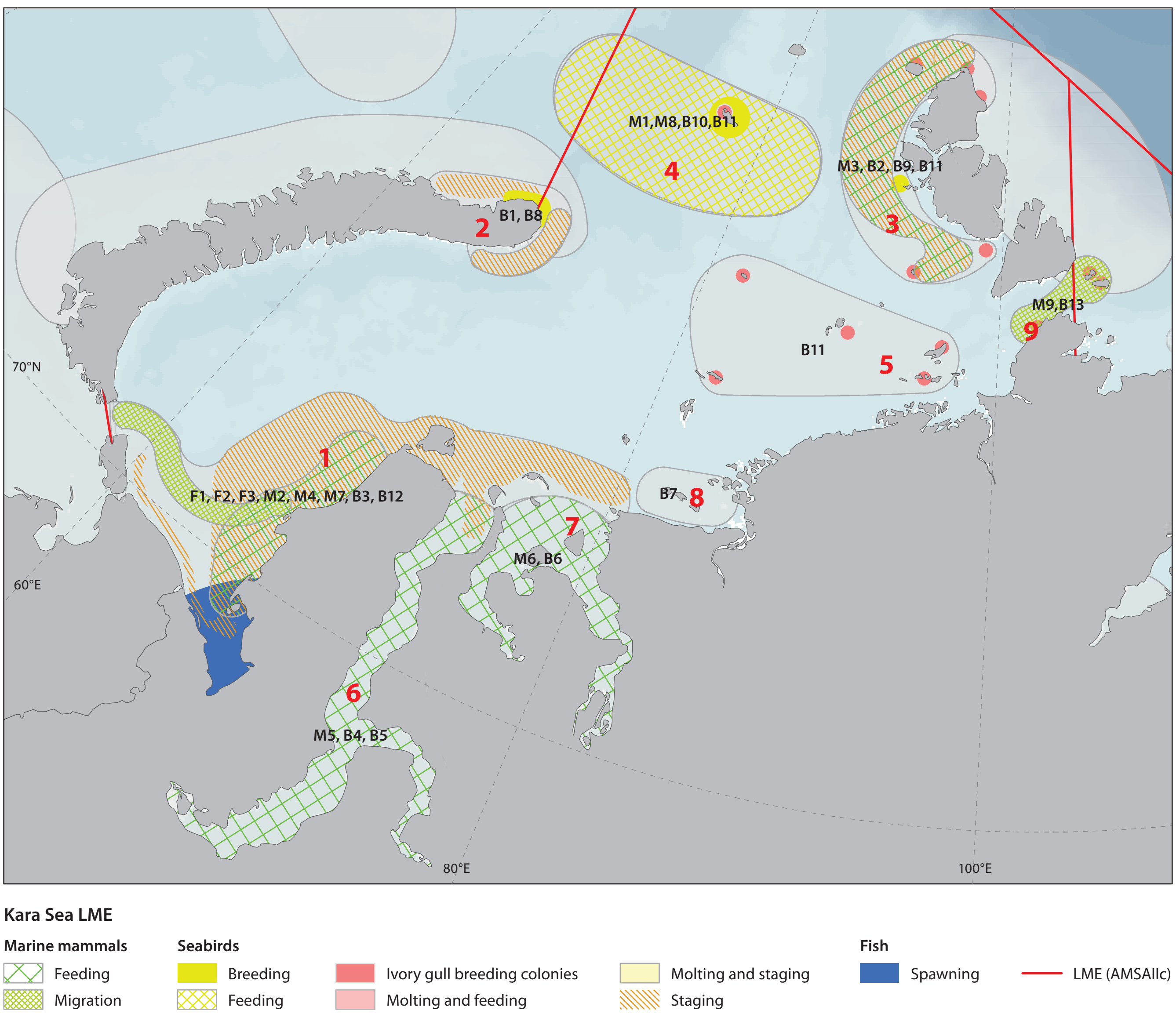


Figure A.7. Areas of heightened ecological significance in the Kara Sea LME.

Table A.11. Areas of heightened ecological significance within the Kara Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		OGA No.	Ecological function	Month/Season	PSSA criteria										
No.	Location				Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Baydaratskaya Inlet - Western Yamal	F1	Spawning area navaga	XII-II		×	×				×	×		×	
		F2	Spawning area polar cod	I-III		×	×				×	×		×	
		F3	Spawning area Chesk-Pechora herring	V-VII		×	×				×	×		×	
		M2	Spring migration area beluga and walrus	Spring		×	×				×	×		×	
		M4	Ringed seal breeding area	Winter		×	×				×	×		×	
		M7	Walrus summer feeding and haul-out	Summer		×				×		×		×	
		B3	Spring staging and migration area for seaducks	Spring		×	×				×	×		×	
		B12	Autumn staging area for seaducks	Summer/Autumn		×				×	×	×		×	
2	Northeastern Novaya Zemlya	B1	Spring staging area for seabirds	Spring		×	×				×	×		×	
		B8	Seabird breeding colonies			×					×	×		×	
3	Western Severnaya Zemlya	M3	Polar bear feeding area	Spring/Summer		×	×					×		×	
		B2	Spring staging area for seabirds	Spring		×	×				×	×		×	
		B9	Seabird breeding colonies			×					×	×		×	×
		B11	Breeding colonies for ivory gull			×					×	×		×	×
4	Northern Kara Sea - marginal ice zone	M1	Spring migration area for beluga whale	Spring		×	×				×	×		×	
		M8	Summer feeding area polar bear	Summer/Autumn		×	×			×		×		×	
		B10	Feeding area for seabirds			×					×	×		×	
		B11	Breeding colonies for ivory gull		×	×					×	×		×	×
5	Northeastern Kara Sea islands	B11	Breeding colonies for ivory gull		×	×					×	×		×	×
6-8	Ob (6), Yenisey (7) and Pyasina (8) estuaries	M5	Summer feeding area beluga whale	Summer		×					×	×		×	×
		B5	Molting and feeding areas for ducks and geese	Summer/Autumn		×			×	×		×		×	×
		B4	Molting and autumn staging areas for ducks, geese and waders	Autumn		×				×	×	×		×	
		M6	Summer feeding area beluga whale	Summer		×						×		×	
		B6	Molting and feeding area for ducks and geese	Summer/Autumn		×						×		×	
		B7	Molting and feeding area for ducks, geese and waders	Summer/Autumn		×						×		×	
9	Vilkitskij Strait	B11	Breeding colonies for ivory gull			×					×	×		×	
		M9	Migration corridor for beluga whale in autumn			×					×	×		×	

Area 3 – Western Severnaya Zemlya

There are some colonies of seabirds on the western part of the High Arctic Severnaya Zemlya archipelago, notably of black-legged kittiwake (B9). The Near Threatened ivory gull breeds here with the largest colonies globally and is the most prominent feature of the regional biodiversity (B11). These colonies are dependent in spring and early summer on the western Severnaya Zemlya flaw polynya. Its northernmost portion off northern Severnaya Zemlya is used as a spring staging area and early season feeding area for seabirds including dovekie, black-legged kittiwake, and black guillemot (*Cepphus grylle*) breeding in large colonies in eastern Severnaya Zemlya (B2).

The fast ice edge and polynya west of Severnaya Zemlya are also a feeding area for polar bears in spring and summer (M3).

Area 4 – Northern Kara Sea – marginal ice zone

The ice edge zone is a feeding area for seabirds including ivory gull, black-legged kittiwake, black guillemot, skuas and gulls (B10). The Near Threatened ivory gull aggregates to breed on islands in this area (B11).

The drift ice in the northern Kara Sea is a migration area for beluga of the Karskaya population in spring and early summer when they move north and east toward the Laptev Sea (M1). The ice edge zone is a summer and autumn feeding area for polar bears (M8).

Area 5 – Northeastern Kara Sea islands

Vize and Uedinenia islands located in the northern Kara Sea between Franz Joseph Land and Severnaya Zemlya hold colonies of the Near Threatened ivory gull (B11). There are recently, under conditions of little summer sea ice, established Atlantic walrus rookeries on these islands.

Areas 6-8 – Ob (6), Yenisey (7) and Pyasina (8) estuaries

Ob Gulf is a major estuary, nearly 1000 km long from the Ob Delta to the opening to the south-central Kara Sea in the north. There are summer aggregations of beluga in this gulf that are considered to be of a separate stock (M5).

The Ob Delta is a molting and autumn staging area for dabbling and diving ducks, geese and waders (B4). The estuary also provides molting and feeding areas for ducks, geese and swans, including long-tailed duck, scoters, dark-bellied brent goose and Bewick's swan (*Cygnus bewickii*) (B5).

Yenisey Gulf has summer aggregations of beluga possibly constituting a separate stock (M6). Like the Ob estuary, it also provides important molting and feeding areas for ducks, geese and swans (B6).

Large stocks of different coregonid whitefishes as well as the Threatened Ob stock of Siberian sturgeon have feeding and nursery areas in the Ob and Yenisey estuaries.

The smaller Pyasina Estuary to the northeast has a well developed delta and is also an important molting and feeding area for ducks and geese including dark-bellied brent goose, as well as for waders (B7).

Area 9 – Vilkitskij Strait

The Near Threatened ivory gull breeds on islands in this area (B11). The Vilkitskij Strait is also used as a migration corridor for beluga on their return migration from the Laptev Sea in autumn (M9).

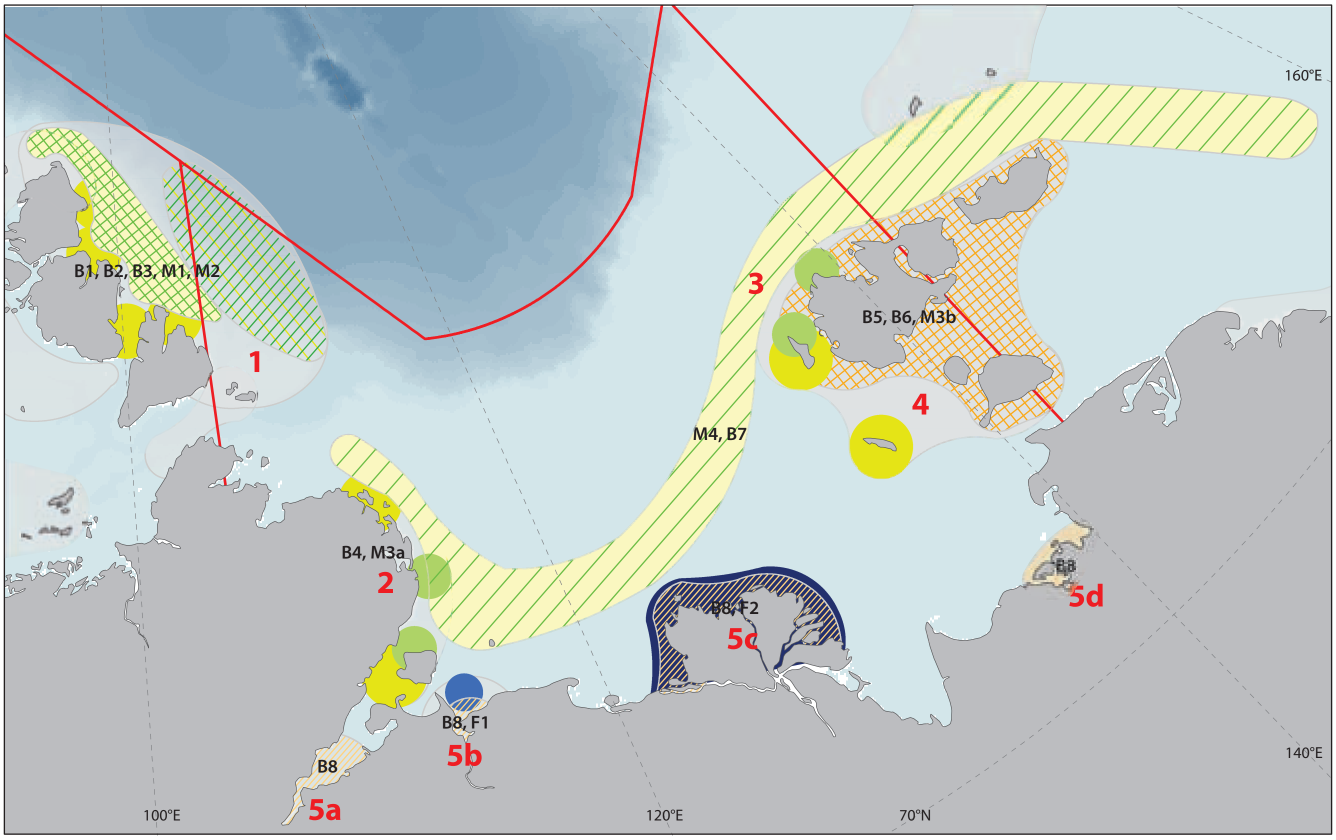
Laptev Sea LME

Areas of heightened ecological significance in the Laptev Sea LME are shown in Figure A.8, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.12.

Area 1 – Northwestern Laptev Sea (including polynyas north and northeast of Severnaya Zemlya)

Beluga presumably of the Karskaya population occur regularly in fairly high abundance in the western Laptev Sea during summer. They migrate into the Laptev Sea mainly north of Severnaya Zemlya in spring, probably using leads and polynyas north and east of the archipelago (M1). This area is also used for summer feeding by beluga (M2). Narwhal possibly also occur in this region.

Dovekie (ssp. *polaris*) breed in colonies on Severnaya Zemlya, mainly on the eastern side foraging out in the northwestern Laptev Sea (B2). Dovekie, along with ivory gull and black guillemot which also breed on these islands, make extensive use of polynyas off Severnaya Zemlya where they arrive in spring as early as April (B1). These species use the sea areas in the northwestern Laptev Sea along the ice edge and shelf break as foraging areas in late summer and autumn (B3). This is a particularly important post-breeding staging area for all ivory gulls of East Atlantic breeding populations from Greenland to Severnaya Zemlya.



Laptev Sea LME

Marine mammals	Seabirds		Fish	
Feeding	Breeding colonies	Feeding, moulting and staging	Nursery	LME (AMSAIIc)
Migration	Feeding	Staging and migration	Spawning area	
Wintering-walrus	Feeding and moulting			
Haul-out-walrus				

Figure A.8. Areas of heightened ecological significance in the Laptev Sea LME.

Area 2 – Northeast Taymir and Preobrazheniya Island

Seabird breeding colonies primarily of black-legged kittiwake are located at the northeastern Taymir Peninsula and at Preobrazheniya Island in outer Khatanga Bay at the base of the Taymir Peninsula where thick-billed murre also breed (B4).

There are haul-outs on land for walrus of the Laptev population along the eastern Taymir coast and on small islands (M3a), and adjacent areas provide important summer feeding grounds for Laptev walrus.

Area 3 – Great Siberian polynya system

A major lead polynya system forms off the fast ice edge north and west of the New Siberian Islands. This polynya overlying relatively productive shallows constitutes the main winter habitat for the Laptev population of walrus (sometimes considered a separate subspecies). Walruses reside in this area year-round and also use it for summer feeding (M4).

The polynya is also a major spring staging and migration area for seabirds and waterfowl including thick-billed murre, black-legged kittiwake, long-tailed duck, and king eider (B7).

Area 4 – New Siberian Islands

There are seabird breeding colonies on the westernmost Stolbovoy and Belkovsky islands with thick-billed murre, black-legged kittiwake and black guillemot as the dominant species (B5). The shallow waters around the New Siberian Islands are an important feeding and molting area for various waterbirds including king and Pacific eiders, long-tailed duck, and red phalarope (*Phalaropus fulicarius*) (B6).

There are known haul-outs for walrus on the northwestern side of the archipelago with important adjacent summer feeding areas (M3b).

Area 5 – Deltas and estuaries – Khatanga (5a), Anabar (5b), Lena (5c), Yana (5d)

The large Lena Delta along with the Yana Delta further east and the Khatanga and Anabar deltas to the west constitute extensive and important habitats for feeding, molting and staging of waterfowl and waders (B8). The species which use these deltas and estuaries include king, spectacled and Steller's eiders, long-tailed duck, black scoter (*Melanitta nigra*), dark-bellied and black brant (*Branta bernicla nigricans*) geese, tundra swan (*Cygnus columbianus*), divers, red phalarope and many other shorebirds.

Table A.12. Areas of heightened ecological significance within the Laptev Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		OGA No.	Ecological function	Month/ Season	PSSA criteria										
No	Location				Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Northwestern Laptev Sea (including polynyas north and northeast of Severnaya Zemlya)	M1	Beluga migration and feeding area in spring, possibly also for narwhal	Spring		×	×					×		×	
		M2	Beluga summer feeding area, possibly also for narwhal	Summer		×	×				×	×		×	
		B1	Spring staging and migration area for seabirds	Spring	×	×					×	×		×	
		B2	Seabird breeding colonies		×	×					×	×		×	
		B3	Feeding area for seabirds	Summer/ Autumn		×	×					×		×	
2	Northeast Taymir and Preobrazheniya Island	B4	Seabird breeding colonies			×					×	×		×	
		M3a	Walrus feeding and haul-out	Summer/ Autumn		×	×					×		×	×
3	Great Siberian Polynya system	M4	Walrus wintering and feeding area	Winter/ Spring	×	×	×					×		×	×
		B7	Spring staging and migration area for seabirds and waterfowl	Spring		×	×				×	×		×	×
4	New Siberian Islands	B5	Seabird breeding colonies			×					×	×		×	
		B6	Feeding and molting area for waterbirds	Summer/ Autumn		×	×			×		×		×	
		M3b	Walrus summer and haul-out area	Summer/ Autumn		×	×					×		×	×
5	Deltas and estuaries - Khatanga (5a), Anabar (5b), Lena (5c), Yana (5d)	B8	Waterfowl feeding, molting and staging area. Shorebird feeding and staging area	Summer/ Autumn	×	×	×		×	×	×	×		×	×
		F2	Whitefish and sturgeon feeding areas	Summer/ Autumn	×	×	×			×	×	×	×	×	×
		F1	Possible spawning area polar cod	Winter		×	×				×	×		×	

These estuaries form nursery and feeding areas for several species of coregonid whitefishes as well as the Lena stock of Siberian sturgeon (*Acipenser baerii*) (F2). Polar cod (*Boreogadus saida*) is the most important marine fish species in the Laptev Sea. This stock feeds in the open parts of the sea and winters and spawns in the coastal zone. The area of Anabar Bay is possibly a main spawning area (F1).

East Siberian Sea LME

Areas of heightened ecological significance in the East Siberian Sea LME are shown in Figure A.9, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.13.

Area 1 – New Siberian Islands

This area lies in the boundary zone between the Laptev and East Siberian seas and has been included in both LMEs. The shallow waters around the New Siberian Islands are an important feeding and molting area for various waterbirds including king and Pacific eiders, long-tailed duck and red phalarope (B1).

Area 2 – Great Siberian Polynya System

The polynya is an important spring staging and feeding area for seabirds and waterfowl including thick-billed murre, black-legged kittiwake, long-tailed duck, and king eider (B3).

The polynya and the shallow waters around the New Siberian Islands are year-round habitat for the Laptev walrus population (M4).

Area 3 – De Long Islands

This is a group of relatively small and remote islands located on the outer shelf northeast of the New Siberian Islands. There are seabird colonies on these islands with black-legged kittiwake, black guillemot and thick-billed murre as the major species (B2).

Area 4 – Ice zone on the northern shelf

The pack ice and ice edge zone over the central and northern East Siberian shelf is a feeding area for ringed seal and Pacific walrus in late summer and autumn (M4). This zone is also used for feeding in the post-breeding period by seabirds including ivory and Ross's gulls, thick-billed murre, black-legged kittiwake and skua species (B4).

Beluga of the large Beaufort Sea stock and possibly also the eastern Chukchi stock use the northeastern part of the East Siberian Sea for feeding in late summer and autumn before they return south toward the wintering areas in the northern Bering Sea (M3).

Area 5 – Indigirka and Kolyma deltas and estuaries

The deltas and estuaries of these relatively large Siberian rivers are important feeding, molting and staging areas for waterfowl such as king, spectacled and Steller's eiders, black brants and tundra swans, and feeding and staging area for many shorebirds including red and red-necked (*Phalaropus lobatus*) phalaropes, short-billed dowitcher (*Limnodromus griseus*) and others (B5).

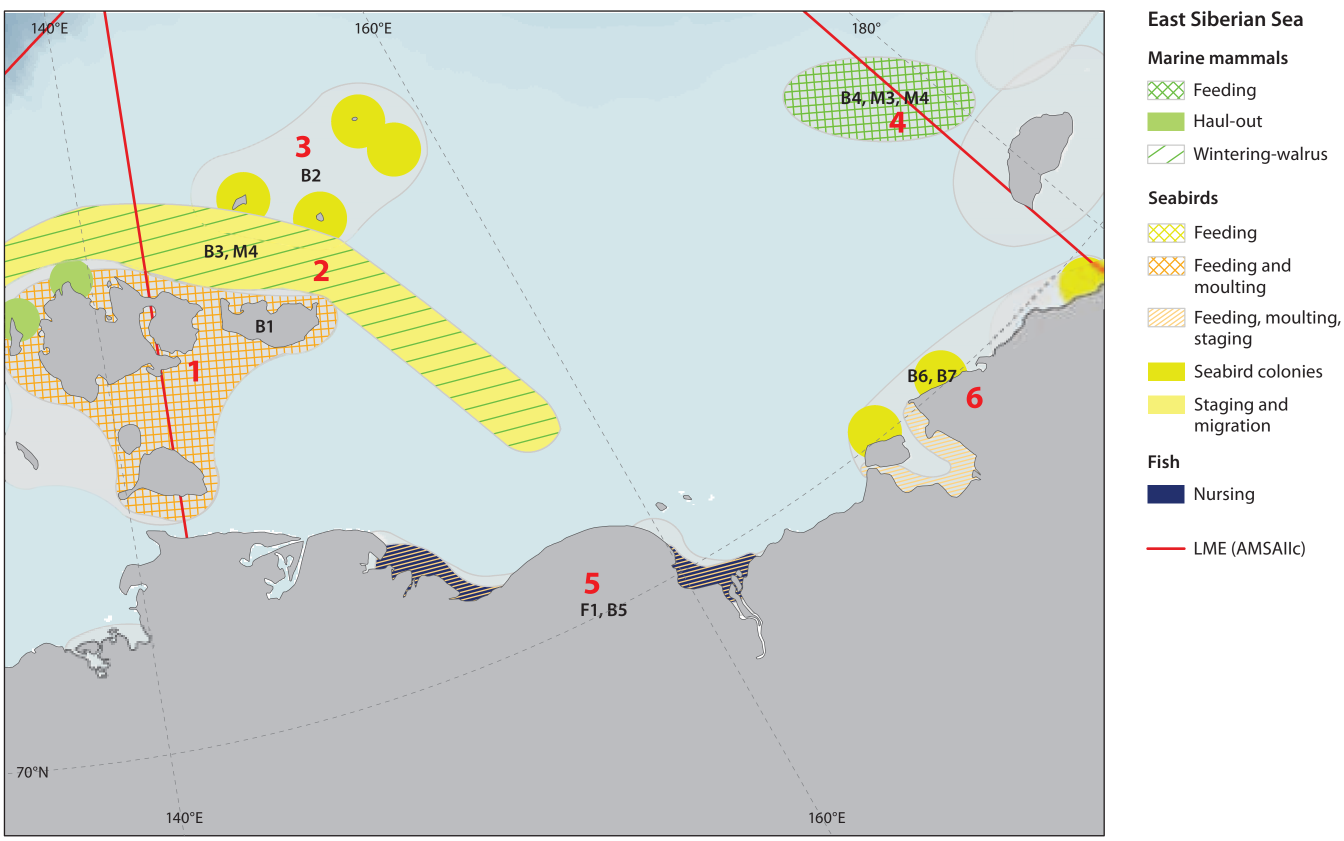


Figure A.9. Areas of heightened ecological significance in the East Siberian Sea LME.

Table A.13. Areas of heightened ecological significance within the East Siberian Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		OGA No.	Ecological function	Month/ Season	PSSA criteria										
No	Location				Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	New Siberian Islands	B1	Feeding and molting area for waterbirds	Summer/ Autumn		×	×				×	×		×	
2	Great Siberian Polynya System	B3	Seabird spring feeding and migration area, spring stopover area for waterfowl	Spring		×	×				×	×		×	
		M4	Feeding area for walrus and ringed seals	Winter/ Spring		×	×			×		×		×	
3	De Long Islands	B2	Seabird colonies	Summer	×	×						×		×	
4	Ice zone on the northern shelf	M4	Seals and walrus feeding area	VIII-X		×	×			×		×		×	
		M3	Beluga and bowhead feeding area late summer/autumn	Summer/ Autumn		×				×	×	×		×	
		B4	Feeding area for seabirds	Summer/ Autumn		×						×		×	
5	Indigirka and Kolyma deltas and estuaries	B5	Waterfowl feeding, molting and staging area. Shorebird feeding and staging area	Summer/ Autumn		×	×		×		×	×		×	×
		F1	Feeding and nursery areas for anadromous or amphi-dromous fishes	Summer/ Autumn		×					×	×		×	
6	Chaun Bay	B6	Waterfowl feeding, molting and staging area. Shorebird feeding and staging area	Summer/ Autumn		×	×				×	×		×	
		B7	Seabird colonies	Summer		×					×	×		×	

These estuaries are also nursery and feeding areas for amphidromous and anadromous whitefishes and Siberian sturgeon (F1).

Area 6 – Chaun Bay

Long-tailed ducks have breeding grounds located mostly within southern tundra on the mainland with the highest density found in Kolyma delta and in the Chaun Lowland. Chaun Bay and adjacent areas along the Chukotka coast contain feeding, molting and staging areas for waterfowl and shorebirds (B6). There are seabird colonies dominated by thick-billed murre, black-legged kittiwake, and black guillemot (B7).

Bering Sea (East and West) LMEs

Areas of heightened ecological significance in the Bering Sea (East and West) LMEs are shown in Figure A.10, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.14.

Area 1 – Aleutian Islands

Bogoslof Island

The waters off Bogoslof Island (F8) and the slope region off Bristol Bay north to beyond the Pribilof Islands (F9) are the main spawning areas of the large walleye pollock stock which is a key component in the eastern Bering Sea ecosystem.

Bogoslof Island is also one of two northern fur seal rookeries (the other being in the Pribilof Islands). In the past few years more pups have been produced at Bogoslof Island than at the Pribilof Islands.

Aleutian Islands

Steller sea lions (*Eumetopias jubatus*) breed on a number of rookeries throughout the Aleutian Islands, on the Alaska Peninsula, and along the coast of Kamchatka (M4). The areas with the main rookeries are key sites in the life cycle and for the conservation of the species, which is a key component in the southern part of the Bering Sea ecosystem. The large Steller sea lion population in the Bering Sea (western population) has been declining dramatically in recent decades (Angliss and Outlaw, 2008; Loughlin, 2009) and is listed as 'Near Threatened' by the IUCN.

The chain of the Aleutian Islands provides important habitat for seabirds with many breeding colonies (Springer et al., 1999). There are many species of birds in these colonies, including large numbers of fork-tailed (*Oceanodroma furcata*) and Leach's (*O. leucorhoa*) storm-petrels, least and crested (*Aethia cristatella*) auklets, tufted puffin (*Fratercula cirrhata*) and northern fulmar. The Aleutian Islands form part of the breeding area of marbled (*Brachyramphus marmoratus*) and Kittlitz's (*B. brevirostris*) murrelets which are assessed as being 'Endangered' and 'Critically Endangered' by the IUCN (B5). Rhinoceros auklet (*Cerorhinca monocerata*) breeds presently only at Buldir Island in the western Aleutian Islands but was formerly much more abundant in the southern Bering Sea. Along with several other seabird species it was drastically reduced and locally extirpated from parts of the Aleutian Islands through introduction of mammals and harvesting. The Aleutian Islands are also breeding area for shorebirds, notably rock sandpiper (ssp. *couesi*) and black oystercatcher (*Haematopus bachmani*).

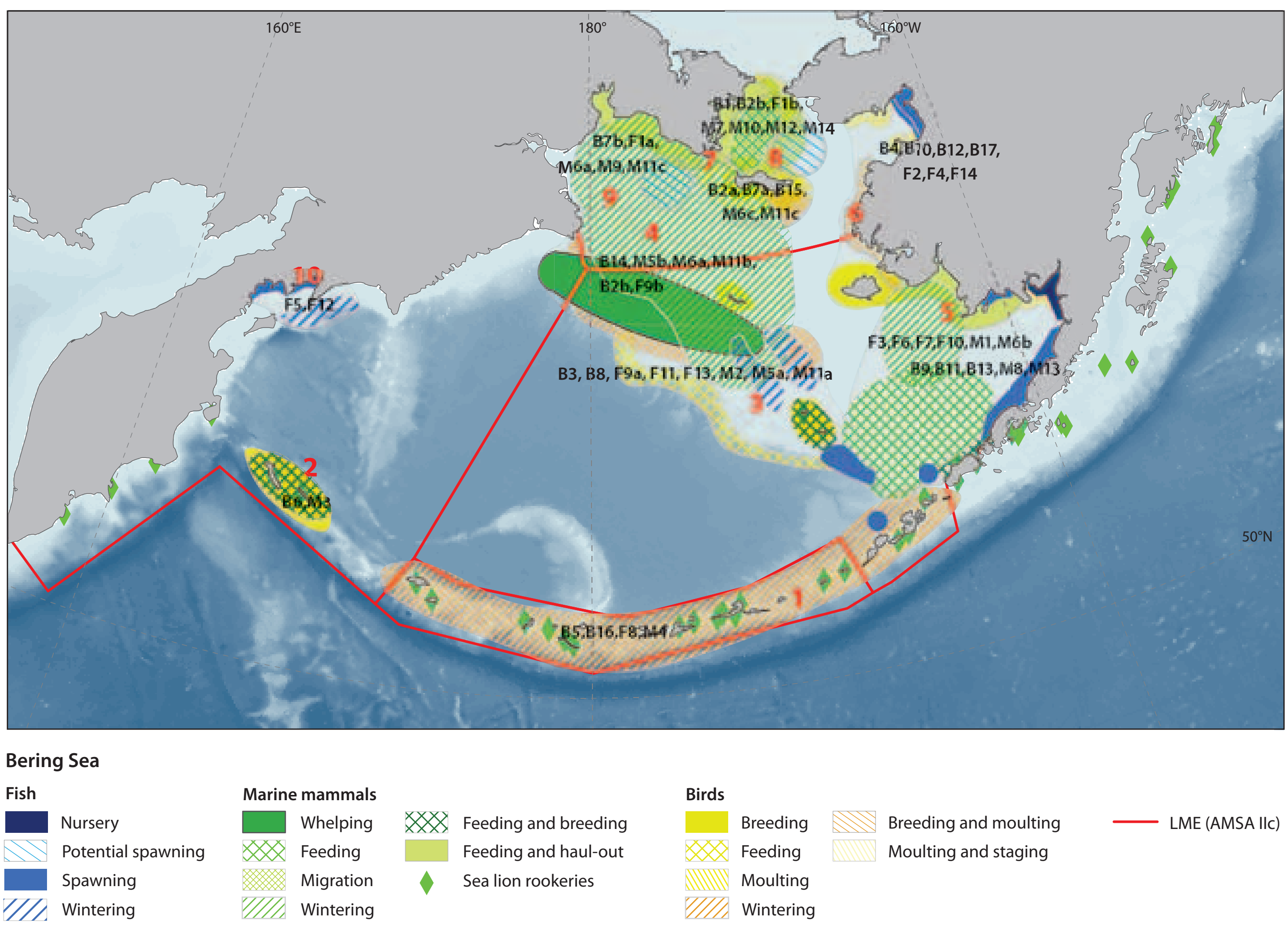


Figure A.10. Areas of heightened ecological significance in the Bering Sea LME.

Table A.14 Areas of heightened ecological significance within the Bering Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		OGA No.	Ecological function	Season	PSSA criteria										
No.	Location				Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Aleutian Islands	F8	Spawning area fish (pelagic) off Bogoslof Island; walleye pollock	Winter-Summer		×					×	×		×	
		M4	Seal feeding and breeding area Aleutian Islands; Steller sea lion			×					×	×		×	×
		B5	Seabird breeding colonies in the Aleutian Islands; marbled murrelet, Kittlitz's murrelet, rhinoceros auklet		×	×				×	×	×		×	×
		B16	Seabirds and waterfowl wintering habitat in the Aleutian Islands; king eider, Steller's eider, greater scaup, common teal	Winter	×	×	×			×		×		×	×
2	Komandorsky Islands	M3	Seal feeding and breeding area in waters around Komandorsky Islands; northern fur seal	Spring-late Autumn		×					×	×		×	
		B6	Seabird breeding colonies Komandorsky Islands; red-legged kittiwake, ancient murrelet			×				×	×	×		×	×
3	Continental southeastern shelf and shelf break	F9a	Spawning area fish (pelagic) on the slope, southeastern Bering Sea; walleye pollock	Spring-Summer		×				×	×	×		×	×
		F11	Wintering area fish on the outer shelf between the Pribilof and St Matthew islands; Pacific herring	Winter		×						×		×	
		F13	Wintering area fish on the mid-shelf northwest of the Pribilof Islands; capelin	Winter		×						×		×	
		M2	Seal feeding and breeding area in waters around the Pribilof Islands; northern fur seal		×	×				×	×	×		×	×
		M5a	Seal whelping area ice-front zone on outer northern shelf; ribbon seal, spotted seal		×	×	×				×	×		×	×
		M11a	Whale wintering area in pack ice; bowhead whale, beluga	Winter	×	×	×				×	×		×	×
		B3	Seabird breeding colonies, breeding, spring and autumn staging of shorebirds; least auklet, red-legged kittiwake, thick-billed murre, rock sandpipers (ssp. *ptilocnemis*)		×	×				×	×	×		×	×
		B8	Seabird feeding area near shelf edge; short-tailed albatross, fork-tailed storm-petrel, red-legged kittiwake			×	×			×		×		×	

Area No.	Area Location	OGA No.	Ecological function	Season	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
4	Continental northeastern shelf and shelf break	M5b	Seal whelping area ice-front zone on outer northern shelf; ribbon seal, spotted seal		×	×	×				×	×		×	×
		M6a	Walrus wintering area in drifting pack ice on northern and northeastern shelf; Pacific walrus	Winter	×	×	×				×	×		×	×
		M11b	Whale wintering area in pack ice and polynyas in northern Bering Sea; bowhead whale, beluga	Winter	×	×	×				×	×		×	×
		B2b	Seabird breeding colonies, breeding, spring and autumn staging of shorebirds; least auklet, thick-billed murre, rock sandpipers (ssp. *ptilocnemis*), red phalarope			×				×	×	×		×	
		B14	Seabird wintering habitat at the ice edge in the northern Bering Sea; ivory gull, Ross's gull, black guillemot	Winter		×	×					×		×	
		F9b	Spawning area fish (pelagic) on the slope; walleye pollock	Late Winter-Summer		×					×	×		×	
5	Bristol Bay and Southeastern Bering Shelf/ Northern Alaska Peninsula	F3	Spawning area fish (demersal, beach and shallow subtidal) in Togiak Bay; Pacific herring, capelin			×	×				×	×		×	
		F6	Spawning area fish (demersal, beach and shallow subtidal) in northern shore of the Alaska Peninsula; Pacific herring, capelin			×	×				×	×		×	
		F7	Spawning area fish (demersal) north of Unimak Pass; Pacific cod			×					×	×			
		F10	Nursery area fish in Inner Bristol Bay – estuaries and coastal waters; sockeye salmon, pink salmon, eulachon			×	×			×	×	×		×	×
		M1	Sea otter feeding and breeding area Unimak Island and western Alaska Peninsula, sea otter refugium and Pacific walrus male haul-out northern Alaska Peninsula			×	×			×	×	×		×	×
		M6b	Walrus wintering area in drifting pack ice on northern and northeastern shelf; Pacific walrus			×	×				×	×		×	
		M8	Walrus feeding and haul-out in Northern Bristol Bay; Pacific walrus			×	×			×		×		×	×
		M13	Whale feeding area in waters off Unalaska and into outer Bristol Bay; Critically Endangered North Pacific right whale		×	×				×		×		×	×

Area No.	Area Location	OGA No.	Ecological function	Season	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
		B9	Seabird feeding area, southeast Bering Shelf; short-tailed shearwaters			×				×		×		×	
		B11	Waterfowl molting and staging area, summer feeding and autumn staging of shorebirds in northern Alaska Peninsula with lagoons (Izembek, Nelson, Mud Bay, Cinder, Hook, Ugashik, Egegik, Kvichak, Nushagak, Nanvak, Chagvan, Goodnews, Carter); Steller's eider, black scoter, northern pintail, cackling goose, black brant, rock sandpiper, dunlin, western sandpiper, marbled godwit, bar-tailed godwit, Hudsonian godwit		×	×	×		×	×	×	×		×	×
		B13	Molting area northern and inner Bristol Bay; Steller's eider, black scoter, white-winged scoter			×	×			×	×	×		×	
6	East Coast (Yukon and Kuskokwim Deltas to Norton Sound) including Nunivak Island	F2	Under ice spawning area for saffron cod			×	×				×	×		×	
		F4	Spawning area fish (demersal, beach and shallow subtidal); Pacific herring, capelin			×	×				×	×		×	
		F14	Wintering area fish in estuaries; Pacific herring			×	×				×	×		×	
		B4	Seabird breeding colonies Nunivak Island and Cape Newenham; common murre			×				×	×	×		×	
		B10	Waterfowl breeding and molting area, summer use, and spring and autumn staging area for shorebirds on Yukon-Kuskokwim Delta; spectacled eider, black, white-winged and surf scoters, northern pintail, cackling, brent, emperor and snow geese, dunlin, bar-tailed godwit, bristle-thighed curlew, western, rock and sharp-tailed sandpiper, red knot and black turnstone		×	×	×		×	×	×	×		×	×
		B12	Molting area of waterfowl in eastern Norton Sound; spectacled eider			×					×	×		×	×
		B17	Summer feeding and autumn staging of shorebirds in Safety Sound, Norton Bay, Stebbins-St Michael, Golovin Lagoon; western sandpiper, semipalmated sandpiper, dunlin, red-necked phalarope, long-billed dowitcher			×	×				×	×		×	

Area No.	Area Location	OGA No.	Ecological function	Season	PSSA criteria: Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
7	St Lawrence Island area including St Lawrence Polynya (south)	M6c	Walrus wintering area in drifting pack ice on northern and northeastern shelf; Pacific walrus		×	×	×				×	×		×	×
		M11c	Whale wintering area in pack ice and polynyas in northern Bering Sea; bowhead whale, beluga		×	×	×				×	×		×	×
		B2a	Seabird breeding colonies, breeding, spring and autumn staging of shorebirds on St Lawrence Island; least auklet, thick-billed murre, rock sandpiper (ssp. *ptilocnemis*), red phalarope			×	×			×	×	×		×	×
		B7a	Resting and feeding areas for seabirds and waterfowl during spring migration in northern Bering Sea leads and polynyas; thick-billed murre, common murre, least auklet, crested auklet			×	×			×	×	×		×	
		B15	Waterfowl wintering habitat St Lawrence Island polynya; king eider, long-tailed duck, and total world population of spectacled eider		×	×	×			×	×	×		×	×
8	Bering Strait (St Lawrence Island north to the Diomede Islands)	F1b	Likely a large migratory stock of polar cod (*Boreogadus saida*) that migrates south in autumn to spawn in winter under the ice in the southern Chukchi Sea and/or the northern Bering Sea			×	×				×	×		×	
		M7	Walrus breeding and migration area in drifting pack ice in northern Bering Sea, Pacific walrus			×	×				×	×		×	×
		M10	Walrus feeding and haul-out in eastern Chukotka Peninsula, Pacific walrus			×	×			×	×	×		×	
		M12	Whale migration area in lead system in northern Bering Sea; bowhead whale and beluga		×	×	×				×	×		×	×
		M14	Whale feeding area in Chirikov Basin; gray whale		×	×	×			×		×		×	×
		B1	Seabird breeding colonies in Bering Strait region; least auklet, crested auklet, parakeet auklet, Kittlitz's murrelet			×				×	×	×		×	×
		B2b	Seabird breeding colonies; breeding, spring and autumn staging of shorebirds; least auklet, thick-billed murre, rock sandpiper (ssp. *ptilocnemis*), red phalarope			×				×	×	×		×	×

Area No.	Area Location	OGA No.	Ecological function	Season	PSSA criteria: Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
9	Gulf of Anadyr	F1a	Potential spawning area for migratory stock of polar cod			×	×				×	×		×	
		M6a	Walrus wintering area in drifting pack ice on northern and northeastern shelf, Pacific walrus		×	×	×			×	×	×		×	×
		M9	Walrus feeding and haul-out in northern gulf of Anadyr; Pacific walrus			×	×			×		×		×	×
		M11c	Whale wintering area in pack ice and polynyas in northern Bering Sea; bowhead whale, beluga		×	×	×				×	×		×	×
		B7b	Resting and feeding areas for seabirds and waterfowl during spring migration in northern Bering Sea leads and polynyas; thick-billed murre, common murre, least auklet, crested auklet			×	×			×	×	×		×	×
10	Northeastern coast of Kamchatka and offshore areas	F5	Spawning area fish (demersal, beach and shallow subtidal) in northern Karagin and Korf bays; Pacific herring, capelin			×	×				×	×		×	
		F12	Wintering area fish in outer shelf off Olyutorsky and the northern Karagin Bay; Pacific herring			×					×	×		×	

Note: sub-divisions of area designation such as B2a and B2b refer to habitat or ecological regions that cross the somewhat arbitrary geographical boundaries of defined areas.

The Aleutian Islands constitute important wintering habitat for many seabirds and waterfowl that breed further north in the Pacific sector of the Arctic. These include king and Steller's eiders, emperor goose, greater scaup (*Aythya marila*) and common teal (*Anas crecca*) (B16). Emperor goose is a Beringean endemic species that winters in large numbers in the Aleutian Islands.

Area 2 – Komandorsky Islands

Waters around the Komandorsky Islands

Northern fur seals breed on the Komandorsky Islands which is the main breeding site after the Pribilof and Bogoslof islands (M3). The colonies are occupied for about the same period of time, from spring to late autumn, and the females feed in a wide zone around the islands while they nurse their pups in the colonies.

Komandorsky Islands

The Komandorsky Islands lie in the western Bering Sea in the continuation of the Aleutian Islands chain. They hold large breeding colonies of seabirds, including red-legged kittiwake (*Rissa brevirostris*; assessed as 'Vulnerable' by the IUCN) and ancient murrelet (*Synthliboramphus antiquus*, spp. *microrhynchos*) which is restricted to these islands (B6). Rock sandpiper (*Calidris ptilocnemis*, ssp. *quarta* known as Commander sandpiper) breeds on the Komandorsky Islands and also in southern Kamchatka and on the Kurile Islands. These birds are probably sedentary on the Komandorsky Islands where they are estimated to occur with 5000 breeding pairs (Gill et al., 2002).

Area 3 – Continental southeastern shelf and shelf break

Slope region of the southeastern Bering Sea

The waters on the slope region off Bristol Bay north to beyond the Pribilof Islands are a main spawning area of the large walleye pollock stock which is a key component in the eastern Bering Sea ecosystem (F9a). While pollock spawns over a wide area and an extended time period from late winter to early summer, the core areas of the spawning grounds are no doubt areas of ecological significance given the great ecological role of walleye pollock in the ecosystem.

Outer shelf between the Pribilof Islands and St Matthew Islands

Pacific herring of the large migratory eastern Bering Sea stock has (or used to have) its main wintering area on the outer shelf in the layer of warmer water that extends as a bottom layer under the colder water of the mid-shelf (F11). There is limited information on this wintering area, but it is expected that herring forms dense aggregations in a concentrated zone along the outer shelf.

Mid-shelf region northwest of the Pribilof Islands

A major wintering area for capelin in the eastern Bering Sea is in the mid-shelf domain around the 100 m isobath in the 'cold pool' region in the area between the Pribilof and St Matthew islands (F13). Capelin is expected to occur concentrated in this wintering area, from where the maturing part of the population moves toward the coastal spawning grounds in spring.

Pribilof Islands

Northern fur seal breeds almost exclusively in the Bering Sea with about half of the population at large colonies on the Pribilof Islands on the outer shelf in the southeastern Bering Sea (M2). The colonies are occupied from late April to November, and the females feed in a wide zone around the islands during the period when they are nursing their pups in the colonies for about four months. Northern fur seal is numerous (0.7 million individuals) and an important species in the eastern Bering Sea ecosystem. The population has been declining reflecting changes in the ecosystem probably due to a combination of factors including climate, food and predation (notably by killer whales) (Angliss and Outlaw, 2008; Gentry, 2009).

The Pribilof Islands hold major breeding colonies of seabirds, with large numbers of least auklet and thick-billed murre (Hunt et al., 1981) (B3). The majority of the total global population of red-legged kittiwakes (about 80 %) breeds on these islands. The Pribilof Islands are also important breeding and staging areas in spring and autumn for shorebirds, notably rock sandpiper (*C. p. ptilocnemis*).

Ice front zone on outer northern shelf

Ribbon seal and spotted seal are two ice-associated species that whelp on the southern extent of sea ice in late winter in the northern Bering Sea (M5a). Ribbon seal has its main whelping area in the central and western Bering Sea from south of St Matthew Island and westward along the shelf to around Cape Olyutorski. Spotted seal has its whelping area overlapping with that of ribbon seal but with centers of abundance further south, in northwestern Bristol Bay near the Pribilof Islands, and in the Karaginsky Bay on the western shelf. After breeding the seals move north with the ice in spring when they molt on ice in the northern Bering Sea (there is little information on molting for spotted seal). Both species may be vulnerable to climate change which might affect their ice habitats but they were recently assessed in the United States as not being at risk of extinction within the foreseeable future (Boveng et al., 2008, 2009); they have been assessed as 'Data Deficient' by the IUCN due to limited information.

Pack ice on the southeastern shelf

Bowhead whales of the Bering–Chukchi–Beaufort stock and beluga of several stocks including the large migratory Beaufort stock, winter in polynyas and pack ice of the northern Bering Sea, probably extending south onto the southeastern shelf (M11a). In spring they start to move north through leads in the ice, with some whales moving through the Bering Strait in April.

Shelf edge of the eastern Bering Sea

The shelf edge area of the eastern Bering Sea is a very productive region and constitutes important feeding habitat for seabirds (B8). In addition to high rates of basic production, this area is also one where vertically migrating macrozooplankton, fish and squid from the deep basin and slope waters come close to the surface at night. The species of seabirds which forage here include large numbers of fork-tailed storm-petrels and red-legged kittiwakes, and short-tailed albatross (*Phoebastria albatrus*) which is assessed as 'Vulnerable' by the IUCN.

Area 4 – Continental northeastern shelf and shelf break

Ice front zone on the outer northern shelf

The ice edge in the northern and central shelf regions of the Bering Sea constitute winter habitat for some Arctic seabirds, notably ivory and Ross's gulls and black guillemot that migrate south from breeding and summering areas in the Chukchi Sea and adjacent areas (B14).

Ribbon seal and spotted seal are two ice-associated species that whelp on the southern extent of sea ice in late winter in the northern Bering Sea (M5b). Ribbon seal has its main whelping area in the central and western Bering Sea from south of St Matthew Island and westward along the shelf to around Cape Olyutorski. Spotted seal has its whelping area overlapping with that of ribbon seal but with centers of abundance further south, in northwestern Bristol Bay near the Pribilof Islands, and in the Karaginsky Bay on the western shelf (Boveng et al., 2008, 2009). After breeding the seals move north with the ice in spring when they molt on ice in the northern Bering Sea (there is little information on molting for spotted seal). Both species may be vulnerable to climate change which might affect their ice habitats but they were recently assessed as not being at risk of extinction within the foreseeable future (Boveng et al., 2008, 2009).

The large population of Pacific walrus has its wintering area in polynyas and drifting pack ice over the shelves of the northern Bering Sea (M6a) (Fay, 1982; Ray and Hufford, 1989). One core area is in the northern Bering Sea including the St Lawrence and Sireniki polynyas. In spring the females and young animals start to move north through Chirikov Basin toward Bering Strait.

During this phase of early migration, the pregnant females give birth to their calves. Pacific walrus is still numerous but may be declining (Smirnov et al., 2004; Cooper et al., 2006), and it is expected that this species may be severely negatively affected by climate change (the species is assessed as being 'Data Deficient' by the IUCN).

Bowhead whales of the Bering–Chukchi–Beaufort stock and beluga of several stocks including the large migratory Beaufort stock, winter in polynyas and pack ice of the northern Bering Sea (M11b). This includes the St Lawrence and Sireniki polynyas. In spring they start to move north through leads in the ice, with some whales moving through the Bering Strait in April. Breeding takes place in late winter, and both species give birth to their calves during the northward spring migration.

Slope region of the northeastern Bering Sea

The waters on the slope region of the eastern Bering Sea are a main spawning area of the large walleye pollock stock which is a key component in the eastern Bering Sea ecosystem (F9b).

St Matthew and Hall islands

The St Matthew and Hall islands are located on the shelf of the northern Bering Sea. Both islands hold large breeding colonies of seabirds with least auklet and thick-billed murre as particularly abundant species (Hunt et al., 1981) (B2b). The seabirds forage out from the colonies typically some tens of kilometers. These islands are also breeding and staging areas in spring and autumn for shorebirds, notably rock sandpiper (*C. p. ptilocnemis*) and red phalarope. Most of the global population of McCay's bunting (*Plectrophenax hyperboreus*) breeds here.

Area 5 – Bristol Bay and the southeastern Bering Shelf/Northern Alaska Peninsula

Bristol Bay

The northern and inner parts of Bristol Bay in the southeastern Bering Sea contain important molting areas for several seaducks including Steller's eider and black and white-winged (*Melanitta fusca*) scoters (B13).

Pacific walrus males live segregated from the females and young animals for most of the year. They remain for the large part in the ice-free waters of the Bering Sea during summer. One major summering area is in northern Bristol Bay where concentrations of male walrus occur on haul-outs on islands within the Walrus Islands State Game Sanctuary (M8). Hagemeister Island outside the sanctuary is a haul-out of emerging importance for male walrus during the non-breeding season. Boating and fishing restrictions have been placed around many of these haul-out areas (but not Hagemeister Island) to protect walrus from human disturbance. Bristol Bay is an important area for beluga, which summer in the bay and are an important subsistence food.

Inner Bristol Bay

Rivers in the inner Bristol Bay area are important spawning habitat for Pacific salmon (*Oncorhynchus spp.*), in particular perhaps the largest sockeye (*O. nerka*) run in the world as well as pink salmon (*O. gorbuscha*). Juvenile salmon move from the rivers into estuaries and nearshore coastal waters where they reside for some weeks or months (F10) before continuing to offshore feeding areas. Eulachon (*Thaleichthys pacificus*; a species of smelt) also spawns in rivers and the young juveniles have their nursery area in estuaries before migrating further off to the outer shelf region.

Togiak Bay is located on the north side of Bristol Bay (F3). It is the main spawning area for Pacific herring in the eastern Bering Sea and also an important spawning area for capelin. These fishes spawn intertidally on beaches or in shallow sediments close to shore and both species are important as 'forage fish' in the rich food webs of the eastern Bering Sea.

North shore of the Alaska Peninsula

There are several sites along the north shore of the Alaska Peninsula where Pacific herring and capelin spawn intertidally on beaches or on shallow subtidal sediments (F6). These are mainly local populations but they are important as prey for seabirds and other consumers in the food webs in this part of the eastern Bering Sea ecosystem.

There are several estuaries and lagoons along the northern shore of the Alaska Peninsula which are very important molting and staging areas for waterfowl and summer feeding and autumn staging areas for shorebirds (B11). The lagoons include Izembek, Nelson and several others. Among waterfowl species that use these estuaries and lagoons are Steller's eider, black scoter, northern pintail (*Anas acuta*), cackling goose (*Branta hutchinsii*, ssp. *minima* and *taverneri*), black brant and emperor goose. The area is also important as a summer feeding and staging area in autumn for shorebird species including rock and western (*Calidris mauri*) sandpipers, dunlin, and marbled (*Limosa fedoa*), bar-tailed (*L. lapponica*) and Hudsonian (*L. haemastica*) godwits.

There is a walrus haul-out along the north shore of the Alaska Peninsula which is used by walrus feeding in Bristol Bay, especially male walrus during the non-breeding season. It is also a refugium for Threatened Northern sea otters (M1), although sea otters are more common along the southern side of the Alaska Peninsula.

Unimak Island and the western Alaska Peninsula

Nearshore areas along Unimak Island and the western Alaska Peninsula are core habitat for sea otter (*E. l. kenyoni*) in southwestern Alaska (M1). Sea otter was brought close to extinction due to harvesting for their fur, but has recovered in many parts of its former range. There was a dramatic decline of 80–90 % in sea otter abundance in the central Aleutian Islands during the 1990s, possibly due to increased predation by killer whales (*Orcinus orca*) and with consequences for sea urchin grazing on kelp beds. Sea otter is a keystone species in the coastal habitats of southwestern Alaska.

North of Unimak Pass

One of the three main spawning areas of the East Bering stock of Pacific cod is located in a restricted area on the shelf north of Unimak Pass in the southeastern Bering Sea (F7). Pacific cod spawns demersal eggs (on the bottom substrate) that could be sensitive to sinking oil and other stressors.

Waters north of Unalaska and outer Bristol Bay

North Pacific right whale is listed as an 'Endangered' species by the IUCN and the eastern population is believed to have some tens of individuals. The waters north of Unalaska Island used to be an important summer feeding area for right whales (M13). In recent years there have been sightings of right whales in the southeastern Bering Sea (Wade et al., 2006). This area appears now to be a core area and has been designated as 'critical habitat' for North Pacific right whales (NOAA, 2008).

The outer Bristol Bay area on the southeastern shelf is an important feeding area for seabirds during summer (B9). Species which use this area include large numbers of short-tailed shearwaters (*Puffinus tenuirostris*) which are austral winter visitors from the southern hemisphere.

Drifting pack ice on the eastern Bering shelf

The large population of Pacific walrus has its wintering area in polynyas and drifting pack ice over the shelves of the northeastern Bering Sea (Fay, 1982; Ray and Hufford, 1989) (M6b). One core area is in the eastern shelf in the area from northwestern Bristol Bay to south of Nunivak Island. In spring the females and young animals start to move north through Chirikov Basin toward Bering Strait. During this phase of early migration, the pregnant females give birth to their calves. Pacific walrus is still numerous but may be declining (Smirnov et al., 2004; Cooper et al., 2006), and it is expected that this species may be severely negatively affected by climate change (the species is listed as being 'Data Deficient' by the IUCN).

Area 6 – East Coast (Yukon and Kuskokwim Deltas to Norton Sound) including Nunivak Island

Norton Sound

Norton Sound located south of the Bering Strait and Seward Peninsula contains spawning ground for saffron cod (*Eleginus gracilis*), Pacific herring and capelin. Saffron cod spawn under ice in winter and is an important species in the local food webs and for subsistence harvest (F2). Pacific herring and capelin spawn on beaches and in shallow subtidal sediments in inner parts of Norton Sound (F4). Herring is considered to belong to the migratory stock (or stock complex) on the eastern shelf where the majority spawns in Togiak Bay. The spawners in Norton Sound may be a separate spawning component or population. For capelin the stock structure is not well known. Herring and capelin are important 'forage fishes' in the food webs. The Norton Sound herring migrate out to feed on the shelf in summer but return in autumn to spend the winter in estuaries in Norton Sound (F14).

The eastern Norton Sound is an important molting area for spectacled eiders (Petersen et al., 2000) (B12). Much of the eastern two-thirds of Norton Sound have been designated as critical habitat for spectacled eider under the U.S. Endangered Species Act. This species undergoes flightless molt here. It is especially important for breeding females and fledged broods from the Yukon-Kuskokwim Delta, the most imperiled of the spectacled eider populations.

Coastal areas along northern and eastern Norton Sound (including Norton Bay, Safety Sound, Stebbins-St. Michael and Golovin Lagoon) provide summer feeding and autumn staging areas for shorebirds (B17). Species include dunlin, western and semipalmated (*Calidris pusilla*) sandpipers, red-necked phalarope, and long-billed dowitcher (*Limnodromus scolopaceus*).

Nunivak Island and Cape Newenham

Nunivak Island on the inner shelf of the eastern Bering Sea and Cape Newenham in northern Bristol Bay are the locations of large seabird colonies (B4). Common murre is a dominant species and the spawning ground and nursery areas for Pacific herring and capelin in this area provide important food sources for the seabirds.

Yukon-Kuskokwim Delta

The Yukon-Kuskokwim Delta contains a very large intertidal area (about 10 000 km^2 including areas inundated during storm tides) which is of regional and hemispherical significance for migratory birds (B10). The area is a very important breeding and molting area for waterfowl including spectacled eider, black, white-winged and surf scoters, northern pintail, cackling goose (*B. h. minima* and *B. h. taverneri*), brent goose (subspecies black brant), emperor goose and snow goose (*Chen caerulescens*). The delta is also important as a post-breeding and staging area during spring and particularly autumn for a number of shorebirds including dunlin, bar-tailed godwit, bristle-thighed curlew (*Numenius tahitiensis*), western, rock and sharp-tailed (*Calidris acuminata*) sandpiper, red knot and black turnstone (*Arenaria melanocephala*). Kuskokwim Shoals, off the mouth of the Kuskokwim delta, is designated as critical habitat for Steller's eider under the U.S. Endangered Species Act. Tens of thousands of Steller's eiders congregate here to undergo flightless molt in the autumn, and also use the area during spring migration.

Area 7 – St Lawrence Island area including St Lawrence Polynya (South)

Drifting pack ice, leads and polynyas in the northern Bering Sea

The large population of Pacific walrus has its wintering area in polynyas and drifting pack ice over the shelves of the northern Bering Sea (Fay, 1982; Ray and Hufford, 1989) (M6c). One of the core areas is in the northern Bering Sea including the St Lawrence and Sireniki polynyas. In spring the females and young animals start to move north through Chirikov Basin toward Bering Strait. During this phase of early migration, the pregnant females give birth to their calves. Pacific walrus is still numerous but may be declining (Smirnov et al., 2004; Cooper et al., 2006), and it is expected that this species may be severely negatively affected by climate change (the species is assessed as being 'Data Deficient' by the IUCN).

Bowhead whales of the 'Bering-Chukchi-Beaufort stock' and beluga of several stocks including the large migratory 'Beaufort stock', winter in polynyas and pack ice of the northern Bering Sea (Ray and Hufford, 1989; Moore and Reeves, 1993; Angliss and Outlaw, 2008). This includes the St Lawrence and Sireniki polynyas (M11c). In spring they start to move north through leads in the ice, with some whales moving through the Bering Strait in April. Breeding takes place in late winter, and both species give birth to their calves during the northward spring migration.

The St Lawrence Island Polynya south of St Lawrence Island is a prominent and very important wintering habitat for waterfowl. The total world population of spectacled eiders resides in this area for about six months during the winter season each year in small open leads between St Lawrence and St Matthew islands and the area is designated as spectacled eider critical habitat under the U.S. Endangered Species Act (B15). This species does not use recurring polynyas during the majority of the winter season. Rather, they crowd into small cracks and openings in the ice and hold them open by virtue of their presence at extremely high densities, as the ice drifts over areas of high clam density in the substrate beneath them. The area is also used by king eider and long-tailed ducks. The leads and polynyas of the northern Bering Sea are used for resting and feeding by seabirds and waterfowl during spring migration (B7a). This is the case for large numbers of thick-billed and common murres and least and crested auklets.

St Lawrence Island

St Lawrence Island is located on the shelf of the northern Bering Sea (B2a). It holds large breeding colonies of seabirds with least auklet and thick-billed murre as particularly abundant species (Hunt et al., 1981). The seabirds forage out from the colonies typically some tens of kilometers. The island is also breeding and staging areas in spring and autumn for shorebirds, notably rock sandpiper (*C. p. ptilocnemis*) and red phalarope.

Area 8 – Bering Strait (St Lawrence Island north to the Diomede Islands)

Northern Bering Sea–Chirikov Basin

Although not well documented, there is likely to be a large migratory stock of polar cod (*Boreogadus saida*) that migrates south in autumn to spawn in winter under the ice in the southern Chukchi Sea and/or the northern Bering Sea (F1b). The location of spawning area(s) is not known and the area is therefore hypothetical at present. Given the great ecological importance of polar cod in the food webs of the northern Bering and Chukchi seas, the spawning area(s) of this species are clearly of heightened ecological significance.

Gray whale (*Eschrichtius robustus*) uses the Chirikov Basin in the northern Bering Sea as one of its main feeding areas in summer (M14). It feeds on the bottom on the very rich benthic communities (particularly amphipods) in these highly productive shallow waters (Highsmith and Coyle, 1992; Moore et al., 2003). Gray whale (eastern population) forms a large migratory population that has recovered from the commercial whaling of the 19th and early 20th centuries and may now have reached its carrying capacity.

The large population of Pacific walrus has its wintering area in polynyas and drifting pack ice over the shelves of the northern Bering Sea. In spring the females and young animals start to move north through Chirikov Basin toward Bering Strait (M7). During this phase of early migration, the pregnant females give birth to their calves. Pacific walrus is still numerous but may be declining (Smirnov et al., 2004; Cooper et al., 2006), and it is expected that climate change may have severe negative consequences for this species (the species is listed as being 'Data Deficient' by the IUCN).

Bowhead whale of the 'Bering-Chukchi-Beaufort stock' and beluga of several stocks including the large migratory 'Beaufort stock', winter in polynyas and pack ice of the northern Bering Sea. In spring they start to move north through leads in the ice, with some whales moving through the Bering Strait in April (M12). Breeding takes place in late winter, and both species give birth to their calves during the northward spring migration.

Eastern Chukchi Peninsula

Western Chirikov Basin and the adjacent coast of the eastern Chukchi Peninsula are important habitats for Pacific walrus (M10). Males use haul-outs in this area during summer. Females and young animals also use coastal haul-outs in autumn when they return south from the summer feeding areas in the Chukchi Sea.

Bering Strait region

There are major breeding colonies of seabirds on islands in the Bering Strait region (Big and Little Diomede and King islands) (B1). Small auklets (least, crested and parakeet *Aethia psittacula*) that feed on the rich zooplankton transported north with the highly productive Anadyr-Bering shelf waters, are particularly abundant. The 'Critically Endangered' Kittlitz's murrelet also feeds in this area during and after breeding (it breeds inland in adjacent mountainous areas).

St Lawrence Island (area B2b)

See St Lawrence Island including St Lawrence Polynya (South).

Area 9 – Gulf of Anadyr

Northern Bering Sea –Anadyr Gulf

Although not well documented, there is likely to be a large migratory stock of polar cod (*Boreogadus saida*) that migrates south in autumn to spawn in winter under the ice in the southern Chukchi Sea and/or the northern Bering Sea (F1a). The location of spawning area(s) is not known and the area is therefore hypothetical at present. Given the great ecological importance of polar cod in the food webs of the northern Bering and Chukchi seas, the spawning area(s) of this species are clearly of heightened ecological significance.

Drifting pack ice on the northern shelf

The large population of Pacific walrus has its wintering area in polynyas and drifting pack ice over the shelves of the northern Bering Sea (M6a). One of the core areas is in the northern Bering Sea including the St Lawrence and Sireniki polynyas. In spring the females and young animals start to move north through Chirikov Basin toward Bering Strait. During this phase of early migration, the pregnant females give birth to their calves. Pacific walrus is still numerous but may be declining, and it is expected that this species may be severely negatively affected by climate change (the species is listed as being 'Data Deficient' by the IUCN).

Northern Gulf of Anadyr

The northern Gulf of Anadyr is a major summering area with haul-outs for male Pacific walrus along the southern coast of the Chukchi Peninsula (M9).

Pack ice and polynyas in the northern Bering Sea

Bowhead whales of the 'Bering-Chukchi-Beaufort stock' and beluga of several stocks including the large migratory 'Beaufort stock', winter in polynyas and pack ice of the northern Bering Sea (M11c). This includes the St Lawrence and Sireniki polynyas. In spring they start to move north through leads in the ice, with some whales moving through the Bering Strait in April. Breeding takes place in late winter, and both species give birth to their calves during the northward spring migration.

The Sireniki Polynya south of the Chukchi Peninsula is used for resting and feeding by seabirds and waterfowl during spring migration (B7b). This is the case for large numbers of thick-billed and common murres and least and crested auklets.

Area 10 – Northeastern coast of Kamchatka and offshore areas

Northern Karagin and Korf bays

Karagin and Korf Bays are located at the base of the Kamchatka isthmus in the western Bering Sea. Beaches and subtidal sediments in the inner parts of these bays are spawning areas for Pacific herring and capelin of western Bering Sea stocks (F5). As in the eastern Bering Sea, herring and capelin are important species in the food webs; they are eaten, as eggs on the spawning grounds by diving eiders and other species, as larvae and juveniles by murres and other seabirds, and as adults by seals, fish and other predators.

Outer shelf off Olyutorskiy and northern Karaginsky bays

The main wintering area for the stock of Pacific herring in the western Bering Sea is on the outer shelf off Olyutorskiy and northern Karaginsky bays (F12). In a similar manner as for the stock in the eastern Bering Sea, the herring occurs as a concentrated band along the outer shelf at depth of 100–150 m.

Chukchi Sea LME

Areas of heightened ecological significance in the Chukchi Sea LME are shown in Figures A.11a and A.11b, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.15.

Area 1 – Chukchi Plateau

Chukchi Rise area

Arctic cod (*Arctogadus glacialis*) is possibly an important species in the northern Chukchi Sea LME in the slope and deep water beyond the shelf (F3). It has been suggested (Walters, 1961; Andriyashev et al., 1980) that they undertake a winter migration, possibly to spawn over the Chukchi Rise. The location of the spawning area is not known and is therefore hypothetical at present.

Area 2 – Northeast coastal area (Alaska)

Nearshore areas in northwestern Alaska

Capelin is known to spawn in summer along the sandy seaward beaches of barrier islands in the area of Point Lay and also near

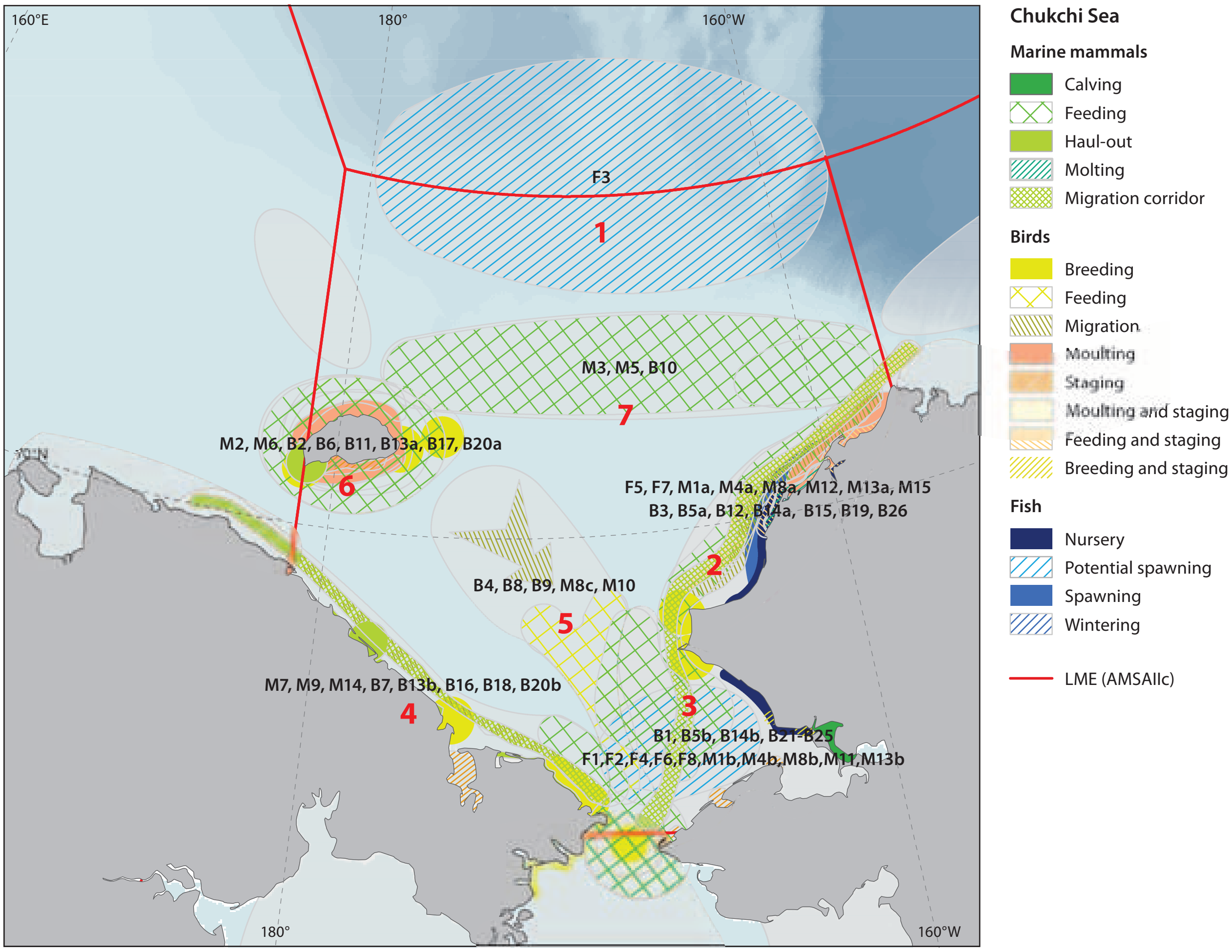


Figure A.11a. Areas of heightened ecological significance in the Chukchi Sea LME.

Point Barrow (F5). There is limited information on capelin in the Chukchi Sea where it appears to be mainly a coastal species.

Estuaries and lagoons along the coast of Alaska

In addition to the estuaries and lagoons in the Kotzebue Sound area, there are several other estuaries and lagoons along the Alaskan Chukchi coast (F7) that serve as nursery areas for juvenile whitefish (Mecklenburg et al., 2002) and as migration corridors for juvenile and adult whitefish (humpback *Coregonus pidschian* and broad *C. nasus* whitefish, least *C. sardinella* and Bering *C. laurettae* ciscoes).

Beluga of the Eastern Chukchi Sea stock move into Kasegaluk Lagoon in northwestern Alaska (M12) where they stay for a few weeks from late June or early July (Frost and Lowry, 1990; Frost et al., 1993; Huntington et al., 1999). The area is probably used primarily for molting, when the beluga use the gravel bottoms to rub off the old layer of skin (Frost et al., 1993).

Kasegaluk Lagoon in northwestern Alaska is an important summer feeding and staging area for geese, with black brant and greater white-fronted goose (*Anser albifrons*) as the main species (B15). The lagoon is also used for breeding and as spring and autumn staging area for shorebirds, notably dunlin (*C. a. arcticola*) and red phalarope (B26).

Coastal waters along Alaska

Coastal waters off northwestern Alaska, in particular Peard and Ledyard bays, are important molt areas for several species of seaduck, including common and king eiders and long-tailed duck, and Ledyard Bay in particular is used by tens of thousands of spectacled eider during their flightless autumn molt (Petersen et al., 2000; Oppel et al., 2009) (B12). These species are flightless for about four weeks during molt of their wing feathers when they occur concentrated at favorable feeding areas in relatively shallow and productive waters. Ledyard Bay is of particular importance to female spectacled eider that have bred on Alaska's Arctic Coastal Plain, along with their broods, and is designated as spectacled eider critical habitat under the U.S. Endangered Species Act.

Peard Bay in northwestern Alaska is a summer feeding and autumn staging area for red phalarope from breeding areas in northern Alaska (B19).

Seaducks and divers (or loons) use migration corridors along the coasts during the southbound autumn migration (B14a). These corridors are usually centered around the 20 m isobath where the birds can dive to feed on bottom-living animals (seaducks) or fish (divers). Species that use this corridor include common and king eiders, long-tailed duck, black scoter, and red-throated (*Gavia stellata*), black-throated (*G. arctica*) and white-billed (*G. adamsii*) divers.

Table A.15. Areas of heightened ecological significance within the Chukchi Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		OGA No.	Ecological function	PSSA criteria										
No.	Location			Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Chukchi Plateau	F3	Potential spawning area on the slope and deep water beyond the shelf; Arctic cod (*Arctogadus glacialis*)		×	×				×	×		×	×
2	Northeast coastal area (Alaska)	F5	Fish spawning areas along the coast; capelin		×	×				×	×		×	
		F7	Nursery areas for fish in estuaries and lagoons; humpback whitefish, broad whitefish, least cisco, Bering cisco		×					×	×		×	
		M1a	Spring polar bear feeding area in ice leads along the coast		×	×					×		×	
		M4a	Pacific walrus migration area in spring		×	×				×	×		×	
		M12	Molting area for beluga of the Chukchi stock in Kasegaluk lagoon		×					×	×		×	
		M13a	Summer feeding areas; gray whale		×				×		×		×	
		M15	Walrus haul out		×						×		×	
		M8a	Spring migration corridor in leads along the coast; bowhead whale and Beaufort Sea stock of beluga	×	×	×				×	×		×	×
		B3	Spring staging and feeding in leads along the coast; common eider, king eider, red phalarope		×	×				×	×		×	
		B5a	Seabird breeding colonies at Cape Lisburne; thick-billed murre, common murre, horned puffin, black-legged kittiwake		×				×	×	×		×	
		B12	Molt area for seaducks, Peard Bay, Ledyard Bay; common eider, king eider, spectacled eider, long-tailed duck		×	×			×	×	×		×	
		B14a	Migration corridor for seaducks and divers, coastal waters along Alaska; common eider, king eider, long-tailed duck, black scoter, red-throated diver, black-throated diver, white-billed diver		×	×			×	×	×		×	
		B26	Kasegaluk lagoon: summer feeding and staging area for geese; black brant, greater white-fronted goose		×	×			×	×	×		×	
		B15	Kasegaluk lagoon: breeding and spring and autumn staging area for shorebirds; dunlin, red phalarope		×	×		×	×	×	×		×	×
		B19	Summer feeding and autumn staging area for shorebirds in Peard Bay; red phalarope		×					×	×		×	

Area No.	Area Location	OGA No.	Ecological function	PSSA criteria: Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
3	Southeastern Chukchi Sea (Chukchi Bight, Kotzebue Sound area)	F1	Potential fish spawning area; polar cod (*Boreogadus saida*)		×	×				×	×		×	
		F2	Potential fish spawning area; saffron cod		×	×				×	×		×	
		F4	Fish spawning area; Pacific herring		×	×				×	×		×	
		F6	Nursery areas for fish in estuaries; chum and pink salmon		×					×	×		×	
		F8	Wintering area for fish in estuaries; Pacific herring		×	×					×		×	
		M4b	Spring migration corridor north of Bering Strait; Pacific walrus	×	×	×				×	×		×	×
		M1b	Spring polar bear feeding area in ice leads along the coast		×	×			×		×		×	
		M8b	Spring migration corridor in leads along the coast; Bowhead whale and Beaufort Sea stock of beluga		×	×				×	×		×	×
		M11	Kotzebue Sound: early summer habitat for beluga		×	×				×	×		×	
		M13b	Summer feeding areas, offshore; gray whale		×				×				×	
		B1	Migration route and spring feeding by seabirds, seaducks and phalaropes in leads and polynyas; thick-billed murre, common murre, common (Pacific) eider, king eider, long-tailed duck, red phalarope, red-necked phalarope		×	×			×	×	×		×	×
		B5b	Seabird breeding colonies at Cape Thompson; thick-billed murre, common murre, horned puffin, black-legged kittiwake		×				×	×	×		×	
		B14b	Migration corridor for seaducks and divers in coastal waters along Alaska; common eider, king eider, long-tailed duck, black scoter, red-throated diver, black-throated diver, white-billed diver		×	×			×	×	×		×	
		B21	Breeding, and spring and autumn staging area for shorebirds in the Noatak River Delta; dunlin, western sandpiper, semipalmated sandpiper, long-billed dowitcher		×	×				×	×		×	
		B22	Autumn staging of shorebirds in Shishmaref Inlet; western sandpiper, dunlin, Pacific golden plover		×	×				×	×		×	
		B23	Autumn staging of shorebirds near Cape Espenberg; western sandpiper, semipalmated sandpiper, dunlin		×	×				×	×		×	
		B24	Autumn staging of shorebirds in Lopp Lagoon; western sandpiper, semipalmated sandpiper, dunlin		×	×				×	×		×	
		B25	Breeding and autumn staging of shorebirds at Krusenstern Lagoon; red-necked phalarope, long-billed dowitcher, western sandpiper, semipalmated sandpiper, pectoral sandpiper		×	×				×	×		×	

Area No.	Area Location	OGA No.	Ecological function	PSSA criteria: Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
4	Northern Chukchi Peninsula	M7	Autumn haul-outs on the north coast of Chukotka Peninsula; Pacific walrus		×				×		×		×	
		M9	Spring migration corridor in ice leads of northern Chukotka; Bowhead whale and western Chukchi stock of beluga		×	×				×	×		×	
		M14	Summer feeding areas, offshore; gray whale		×					×	×		×	
		B7	Seabird breeding colonies at Kolyuchin Island; thick-billed murre, horned puffin		×					×	×		×	
		B16	Staging area in Kolyuchin Bay; black brant goose		×	×				×	×		×	
		B18	Shorebird breeding and feeding area in the coastal habitats in northern and eastern Chukotka; Critically Endangered spoon-billed sandpiper		×	×			×	×			×	
		B13b	Molt area for seaducks along northern Chukotka; common eider, king eider, long-tailed duck		×					×	×		×	
		B20b	Summer feeding and migration area for shorebirds in waters along northern Chukotka; red phalarope, red-necked phalarope		×					×	×		×	
5	South-central Chukchi Sea (including Bering Strait region)	B4	Seabird breeding colonies; least auklet, crested auklet, parakeet auklet, thick-billed murre, common murre, dovekie, black-legged kittiwake		×				×	×	×		×	×
		B9	Molt migration; thick-billed murre (juveniles and males are flightless, swimming from colonies)		×					×	×		×	
		M8c	Spring migration corridor for bowhead whale, beluga, and Pacific walrus	×	×	×				×	×		×	×
		M10	Potential summer feeding area in the Bering Strait region for bowhead whale (possibly individuals from resident stock component)		×						×		×	
		B8	Summer/autumn feeding area for seabirds in the 'Plume' area north from Bering Strait; least auklet, crested auklet, parakeet auklet, black-legged kittiwake, short-tailed shearwater		×				×		×		×	
6	Wrangel/Herald Islands area	M2	Feeding area in summer; polar bear	×	×	×			×		×		×	×
		M6	Feeding area in summer, Pacific walrus		×				×		×		×	×
		B2	Spring feeding by seabirds, seaducks and phalaropes in leads and polynyas; thick-billed murre, common eider, red phalarope		×	×				×	×		×	
		B6	Seabird breeding colonies; thick-billed murre, black guillemot, horned puffin, black-legged kittiwake		×				×	×	×		×	

Area No.	Area Location	OGA No.	Ecological function	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
		B11	Summer/autumn feeding area for seabirds in coastal waters; Critically Endangered Kittlitz's murrelet		×						×		×	×
		B13a	Molt area for seaducks in waters around Wrangel Island; Common eider, king eider, long-tailed duck		×	×			×	×	×		×	
		B17	Molting and staging area in coastal habitats; black brant goose, snow goose		×	×				×	×		×	
		B20a	Summer feeding and migration area for shorebirds in waters around Wrangel Island; red phalarope, red-necked phalarope		×	×				×	×		×	
7	Chukchi Shelf (northern and central parts)	M3	Marginal ice zone in northern Chukchi, feeding area in summer and autumn for polar bear		×	×			×		×		×	
		M5	Hannas Shoal: feeding area in summer for Pacific walrus		×				×		×		×	
		B10	Summer/autumn feeding area for seabirds in drift ice in northern Chukchi Sea; black guillemot, ivory gull, Ross's gull		×	×					×		×	

Note: sub-divisions of area designation such as B2a and B2b refer to habitat or ecological regions that cross the somewhat arbitrary geographical boundaries.

Sites on the Lisburne Peninsula hold large breeding colonies of seabirds (B5a). The main species that breed here are thick-billed and common murres, horned puffin and black-legged kittiwake. This area holds some of the major seabird colonies in the eastern Chukchi Sea and the birds feed out from them in the rich waters around Cape Lisburne (Piatt and Springer, 2003). They are also among the northernmost major colonies of common murre and horned puffin (*Fratercula corniculata*) in the Pacific sector (Ainley et al., 2002; Piatt and Kitaysky, 2002).

The coastal areas near Point Lay have increased in importance for Pacific walrus, which are now hauling out there in groups of up to 10 000 to 15 000 when sea ice retreats northward of the continental shelf during the open water season (M15). Walrus are particularly vulnerable to disturbance, and deaths occur from stampedes that happen in response to disturbance events. Calves are particularly vulnerable.

Gray whales of the large migratory eastern population (about 20 000 to 25 000 animals) (Rugh et al., 2005; Angliss and Outlaw, 2008) have main benthic feeding grounds in offshore areas in the eastern Chukchi Sea, primarily in areas located southwest of Point Hope, along the coast between Icy Cape and Point Barrow, and further offshore from Barrow toward Hannah Shoal (M13a) (Moore and DeMaster, 1998; Moore et al., 2000, 2003). The gray whale population has recovered and may now be at its carrying capacity (Moore et al., 2001, 2003; Rugh et al., 2005). There has been a trend in recent years that the feeding grounds in the Chukchi Sea have become relatively more important, probably related to warming with less summer sea ice in the Chukchi Sea.

Flaw lead system along the coast of Alaska

The predominant northerly winds over the Chukchi Sea in winter open a lead system at the transition between the landfast and drifting ice. This lead system is used as a major migration corridor in spring (April–May) for the large stocks of bowhead whale (about 10 000) (Moore and Reeves, 1993; George et al., 2004) and beluga (about 40 000) (Angliss and Outlaw, 2008) on their way from wintering areas in the northern Bering Sea to summer feeding areas in the eastern Beaufort Sea (M8a). The whales mate and give birth to young during the spring migration. These migratory 'trains' of whales moving into the Arctic in spring are of very high ecological significance.

The system of leads along Alaska is also a major migration corridor and feeding area for polar bears of the Bering-Chukchi subpopulation (M1a) (Durner and Amstrup, 2000; Amstrup et al., 2006) as they retreat north in spring prior to ice break-up. Somewhat later in the season, Pacific walrus move north from the Bering Strait through the same area toward their feeding grounds in the northeastern Chukchi Sea (M4a) (Fay, 1982; Ray and Hufford, 1989).

The lead system is also used as an important migratory route and feeding area during the spring migration for common and king eiders and red phalarope (B3). Ledyard Bay north of Cape Lisburne is particularly important for king eider in spring and is designated as critical habitat for spectacled eider under the U.S. Endangered Species Act.

Area 3 – Southeastern Chukchi Sea (Chukchi Bight, Kotzebue Sound area)

Southern Chukchi Sea

Polar cod (*Boreogadus saida*) is a key species in the Chukchi Sea ecosystem. Although not well documented, there is likely to be a large migratory stock that migrates south in autumn to spawn in winter under the ice in the southern Chukchi Sea and/or the northern Bering Sea (F1) (Ponomarenko, 1968; Lowry and Frost, 1981). The location of spawning area(s) is not known and the area is therefore hypothetical at present.

Kotzebue Sound

Kotzebue Sound, located in western Alaska north of the Bering Strait and the Seward Peninsula, is a potential spawning area for saffron cod which spawns under the ice in winter (F2). Pacific herring occurs possibly with a separate stock which is resident year round in Kotzebue Sound and the adjacent Chukchi Bight (Wespestad and Barton, 1981). Herring spawns along the north shore of the Seward Peninsula and in Kotzebue Bay after ice clearance in summer (F4).

Estuaries in Kotzebue Sound are nursery areas for juvenile chum (*Oncorhynchus keta*) and pink salmon that spawn in the rivers in the area (F6) (McPhail and Lindsey, 1970; Craig and Haldorson, 1986; Stephenson, 2006). The juveniles move down-river to spend the first summer in estuaries and tidal wetlands near their natal streams where they may form schools and occur in large aggregations (NMFS, 2005; MMS, 2007). The estuarine nursery areas used by chum and pink salmon are considered essential fish habitat by the U.S. National Marine Fisheries Service (NMFS, 2005). Estuaries and plumes of brackish water that extend from them in shallow coastal waters and lagoons serve as nursery areas for juvenile whitefish and as migration corridors for juvenile and adult whitefish. There are four species of coregonid whitefishes that occur with amphidromous populations in the Chukchi Sea area: humpback whitefish, broad whitefish, least cisco, and Bering cisco. They spawn in freshwater, and juveniles and adults move to estuaries and brackish coastal waters to feed in summer, before retreating back into rivers as winter approaches. These areas provide important ecological links between the marine and freshwater environments.

The estuaries of the major rivers discharging to the Kotzebue Sound area are probably important wintering habitat for herring in the southeastern Chukchi Sea (F8) (Wespestad and Barton, 1981). Herring is an important prey species for many predators in the ecosystem.

Beluga of the Eastern Chukchi Sea stock (about 4000 individuals) use areas in Kotzebue Sound as early summer feeding areas and possibly as calving grounds (M11) (Frost and Lowry, 1990; Huntington et al., 1999). They stay in this area for some weeks in June before they continue further north to Kasegaluk Lagoon and beyond.

Cape Thompson and Cape Lisburne

Cape Thompson and Cape Lisburne on the Lisburne Peninsula hold large breeding colonies of seabirds (B5b). The main species that breed here are thick-billed and common murres, horned puffin and black-legged kittiwake (Fadely et al., 1989; Gaston and Hipfner, 2000; Dragoo et al., 2004). These are the major seabird colonies in the eastern Chukchi Sea and the birds feed out from them in the rich waters around Cape Lisburne. They are also among the northernmost major colonies of common murre and horned puffin in the Pacific sector of the Arctic.

Noatak River Delta

Noatak River Delta is located north of Kotzebue at the entrance to Kotzebue Sound. This is an important breeding and spring and autumn staging area for shorebirds (B21). Major species are dunlin, western and semipalmated sandpipers and long-billed dowitcher.

Coastal sites in the southeastern Chukchi Sea (Shishmaref Inlet, Cape Espenberg, Lopp Lagoon, Krusenstern Lagoon)

Lopp Lagoon (B24), Shismaref Inlet (B22) and Cape Espenberg (B23) are lagoons and inlets along the north shore of Seward Peninsula in western Alaska just north of the Bering Strait. These sites are used as autumn staging areas for migratory shorebirds, notably western sandpiper, semipalmated sandpiper, dunlin and Pacific golden plover (*Pluvialis fulva*).

Krusenstern Lagoon (B25) is located northwest of Kotzebue outside the entrance to Kotzebue Sound. This area is a breeding and autumn staging area for shorebirds, including red-necked phalarope, long-billed dowitcher, and western, semipalmated and pectoral (*Calidris melanotos*) sandpipers.

Offshore areas in the eastern Chukchi Sea

Gray whales of the large migratory eastern population (about 20 000 to 25 000 animals) (Rugh et al., 2005; Angliss and Outlaw, 2008) have main benthic feeding grounds in offshore areas in the eastern Chukchi Sea, including in areas located southwest of Point Hope (M13b) (Moore and DeMaster, 1998; Moore et al., 2000, 2003). The gray whale population has recovered and may now be at its carrying capacity. There has been a trend in recent years that the feeding grounds in the Chukchi Sea have become relatively more important, probably related to warming with less summer sea ice in the Chukchi Sea.

Seaducks and divers (or loons) use migration corridors along the coasts during the southbound autumn migration (B14b). These corridors are usually centered around the 20 m isobaths where these birds can dive to feed on bottom-living animals (seaducks) or fish (divers). Species that use this corridor include common and king eiders, long-tailed duck, black scoter, and red-throated, black-throated and white-billed divers.

Flaw lead system along the coast of Alaska

The predominant northerly winds over the Chukchi Sea in winter open a lead system at the transition between the landfast and drifting ice. This lead system is used as a major migration corridor in spring (April-May) for the large stocks of bowhead whale (about 10 000) (Moore and Reeves, 1993; George et al., 2004) and beluga (about 40 000) (Frost and Lowry, 1990; Huntington et al., 1999) on their way from wintering areas in the northern Bering Sea to summer feeding areas in the eastern Beaufort Sea (M8b). The whales mate and give birth to young during the spring migration (Koski et al., 1993, 2004; Reese et al., 2001). These migratory 'trains' of whales moving into the Arctic in spring are of very high ecological significance.

The system of leads along Alaska is also a major migration corridor and feeding area for polar bears of the Bering-Chukchi subpopulation as they retreat north in spring prior to ice break-up (M1b) (Durner and Amstrup, 2000; Amstrup et al., 2006). Somewhat later in the season, Pacific walrus move north from the Bering Strait through the same area toward their feeding grounds in the northeastern Chukchi Sea (M4b) (Fay, 1982; Ray and Hufford, 1989).

The lead system extending north from Bering Strait along western Alaska and persistent polynyas in this area provide an important migratory route and feeding areas during spring migration for seabirds, seaducks and phalaropes (B1). This is the case for thick-billed and common murres (Hunt et al., 1981; Fadely et al., 1989; Gaston and Hipfner, 2000), common (Pacific) and king eiders, long-tailed duck, and red and red-necked phalaropes.

Area 4 – Northern Chukchi Peninsula

Waters off northern Chukotka

Pacific walrus feed in the waters off Chukotka and use coastal haul-outs during late summer and autumn (M7) (Kochnev, 2004). With less sea ice in recent years, the use of coastal haul-outs in this area has increased. This may be associated with less favorable feeding conditions due to unavailability of offshore feeding grounds when there is no ice to use for resting between feeding bouts (Tynan and DeMaster, 1997; Kochnev, 2004; Cooper et al., 2006).

Leads along the northern coast of Chukotka provide a migration corridor in spring or early summer for bowhead whales and beluga (M9) (Braham et al., 1984; Melnikov et al., 2004). The beluga are considered to be a separate stock (Western Chukchi stock) (Frost and Lowry, 1990; O'Corry-Crowe et al., 1997; Mymrin et al., 1999) which is also possibly the case for bowhead whale (Moore and Reeves, 1993; Bogoslovskaya, 2003).

Some gray whales of the large migratory eastern population move northwest from Bering Strait to feeding grounds along Chukotka west to Cape Serdtse-Kamen (M14) (Bogoslovskaya et al., 1982; Miller et al., 1985; Belikov and Boltunov, 2002).

Kolyuchin Island

Kolyuchin Island outside Kolyuchin Bay in northern Chukotka holds seabird breeding colonies, with thick-billed murre and horned puffin as important species (B7) (Konyukhov et al., 1998; Kondratyev et al., 2000).

Kolyuchin Bay

Kolyuchin Bay on the northern Chukchi Peninsula is a major staging area for black brant prior to autumn migration for birds that breed in northern Chukotka (B16).

Coastal habitats in northern and eastern Chukotka

Spooned-billed sandpiper (*Eurynorhynchus pygmeus*) has a restricted breeding range along the coasts of the southwestern Chukchi Sea and northwestern Bering Sea south to northern Kamchatka (B18). It nests on coastal habitats with sparsely vegetated sandy ridges near lakes and marshes and also on dry and gravely tundra. Spooned-billed sandpiper is listed as 'Critically Endangered' and their number is estimated to be less than 1000 individuals and declining (IUCN). The breeding area includes coastal habitat along the eastern and northeastern Chukchi Peninsula.

Molt areas for seaducks (common and king eiders and long-tailed duck) are found in relatively shallow and productive waters around Wrangel Island and along northern Chukotka (B13b). Coastal habitats along Chukotka are also summer feeding and autumn migration areas for large numbers of red and red-necked phalaropes that breed on tundra in northeastern Siberia (B20b).

Area 5 – South-central Chukchi Sea (including Bering Strait region)

Bering Strait region

This area harbors seabird breeding colonies of least auklet, crested auklet, parakeet auklet, thick-billed murre, common murre, and black-legged kittiwake (Hunt et al., 1981; Konyukhov et al., 1998; Gaston and Hipfner, 2000; Kondratyev et al., 2000; Piatt and Springer, 2003; Dragoo et al., 2004) (B4). Dovekie also breed in this region, far from the main breeding areas in the Atlantic sector of the Arctic.

Large numbers of bowhead whale, beluga and Pacific walrus move through the Bering Strait in spring (late March–June; Frost and Lowry, 1990; Moore and Reeves, 1993; Melnikov et al., 1997, 2004; Angliss and Outlaw, 2008). Depending on ice conditions they may linger in the Bering Strait region for some time before proceeding north through the lead systems they use for the spring migration (M8c).

In the previous whaling period, many bowhead whales were hunted in the Bering Strait region in summer (Townsend, 1935; Braham et al., 1980; Bockstoce and Burns, 1993). These whales were possibly of a more resident stock component that did not migrate north to the Beaufort Sea or the northern Chukchi Sea (M10) (Bogoslovskaya, 2003). The Bering Strait region could still possibly be a summer feeding ground for recovering remnants of such a stock component.

'Plume' area north from Bering Strait

The highly productive Anadyr–Bering shelf waters transport large amounts of zooplankton (Springer et al., 1989; Piatt and Springer, 2003) and small fish north through the Bering Strait and continuing as a plume of rich waters through Hope Sea Valley in the southern and central Chukchi Sea (Woodgate et al., 2005). This 'plume' area is an important feeding area for seabirds in late summer and early autumn, including least, crested and parakeet auklets from the breeding colonies in the northern Bering Sea and Bering Strait, black-legged kittiwakes, and summer-visiting short-tailed shearwaters from the southern hemisphere (B8).

Juvenile thick-billed murres accompanied by their male parents swim away from the breeding colonies in the Chukchi Sea (Wrangel and Herald islands and Cape Lisburne and Cape Thompson) toward feeding areas presumably in the south-central parts of the Chukchi Sea (B9) (Hatch et al., 2000). The males are flightless due to molt of wing feathers for about four weeks during this period. This swimming migration is not well documented but represents an ecologically important and sensitive phase in the life history of thick-billed murre in the Chukchi Sea.

Area 6 – Wrangel/Herald Islands area

Wrangel and Herald Islands

Lesser snow geese (*C. c. caerulescens*) breed with a population of about 60 000 individuals at Wrangel Island. Some aggregate in coastal habitats along estuaries and bays on the south shore of the island during molt and staging for the autumn migration. Black brant is a more coastal species of goose and large numbers of non- and failed breeders appear to use coastal habitats on Wrangel Island as molting and staging area prior to autumn migration (B17).

Wrangel Island and the sea areas surrounding it are important habitat for polar bears in spring and summer when they hunt seals in polynyas and leads in the pack ice (M2) (Aars et al., 2006; Schliebe et al., 2006b). Many polar bears of the Bering–Chukchi subpopulation retreat north with the pack ice in summer, and the area around Wrangel Island is used by relatively large numbers of polar bears (Kochnev et al., 2003; Schliebe et al., 2006a). Many come ashore when the ice clears away from the island in late summer or autumn (Kochnev, 2002; Kochnev et al., 2003; Ovsyanikov, 2003; Aars et al., 2006). Wrangel Island is an important denning area for the Chukchi population of polar bears.

The area around Wrangel Island is also an important feeding ground for the large migratory population of Pacific walrus (females and young animals) that use haul-outs on the island (M6) (Kochnev, 2004). The polar bear and walrus populations may both be declining and are considered to be stressed by more rapid summer sea-ice melt due to global warming (Kochnev, 2004; Aars et al., 2006; Cooper et al., 2006).

There are relatively large breeding colonies of seabirds on the west and east coast of Wrangel Island and on the smaller Herald Island in the northwestern Chukchi Sea (B6). Main species are thick-billed murre (*U. l. heckeri*) (Gaston and Hipfner, 2000), black-legged kittiwake and black guillemot. Horned puffin breeds in smaller numbers as the northernmost occurrence on Wrangel Island (Konyukhov et al., 1998). Common murre has been extending its breeding range and also breeds now in low numbers at Wrangel and Herald Islands (Kondratyev et al., 2000). The seabirds feed out some tens of kilometers from the colonies during the breeding season.

Coastal waters in the southern Chukchi Sea and around Wrangel Island

The 'Critically Endangered' (IUCN) Kittlitz's murrelet uses coastal waters in the southern Chukchi Sea (from the Bering Strait and north to beyond Cape Lisburne in Alaska and northwest along the northern coast of Chukotka) and around Wrangel Island as feeding habitats in summer and autumn after breeding (B11).

Molt areas for seaducks (common and king eiders and long-tailed duck) are found in relatively shallow and productive waters around Wrangel Island (B13a). These areas are also summer feeding and autumn migration areas for large numbers of red and red-necked phalaropes that breed on tundra in northeastern Siberia (B20a).

Leads and polynyas around Wrangel and Herald Islands

Leads and polynyas are used for spring feeding prior to breeding for birds that breed on Wrangel and Herald islands in the northwestern Chukchi Sea, including thick-billed murre (Gaston and Hipfner, 2000), common eider and red phalarope (B2).

Area 7 – Chukchi Shelf (northern and central parts)

The marginal ice zone in the northern Chukchi Sea

Polar bears of the Bering–Chukchi subpopulation retreat with the ice northward and get concentrated in the marginal ice zone of the northern Chukchi Sea in late summer and autumn (Kochnev et al., 2003; Schliebe et al., 2006a). This constitutes therefore an important feeding habitat for polar bear (M3) (Durner and Amstrup, 2000; Amstrup et al., 2006). With the more rapid and extensive sea-ice melt that has been witnessed in recent years, this habitat may not be available or may be of much reduced quality as a feeding habitat for polar bear. This is a factor that adds stress to the polar bear subpopulation in the Chukchi Sea (Aars et al., 2006).

The drifting pack ice and ice edge zone in the northern Chukchi Sea is a main feeding area for ivory and Ross's gulls and black guillemot in late summer and autumn after breeding (B10).

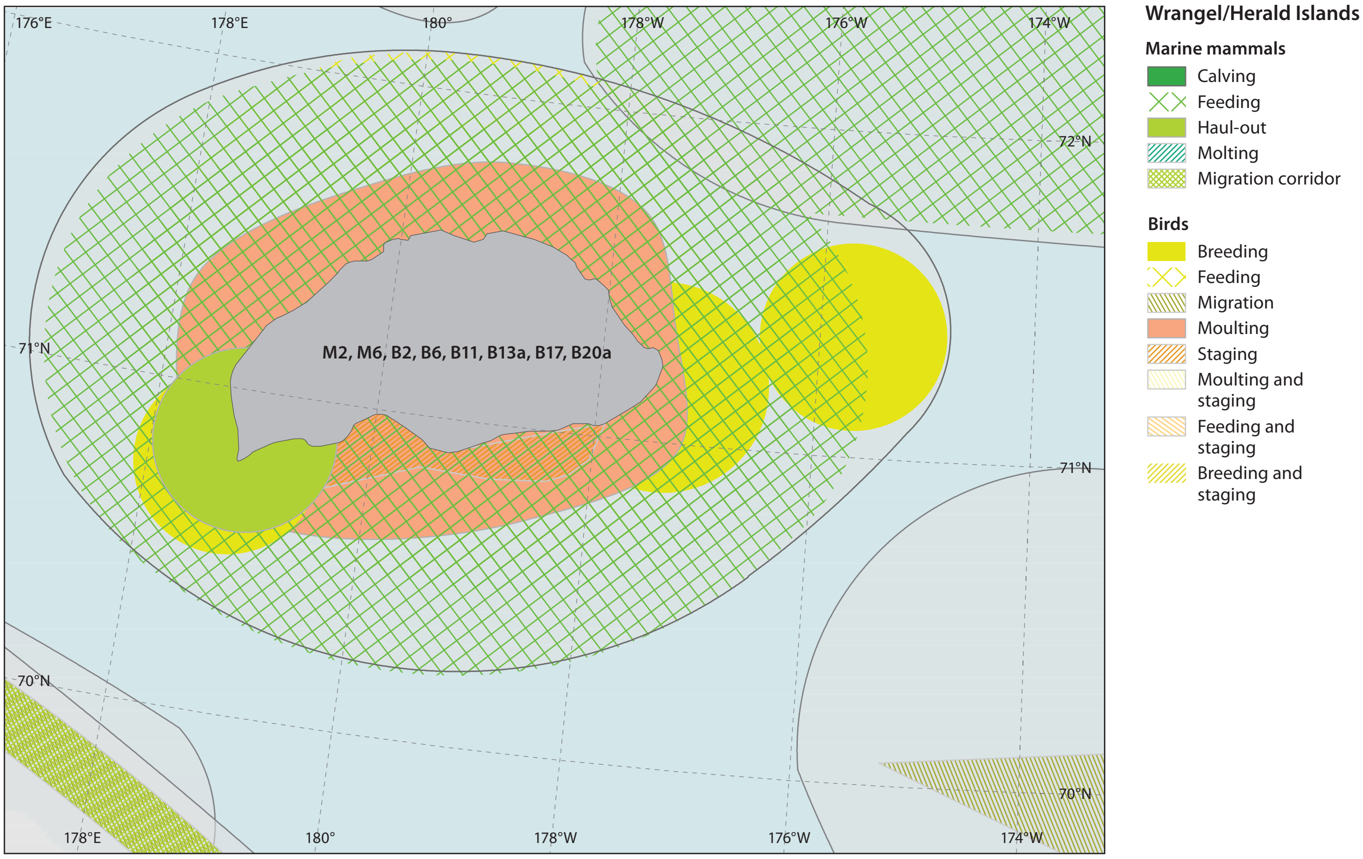


Figure A.11b. Areas of heightened ecological significance in the Chukchi Sea LME, Wrangel Island.

Hanna Shoal

Hanna Shoal is a shallow area located in the northeastern Chukchi Sea northwest of Barrow. This area is an important feeding ground for Pacific walrus during late summer and autumn (M5) (Kochnev, 2004; MMS, 2007). In addition to walrus, this area is also an important gray whale feeding area in some years.

Beaufort Sea LME

Areas of heightened ecological significance in the Beaufort Sea LME are shown in Figure A.12, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.16.

Area 1 – Amundsen Gulf area

1.1: Cape Bathurst Polynya

The recurrent polynya and ice-edge habitat make the Cape Bathurst Polynya an important beluga, bowhead whale, polar bear, and ringed seal feeding ground. Beluga (around 40 000 individuals) and bowhead whales (about 10 000 individuals) of the large migratory Beaufort Sea and Bering-Chukchi-Beaufort Sea populations, respectively, use the polynya area in the eastern Beaufort Sea as their main feeding ground in the early part of summer (May–June). Polar bears of two subpopulations (northern and southern Beaufort Sea) also use this area as a migration corridor and for breeding purposes. Polar bears migrate into the inner reaches of the Amundsen Gulf area in autumn to access bays with fast ice that are prime breeding habitat for ringed seal. In spring they move back to the pack ice where they may occur concentrated around the Cape Bathurst Polynya and later in summer may be found concentrated along the edge of the pack ice. The Cape Bathurst Polynya is also an important spring staging and feeding area for seabirds and seaducks (glaucous gull, king and common eiders, long-tailed duck).

1.2: Banks Island Shorelead

This flaw lead system, which extends from the Cape Bathurst Polynya, lies over relatively shallow waters, creating habitat

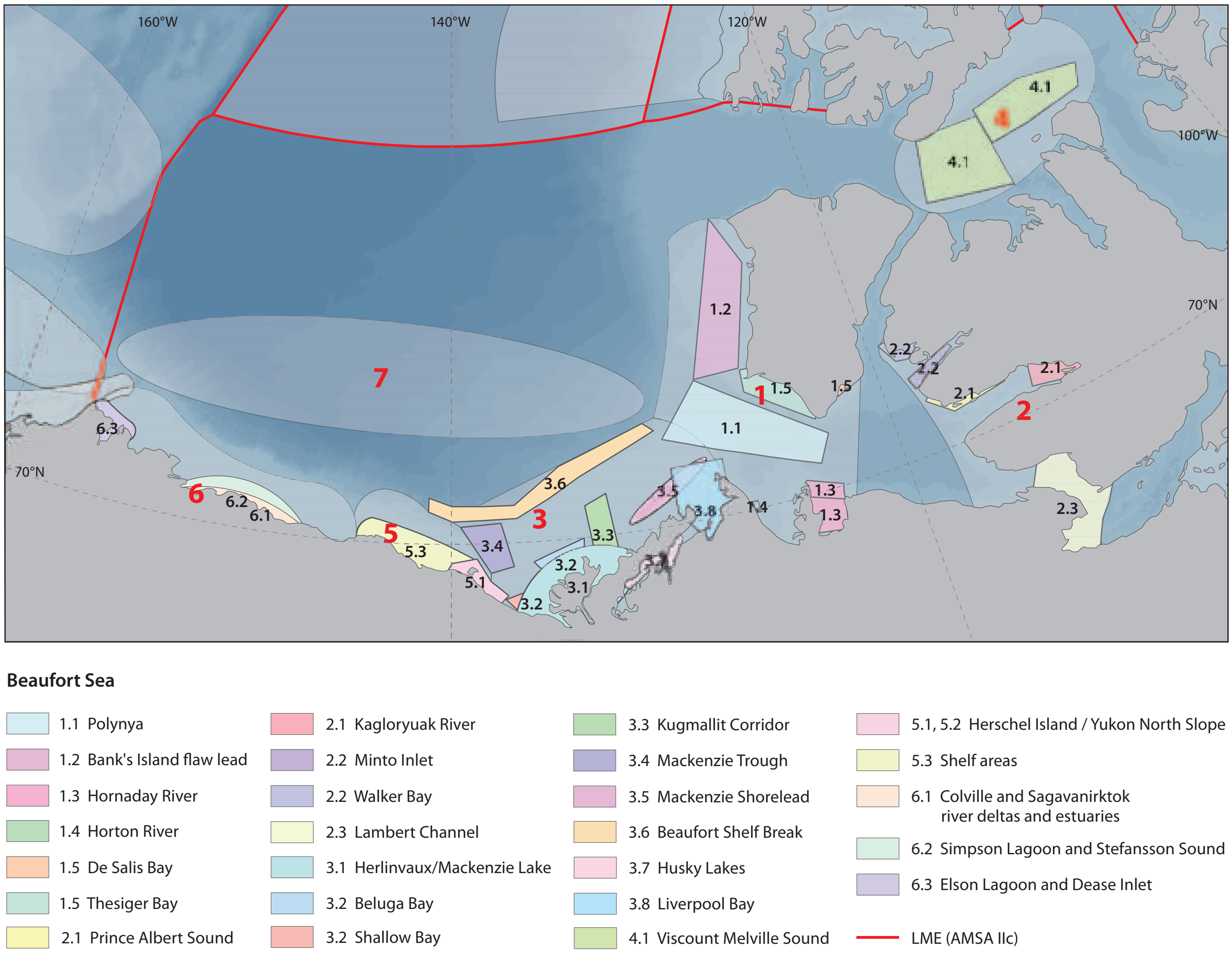


Figure A.12. Areas of heightened ecological significance in the Beaufort Sea LME.

important for spring staging and feeding seaducks, notably a large fraction of the western Canadian Arctic breeding population of king eider which aggregate here in spring. This is also an important spring feeding area for beluga, bearded seal (*Erignathus barbatus*), ringed seal, and polar bear.

1.3: Franklin Bay and 1.4: Darnley Bay

Large aggregations of polar cod (*Boreogadus saida*; termed 'Arctic cod' in North America) have been recorded throughout winter under fast ice over relatively deep water in outer Franklin Bay. Franklin and Darnley bays (on both sides of the Parry Peninsula) are important prime breeding habitat for ringed seal and important winter and spring breeding and feeding areas for polar bear. Cape Parry is home to the only colony of thick-billed murre in the western Arctic, and the only colony of the Pacific sub-species (*U. l. arra*) in Canada. In addition, one of only two western Arctic black guillemot colonies is located here. Pearce Point, an important upwelling area, has aggregations of bowhead whale, Arctic char (*Salvelinus alpinus*) and capelin. Pacific herring aggregate in the Hornaday River area of Darnley Bay and kelp beds may be located along the coastline but have not yet been confirmed. The Horton River area of Franklin Bay has steep bathymetry and as a result includes an area of upwelling which supports diverse meiofauna communities. It is an important migration and feeding pathway for beluga, bowhead whale, and Arctic char, and polar bear are known to migrate through the area.

1.5: De Salis Bay and Thesiger Bay

These two bays are located along southern Banks Island on the northern side of Amundsen Gulf. De Salis Bay includes an area of upwelling, and marine mammals, such as bowhead whale, beluga, and various seals, feed and nurse here, as well as migrate through this area. Arctic char also uses this area as a migration and feeding corridor, and a variety of seabirds and seaducks aggregate here to feed and nest. Thesiger Bay is characterized by the presence of a flaw-lead polynya. The possible presence of kelp beds is a unique feature of this area which also includes benthic communities and a migration and feeding corridor for Arctic char. Beluga, polar bear, and ringed and bearded seals aggregate on these feeding grounds. Capelin is also known to occur in this area.

Table A.16. Areas of heightened ecological significance within the Beaufort Sea LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area No.	Area Location	Index No.	Ecological function	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Cape Bathurst Polynya	1.1 (B-3.14)	Migration routes and summer feeding areas for bowhead, beluga, ringed seal, and polar bear	×	×	×			×	×	×		×	×
			Migration route, spring staging and summer feeding areas for seabirds and seaducks											
	Banks Island Shorelead	1.2 (B-3.15)	Spring feeding area for beluga, bearded seal, ringed seal, and polar bear		×	×			×	×	×		×	
			Spring staging and feeding area for seaducks, in particular king eider											
	Franklin Bay, Darnley Bay	1.3/1.4 (B-3.16) (B-3.17) (B-3.25)	Wintering and spawning area for polar cod, migration and feeding area for Arctic char		×	×			×	×	×		×	×
			Winter and spring breeding and feeding area for ringed seal and polar bear; migration and feeding area for beluga and bowhead whale											
			Breeding and feeding area for thick-billed murre and black guillemot											
	De Salis Bay and Thesiger Bay	1.5 (B-3.22) (B-3.23)	Capelin spawning area; migration and feeding area for Arctic char		×	×				×	×		×	
2	Prince Albert Sound	2.1 (B-3.18) (B-3.19)	Migration and feeding areas for Arctic char		×	×			×	×	×		×	
			Breeding and feeding area for ringed seal and bearded seal. Polar bear den, feed, and raise young here											
			Feeding area for seaducks and seabirds											
	Minto Inlet	2.2 (B-3.20) (B-3.21)	Migration and feeding area for Arctic char		×	×			×	×	×		×	
			Breeding and feeding area for ringed seal, bearded seal and polar bear											
			Feeding area for seaducks and seabirds. High benthic diversity											
	Union and Dolphin Strait	2.3 (B-3.1)	Migration and feeding area for Arctic char	×	×	×			×	×	×		×	×
			Breeding area for ringed seal; winter and spring feeding area for polar bear											
			Spring staging and feeding area for common eider, loons and other birds											

Area No.	Area Location	Index No.	Ecological function	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
3	Herlinvaux/Mackenzie Lake	3.1	Winter habitat for anadromous or amphidromous fish	×	×	×					×		×	
	Shallow Bay, Beluga Bay and Kugmallit Bay	3.2 (A-3.10) (A-3.11) (A-3.13)	Fish nursery and feeding areas		×	×				×	×		×	
			Molting, feeding and migration areas for beluga; feeding area for ringed seal											
			Feeding, rearing and molting areas for seabirds, seaducks and geese											
	Kugmallit Corridor	3.3 (A-3.13)	Migration and feeding area for ringed seal		×					×	×		×	
	Mackenzie Trough	3.4 (A-3.8)	Migration area for bowhead whale, beluga and ringed seal; polar bear feeding and breeding area		×				×	×	×		×	
	Mackenzie Shorelead	3.5	Spring staging and feeding area and summer feeding, rearing and molting area for seaducks (common eider, long-tailed duck and others)		×	×			×	×	×		×	
	Outer Mackenzie Shelf	3.6 (A-3.9)	Important area for marine fish. High benthic diversity		×	×					×		×	
			Feeding and migration area for polar bear, beluga and bowhead whale											
	Husky Lakes	3.7 (B-3.12)	Spawning area for Pacific herring; feeding area for fish such as lake trout		×	×				×	×		×	×
			Marine mammal nursing, and feeding areas											
			Migration and feeding area for seabirds and seaducks											
	Liverpool Bay	3.8 (B-3.26)	Nursery area for coregonid whitefish		×	×				×	×		×	
			Feeding and migration area for bowhead whale and polar bear											
			Feeding, nesting, and staging area for seabirds, seaducks and geese											
4	Viscount Melville Sound	4.1 (B-3.24)	Beluga feeding area and polar bear feeding ground and rearing area		×	×					×		×	
5	Coastal areas and lagoons	5.1 (A-3.7)	Fish migration corridor and feeding area (Arctic char, Dolly Varden and coregonid whitefishes)		×	×				×	×		×	
			Post-breeding feeding, molting and staging areas for waterfowl and shorebirds											
	Herschel Island and adjacent waters	5.2 (A-3.7)	Capelin spawning area		×	×				×	×		×	×
			Black guillemot breeding and feeding areas. Feeding and molting areas for waterfowl											
	Shelf areas	5.3	Feeding area for bowhead whale		×				×		×		×	

Area No.	Area Location	Index No.	Ecological function	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
6	Colville and Sagavanirktok river deltas and estuaries	6.1	Winter habitat and summer feeding and migration habitat for coregonid whitefishes and Dolly Varden		×	×				×	×		×	
			Summer nesting, feeding, brood-rearing, molting and staging habitat for geese and shorebirds											
	Simpson Lagoon and Stefansson Sound	6.2	Summer feeding area and migration corridor for whitefishes and Dolly Varden		×	×			×	×	×		×	
			Breeding and brood-rearing habitat for common eiders and seabirds. Molting habitat for long-tailed duck and other seaducks											
	Elson Lagoon and Dease Inlet	6.3	Summer feeding area for whitefishes		×	×			×	×	×		×	
			Autumn feeding, staging and migration areas for seabirds (Ross's gull), waterfowl (common and king eiders) and some shorebirds (phalaropes)											
			Autumn feeding area for bowhead whales											
	Shoreline and barrier islands	6.4	Denning areas for polar bears of the southern Beaufort Sea subpopulation		×					×	×		×	
7	Offshore pack ice		Spring migration area for bowhead whales and beluga of large migratory populations (Bering-Chukchi-Beaufort)		×	×				×	×		×	

Area 2 – Western Victoria Island inlets

2.1: Prince Albert Sound

This relatively shallow and long inlet in the inner Amundsen Gulf (into western Victoria Island) is prime breeding habitat for ringed seal and is also an important area for bearded seal. Prince Albert Sound is also used as a feeding area for seaducks and seabirds. The estuary of the Kagloryuak River and the coastlines of the sound, particularly into the Albert Islands/Safety Channel area are important migration and feeding areas for Arctic char in summer.

2.2: Minto Inlet

Minto Inlet and Walker Bay (located north of Prince Albert Sound) provide prime breeding habitat for ringed seal, and are also used by bearded seal. Polar bear may aggregate here to nurse and rear their cubs. The area is also used as an important feeding and migration corridor for Arctic char, and as a feeding area for seabirds and seaducks.

2.3: Union and Dolphin Strait

This strait connects inner Amundsen Gulf with Coronation Gulf south of Victoria Island. The area contains a recurrent polynya that is located at the mouth of Lambert Channel which is an area of enhanced biological productivity. This polynya is a very important spring staging and feeding area for common eider, yellow-billed loon and other birds during spring migration. It is also used by Arctic char for migration and feeding. The fast ice at the western entrance to the strait is prime breeding habitat for ringed seal and a winter and spring feeding area for polar bear.

Area 3 – Mackenzie Estuary and Shelf

3.1: Herlinvaux/Mackenzie Lake

In winter a floating lake forms off the Mackenzie Delta by the Mackenzie River water being dammed by the stamukhi ice zone. This is a globally unique feature and although little studied, is probably an important winter habitat for anadromous or amphidromous fish.

3.2: Shallow Bay, Beluga Bay and Kugmallit Bay

These three bays form the inner part of the Mackenzie Estuary and constitute important nursery areas for juvenile anadromous/amphidromous coregonid whitefishes and seasonal feeding areas for adult fish (Arctic cisco *Coregonus autumnalis*, least cisco, broad whitefish, lake whitefish *C. clupeaformis*, inconnu *Stenodus leucichthys nelma*). These bays are also important molting, feeding and migration areas for beluga and feeding areas for ringed seal, as well as important feeding, brood rearing and molting areas for various seabirds, seaducks and geese including Arctic tern, common eider, scoters, and brent goose.

3.3: Kugmallit Corridor

This area extends north across the shelf from Kugmallit Bay. It includes a deep trough where upwelling occurs and is influenced by plumes of freshwater from the Mackenzie River. The Kugmallit Corridor has a high food supply for the benthos and is important to ringed seal for migration and feeding.

3.4: Mackenzie Trough

This area includes a deep trough where upwelling occurs and is influenced by plumes of freshwater from the Mackenzie River. It has a high benthic diversity and production. Bowhead whale, beluga, and ringed seal migrate through the area and polar bear come here to feed and breed.

3.5: Mackenzie Shorelead

The shorelead off the fast ice on the eastern Mackenzie Shelf (off the Tuktoyaktuk Peninsula) is an important spring staging and feeding area for seaducks, particularly for common eider but also for king eider and long-tailed duck. This lead is typically connected to the Cape Bathurst Polynya but the location over the relatively shallow shelf allows access for the seaducks to relatively rich benthic communities. The shallow waters off the Tuktoyaktuk Peninsula are also used by common eider, long-tailed ducks and other waterfowl during brood rearing and molting in the ice-free period in late summer.

3.6: Outer Mackenzie Shelf

Similar to the characteristics of the Mackenzie Trough, this area has steep bathymetry associated with the continental shelf edge and areas of upwelling. High benthic diversity and production are found here and marine fish aggregate in this area. Polar bear feed and migrate throughout the area, as do beluga and bowhead whale.

3.7: Husky Lakes

The Husky Lakes form a unique brackish water transitional area from fresh to marine waters located inland from Tuktoyaktuk Peninsula. It is characterized by strong tidal flows and a complex coastline with the Fingers area forming a 'labyrinth' in the outer part. The area is important for ringed seal and lake trout (*Salvelinus namaycush*) spawning, nursing, and feeding. Arctic seabirds and seaducks also use this area for migration and feeding, and beluga are known to aggregate here in some years. Pacific herring are known to spawn in the Fingers area.

3.8: Liverpool Bay

Liverpool Bay lies between the Tuktoyaktuk and Cape Bathurst peninsulas. It includes an area of upwelling and has significant tides and potentially kelp beds. The area is used as feeding and nursery grounds for polar bear, and for migration and feeding by bowhead whale. It is also an important feeding, nesting, and staging area for seabirds and seaducks. The Anderson River estuary is a nursery area for juvenile coregonid whitefishes and a molting and staging area for ducks and geese.

Area 4 – Viscount Melville Sound

4.1: Viscount Melville Sound

This area is primarily characterized by the late summer presence of feeding beluga in the deep offshore basin. The area is also an important feeding ground and rearing area for polar bear. A separate subpopulation of polar bears is recognized in this area numbering around 200 individuals.

Area 5 – Northeast Alaska and Yukon coasts and shelves

5.1: Coastal areas and lagoons

This area is characterized by the presence of a freshwater corridor in summer that is used as a migration and feeding corridor by fish species such as Arctic char, Arctic cisco and Dolly Varden (*Salvelinus malma*). It is also used as post-breeding feeding and molting areas for waterfowl such as common eider, long-tailed duck, surf scoter (*Melanitta perspicillata*) and red-breasted merganser (*Mergus serrator*). The area also serves as post-breeding feeding and staging areas for shorebirds such as red and red-necked phalaropes, dunlin and semipalmated sandpiper.

5.2: Herschel Island and adjacent waters

Herschel Island is one of only two sites where black guillemot breeds in the western Canadian Arctic. The waters adjacent to the island constitute the feeding areas for this small colony. The area is also used as feeding and molting areas for waterfowl. Capelin has been reported to spawn along coastal beaches at Herschel Island.

5.3: Shelf areas

The narrow and relatively shallow Beaufort shelf west of the Mackenzie Trough is an important feeding area for bowhead whales in early autumn (August) before they continue further west on their seasonal migration.

Area 6 – North Alaskan coast and shelf

6.1: Colville and Sagavanirktok river deltas and estuaries

The Colville River Delta is an important winter habitat for coregonid whitefishes, notably Arctic and least ciscoes that support a fishery in this area. Both the Colville and Sagavanirktok estuaries are important summer feeding and migration habitat for coregonid whitefishes and Dolly Varden. The deltas with associated wetlands and salt marshes provide summer nesting, feeding, brood-rearing and molting habitat for geese such as lesser snow goose and black brant. They also provide post-breeding feeding and staging areas for shorebirds such as dunlin, and semipalmated and pectoral sandpipers.

6.2: Simpson Lagoon and Stefansson Sound

The barrier islands bounding the lagoons provide breeding and brood-rearing habitat for common eider and seabirds such as Arctic tern and glaucous gull. The lagoons provide molting habitat for long-tailed duck and other seaducks. They are also used as a summer feeding area and migration corridor for anadromous/amphidromous whitefishes and Dolly Varden. The Boulder Patch in Stefansson Sound is a very special and rare hard-bottom habitat with kelp beds and associated fauna on the mostly soft-bottom Beaufort shelf.

6.3: Elson Lagoon and Dease Inlet

Elson Lagoon and the waters around Plover Islands are important autumn feeding, staging and migration areas for seabirds, waterfowl and some shorebirds. This area is used by Ross's gull, king and common eiders, long-tailed duck, and red and red-necked phalaropes. The shelf area off the Plover Islands (east of Point Barrow) is an important feeding area for bowhead whale in autumn. Dease Inlet is a summer feeding area for amphidromous coregonid whitefishes such as least cisco and humpback whitefish.

6.4: Shoreline and barrier islands

The shoreline and barrier islands are important polar bear denning areas for bears of the Southern Beaufort Sea stock, and polar bears are often concentrated near Cross and Barter Islands in autumn after the bowhead whaling season. This stock numbers around 1500 polar bears. The shallow waters offshore of the coast are important ringed seal habitat including winter breeding areas.

Area 7 – Offshore pack ice

Bowhead whale (about 10 000 individuals) and beluga (about 40 000 individuals) of the large populations that winter in the northern Bering Sea migrate east toward the Amundsen Gulf and the Cape Bathurst Polynya through leads in the offshore pack ice in the southern Beaufort Sea. This migration takes place during May and June. There is a return migration through offshore areas in the autumn.

Central Arctic Ocean LME

The Area of heightened ecological significance in the Central Arctic Ocean LME is shown in Figure A.13, with information on ecological function and the extent to which the area meets the IMO ecological criteria for PSSAs shown in Table A.17.

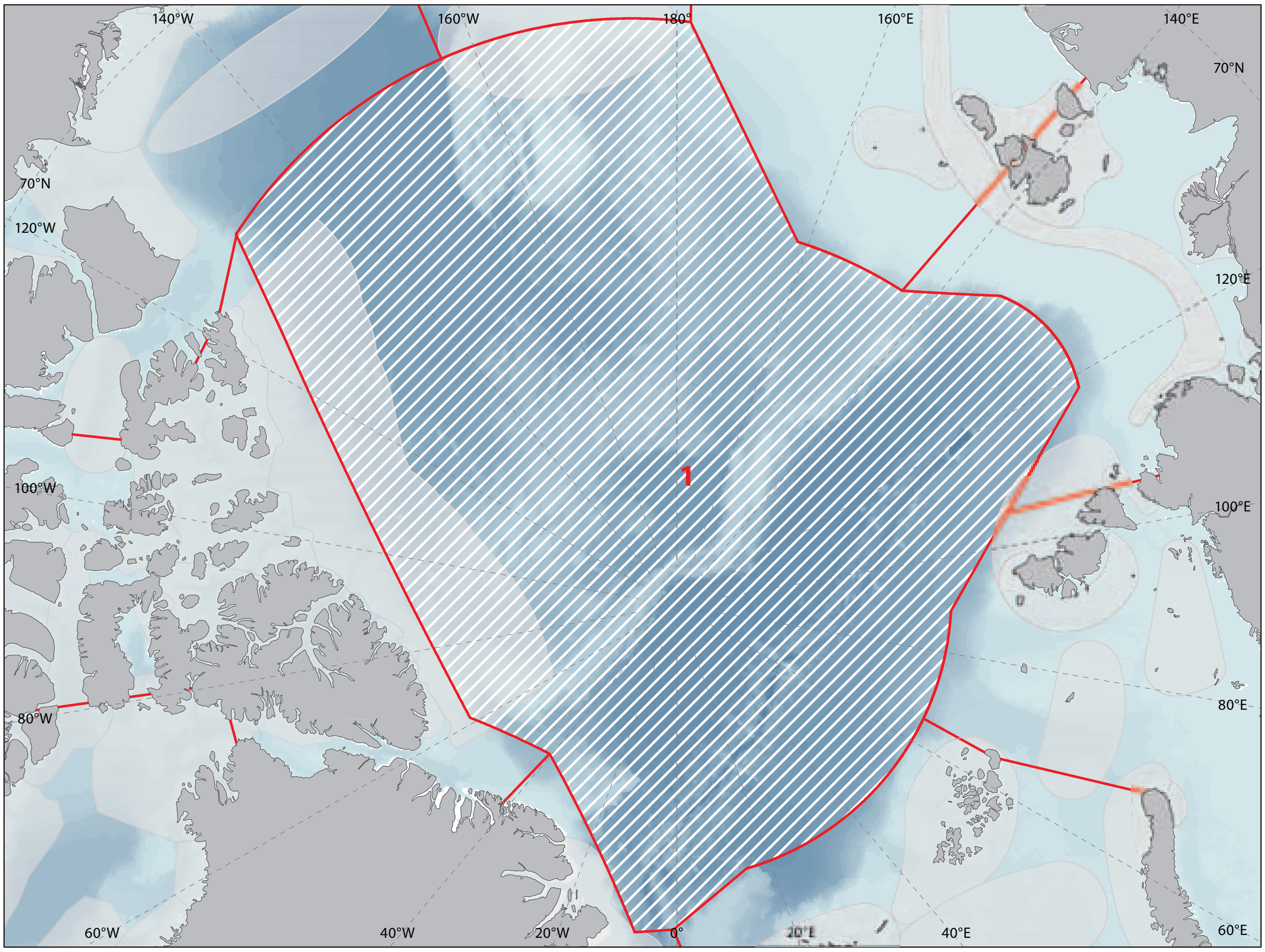
Pack ice

The drifting pack ice of the Central Arctic Ocean is a globally unique environment characterized by low primary productivity by specially adapted ice algae and phytoplankton in the water column below the ice (Sakshaug, 2003; von Quillefeldt et al., 2009). In addition to ice algae, the sea-ice biota contains an endemic fauna component including sea-ice amphipods that live in association with the ice. The sea-ice (or sympagic) fauna includes forms that live permanently in association with sea ice (so-called autochthonous species). The large amphipod *Gammarus wilkitzkii* (up to 6 cm) and the smaller (1.5 cm) *Apherusa glacialis* belong to this group, and are abundant and dominant species in Arctic sea-ice habitats, particularly in multi-year ice (Melnikov, 1997; Melnikov et al., 2002; Arndt and Lønne, 2002; Arndt et al., 2009). Autochthonous species are also found in other groups such as copepods. The ice amphipods including *Gammarus wilkitzkii* are important prey for polar cod (*Boreogadus saida*) and Arctic cod (*Arctogadus glacialis*), and also for ringed seal. They also support directly or indirectly other species that live in ice-covered waters including polar bear, ivory gull and Ross's gull.

The multi-year pack ice may be of particular importance for maintenance of the special autochthonous ice biota. The reduced ice cover in summer in recent years has been associated with a pronounced loss of multi-year ice (AMAP, 2012). With climate change, future projections suggest that the current area of multi-year pack ice will shrink further, and the areas north of the Canadian Arctic Archipelago and Greenland may be the last refugia for multi-year ice, the endemic sea-ice biota and for many ice-dependent species, such as ringed seal, polar bear and other species (DFO, 2011). The pack ice of the Central Arctic Ocean ecosystem may therefore be considered a threatened habitat in light of climate change.

Notwithstanding possible future impacts of climate change, at this time, the drifting pack ice comprising the unique

Figure A.13. The Central Arctic Ocean LME. The drifting pack ice identified as an area of heightened ecological significance covers the whole LME. It should be noted that this area is not homogenous in terms of the biological features, and that specific subareas of heightened ecological significance have not yet been identified like they have for other LMEs.



Central Arctic Ocean LME

Drift pack ice — LME (AMSAIIc)

Table A.17. Area of heightened ecological significance within the Central Arctic Ocean LME, its ecological function, and the extent to which this area meets the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		OGA No.	Ecological function	PSSA criteria										
No.	Location			Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Pack ice	1	Unique environment with very low primary productivity, however the multi-year pack ice biota contains an endemic fauna component; summer feeding area for polar bears from several subpopulations; summer and post-breeding feeding area for ivory and Ross's gulls	×	×	×					×	×	×	×

environment covers essentially all of the Central Arctic Ocean LME. However, it is clear that the Central Arctic Ocean LME is not homogenous, so not every area within it is of equal ecological significance. For the endemic sea-ice fauna it is difficult to identify specific subareas which are more important than others with the information available at present. It can be assumed that the Beaufort Gyre system in the Canada Basin plays a role in the maintenance of the sea-ice biota through its influence on the multi-year ice dynamics. The area north of the Canadian Arctic Archipelago is of special importance as the area with the heaviest ice conditions in the Arctic Ocean (see section on Area 10 of the Canadian Arctic Archipelago LME). The endemic fauna associated with the drifting pack ice is sensitive to potential oil spills. The large extent of the pack ice would tend to lower the vulnerability of this habitat to an oil spill. However, shrinking ice cover would increase the vulnerability due to the lesser extent of the habitat combined with greater mobility of spilled oil with more open water in summer.

Polar bear from several subpopulations use the peripheral areas of the pack ice of the Central Arctic Ocean as part of their summer feeding habitat. Bears from the Barents Sea, Kara Sea and Laptev Sea subpopulations are expected to use areas with pack ice in the Nansen Basin and eastern Amundsen Basin, while bears from the Chukchi Sea and southern and northern Beaufort Sea subpopulations use pack ice in the Canada Basin (Mauritzen et al., 2002; Stirling, 2002; Durner et al., 2004; Aars et al., 2006; Schliebe et al., 2006b; COSEWIC, 2008). Ivory gull and Ross's gull also use this habitat for foraging during the post-breeding period in late summer and autumn. Ivory gull (which is assessed to be Near Threatened by IUCN) has its main breeding area on islands in the northern Kara Sea (BirdLife International, 2012), while Ross's gull has its main breeding area on tundra and wetlands in northeastern Siberia. After breeding, both species move to the periphery of the pack ice where they feed on polar cod, amphipods, and remains of polar bear kills. For ivory gull the pack ice of the Nansen Basin may be an important post-breeding area (Gilg et al., 2010). Polar bears and the High Arctic gulls are generally sensitive to oil spills. Polar bear is assessed as Vulnerable by IUCN (Schliebe et al., 2008).

Canadian Arctic Archipelago LME

Areas of heightened ecological significance in the Canadian Arctic Archipelago LME are shown in Figure A.14, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.18.

Area 1 – Coronation Gulf/Queen Maud Gulf – coasts and inlets

1.1: Bathurst Inlet

With depths of 100–200 m, and with the influence of the Burnside River, Bathurst Inlet is an important summer habitat for ringed seal and marine fish communities, particularly Arctic char. Seabird colonies are found on small islands near the mouth of the inlet where they feed. Based on the occurrence of a polynya there may be productive benthic epifauna communities, however no data are currently available.

1.2: Queen Maud Gulf coastline

The relatively shallow (<100 m) waters along the coast of the Queen Maud Gulf are heavily influenced by freshwater inputs from four major rivers, the Armak, Ellice, Perry and Simpson rivers. Nutrients from these rivers and those released from sediments lead to enhanced primary productivity in this area. The area is an important marine feeding ground and migration corridor for Arctic char, and ringed seal are common throughout the area.

1.3: Chantrey Inlet

Chantrey Inlet is a shallow (<100 m), heavily protected, and enclosed ecosystem that is strongly influenced by the Black River which results in very low salinities. These conditions present a unique ecosystem that is very productive and utilized by Arctic char for migration and feeding. This area also includes prime ringed seal summer habitat and a key migratory bird terrestrial habitat site.

Area 2 – King William and southern Victoria islands

2.1: King William Island

The marine area around West King William Island includes several islands around which strong tidal currents flow, resulting in tidal mixing zones. These currents enhance the productivity of the area and a high food supply for the benthos results in increased benthic diversity and production in this area. Ringed seal and a depleted polar bear population (M'Clintock Channel) aggregate in the area to feed.

2.2: Southern Victoria Island coastline

The nearshore Arctic char migratory and feeding corridor that is present in this area was deemed an EBSA since the ecological properties here are different to those in the King William Island EBSA.

Area 3 – Lancaster Sound and adjacent inlets

3.1: Eclipse Sound – Navy Board

This area was selected as an EBSA based on its importance to seabirds, narwhal, beluga, killer whale, ringed seal, and harp seal. The relatively deep waters (maximum depth of 200 m) surrounding Bylot Island and its connection to Lancaster Sound are very important migration routes and summer feeding areas for beluga and about 20 000 narwhal. Cape Hay on the northwest end of Bylot Island supports colonies of thick-billed murre and black-legged kittiwake which forage 30–60 km offshore; northern fulmar use this area as a staging area. In addition, Cape Graham Moore on the southeast point of Bylot Island is home to thick-billed murre and black-legged kittiwake.

3.2: Lancaster Sound

Lancaster Sound contains a recurrent polynya and associated sea ice-edge habitats. This area is a major migration corridor for marine mammals (e.g., bowhead whale, narwhal, beluga, killer whale, and seals) and contains the highest density of polar bear in the world. The area is very productive, has a high export of sea-ice algae, and has high benthic diversity, production, and re-mineralization – likely to reflect the high quality food supply for the benthos. Over one million seabirds and seaducks (e.g., thick-billed murre, black-legged kittiwake, northern fulmar, and black guillemot) use this area as a nesting, breeding, and feeding area. Walrus haul-out sites are located here and polar cod (*Boreogadus saida:* Arctic cod in North America) is abundant in all stages of its life cycle.

3.3: Admiralty Inlet

This is an area of local nutrient enrichment and the high productivity is reflected in its extensive use by seabirds and marine mammals, particularly bowhead whale and narwhal, but also beluga, ringed seal, and harp seal. The presence of these mammals, which feed primarily on marine fish, is suggestive of a substantial marine fish population. About 18 000 narwhal spend the summer in Admiralty Inlet and migrate to southern Baffin Bay for winter. Traditional Ecological Knowledge (TEK) suggests significant seabird feeding in the marine areas of Admiralty Inlet, and Baillarge Bay on Admiralty Inlet is occupied by northern fulmar and glaucous gull.

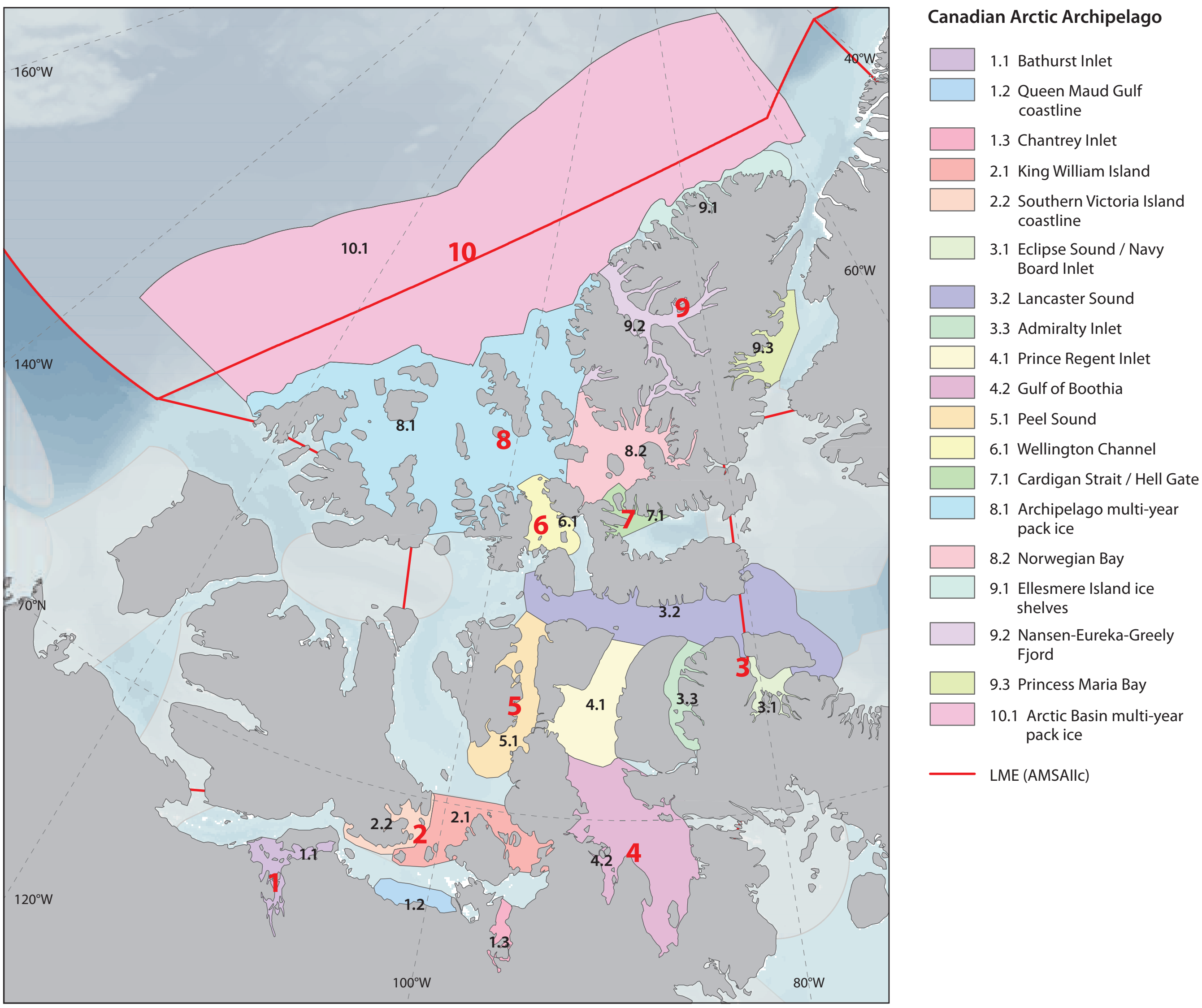


Figure A.14. Areas of heightened ecological significance in the Canadian Arctic Archipelago LME.

Table A.18. Areas of heightened ecological significance within the Canadian Arctic Archipelago LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area No.	Area Location	Index No.	Ecological function	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Bathurst Inlet	1.1 (B-3.2)	Marine fish communities		×				×	×	×		×	
			Summer habitat for ringed seal											
			Seabird colonies/feeding											
	Queen Maud Gulf coastline	1.2 (B-3.3)	Feeding ground and migration corridor for Arctic char		×	×					×		×	
	Chantrey Inlet	1.3 (B-3.4)	Arctic char migration and feeding area.		×	×					×		×	
			Ringed seal summer habitat/feeding											
2	King William Island	2.1 (B-3.5)	Ringed seal and polar bear feeding area		×	×		×	×		×		×	
			Benthic diversity											
	Southern Victoria Island coastline	2.2 (B-3.6)	Arctic char migratory and feeding corridor			×					×		×	
3	Eclipse Sound – Navy Board	3.1 (B-2.1)	Migration routes and summer feeding areas for narwhal, beluga, killer whale, ringed seal and harp seal		×	×			×	×	×		×	
			Staging, breeding and feeding areas for seabirds											
	Lancaster Sound	3.2 (B-2.6)	Polar cod aggregations	×	×	×		×	×	×	×		×	×
			Major migratory route for beluga, bowhead whale, narwhal; high density polar bear denning/feeding											
			Major foraging area for staging and breeding seabirds/seaducks; ivory gull aggregation											
	Admiralty Inlet	3.3 (B-2.2)	Summering/feeding narwhal, bowhead whale, ringed seal, harp seal		×	×			×	×	×		×	
			Breeding/feeding seabirds											
4	Prince Regent Inlet	4.1 (B-2.3)	Arctic char migration and feeding	×	×	×			×	×	×	×	×	×
			Migrating and feeding narwhal, bowhead whale and beluga; bowhead nursery area											
			Seaduck, molting; seabird/seaduck feeding											
	Gulf of Boothia	4.2 (B-2.4)	Arctic char migration and feeding	×	×	×			×	×	×		×	
			Migratory corridor for narwhal and bowhead whale; bowhead nursery area; polar bear denning, rearing, feeding											
5	Peel Sound	5.1 (B-2.5)	Marine fish aggregation	×	×	×			×		×		×	
			Large narwhal summer aggregations; narwhal and beluga feeding											

Area No.	Location	Index No.	Ecological function	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
6	Wellington Channel	6.1 (B-2.7)	Haul-out and wintering ground for walrus		×	×			×	×	×		×	
			Ross's gull nesting; seabird and seaduck breeding and feeding											
7	Cardigan Strait – Hell Gate	7.1 (B-2.16)	Year-round haul-outs and feeding for distinct stock of walrus; summering beluga, killer whale and seal.		×	×			×	×	×		×	
			Seabird breeding and feeding											
8	Archipelago multi-year pack ice	8.1 (B-5.3)	Polar bear denning, feeding, and rearing area; likely refugium for ice dependent species	×	×	×				×	×		×	
			Ivory gull nesting and foraging											
	Norwegian Bay	8.2 (B-5.4)	Feeding and rearing habitat for genetically differentiated polar bear		×	×				×	×		×	
9	Ellesmere Island ice shelves	9.1 (B-5.1)	Shallow (< 200 m) area covered by old multi-year ice, with possibly unique under-ice communities. Refugium for ice-dependent species	×	×	×					×		×	
	Nansen-Eureka-Greely Fjord	9.2 (B-5.2)	Aggregations of unique fish communities	×	×	×				×	×		×	
			Aggregations of polar bear and ringed seal.											
	Princess Maria Bay	9.3 (B-5.5)	Feeding narwhal and seals; walrus feeding and haul-outs		×	×			×		×		×	
10	Multi-year pack ice	10.1 (B-5.3)	Feeding area for polar bears	×	×	×				×	×		×	

Area 4 – Prince Regent Inlet and Gulf of Boothia

4.1: Prince Regent Inlet

This area is characterized by strong currents and a recurrent polynya in Bellot Strait owing to tidal currents in the area. Prince Regent Inlet is an important feeding area, migration route, and/or nursery ground for marine mammals (e.g., bowhead whale, narwhal, beluga) and seabirds (such as black-legged kittiwake, northern fulmar, king eider and common eider), while Arctic char use the nearshore waters.

4.2: Gulf of Boothia

The Gulf of Boothia is an important migration corridor and feeding ground for narwhal and bowhead whale, while Arctic char concentrate in nearshore waters. Bowhead also use it as a nursery area. Polar bear den, feed, and raise their young here.

Area 5 – Peel Sound

Peel Sound contains a polynya and is a highly productive area. The largest Canadian summering aggregation of narwhal (about 45 000 individuals) frequents this area, which is likely to support large populations of marine fish owing to its use as a feeding ground for narwhal as well as beluga. In addition, Peel Sound has areas of high benthic diversity and production.

Area 6 – Wellington Channel

Strong currents maintain a polynya in the Penny Strait/Dundas Island area and this is an important haul-out and wintering ground for walrus. The Cheyne Islands located in Wellington Channel support the largest known nesting population of Ross's gull in the Canadian Arctic.

Area 7 – Cardigan Strait-Hell Gate

A recurrent polynya occurs in this area owing to strong currents flowing from Norwegian Bay. The area is frozen during October and

November, with open water reappearing in December through to July; however this area does not usually become ice-free during the summer owing to ice flowing south from Norwegian Bay. Cardigan Strait – Hell Gate is used year-round for feeding and haul-out by an aggregation of about 300–500 walrus, which represent a distinct stock. The area is also used during summer by beluga, killer whale, and seals. In addition, several major seabird colonies use this area for feeding, breeding, and nesting, the most numerous being black guillemot, although northern fulmar, common eider, and glaucous gull are also found here.

Area 8 – Northern Archipelago/Norwegian Bay

8.1: Archipelago multi-year pack ice

The multi-year pack ice present in this area supports different communities to those within the Arctic Basin (see area 10.1 below) and constitutes the largest remaining island pack ice refugium in the world. This EBSA includes interesting under-ice communities and is important for seabird nesting and foraging, particularly ivory gull, a species at risk in Canadian waters. In addition, polar bear aggregate in this area for denning, feeding, and rearing their young.

8.2: Norwegian Bay

Although marine mammal aggregations and current concentrations/densities appear to be low compared to other regions of the Arctic, this is a regionally-important area for a number of marine mammals. It is also an important feeding and rearing area for the most genetically differentiated polar bear population in the world (Norwegian Bay subpopulation).

Area 9 – Ellesmere Island

9.1: Ellesmere Island ice shelves

The largest and most significant glaciers flow from Ellesmere Island into fjords as ice shelves. This area is relatively shallow (< 200 m) and covered by greater than 90 % old multi-year ice which is likely to support unique under-ice communities. A total absence of biological data makes this area unique.

9.2: Nansen-Eureka-Greely Fjord

The Nansen-Eureka-Greely Fjord marine complex separates Ellesmere and Axel Heiberg islands. At the outer end of the fjords, shallow sills inhibit water transport and this lack of exchange creates unique water masses which support unique fish communities and aggregations of polar bear and ringed seal; these unique ecosystems are poorly understood.

9.3: Princess Maria Bay

A number of important walrus feeding and haul-out sites are located in this EBSA which is considered highly productive; various seal species and narwhal use this area as a feeding ground.

Area 10 – Arctic Basin pack ice

10.1: Multi-year pack ice

The region of the Canadian Arctic Ocean between M'Clure Strait and Nares Strait is the source of the thickest multi-year ice in the Arctic Ocean. This multi-year ice is a unique habitat whose community structure is not well known. It is thought to be particularly important for long-lived (i.e., 6+ years) autochthonous amphipods (e.g., *Gammarus wilkitzkii*) and the mat-forming centric diatom *Melosira arctica* that is generally associated with Arctic under-ice communities. This region is also likely to be a core habitat for a variety of ice-adapted heterotrophic microbes and zooplankton. In addition, the edge of the multi-year pack ice is an important summer refuge for a significant proportion of individuals from the Beaufort polar bear populations. The Beaufort Gyre is also an important and unique physical feature in this EBSA as it contains a globally significant accumulation of freshwater from North American and Eurasian rivers.

Hudson Bay Complex LME

Areas of heightened ecological significance in the Hudson Bay Complex LME are shown in Figure A.15, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.19.

Area 1 – Northern Foxe Basin

1.1: Fury and Hecla Strait

The main features of the Fury and Hecla Strait area are its importance as a migratory corridor for bowhead whale, narwhal, beluga, and killer whale as well as the availability of polar bear denning sites. There is a large proportion of bowhead juveniles and calves present in the eastern mouth of the Fury and Hecla Strait which suggests this is an important nursery area.

1.2: Igloolik Island

The Igloolik Island area features the Fury and Hecla polynya and increased nutrients and productivity compared to other areas. The area is an important migration corridor and feeding area for marine mammals (i.e., bowhead whale, narwhal, beluga, killer whale), as well as Arctic char and other marine fish. The Igloolik Island EBSA also includes walrus haul-out areas and polar bear denning sites.

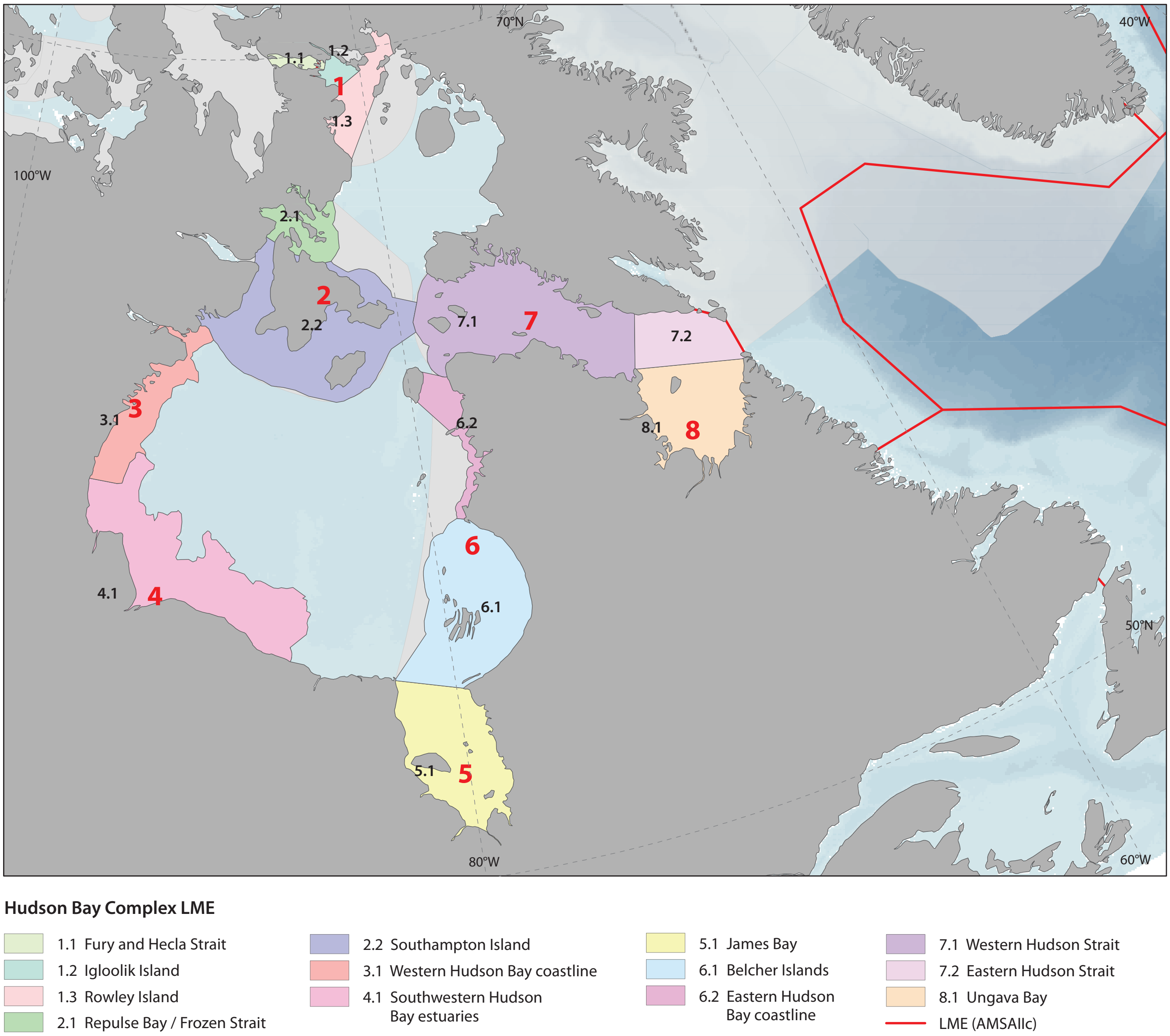


Figure A.15. Areas of heightened ecological significance in the Hudson Bay Complex LME.

1.3: Rowley Island

A migratory pathway for bowhead whale, narwhal, beluga, and killer whales, the Rowley Island EBSA is also a preferred year-round walrus habitat providing haul-out sites, calving areas, and feeding grounds for this species. The presence of islands and sea ice-edge habitat are important physical features of this EBSA.

Area 2 – Northern Hudson Bay

2.1: Repulse Bay and Frozen Strait

With a complex oceanography resulting from bathymetry and strong currents (including two recurrent polynyas), the Repulse Bay and Frozen Strait area is considered an important area for a number of marine mammals, seabirds and Arctic char. The only summering aggregation for the genetically distinct Northern Hudson Bay narwhal population occurs in Repulse Bay, Frozen Strait, western Foxe Channel and Lyon Inlet. This area is also important summering habitat for bowhead whale. In addition, walrus use this area year-round and the presence and seasonal migration of narwhal through the area has been documented. A significant proportion of the Canadian population of Iceland gulls (*Larus glaucoides*) occurs in Frozen Strait.

2.2: Southampton Island (including Coats Island)

Southampton Island is the largest island in Hudson Bay and is situated near the confluence of Hudson Bay and Foxe Basin waters which results in dynamic oceanographic mixing and fairly high marine productivity. The waters surrounding Southampton Island are important spring and autumn migration routes for beluga and bowhead whale. The area is also used during summer and winter by walrus, with important haul-out sites on Bencas, Coats and Walrus islands. Coats Island is an important nesting area for seabirds such as thick-billed murre, common eider, and black guillemot which feed on aggregations of marine fish, particularly capelin and polar cod. The largest single colony of common eider in Nunavut occurs in this EBSA in East Bay. Southampton, Coats and Mansel islands are also considered important for polar bear denning and as important summer refuge habitat for the Foxe Basin polar bear population. The bears also frequent the landfast ice adjacent to the islands during winter.

Area 3 – Western Hudson Bay

3.1: Western Hudson Bay coastline

The western Hudson Bay coastline (from Whale Cove to Arviat) is an important aggregation area for beluga, an autumn migration area for polar bear, and a migration corridor and feeding area for Arctic char. Dense kelp beds occur along this coastline and provide important habitat for marine fish. One of the defining physical features of this area is the winter shorelead and persistent sea-surface temperature front that exists during summer.

Area 4 – Southwestern Hudson Bay

4.1: Southwestern Hudson Bay estuaries

The Nelson, Churchill, and Seal River estuaries provide important habitat for a number of marine mammals (particularly beluga and harbor seal), seabirds, polar bear, caribou, and fish. The world's largest summering aggregation (about 70 000 individuals) of beluga occurs in the Nelson River estuary, with lower numbers aggregating in the Churchill River estuary which is also a key migration corridor, denning, feeding, and rearing area for polar bear and important for Ross's gull. The Seal River estuary is considered globally significant for migrating black scoter and is also an important migration route for harbor seal. This estuary also supports summer and autumn concentrations of polar bear and a population of about 3000 beluga that use the area as a nursery and feeding ground.

Area 5 – James Bay

5.1: James Bay

James Bay is defined by shallow waters and low salinity and supports a variety of warm-water species that are relicts of an earlier connection with the Atlantic and Pacific oceans, many of which have disconnected distributions and are rare or absent elsewhere in Canadian Arctic waters. About 8000–16 000 beluga, which may be a distinct stock, aggregate here during summer and there are indications based on TEK that some may remain year-round. The area is also important for walrus haul-out and feeding, as well as for polar bear denning and feeding, particularly near the Belcher Islands where prime ringed seal habitat exists. The sub-tidal eelgrass (*Zostera* spp.) beds that occur along the east coast of James Bay and along the coasts of Akimiski Island provide a unique habitat feature used by waterfowl and juvenile sculpins. Anadromous fish species such as cisco and broad whitefish (*Coregonus* spp.) use this area for migration and feeding. James Bay is also very important for staging, foraging, and molting by a variety of seaducks, shorebirds, and waterfowl such as Hudsonian godwit, red knot and black scoter.

Area 6 – Eastern Hudson Bay

6.1: Belcher Islands

The Belcher Islands area includes several small polynyas and estuaries, and cooler water temperatures than surrounding waters in Hudson Bay. The currents that move around the islands and the presence of landfast ice make this area particularly important to walrus, common eider, beluga, bearded seal, and polar bear. The area houses the entire population (about 100 000 to 200 000 individuals) of the Hudson Bay subspecies of common eider (*S. m. sedentaria*) in summer and winter. The Belcher Islands area represents important beluga habitat as the Eastern Hudson Bay stock aggregates here in summer and possibly during winter as well. Ringed seal and polar bear are common in this region and summer and winter walrus haul-out sites are located here. A diversity of habitats, including eelgrass beds, are found in the waters surrounding the Belcher Islands and result in high benthic diversity and productivity, including invertebrates such as sea urchins, sea cucumbers, and bivalves that form traditional Inuit diets.

6.2: Eastern Hudson Bay coastline

This area is an important migration pathway for the Eastern Hudson Bay beluga, an Endangered population in Canada. It is also an important feeding area for a significant proportion of the thick-billed murre breeding at the very large Digges Sound colony.

Area 7 – Hudson Strait

7.1: Western Hudson Strait

The Western Hudson Strait is characterized by strong currents as it is a conduit for Arctic waters via Foxe Basin, the outflow of Hudson Bay water, and also periodic intrusions of Atlantic water into northeastern Hudson Bay. It is a major seasonal migration route for many marine mammals that spend the summer feeding and nursing in the Hudson Bay LME and Arctic Archipelago LME (e.g., killer whale, walrus, beluga, narwhal, bowhead whale). In addition, this is an overwintering ground for beluga, bowhead whale, and walrus. This area is highly productive and there are a number of important seabird colonies and seaduck nesting and foraging areas located here. There are also important walrus haul-out sites on Mills, Salisbury and Nottingham islands. Twenty percent of the North American population of thick-billed murre and a small colony of Atlantic puffin are found near Digges Sound and 10 % of the Canadian population of common eider breed and feed near Markham Bay. This area covers important epibenthic habitat, including sponge beds.

7.2: Eastern Hudson Strait

In addition to the same factors that contribute to the ecological significance of Western Hudson Strait, the Eastern Hudson Strait area is heavily influenced by oceanographic conditions from Davis Strait. This area is a migration corridor to summer feeding and nursery grounds for marine mammals (e.g., walrus, beluga, bowhead whale). It is an important area for northern

Table A.19. Areas of heightened ecological significance within the Hudson Bay LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area		Index No.	Ecological function	PSSA criteria										
No.	Location			Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	Fury and Hecla Strait	1.1 (C-1.1)	Migratory corridor for bowhead whale, narwhal, killer whale and beluga; nursery area for bowhead; polar bear denning	×	×	×			×	×	×		×	×
	Igloolik Island	1.2 (C-1.2)	Arctic char feeding and migration Migration corridor and feeding area for bowhead whale, narwhal, killer whale and beluga. Walrus feeding and haul-out areas		×	×			×	×	×		×	
	Rowley Island	1.3 (C-1.3)	Migratory corridor for bowhead whale, narwhal, beluga and killer whale; year-round habitat for walrus including haul-out sites, calving areas, and feeding grounds		×	×			×	×	×		×	
2	Repulse Bay and Frozen Strait	2.1 (C-1.4)	Arctic char Summering and feeding bowhead whale, and genetically distinct narwhal; year-round walrus Important summering and feeding habitat for seabirds; Iceland gull breeding aggregation		×	×			×	×	×		×	
	Southampton Island (including Coats Island)	2.2 (C-1.5)	Aggregations of capelin and polar cod Spring and autumn migration routes for bowhead whale and beluga; polar bear denning, feeding, rearing, and summer refugia; walrus summer and winter feeding and haul-outs Breeding and feeding seabirds and seaducks		×	×			×	×	×		×	
3	Western Hudson Bay coastline	3.1 (C-1.6)	Migration corridor and feeding area for Arctic char Autumn migration area for polar bear, and aggregation area for beluga		×	×			×		×		×	
4	Southwestern Hudson Bay estuaries	4.1 (C-1.7)	Beluga summer aggregation and feeding; polar bear denning, feeding and rearing; migrating and summering harbor seals	×	×	×			×	×	×		×	×
5	James Bay	5.1 (C-1.8)	Feeding area for marine and estuarine fish Walrus haul-out and feeding; polar bear denning and feeding; beluga summering, feeding and overwintering Critical staging, feeding, and molting area for a variety of seaducks, shorebirds, and waterfowl	×	×	×		×	×	×	×		×	

Area		Index No.	Ecological function	PSSA criteria										
No.	Location			Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
6	Belcher Islands	6.1 (C-1.9)	Polar bear feeding; summering and overwintering beluga; aggregation of bearded seal; walrus haul-outs	×	×	×		×	×	×	×		×	
			Aggregation of resident common eider subspecies											
			Eelgrass beds; aggregation of invertebrates											
	Eastern Hudson Bay coastline	6.2 (C-1.10)	Beluga migration corridor		×	×				×	×		×	
7	Western Hudson Strait	7.1 (C-1.11)	Migratory corridor for beluga, bowhead whale, narwhal, killer whale and walrus; overwintering bowhead, narwhal and walrus	×	×	×		×	×	×	×		×	×
			Important seabird and seaduck colonies; feeding seabirds and seaducks											
			Aggregation of sponges											
	Eastern Hudson Strait	7.2 (C-1.12)	Migration corridor for beluga, bowhead whale and narwhal; overwintering bowhead and beluga; walrus haul-outs	×	×	×		×	×	×	×		×	×
			Seabird nesting/feeding; aggregation of ivory gull											
			Aggregation of coldwater corals											
8	Ungava Bay	8.1 (C-1.13)	Beluga summering; polar bear denning, rearing and summer refugium		×	×			×	×	×		×	
			Seabird/seaduck breeding/feeding											
			Aggregation of coldwater corals											

shrimp (*Pandalus borealis*) and the western extent of Greenland halibut habitat exists within this area. The area is a significant overwintering area for beluga and about 5000–8000 bowhead whales also overwinter here. There are relatively significant occurrences of cold water corals in the deeper waters of the Strait. The area represents important nesting and foraging sites for seabirds, particularly the Endangered ivory gull.

Area 8 – Ungava Bay

8.1: Ungava Bay

Ungava Bay is characterized by small islands and very high tides. There are relatively significant occurrences of coldwater corals in the deeper waters of Ungava Bay, and the stock of beluga in this area has been reduced to about 50 individuals and may be extirpated. Two large colonies of thick-billed murre occur on Akpatok Island. Collectively, these colonies constitute the largest number of breeding thick-billed murre in Canada (>20 % of the Canadian population). Black guillemot also nests along the Akpatok Island coast. In addition, a large proportion of the breeding population of common eider aggregates on the islands of the western shore of Ungava Bay. About 80–100 polar bear (about 5 % of the Davis Strait population) den and rear their young along the southern shore of Akpatok Island during summer.

Baffin Bay-Davis Strait LME

Areas of heightened ecological significance in the Baffin Bay – Davis Strait LME are shown in Figure A.16, with information on ecological function and the extent to which these areas meet the IMO ecological criteria for PSSAs shown in Table A.20.

Area 1 – North Water-Northern Baffin Bay

1.1: North Water Polynya (Canadian side; D-2.14)

The North Water Polynya is the largest and most productive polynya in the Canadian Arctic. In addition to the tremendous marine bird resources in this area, the North Water Polynya is of significance to more species of marine mammal than any other polynya in the Canadian Arctic. For example, it is used by beluga during summer and winter, bowhead whale and narwhal during summer, migratory walrus, and ringed, bearded, and harp seals throughout the year. In addition, polar bear feed on ringed seal here during winter and into spring, and walrus use the area as a haul-out and migration corridor. Millions of seabirds (e.g., black-legged kittiwake, thick-billed murre, ivory gull, black guillemot, and dovekie (*Alle alle:* also called little auk)) breed in the vicinity of the North Water Polynya. Most of them feed here during summer, while some birds also use the area for overwintering.

1.2: North Water Polynya (Greenland side; C1)

The North Water Polynya is the most productive polynya in the Arctic (Deming et al., 2002) and globally unique. Especially in the eastern parts along Greenland, upwelling of nutrient-rich waters and the associated high biological production provides favorable foraging conditions for seabirds and mammals, mostly in the summer, but even some marine mammal populations winter here.

- More than 80 % of the world population of little auk is dependent on the North Water Polynya from May to September, when about 30 million pairs are estimated to nest along the Greenland coast (Egevang et al., 2003).
- Over half of Greenland's breeding population of thick-billed murre are nesting in five colonies with a total of about 200 000 breeding pairs (Boertmann et al., 1996). They are dependent on the northeastern parts of the area from mid-May to late August, and during the autumn migration in August–September also on the western (Canadian) side (Falk et al., 2001).
- The endangered ivory gull (Near Threatened globally) occurs scattered throughout the North Water Polynya in summer and breeds on adjacent Ellesmere Island (Gilchrist and Mallory, 2005; Gilchrist et al., 2008; Boertmann and Mosbech, 2011a).
- Seaduck molting areas, especially for king eider, occur along the Greenland coast (Boertmann and Mosbech, 2011a).

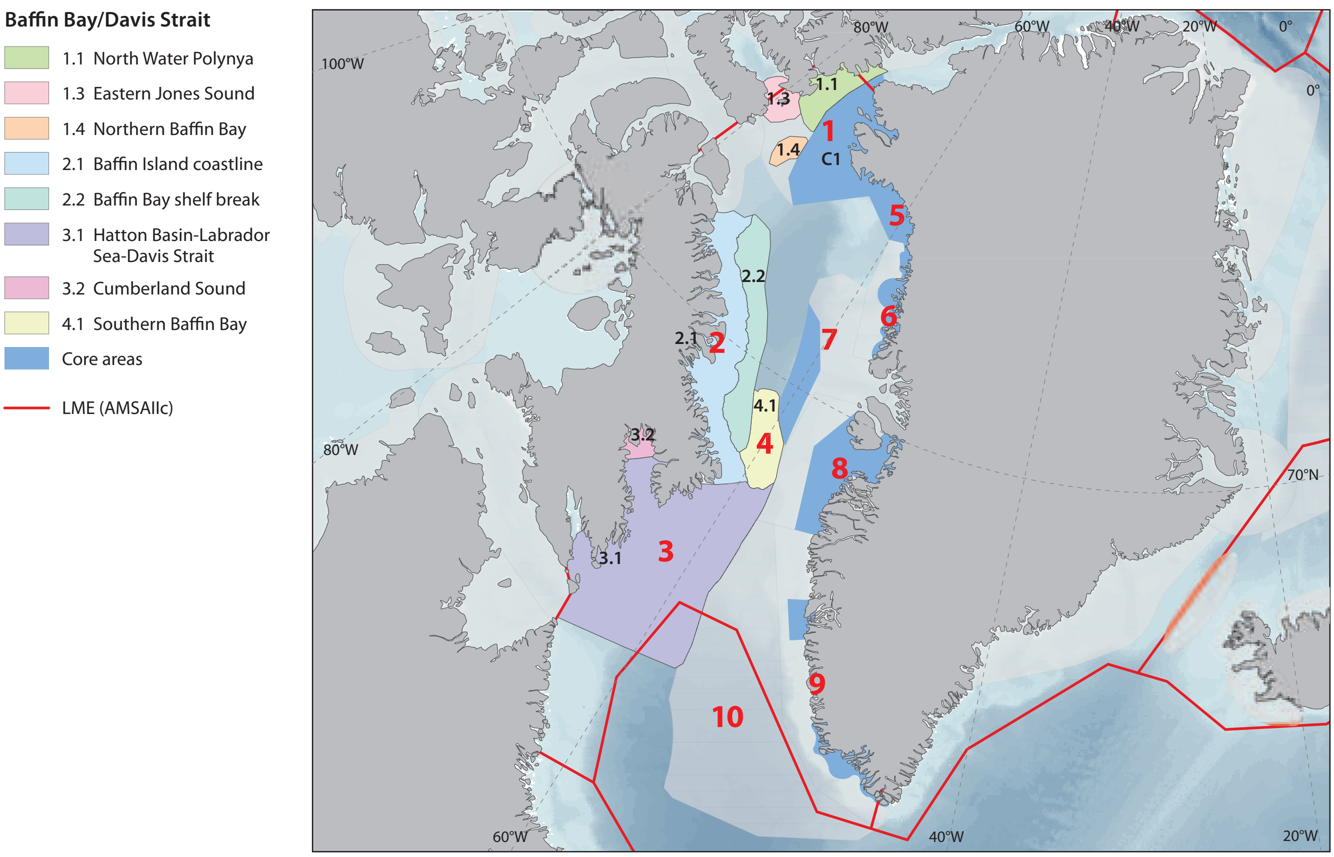


Figure A.16. Areas of heightened ecological significance in the Baffin Bay-Davis Strait LME.

- The North Water Polynya is critical habitat for beluga: an estimated 14 000 animals (Heide-Jørgensen, 2010) migrate from Lancaster Sound in Canada to the North Water Polynya and adjacent waters, a large proportion of them winter in mainly the western parts of the polynya.
- The northernmost parts of the North Water Polynya and Inglefield Bredning are important summer areas for discrete summer populations of narwhal. An estimated population of 8368 individuals (Heide-Jørgensen et al., 2010) exploits Inglefield Bredning. Melville Bay (see Area B5) is the only other summer range in West Greenland.
- Bowhead whales utilize the southern parts of the North Water Polynya in spring, and an unknown number winter here (Boertmann and Mosbech, 2011a).
- The northern parts of the North Water Polynya – Kane Basin – hold a population of a couple of hundred polar bear; they are linked to larger sub-populations in Baffin Bay (about 1600 animals) and Lancaster Sound (2500 bears). The ice edges anywhere in the North Water Polynya and around Cape York in the southern part of the area are particularly important for wintering polar bear (Boertmann and Mosbech, 2011a).
- The North Water Polynya is also an important wintering area for young ringed seal (an important prey for polar bear) benefitting from the relatively thinner ice in the eastern (Greenland) parts (Born et al., 2004).
- At least 1500 walrus (2009 estimate; Born et al., 2009b, and NAMMCO, 2009) summer in the North Water Polynya, mainly in the western parts along Ellesmere, and winter mainly in the eastern parts. The entire Baffin Bay population was estimated at 2100 animals in 2009.

1.3: Eastern Jones Sound

This area is characterized by open water in the vicinity of Coburg Island which remains a separate feature for some months before joining the North Water Polynya in May or June. The recurrent polynya of Eastern Jones Sound provides productive summer habitat for Atlantic walrus, beluga, ringed seal, and is identified as an important maternity area for polar bear. Over 500 000 breeding marine birds are found in this area, including the largest colony of black-legged kittiwake as well as thick-billed murre, northern fulmar, ivory gull, black guillemot, and glaucous gull. This is one of the few known breeding sites for Atlantic puffin in Nunavut.

1.4: Northern Baffin Bay

This EBSA contains significant aggregations of sea pens (*Penatulacea* spp.) and is considered important epibenthic habitat.

Area 2 – Eastern Baffin Island coast and shelf

2.1: Baffin Island coastline

This area is characterized by the presence of deep-sea troughs, which house coldwater corals, and a floe edge. The area provides important feeding and nursing areas for bowhead whale and serves as a migration pathway for marine mammals such as bowhead whale and narwhal, as well as marine and anadromous fish. TEK indicates that dolphins, killer whale, and minke whale (*Balaenoptera acutorostrata*) also migrate through this area. Ringed seal utilize the fjords and coastal areas, walrus haul-out along the complex coastline, and this is an important feeding, denning, and nursery area for polar bear. Key seabird colonies are located along the Baffin Island coastline including glaucous gull, Iceland gull, black guillemot, black-legged kittiwake, thick-billed murre and possibly Atlantic puffin; the largest Canadian colonies of northern fulmar are also found in this area.

2.2: Baffin Bay shelf break

Along eastern Baffin Island, a distinct steep-faced continental shelf break occurs where marine fish aggregate and marine mammals such as bowhead whale, narwhal, and seals (i.e., harp, hooded, ringed, and bearded) migrate and feed; aggregations of corals and sponges are also found here.

Area 3 – Hatton Basin-Labrador Sea-Davis Strait

3.1: Hatton Basin-Labrador Sea-Davis Strait

This is a large area characterized by the continental shelf, a deep basin, mixing waters, and recurrent polynyas in outer Cumberland Sound and Frobisher Bay. As such, this area is highly productive and contains a diversity of deep-water corals and sponges, marine fish, and invertebrates, including a productive shrimp population. The highest recorded biomass of corals was taken here and is the only area containing abundant *Primnoa resedaeformis* and *Paragorgia arborea* north of the Stone Fence off Nova Scotia. The area supports bowhead whale, beluga, and walrus during winter, and is an important summer feeding ground for polar bear, beluga, killer whale, harp seal, and hooded seal, which also use this area for whelping. It is an important feeding, staging, and breeding area for more than 15 species of seabird, including thick-billed murre, black-legged kittiwake, black guillemot, Iceland gull, and dovekie.

3.2: Cumberland Sound

Cumberland Sound (including Millut Bay) is the only summer aggregation area for the Cumberland Sound beluga population which uses this area for feeding and nursing. Common eider aggregate here during the summer and the islands of western Cumberland Sound support what may be the largest breeding concentration of Iceland gull in Canada. This area also provides habitat for Greenland halibut.

Area 4 – Southern Baffin Bay

4.1: Southern Baffin Bay

Southern Baffin Bay is at an oceanographic area that marks a break between the warmer southern Labrador Current and

Table A.20. Areas of heightened ecological significance within the Baffin Bay – Davis Strait LME, their ecological function, and the extent to which these areas meet the IMO ecological criteria for particularly sensitive sea areas. An '×' indicates that the criteria have been met, an empty cell indicates that the criteria are not met or not applicable.

Area No.	Area Location	Index No.	Ecological function	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
1	North Water Polynya	1.1 (D-2.14)	Summering and feeding beluga, bowhead whale and narwhal; wintering and feeding beluga; year-round use by walrus and ringed, bearded and harp seals; polar bear feeding; walrus haul-out and migration	×	×	×		×	×	×	×		×	×
			Seabird breeding, staging and overwintering; ivory gull aggregation											
		1.2 (C1)	Foraging area for mammals, mostly in the summer, but even some marine mammal populations (walrus, beluga) winter here	×	×	×	×	×	×	×	×	×	×	×
	Eastern Jones Sound	1.3 (D-2.15)	Summering and feeding walrus, beluga and ringed seals; polar bear denning and feeding		×	×			×	×	×		×	
			Seabird breeding, staging and feeding; molting seaducks											
			Foraging area for seabirds											
	Northern Baffin Bay	1.4 (D-2.13)	Aggregations of sea pens		×			×			×		×	
2	Baffin Island coastline	2.1 (D-2.10)	Migration corridor for Arctic char	×	×	×			×	×	×		×	
			Migration corridor for bowhead whale and narwhal; bowhead nursery area; walrus haul-outs; polar bear feeding, denning and rearing											
			Seabird breeding and feeding											
	Baffin Bay shelf break	2.2 (D-2.11)	Aggregations of marine fish		×	×		×	×		×		×	×
			Migrating and feeding bowhead whale, narwhal, and ringed, bearded, harp and hooded seal											
			Aggregations of corals and sponges											
3	Hatton Basin-Labrador Sea-Davis Strait	3.1 (D-2.8)	Migration corridor for bowhead whale, harp seals, narwhal, beluga and walrus; overwintering/feeding for beluga, bowhead and narwhal; summering and feeding polar bear, beluga, killer whale, harp and hooded seals; breeding hooded seals	×	×	×		×	×	×	×		×	×
			Seabirds feeding, staging and breeding; overwintering ivory gull											
			Diversity of deep-water corals and sponges											
	Cumberland Sound	3.2 (D-2.9)	Aggregation of Greenland halibut		×	×			×	×	×		×	
			Beluga summer feeding and rearing											
			Breeding/feeding seabirds; Iceland gull											

Area No.	Location	Index No.	Ecological function	Uniqueness or rarity	Critical habitat	Dependency	Representativeness	Diversity	Productivity	Spawning or breeding grounds	Naturalness	Integrity	Fragility	Bio-geographic importance
4	Southern Baffin Bay	4.1 (D-2.12)	Greenland halibut habitat	×	×	×			×	×	×		×	×
			Overwintering/feeding narwhal and bowhead whale											
			Aggregation of coldwater corals											
5	Melville Bay	5.1 (B4)	Critical summer habitat for narwhal, for polar bear winter and spring, and a migration corridor for whales		×	×				×	×		×	
6	Northwest Greenland Shelf	6.1 (B3)	Critical habitat for whales, migration corridor		×	×				×	×		×	×
			Important migration corridor and breeding and staging area for seabirds											
7	Central Baffin Bay (and mouth of Uummannaq Fjord)	7.1 (C2)	Wintering area for narwhal, beluga and polar bear. Bowhead whales migrate through the area in spring		×	×			×	×	×		×	
8	Disko Bay and Store Hellefiske Banke	8.1 (B2)	Wintering, foraging and breeding areas for mammals	×	×	×	×		×	×	×		×	×
			Wintering, breeding, moulting and staging areas for seaducks and seabirds											
			Capelin spawning and productive fisheries areas											
9	Southwest Greenland shelf	9.1 (B1)	Migration corridor for marine mammals		×	×	×	×	×	×	×		×	×
			Migration corridor for seabirds in spring, and summer. Seabirds wintering area											
			Foraging and breeding areas for seabirds											
10	Davis Strait marginal ice zone and Labrador Sea	10.1 (C3)	Whelping area for hooded seal		×	×				×	×		×	
			Wintering area and early spring migration corridor seabirds											

the cold Arctic outflow. This area is an overwintering area for narwhal and bowhead whale, and several species of coldwater coral (including black corals; *Antipatharians*) occur in significant concentrations in this area. Productive Greenland halibut fishing grounds are also found in southern Baffin Bay.

Area 5 – Melville Bay

5.1: Melville Bay

The Melville Bay area is critical habitat for narwhal in summer, for polar bear winter and spring, and a migration corridor for whales and seabirds.

The shelf area in Melville Bay is one of just two West Greenland summering areas (June to end of October) for the Baffin Bay population of narwhal; an estimated population of 6024 (2007) narwhal utilizes the area (Heide-Jørgensen et al., 2010). Narwhal have high site fidelity to migration routes and summering and wintering grounds, and generally use the same areas year after year. The summer stock from Melville Bay has a narrow migration corridor along the continental shelf south to the winter quarters in central Baffin Bay. In spring they move north through the ice shear zone between Disko Bay and Melville Bay (Boertmann et al., 2010).

Some polar bear from the Baffin Bay population (total estimate about 1600 animals) occur in this area. Denning is probably rare along the Melville Bay coastline, but in late winter and spring some bears of the Baffin Bay population forage along the ice edge and in the drift ice in the western parts of the area. However, satellite tracking has revealed that the fast-ice edge is not used much in spite of good foraging options, probably because the bears to some extent try to avoid the zone most frequented by hunters, and therefore tend to remain out in the drift ice. However, in recent decades bears have more frequently been taken/hunted in the coastal areas, which is interpreted as a shift in home range induced by the shrinking sea-ice cover and earlier ice break-up in Baffin Bay (Born et al., 2008).

The inner parts of Melville Bay are important breeding areas for ringed seal serving as the principal prey for polar bear in spring (Rosing-Asvid A., Greenland Institute of Natural Resources, pers. com., 2011).

In early spring the partially open water in Baffin Bay (outer parts of the area) is an extension of the ice break-up zone in the area, and important as part of the general migration corridor for thick-billed murre and other seabirds on their way to breeding grounds in the North Water Polynya.

One of Greenland's largest colonies of Sabine's gull is situated in this area (Boertmann et al., 1996).

Area 6 – Northwest Greenland Shelf

6.1: Northwest Greenland Shelf

The shelf and ice shear zone along the coast of northwestern Greenland is critical habitat for whales as well as an important migration corridor and breeding and staging area for seabirds.

Both common and king eider species are dependent on several undisturbed late summer molting areas in some inner fjord areas, in particular in the southern parts of the area (Boertmann and Mosbech, 2011a).

In early spring, the open water in the ice shear zone along the entire coastline serves as an important migration corridor for thick-billed murre and other seabirds (Boertmann and Mosbech, 2011a).

The area contains a large and diverse seabird fauna. Thick-billed murre from some of Greenland's largest colonies (around 126 000 pairs) are dependent on the region from May to late August (Boertmann and Mosbech, 2011a).

The common eider is dispersed in many colonies (total population about 11 500 nests, increasing) along the outer coast as well as in the fjords in the central parts of the area (Merkel F., Aarhus University, Department of Bioscience, pers. com.) based on data from 2007 in Merkel (2010).

Beluga and narwhal both depend on the area as a migration corridor (Boertmann and Mosbech, 2011a).

Polar bears from the Baffin Bay population (total estimate 1600 bears) roam the area when ice is present (Boertmann and Mosbech, 2011a).

Area 7 – Central Baffin Bay

7.1: Central Baffin Bay (and mouth of Uummannaq Fjord)

In the westernmost parts of the Greenland Exclusive Economic Zone (EEZ) and adjacent areas in Canadian waters, the pack ice and leads are especially important for some species for parts of the year.

- Wintering narwhal (from the population summering in Melville Bay as well as from Canada) areas are found within the 500–1500 m isobaths where they appear to utilize the Greenland halibut stock (Boertmann et al., 2010).
- In autumn and winter, the entire area is critical habitat for migrating and wintering narwhal and beluga; both species obtain a good part of their annual food intake in the wintering grounds (Boertmann and Mosbech, 2011a).
- A small proportion of the walrus wintering in West Greenland occur within this area; the specific sites may shift with ice conditions (Boertmann and Mosbech, 2011a).
- Bowhead whales migrate through the area in spring (Boertmann and Mosbech, 2011a).
- Polar bears from the Baffin Bay population occur in this area, mainly from October to June (Boertmann and Mosbech, 2011a).

Area 8 – Disko Bay and Store Hellefiske Banke

8.1: Disko Bay and Store Hellefiske Banke

The Disko Bay and Store Hellefiskebanke area has complex oceanographic and bathymetric conditions where a tide-induced upwelling forms the basis for high biological spring production, although with large inter-year variation. The production provides favorable foraging and breeding conditions for seabirds and mammals and a range of species are dependent on the resources on the banks on the shelf, in particular on Store Hellefiskebanke. Capelin and sandlance (*Ammodytes* spp.) are most important prey for seabirds and mammals.

- The entire area, but especially Store Hellefiskebanke is critical habitat for the walrus that winter in West Greenland, estimated at 3240 animals in 2008 (Born et al., 2009b; NAMMCO, 2009). In late winter (February–May) they rely on foraging areas within the 100 m isobath; satellite-tagged individuals utilized a fairly limited area of the northern part of the bank.
- The entire area is part of the beluga winter range (December) in West Greenland, where about 7000 animals rely entirely on the ice edge and marginal ice zone (Heide-Jørgensen, 2010); the whales follow the marginal ice zone as it retreats northward in spring (Heide-Jørgensen et al., 2009).
- In summer and autumn this area (like the more southern areas) serves as foraging grounds for harbor porpoise (*Phocoena phocoena*) and a range of baleen whales (blue, sei, minke, fin, and humpback). Evidence suggests that in particular the western part of the area – off the shelf break – is important to the baleen whales (Laidre et al., 2010b).
- The bowhead whale has its main spring (March to June) staging area in and just west of Disko Bay, which is used by perhaps about 1000 whales of the Baffin Bay population. Apparently, the Disko Bay area serves as a foraging and staging area primarily for female bowhead whales without calves (Mosbech et al., 2000, 2004). There are data

suggesting that in addition to foraging, Disko Bay serves as a mating area for bowhead whale (Stafford et al., 2008; Tervo et al., 2009).

- Seaducks – mostly king eider, but also common eider, harlequin duck (*Histrionicus histrionicus*) and red-breasted merganser – have important molting areas (July–September) in coastal areas and fjords (Boertmann and Mosbech, 2001; Merkel et al., 2010); during wing molt, the birds are flightless and extremely shy.
- Narwhal are abundant in the deeper basins of the area during November through May. Narwhal winter in the dense pack ice west of Disko as well as in the coastal areas close to the southern entrance to Disko Bay (Mosbech et al., 2000, 2004).
- Beluga are abundant on the banks of the area from November through May. They arrive from the Canadian summer grounds in November and stay until May (Mosbech et al., 2007).
- Store Hellefiskebanke – specifically within the 50 m isobath – is critical staging and wintering habitat for 500 000 king eider, which is a major proportion of the flyway population.
- Store Hellefiskebanke is also a significant winter/spring area – including whelping grounds – for bearded seal (Boertmann D., Department of Bioscience - Arctic Research Centre, Roskilde, pers. com.).
- Kitsissunnguit / Grønne Ejland in Disko Bay holds the largest Arctic tern colony in Greenland (about 21 800 pairs in 2006); a number of other colonies in the bay are home to up to 5800 pairs – with large inter-year fluctuations (Egevang and Frederiksen, 2011).
- Disko Bay has a high diversity of seabirds including thick-billed murre (one colony), black-legged kittiwake (several colonies), cormorants (several colonies), common eider (several colonies), fulmar (one of Greenland's largest colonies) and small populations of Atlantic puffin and little auk. Finally, the rare Ross's gull occasionally nests here (Mosbech et al., 2007).
- The high productivity is also reflected in the rich commercial fisheries in the area, including Greenland halibut, snow crab, shrimp and scallops.
- The area is part of the wintering area for ivory gull (Gilg et al., 2010).
- Capelin spawning areas occur in the tidal zone several places along the coastline (Mosbech et al., 2000, 2004).

Area 9 – Southwest Greenland Shelf

9.1: Southwest Greenland Shelf

Owing to upwelling at the shelf break, the banks along West Greenland are highly productive. The shelf area serves as a resource-rich migration corridor for marine mammals and seabirds during their northward migration in spring, and during summer it serves as a foraging area. The 'open water area' north to around Sisimiut remains largely ice free all year, and from October the shelf area and the ice-free fjord turns into a major wintering area for a huge number of seabirds from Greenland, Iceland and Svalbard. A large proportion of Greenland's commercial fisheries rely on the productive areas at the shelf.

- Along with coastal areas off Newfoundland in Canada, the 'open water area' along southwestern Greenland is the main wintering area for thick-billed murre from Svalbard, Jan Mayen, Iceland and parts of Greenland; from October to April at least 1.5 million murres (Merkel et al., 2012) are dependent on the fish and zooplankton in the shelf area and fjords.
- More than half of Greenland's populations of razorbill and Atlantic puffin are distributed in many small colonies along the coast, and Kitsissut Avalliit holds Greenland's largest colony of common murre. The common eider breeds in scattered colonies (Boertmann and Mosbech, 2010) along the coast (Rasmussen, 2010).
- In addition to the murres, the entire 'open water area' is wintering area for common and king eiders (>500 000 and >300 000, respectively), long-tailed duck (>100 000), red-breasted merganser (<20 000), black guillemot (>250 000), and Iceland gull (>300 000) (Boertmann et al., 2004).
- Large numbers of auks from the northeastern Atlantic pass by the southern tip of Greenland in autumn – that includes those on their way to wintering in this area, and those continuing onward to Newfoundland: thick-billed murre (at least 1 million), little auk (several million) and Atlantic puffin (unknown number, but recent observations suggest that many birds migrate through the area on their way to unknown wintering grounds). Furthermore, hundreds of thousands of black-legged kittiwake are passing Cape Farewell on their way to winter quarters in the Labrador Sea and other areas (Frederiksen et al., 2012b).
- Harlequin duck (about 7000; Boertmann and Mosbech 2001) from the small Greenlandic breeding population, and from eastern Canada, are dependent on molting areas along the outer coast of southwestern Greenland from Nuuk southward and with a core area around Arsuk; at least 10 000 winter in the area.
- The coastline in the southern parts is staging and spring/summer foraging areas for common eider (Merkel et al., 2010). The whole area including the fjords is winter quarters for both eider species; up to half a million eiders from both Greenland and Canada are estimated to winter in southwestern Greenland (Merkel et al., 2012).
- Outside the breeding season, adult black-legged kittiwake (juveniles not studied) from colonies across the North Atlantic are staging/foraging in this area; in August to November mainly the western parts are used (Frederiksen et al., 2012b).
- In summer and autumn the southern part of West Greenland (from area B3 southward) serves as foraging grounds for harbor porpoise and a range of baleen whales (blue, sei, minke, fin, humpback). Evidence suggests that the areas right off the shelf break in particular are important to the baleen whales (Frederiksen et al., 2012b).
- The Western Atlantic harbor seal is Critically Endangered in Greenland and has its stronghold at the coast of the

southern tip of Greenland (Rosing-Asvid and Ugarte, 2009). In addition, gray seal has recently been found in this area (Rosing-Asvid et al., 2010).

- Greenland's isolated breeding population of Atlantic salmon is dependent on access to a single river near Nuuk. During summer, shelf and fjord areas all along the coast north to Disko Bay are key foraging areas for the Atlantic salmon stock from spawning areas in the rivers of eastern Canada, the northeastern U.S.A. and northern Europe (NOAA Fisheries: www.nmfs.noaa.gov/pr/species/fish/atlanticsalmon.htm).
- The fjords in this area hold local stocks of Atlantic cod; a very large stock of offshore cod disappeared from the shelf areas in the 1970s. Cod eggs and larvae from the Iceland stock drift into the area, but this has not yet given rise to a new offshore stock (Storr-Paulsen and Wieland, 2006).
- Capelin spawning areas occur in the tidal zone in several places along most of the coastline and in the fjords (Mosbech et al., 2000).

Area 10 – Davis Strait marginal ice zone and Labrador Sea

10.1: Davis Strait marginal ice zone and Labrador Sea

This area extends beyond the Baffin Bay-Davis Strait LME into the Labrador Sea. The area, including the marginal ice zone/ ice edge, is important as a staging and migration area for some species.

- The ice edge and marginal ice zone in the central Labrador Sea is a whelping area for hooded seal in March–April (Frederiksen et al., 2012b).
- The entire area is part of the general wintering area and early spring migration corridor for a range of seabirds, including thick-billed murre and black-legged kittiwake (Frederiksen et al., 2012b; Merkel et al., 2012).
- New evidence suggests that the central Labrador Sea is an important wintering area (August-February) for adult black-legged kittiwake from colonies all over the North Atlantic, including Greenland (Frederiksen, 2012a); the number of birds utilizing these offshore areas is unknown, but judging from the proportion of geo-locator-tagged kittiwakes residing here in autumn and spring, it may amount to several hundred thousand adults.

Overview of the identified areas of heightened ecological significance

The identified areas of heightened ecological significance are shown on a combined map for all LMEs (Figure A.17). There are 97 areas in total (note that this number is somewhat arbitrary as it reflects the way smaller areas or area components have been aggregated). The areas are listed in Table A.21 which contains information on the size of the areas and whether they are used by fish, birds and mammals as part of the rationale for why they are considered of heightened ecological significance.

The number of areas ranges from one to ten per LME (12 for the East and West Bering Sea LMEs combined), and the areas range in size from about 10 to 300 thousand km^2. An exception is the Central Arctic Ocean LME with an area of about 3.6 million km^2. Combined, the identified areas of heightened ecological significance constitute more than half of the total area of the Arctic. While this is a high fraction there are two features that should be noted in this regard. First, there is strong seasonality in the use of the areas by the animals which make them ecologically important. Thus the sensitivity and heightened ecological importance may occur in a relatively short period of time, such as spring migration by bowhead whales and beluga through lead systems for a period of 1–2 months early in the season, or molting and staging by waterfowl and shorebirds for a similar duration in early autumn. Second, there is a wide span in sensitivity to oil spills and disturbance from ship traffic across the areas. Some have very dense and concentrated animal life such as at large seabird breeding colonies, while others are characterized by more dispersed animal distributions and variable occurrences and locations. For instance, this is the case for some of the wintering areas at the southern extent of the sea ice and foraging areas for polar bear in summer.

The vast majority of the identified areas of heightened ecological significance are used by birds and marine mammals. Of the 97 areas, 85 are highlighted as being used by birds and 81 as being used by marine mammals. For only two areas are neither birds nor mammals included specifically in the justification as to why the areas have been identified as important. In 71 of the 97 cases the identified areas are used by both birds and mammals, usually by several species and for different purposes such as breeding, feeding, migration, etc. (see Table A.21). Forty areas include use by fish, with spawning areas being part of the justification for 27 of these areas. Other uses by fish are as nursery and feeding areas and migration corridors for chars and whitefishes in estuaries and coastal waters.

The relatively high percentage of the total area identified as being of heightened ecological significance relates to the structuring effects of sea ice on the distribution of animals. The occurrence of sea ice results in a concentration of birds and marine mammals along the edges and transition zones to

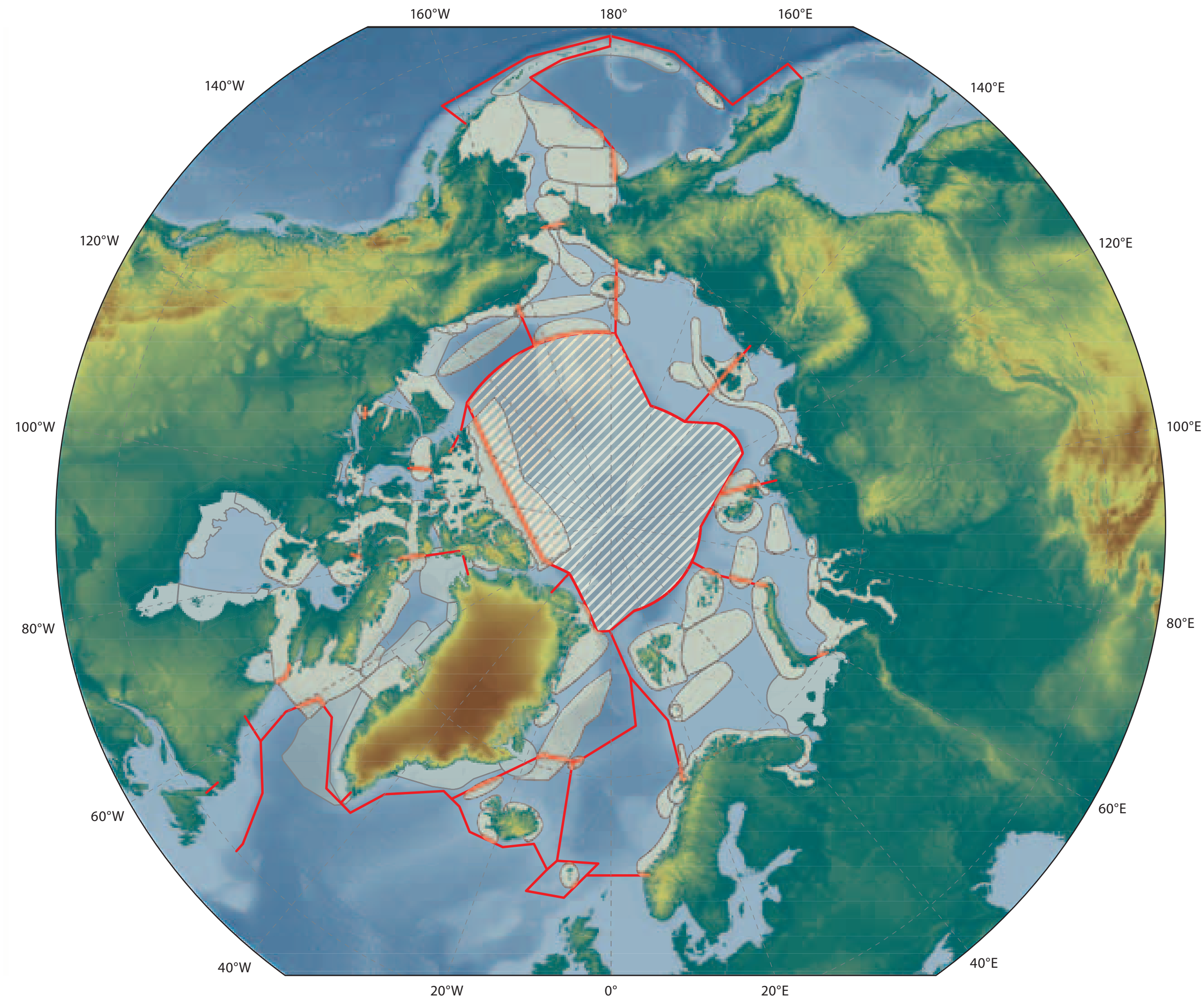


Figure A.17. Map of all the identified Areas of Heightened Ecological Significance in the sixteen Arctic LMEs.

open waters, such as in the marginal ice zone and in polynyas and flaw leads. At any given time, these zones of concentration of animal life may cover relatively restricted areas. As the ice then undergoes its seasonal rhythm of retreat and advance, the zones of concentrated animal life sweep across the Arctic seas reflecting the migratory patterns of birds and marine mammals and also of fish. Cumulatively, over the annual cycle, large areas are therefore being identified as ecologically important because of the functions they serve for animals during their seasonal occurrence in the Arctic. Variability in sea-ice conditions from year to year ('heavy-ice years' versus 'light-ice years' etc.) contribute to the expansion of the identified areas. In any one particular year, a smaller fraction of the area may be considered of heightened ecological importance dependent on the specific ice conditions that year.

The areas identified can be broadly grouped into four classes based on their geographical location: areas along mainland coasts, areas around Arctic archipelagos, areas on seasonally ice-covered Arctic shelves, and areas with drifting pack ice in the central Arctic.

Areas along mainland coasts are often important bird areas. This is the case for the open water coasts of Norway and also for open water coasts around Iceland, the Faroe Islands, along southwestern Greenland, and around the Aleutians and Komandorsky islands. In all these cases there are large breeding colonies of seabirds on cliffs, rocks and islets on suitable locations along the coasts with the combined requirement of protected nesting sites and access to abundant food as zooplankton and juvenile fish. Several of these coasts also serve as wintering areas for seabirds, notably the Aleutian Islands in the Pacific and southwestern Greenland in the Northwest Atlantic. Along the mainland of Russia, Alaska and Canada there are extensive areas of low-lying coasts that provide important habitat for many birds of different types including seabirds, waterfowl and shorebirds. Many of these birds breed inland on adjacent tundra and wetlands and use coastal habitats for feeding, rearing and staging prior to the southward autumn migration. All the major Arctic estuaries are important bird areas such as the Ob, Yenisey, Lena, Indigirka and Kolyma river deltas and estuaries in Russia, the Yukon-Kuskokwim Delta in Alaska, and the Mackenzie and Churchill river deltas and estuaries in Canada. These and other estuaries are also important nursery, feeding and wintering habitats for anadromous fish such as whitefish, chars, and to some extent salmon. The estuaries also provide important summer habitat for beluga.

The archipelagos around the Arctic Ocean are important areas for birds and also for marine mammals, notably walrus and polar bear. Some of the islands and archipelagos hold large

Table A.21. Areas of heightened ecological significance identified within each of the Arctic LMEs, including information on the extent of the area and its use by fish, birds and marine mammals. B: breeding; F: feeding; Mi: migration; Mo: molting; Sp: spawning; St: staging; W: wintering.

LME	Area No.	Area of heightened ecological significance	Extent, thousand km²	Fish	Birds	Marine mammals
1 – Iceland Shelf and Sea	1	Southwest/West Iceland	30	Sp	B F Mo St W	
	2	Northwest Iceland	11		B F	
	3	Denmark Strait	33		W	F
	4	North Iceland	20		B F	
	5	East Iceland	12		B F St	
2 - Greenland Sea	1	Northeast Water polynya area and Peary Land	161		B F St	F B W
	2	Scoresby Sund fjord and adjacent fjord areas on Blosseville coast	70		B F Mo St	F B
	3	Sirius Water/ Young Sund Polynya	24		B F St Mi	F B
	4	Sea ice in the western Greenland Sea	262		M	B F
	5	Southeastern Greenland and Denmark Strait	130		B F Mo Mi St W	F B Mo W
3 - Faroe Plateau	1	Faroe Islands	28	Sp	B F W	
4 - Norwegian Sea	1	Norwegian coast and shelf – Møre-Helgeland	67	Sp	B F Mo W	F B
	2	Lofoten area	73	Sp	B F	F
	3	Jan Mayen Island	12		B F	
5 - Barents Sea	1	Pechora Sea	263	Sp F	F St Mo	B F W
	2	Norwegian and Murman coasts	130	Sp	B F W	
	3	Entrance and northern White Sea	20		Mo W	B Mo Mi W
	4	White Sea (Kandalaksha, Onega and Dvina bays)	32	Sp	B F Mo St W	F W
	5	Bear Island	10		B F St	
	6	Svalbard Archipelago	150	Sp	B F Mo	B F W
	7	Franz Josef Land	117		B F St	B F W
	8	Western and central Barents Sea	139	W	F Mi W	F
	9	Northern Barents Sea - marginal ice zone	228			F
	10	Western Novaya Zemlya	101		F B Mi	Mi
6 - Kara Sea	1	Baydaratskaya Inlet – Western Yamal	124	Sp	Mi St	B Mi F
	2	Northeastern Novaya Zemlya	18		St B F	
	3	Western Severnaya Zemlya	52		St B F	F
	4	Northern Kara Sea – marginal ice zone	86		F	Mi F
	5	Northeastern Kara Sea islands	73		B F	F
	6	Ob Estuary and Fjord	52	F	F Mo St	F

LME	Area No.	Area of heightened ecological significance	Extent, thousand km²	Fish	Birds	Marine mammals
	7	Yenisey Estuary and Bay	34	F	F Mo St	F
	8	Pyasina Estuary	12		F Mo St	
	9	Vilkitskij Strait	9		B F	Mi
7 - Laptev Sea	1	Northwestern Laptev Sea (including polynyas north and northeast of Severnaya Zemlya)	91		B F St	Mi F W
	2	Northeastern Taymir and Preobrazheniya Island	19		B F	F
	3	Great Siberian polynya system	135		St Mi	F W
	4	New Siberian Islands	84		B F Mo	F
	5	Deltas and estuaries along the southern Laptev Sea	22	Sp F	F Mo St	
8 - East Siberian Sea	1	New Siberian Islands	84		F Mo	F W
	2	Great Siberian Polynya	136		St F	F
	3	De Long Islands	51		B F	
	4	Ice zone on the northern shelf	27		F	F
	5	Indigirka and Kolyma deltas and estuaries	13	F	F Mo St	
	6	Chaun Bay	33		B F	
9/10 - Bering Sea (East and West)	1	Aleutian Islands	243	Sp	B F W	B F
	2	Komandorsky Islands	30		B F W	B F
	3	Continental southeastern shelf and shelf break	179	Sp W	B F St	B F
	4	Continental northeastern shelf and shelf break	205	Sp W	B F St W	B F Mo Mi W
	5	Bristol Bay and southeastern Bering Shelf / Northern Alaska Peninsula	251	Sp F Mi	F Mo St	B F
	6	East Coast (Yukon and Kuskokwim deltas to Norton Sound including Unimak Island)	65	Sp F W	B F Mo St	W
	7	St Lawrence Island area including St Lawrence Polynya (south)	43		B F W Mi	W F St
	8	Bering Strait (St Lawrence Island north to the Diomede Islands)	68	Sp	B F	F Mi
	9	Gulf of Anadyr	86	Sp	F St	B F Mi W
	10	Northeastern coast of Kamchatka and offshore areas	29	Sp W		
11 - Chukchi Sea	1	Chukchi Plateau	196	Sp		
	2	Northeast coastal area (Alaska)	41	Sp F Mi	B F St Mo Mi	Mi F Mo
	3	Southeastern Chukchi Sea (Chukchi Bight, Kotzebue Sound area)	60	Sp F Mi W	B F St Mi	B F Mi

LME	Area No.	Area of heightened ecological significance	Extent, thousand km²	Fish	Birds	Marine mammals
	4	Northern Chukchi Peninsula	44		B F St	F Mi
	5	South-central Chukchi Sea (including Bering Strait region)	79		B F Mi	Mi F
	6	Wrangel/Herald Islands area	42		B F Mo St	F
	7	Chukchi Shelf (northern and central parts)	103		F Mo	F
12 - Beaufort Sea	1	Amundsen Gulf area	94	Sp F Mi	B F St	B F Mi W
	2	Western Victoria Island inlets	34	Sp F Mi	B F St	B F Mi W
	3	Mackenzie Estuary and Shelf	82	Sp F W	B F Mo St	F Mo Mi
	4	Viscount Melville Sound	59			B F
	5	Northeastern Alaska and Yukon coasts and shelves	19	Sp F Mi	B F Mo St	F
	6	North Alaskan coast and shelf	33	F Mi W	B F Mo Mi St	F
	7	Offshore pack ice	131			Mi F
13 - Central Arctic Ocean	1	Drifting pack ice	3659		F Mi	Mi F
14 - Canadian Arctic Archipelago	1	Coronation Gulf/Queen Maud Gulf – coasts and inlets	21	F Mi	F St	F
	2	King William and southern Victoria islands	35	F Mi		F
	3	Lancaster Sound and adjacent inlets	84		St B F	B F Mi
	4	Prince Regent Inlet and Gulf of Boothia	94	F Mi	B F Mo	B F Mi
	5	Peel Sound	24			F
	6	Wellington Channel	13		B F	F W
	7	Cardigan Strait-Hell Gate	6		B F	F W
	8	Northern Archipelago/ Norwegian Bay	197		B F	B F W
	9	Ellesmere Island	44			F
	10	Arctic Basin pack ice	530			F
15 - Hudson Bay Complex	1	Northern Foxe Basin	61	F Mi	B F	B F Mi
	2	Northern Hudson Bay	128	F	B F	B F Mi W
	3	Western Hudson Bay	35	F Mi		B F Mi
	4	Southwestern Hudson Bay	101		F Mi St	B F Mi W
	5	James Bay	70	F Mi	F St Mo	F Mi W
	6	Eastern Hudson Bay	142		B F Mo W	F Mi W
	7	Hudson Strait	142		B F	B F Mi W
	8	Ungava Bay	56		B F	B F
16 - Baffin Bay-Davis Strait	1	North Water-Northern Baffin Bay	127		B F St Mo W	F Mi W
	2	Eastern Baffin Island coast and shelf	137		B F	B F Mi

LME	Area No.	Area of heightened ecological significance	Extent, thousand km²	Fish	Birds	Marine mammals
	3	Hatton Basin-Labrador Sea-Davis Strait	234		B F St	B F W
	4	Southern Baffin Bay	30	F		F W
	5	Melville Bay	15		Mi	B F Mi W
	6	Northwest Greenland Shelf	43		B F Mi Mo	Mi F W
	7	Central Baffin Bay	89			F Mi W
	8	Disko Bay and Store Hellefiske Banke	101	Sp F	B F St Mo W	B F Mi W
	9	Southwest Greenland Shelf	108	Sp F	B F St Mi Mo W	F Mi
	10	Davis Strait marginal ice zone and Labrador Sea	310		Mi W	B

seabird colonies of various auks (thick-billed and common murres, little auk, least auklet) and other seabirds. This is the case for islands in the Bering Strait region, in Lancaster Sound and the North Water region in northern Baffin Bay, and around Svalbard in the northeastern Atlantic. Some of the High Arctic archipelagos such as Franz Josef Land, Severnaya Zemlya and the New Siberian Islands in Russia, the northernmost islands in Canada (Ellesmere, Queen Elisabeth Islands), and northern Greenland also hold important breeding and feeding habitats for seabirds (e.g., ivory gull) and other birds.

The seasonally ice-covered waters make up a number of important habitats at different times during the annual cycle. In winter, the southern extent of the sea ice constitutes winter habitats for marine mammals, notably for bowhead whale, beluga and narwhal. Important wintering habitats are found in the northern Bering Sea, the Davis Strait and Hudson Strait regions, and the southeastern Barents Sea. These areas and adjacent areas south of the winter ice are also important winter habitat for seabirds and seaducks. Polynyas, notably the North Water, the Great Siberian polynya system, and polynyas at Franz Josef Land, are also ecologically important winter habitat for marine mammals and sometimes for birds (e.g., St Lawrence Island Polynya). From the wintering areas, marine mammals migrate north into the Arctic through systems of recurrent shore leads and leads in drifting pack ice. Polynyas (notably the North Water and Cape Bathurst polynyas) are used by bowhead whale and beluga for feeding early in the season. Polynyas and leads are also used by migratory seabirds and seaducks for spring staging and feeding prior to breeding.

The fast-ice environment is in some places breeding habitat for the polar cod that spawns in winter under the ice. This is the case in the Pechora Sea area and probably also in Franklin Bay in the Amundsen Gulf. Fast ice is important breeding habitat for ringed seal, such as in inlets along western Victoria Island. Such areas and adjacent leads may also constitute winter and foraging habitat for polar bear that feed on ringed seal. The retreating ice over the seasonally ice-covered seas provides in many places concentrated zones of life that make them of heightened ecological significance. This is particularly the case early in the summer season when spring has arrived but substantial ice melt has not yet taken place, and late in the summer season when the ice edge has retreated north toward its minimum extent. Areas associated with the retreating ice edge have been identified as ecologically important in the Greenland, Barents, Kara and Chukchi seas, and in Baffin Bay.

The drifting pack ice of the central Arctic Ocean is a special case. This LME, which includes the international waters (High Seas) but also parts of national Exclusive Economic Zones (EEZs) of Canada, Denmark/Greenland, Norway and Russia, is a large area of about 3.7 million km². It contains areas with heavy multi-year pack ice as well as areas with more newly formed (annual/seasonal) sea ice. It is well known and documented (e.g., AMAP, 2012) that the extent of summer sea ice has declined in recent decades with open waters forming over a substantial part of the Canada Basin with minimum sea ice cover in 2007 and again in 2012. The extent of the multi-year sea ice has also decreased substantially. The annual duration of the ice melt and ice formation seasons have also changed.

Canada identified the areas with multi-year pack ice within the northern part of the Canadian Arctic Archipelago and the adjacent part of the Arctic Ocean as EBSAs due to the unique habitats and biological communities associated with the sea ice. The drifting pack ice of the Central Arctic Ocean is globally unique as an environment and contains unique ice-associated biota. This whole area has been identified as an area of heightened ecological significance. The truly unique habitat is the multi-year pack ice with its associated biota of ice algae, amphipods and other animals. There is an export of multi-year ice out of the Arctic Ocean through Fram Strait with the East Greenland Current. This loss is compensated by the formation of new ice that accumulates over several seasons to become multi-year ice. The mechanisms that regulate the establishment and maintenance of the unique ice-biota communities are not well known. It is likely that old ice serves as core areas for colonization of new ice by ice biota, and also that younger ice plays some role in the establishment and development of the ice-associated biological communities.

The drifting pack ice is a threatened habitat with global climate change. It is projected that summer sea ice may be largely absent from the Arctic Ocean by the end of this century if not earlier. It is also projected that the last area with multi-year ice will be the region north of Canada. It seems clear that this region is a core area of higher ecological significance than the other portion (toward the Eurasian side) of the Central Arctic Ocean. The area could be roughly divided by the 0-180 degree longitude through the North Pole, with the western (North American) side being of higher ecological significance than the eastern (Eurasian side) with regard to the unique ice-biota communities. However, this distinction is uncertain and it is not therefore possible to determine whether some part of the whole area should be regarded as not being of heightened ecological significance.

The drifting pack ice of the Central Arctic Ocean is a very low production area. This is due to the combination of low incoming light (both low angle and short season), the strong shading effect of ice, and low nutrient supply due to strong stratification of the underlying water. In fact, this low productivity contributes to the unique characteristics of this habitat. On the other hand it means that there is limited food for predators and the area does not attract concentrations of animals. Some beluga, narwhal, ringed seal, and polar bear may venture into this area as do some ivory and glaucous gulls. However, their densities are generally low. The sensitivity of this area to shipping would also be generally low. Oil spills that could remain in this habitat for a long time would be the main concern in this LME, while disturbances from ships would be an issue of little concern due to the low density of animals and the very wide distribution of the ice communities.

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Annex 1: IMO criteria for the identification of a Particularly Sensitive Sea Area

The IMO criteria for the identification of a Particularly Sensitive Sea Area (PSSA) can be divided into three categories: ecological criteria; social, cultural, and economic criteria; and scientific and educational criteria.

Ecological criteria

4.4.1 Uniqueness or rarity – An area or ecosystem is unique if it is "the only one of its kind". Habitats of rare, threatened, or endangered species that occur only in one area are an example. An area or ecosystem is rare if it only occurs in a few locations or has been seriously depleted across its range. An ecosystem may extend beyond country borders, assuming regional or international significance. Nurseries or certain feeding, breeding, or spawning areas may also be rare or unique.

4.4.2 Critical habitat – A sea area that may be essential for the survival, function, or recovery of fish stocks or rare or endangered marine species, or for the support of large marine ecosystems.

4.4.3 Dependency – An area where ecological processes are highly dependent on biotically structured systems (e.g. coral reefs, kelp forests, mangrove forests, seagrass beds). Such ecosystems often have high diversity, which is dependent on the structuring organisms. Dependency also embraces the migratory routes of fish, reptiles, birds, mammals, and invertebrates.

4.4.4 Representativeness – An area that is an outstanding and illustrative example of specific biodiversity, ecosystems, ecological or physiographic processes, or community or habitat types or other natural characteristics.

4.4.5 Diversity – An area that may have an exceptional variety of species or genetic diversity or includes highly varied ecosystems, habitats, and communities.

4.4.6 Productivity – An area that has a particularly high rate of natural biological production. Such productivity is the net result of biological and physical processes which result in an increase in biomass in areas such as oceanic fronts, upwelling areas and some gyres.

4.4.7 Spawning or breeding grounds – An area that may be a critical spawning or breeding ground or nursery area for marine species which may spend the rest of their life-cycle elsewhere, or is recognized as migratory routes for fish, reptiles, birds, mammals, or invertebrates.

4.4.8 Naturalness – An area that has experienced a relative lack of human-induced disturbance or degradation.

4.4.9 Integrity – An area that is a biologically functional unit, an effective, self-sustaining ecological entity.

4.4.10 Fragility – An area that is highly susceptible to degradation by natural events or by the activities of people. Biotic communities associated with coastal habitats may have a low tolerance to changes in environmental conditions, or they may exist close to the limits of their tolerance (e.g., water temperature, salinity, turbidity or depth). Such communities may suffer natural stresses such as storms or other natural conditions (e.g., circulation patterns) that concentrate harmful substances in water or sediments, low flushing rates, and/or oxygen depletion. Additional stress may be caused by human influences such as pollution and changes in salinity. Thus, an area already subject to stress from natural and/or human factors may be in need of special protection from further stress, including that arising from international shipping activities.

4.4.11 Bio-geographic importance – An area that either contains rare biogeographic qualities or is representative of a biogeographic "type" or types, or contains unique or unusual biological, chemical, physical, or geological features.

Social, cultural and economic criteria

4.4.12 Social or economic dependency – An area where the environmental quality and the use of living marine resources are of particular social or economic importance, including fishing, recreation, tourism, and the livelihoods of people who depend on access to the area.

4.4.13 Human dependency – An area that is of particular importance for the support of traditional subsistence or food production activities or for the protection of the cultural resources of the local human populations.

4.4.14 Cultural heritage – An area that is of particular importance because of the presence of significant historical and archaeological sites.

Scientific and educational criteria

4.4.15 Research – An area that has high scientific interest.

4.4.16 Baseline for monitoring studies – An area that provides suitable baseline conditions with regard to biota or environmental characteristics, because it has not had substantial perturbations or has been in such a state for a long period of time such that it is considered to be in a natural or near-natural condition.

4.4.17 Education – An area that offers an exceptional opportunity to demonstrate particular natural phenomena.

4.5 – In some cases a PSSA may be identified within a Special Area and vice versa. It should be noted that the criteria with respect to the identification of PSSAs and the criteria for the designation of Special Areas are not mutually exclusive.

Annex 2: Arctic species of fish, marine mammals and birds and aspects of their biology and ecology

Fish species and communities

Overview of types and species of fish

More than 500 species of fish inhabit Arctic and sub-Arctic marine ecosystems. It is common to distinguish between pelagic species that live in the water column and benthic species that live at the sea floor. However, this distinction is not always clear since many fish show both modes of existence, spending part of their time at the bottom and part of their time in the water column. Sandeel or sand lance (*Ammodytes* spp.) is a good example, burrowing into sand where they remain hidden for much of the time, emerging sporadically to feed on plankton within the water column. Polar cod (*Boreogadus saida*) is another example. This key species in Arctic ecosystems can be found in large aggregations close to the bottom in some areas, but as a schooling pelagic plankton-feeder in others, as well as under the sea ice.

Anadromous or amphidromous fish species are those that live both in seawater and freshwater. Atlantic and Pacific salmon belong to the group of anadromous fishes; feeding and growing in the sea and returning to their natal rivers to spawn. Whitefishes (*Coregonus* spp.), Arctic char (*Salvelinus alpinus*) and Dolly Varden (*S. malma*) show great flexibility and variability in their life cycles, where many fish move to estuaries and coastal waters to feed during summer, returning to spend the winter in rivers and lakes.

Fish feed on zooplankton, bottom-dwelling invertebrates (benthos), and other fish. The plankton-feeders are usually relatively small species. They play an important role in Arctic marine ecosystems linking the lower and higher trophic levels (such as marine mammals and seabirds), and are for that reason often referred to as forage fishes. Many other fish species also feed on the forage fishes. These include cod, pollock and halibut among others. Many demersal fish such as flounders and sculpins feed on benthic polychaetes, bivalve mollusks, amphipods, shrimps and other benthic organisms.

There is a large gradient in productivity from the highly productive sub-Arctic seas to the very low levels of production observed in the ice-covered waters of the High Arctic. The sub-Arctic seas, such as the waters around Iceland, the Norwegian Sea and the Bering Sea, support some of the largest and most productive fish stocks in the world. On a gradient from south to north, there are large stocks of plankton-feeders in the basins and shelf areas of the sub-Arctic seas. These include blue whiting (*Micromesistius poutassou*) and walleye pollock (*Theragra chalcogramma*) which are relatively small codfishes that live in the basins of the Bering Sea and the Nordic Seas, and Atlantic herring (*Clupea harengus*) and Pacific herring (*C. pallasii*) that live over shelves and basins in the sub-Arctic seas. Capelin (*Mallotus villosus*) forms populations over sub-Arctic and Low Arctic shelf regions, whereas polar cod (*Boreogadus saida*) is a true Arctic species found in Low and High Arctic areas. The northernmost species is the little-known Arctic cod (*Arctogadus glacialis*) which is believed to live with a large population (possibly more than one) in the Canada Basin of the Arctic Ocean.

Atlantic halibut (*Hippoglossus hippoglossus*) and Pacific halibut (*H. stenolepis*) are large species of piscivorous flatfish (up to 2 m in length) that live along the continental slopes and shelf areas of the sub-Arctic seas. Greenland halibut (*Reinhardtius hippoglossoides*) has similar life style but is a somewhat more northern species, extending its range well into Low Arctic waters in the northern Bering Sea, Baffin Bay, and Greenland Sea. Along the sub-Arctic slopes there are a number of redfish species (*Sebastes* spp.) that are mainly plankton-feeders and viviparous (i.e., give birth to juveniles). Atlantic cod (*Gadus morhua*) and Pacific cod (*G. macrocephalus*) are important commercial species on the boreal and sub-Arctic shelves as are a number of other species of codfish and flatfish. The latter is particularly important on the wide eastern shelf of the Bering Sea where yellow-fin sole (*Pleuronectes asper*) is the major species in the fisheries. Navaga (*Eleginus nawaga*) and saffron cod (*E. gracilis*) are two medium-sized codfishes (40–50 cm in length) that are important in Low Arctic shelf areas where they spawn in winter under the ice. On the Low and High Arctic shelf regions surrounding the Arctic Ocean there are special demersal Arctic fish communities with several mostly small species of sculpins, eelpouts, sea snails, lumpsuckers among others. Species in these groups also dominate in the fish communities along the low productive Arctic slopes to the Arctic Ocean basins.

In the group of anadromous or amphidromous fishes, Atlantic salmon (*Salmo salar*) and the five species of Pacific salmon (*Oncorhynchus* spp.) are large species that feed in the sub-Arctic basins before returning to their natal rivers in the boreal and sub-Arctic zones. The most northern of the species is chum salmon (*Oncorhynchus keta*) that is found as far north as the Mackenzie and Lena rivers. Smelts are smaller fish related to capelin. There are several species that move to feed in coastal and shelf waters of sub-Arctic seas, such as eulachon (*Thaleichthys pacificus*) on the eastern Bering shelf. Arctic rainbow smelt (*Osmerus mordax dentex*) is widely distributed in the Arctic where it feeds in coastal waters in summer. Arctic char and whitefishes have complex taxonomy and life histories and move in great numbers from Arctic rivers to feed in estuaries and coastal (mostly brackish) waters in summer.

Migrations, spawning and wintering habitats

Migrations are a key feature of all large fish stocks that move between spawning, feeding and wintering areas. This section illustrates these seasonal migrations for some of the key Arctic fish species. Plankton-feeders such as herring, capelin and polar cod have large-scale feeding migrations where they spread out and feed on the zooplankton that grow and develop in the upper waters of the sub-Arctic and Low-Arctic areas during the short summer season. Demersal species such as Atlantic and Pacific cod and Greenland halibut also have large-scale seasonal migrations.

Migratory fish typically have defined spawning grounds from where the spawned eggs and/or larvae drift with the currents to suitable nursery areas. As the juveniles grow and develop swimming capacity they will join older fish on seasonal feeding migrations and when mature will return to the spawning grounds in a spawning migration. The spawning behavior and spawning areas can be broadly grouped into three types: (i) spawning demersal eggs at the bottom; (ii) spawning pelagic eggs in the water column; and (iii) spawning eggs under the ice in winter.

Demersal and pelagic spawning can occur either in shallow water or the upper part of the water column, or in deeper water. Spawning under sea ice and demersal spawning in shallow water were considered by the AMAP oil and gas assessment to be the most sensitive to oil spills.

Polar cod, Arctic cod, navaga and saffron cod spawn under sea ice in winter. For navaga and saffron cod spawning occurs under landfast ice in relatively shallow water. Polar cod appears to spawn under sea ice in relatively shallow water such as in the Pechora Sea area for the East Barents Sea stock.

Herring and capelin spawn demersal eggs. Pacific herring and capelin may in some areas (such as in the Bering Sea and Labrador) spawn on beaches or in shallow water just below beaches. In other areas they may spawn on coastal banks in deeper water (50–200 m); this is the case for the stock of Atlantic herring off the west coast of Norway and capelin in the southern Barents Sea.

Many demersal fish species (codfishes, flatfishes) spawn pelagic eggs in the upper water layer. Spawning usually takes place during spring so that the fish larvae can be nourished by the spring growth of phyto- and zooplankton. This is the case for Atlantic cod (but not Pacific cod that spawns demersal eggs), yellow-fin sole in the Bering Sea, and many others. Other species spawn in deeper water, often in late winter so that the larvae that hatch can ascend to feed in the upper layers during spring and summer. Atlantic and Pacific halibut and Greenland halibut are species with deep spawning along the continental slopes in boreal and sub-Arctic waters (see Figure A.18) where they aggregate in winter.

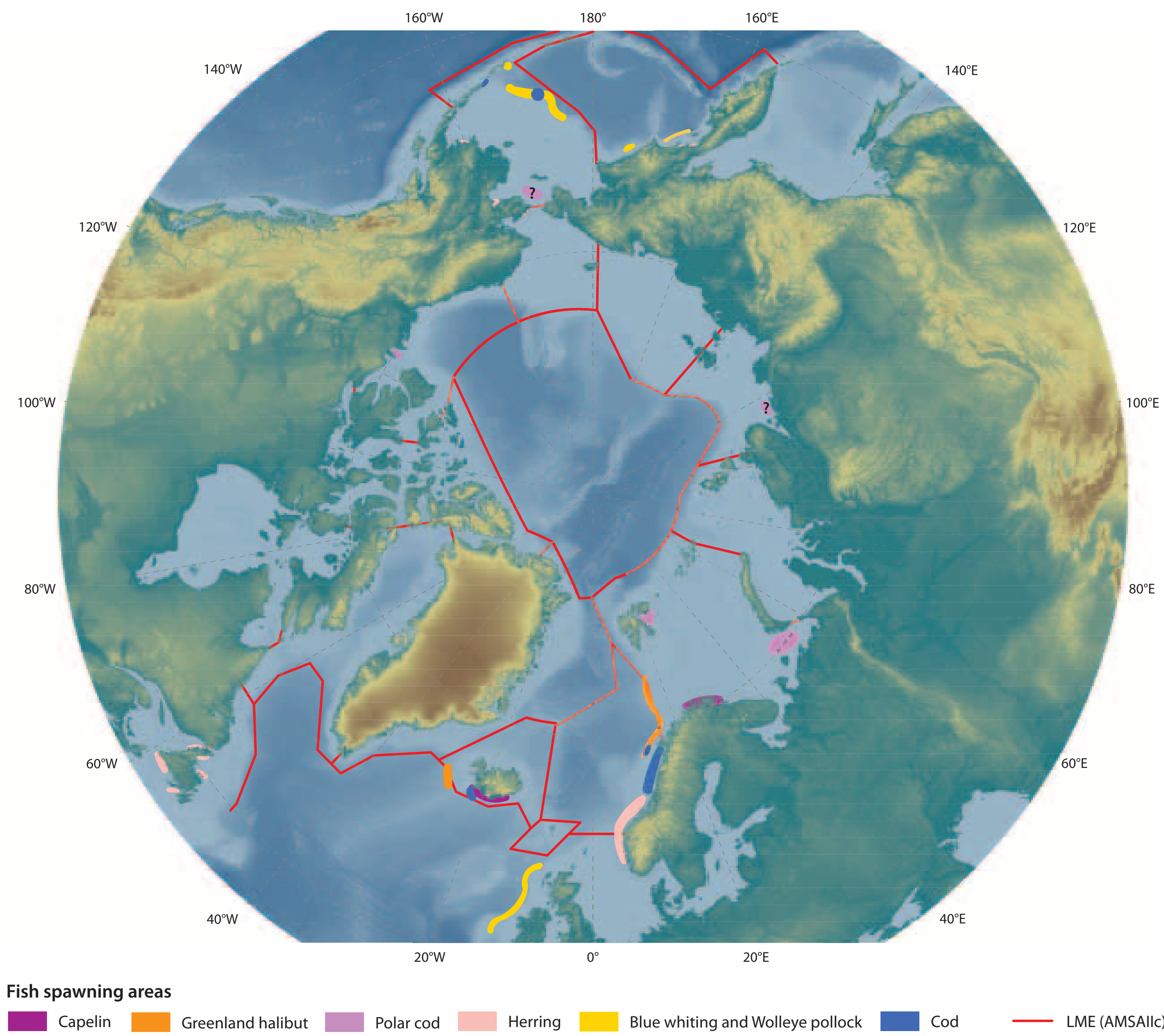


Figure A.18. Location of some of the major spawning areas of fish in the Arctic.

During spawning migrations and on the spawning grounds, the fish may be concentrated and thus potentially sensitive to disturbances such as from seismic surveys. Some species may also concentrate during wintering. This is the case for herring as illustrated by the large stock of Norwegian spring-spawning herring that occurred in one huge aggregation (up to five million tonnes) in a single fjord area (Ofoten-Tysfjord) in the inner Vestfjord in the Lofoten area. Concentrations of Pacific herring may also occur on the outer Bering shelf in the area between the Pribilof Islands and St. Matthew Island in Alaska.

Amphidromous fishes return from the sea to spend the winter in estuaries, rivers and lakes. This is related to the lack of physiological adaptation to cope with the low temperatures (-1.8 °C) that occur at freezing in water with full marine salinity. Herring also presumably survives in Arctic areas by seeking lower-salinity waters in estuaries during winter. These estuaries may be winter habitats of limited spatial extent for herring and other fish species and may therefore constitute areas that are sensitive to pollution and disturbances during winter.

Marine mammals

Overview of species

There are 35 species of marine mammal that occur within the Arctic area. Most are found in the southern sub-Arctic areas where many occur as seasonal visitors from lower latitudes. The marine mammals can be broadly grouped into four main categories: baleen whales, toothed whales, seals and walrus, and other carnivores. There are nine species of baleen whales, 13 species of toothed whales, and 11 species of seals plus walrus. The 'others' comprise two species: polar bear and sea otter. Polar bear is considered to be a marine mammal although it is not in a strict taxonomic sense marine since it belongs to a mainly terrestrial group of carnivores. This is also the case for sea otter.

Eleven of the species are true Arctic residents, living in the Arctic year-round and in association with sea ice to a large extent. These are polar bear (*Ursus maritimus*), three whale species, six seals, and the walrus (*Odobenus rosmarus*). The whales are beluga or white whale (*Delphinapterus leucas*), narwhal (*Monodon monoceros*), and bowhead (*Balaena mysticetus*), while the seals are ringed seal (*Phoca hispida*), bearded seal (*Erignathus barbatus*), spotted seal (*Phoca largha*), ribbon seal (*Histriophoca faciata*), harp seal (*Phoca groenlandica*) and hooded seal (*Cystophora cristata*). Other species are mainly confined to the sub-Arctic and boreal areas. This group includes northern fur seal (*Callorhinus ursinus*), harbor seal (*Phoca vitulina*), gray seal (*Halichoerus grypus*), killer whale (*Orcinus orca*), northern bottlenose whale (*Hyperoodon ampullatus*), minke whale (*Balaenoptera acutorostrata*), and sea otter (*Enhydra lutris*). Several species have large-scale migrations between warmer waters where they spend the winter and reproduce, and the Arctic where they feed during the summer. This group includes the large baleen whales: blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), sei whale (*B. borealis*), humpback whale (*Megaptera novaeangliae*), and gray whale (*Eschrichtius robustus*).

Fifteen of the marine mammal species have circumpolar or amphi-boreal distributions and occur around the Arctic and/or in both the North Atlantic and North Pacific Oceans. Six of the ice-associated species have circumpolar distributions (polar bear, bowhead whale, beluga, walrus, and ringed and bearded seals), while three are found only in the Atlantic sector (narwhal, harp and hooded seals) and three only in the Pacific sector (gray whale and ribbon and spotted seals). Five large baleen whales (blue, fin, sei, humpback and minke) are found both in the Atlantic and Pacific sectors, as are sperm (*Physeter macrocephalus*) and killer whales, harbor porpoise, and harbor seal. Five of the sub-Arctic and boreal species are Atlantic species (northern bottlenose and long-finned pilot whales *Globicephala melas*, white-beaked *Lagenorhynchus albirostris* and Atlantic white-sided *L. acutus* dolphins, and gray seal), while six are Pacific species (Baird's beaked whale *Berardius bairdii*, Pacific white-sided dolphin *L. obliquidens*, Dall's porpoise *Phocoenoides dalli*, Steller sea lion *Eumetopias jubatus*, and sea otter).

Migration, feeding and reproduction

Migration is a key feature for most marine mammals. The ice-associated species move seasonally with the ice. Bowhead whales and beluga winter in the southern part of the winter pack ice or in persistent polynyas. In spring they move north using lead systems to summer feeding grounds in the Arctic that become available as the ice opens up and recedes (see Figure A.19). In autumn they move south again as the sea freezes over and winter approaches. Large migratory populations of both species winter in the northern Bering Sea and migrate seasonally to summer feeding areas in the Beaufort Sea. Similarly, populations in the Baffin Bay area migrate from wintering areas into the Canadian Arctic Archipelago to feeding areas in Prince Regent Inlet and other adjacent inlets (see also, Figure A.14). Narwhal has a similar migration between Baffin Bay and the Canadian Arctic.

Ringed seal is an important species in Arctic marine ecosystems as it is the principal prey item for polar bears and also for subsistence hunting. The fore-flippers are equipped with claws that are used to maintain breathing holes in the sea ice, which allows it to live in High Arctic areas all year round. Nevertheless, many ringed seals migrate seasonally as the ice and feeding conditions change. Migrations are also characteristic for other seals such as harp seal in the Atlantic sector and spotted seal in the Pacific. Pacific walrus has a large-scale migration (mainly of females and juveniles) from wintering areas in the pack ice of the northern Bering Sea to summer feeding areas in the Chukchi Sea and the eastern East Siberian Sea.

Many baleen and toothed whales migrate north to summer feeding grounds in the sub-Arctic seas where they exploit the rich seasonal occurrence of zooplankton, fish and squid. The baleen whales use their baleen feeding apparatus to filter zooplankton and small schooling fish from the water. The right whales (family Balaenidae), including the bowhead whale, skim-feed by swimming with an open mouth and feed to a large extent on zooplankton including large calanoid copepods. The rorquals (family Balaenopteridae) feed by engulfing a large mouthful of water with prey by distending the skin in the throat region and then forcing the water out through the baleen. These

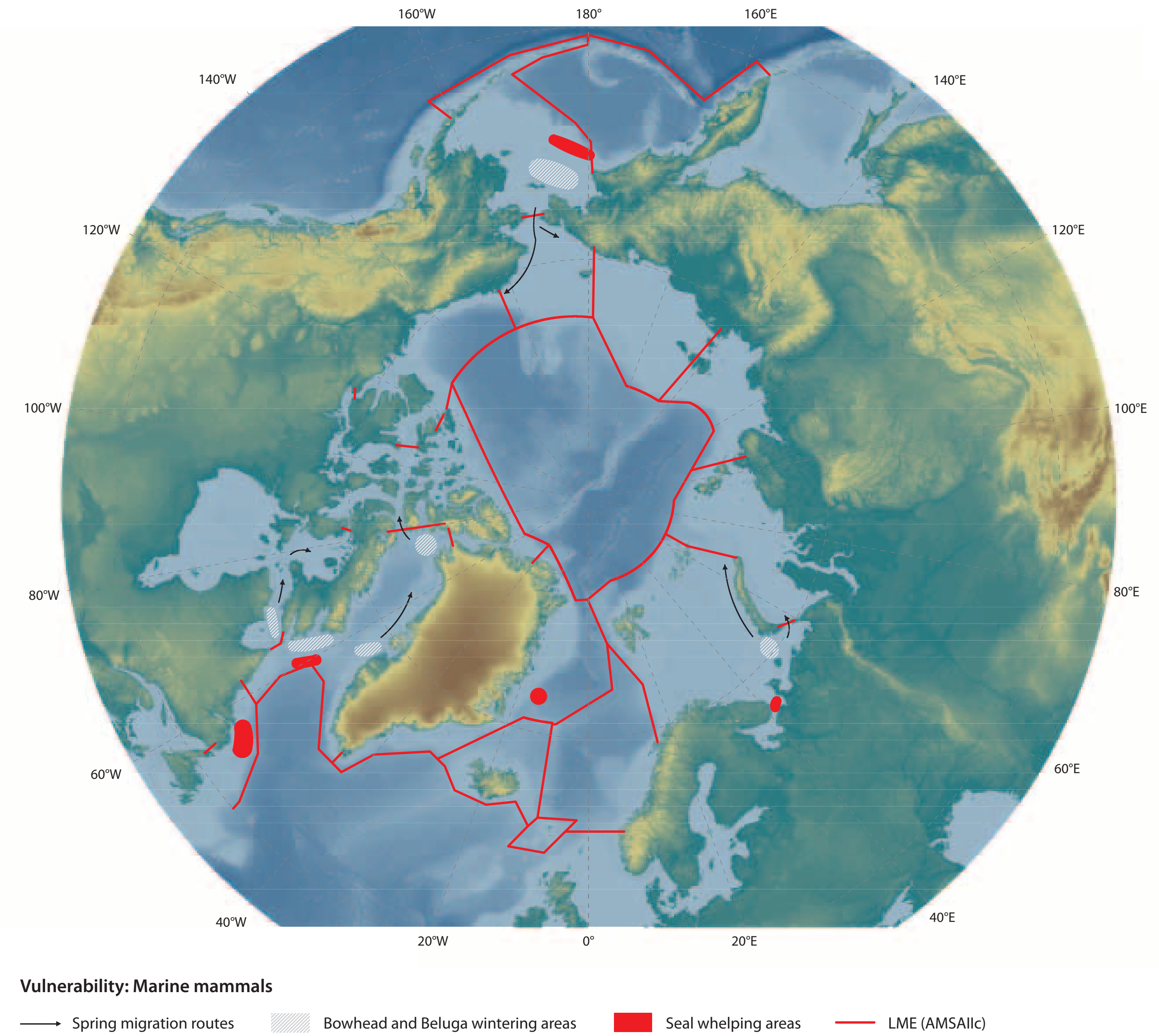


Figure A.19. Location of major wintering areas and spring migration routes of bowhead and beluga whales, and seal whelping areas on sea-ice in late winter and spring.

whales feed largely on krill and schooling fish. Blue whale feeds mainly on krill, whereas humpback and minke whales are more versatile and often target fish schools such as capelin, herring and sandeel/sand lance.

Toothed whales feed mainly on fish and squid. Several of the whales are deep divers and target deepwater squid and fish such as Greenland halibut and redfish (*Sebastes* spp.). Narwhal can dive to 1500 m or more. In winter they live in dense pack ice in southern Baffin Bay and dive to feed on the squid *Gonatus fabricii* and Greenland halibut in deep water. Beluga is also capable of deep diving down to 1000 m. Many of the smaller species of toothed whales including harbor porpoise and dolphins feed mostly on small epipelagic fish or demersal fish in shallower water over shelves. Killer whale is the largest of the dolphins and has as a species a broad range of prey items including fish and marine mammals. Within that broad range there is considerable specialization so that some populations eat fish while others eat marine mammals. For the mammal-eating ecotype, pinnipeds appear to be the predominant prey although killer whales may also attack and kill baleen whales, notably their calves.

The seal species feed to a large extent on fish and crustaceans. Polar cod (*Boreogadus saida*) and capelin are important prey for seals in Arctic waters as are ice-associated and pelagic amphipods such as *Themisto libellula*. This is the case for ringed seal and harp seal. Hooded seal is a deep diver (to 1000 m) and also eats deep-water fish. Bearded seal is a benthic feeder feeding on a variety of invertebrates but also eats polar cod. Walrus feeds predominantly on bivalve shells in relatively shallow sediments. Northern fur seal and Steller sea lion in the Bering Sea feed on a variety of fish and invertebrates.

Most marine mammals produce one baby calf or pup at a time. They typically breed in winter or spring and give birth to the young after around one year. Many of the large whales migrate south to breeding and calving areas in warmer waters. Bowhead whale and beluga give birth to the calves commonly in ice-covered waters during the spring migration to their summer feeding grounds. Seals give birth to their whelps on land or ice. Ringed and bearded seals are mainly solitary and whelp widely dispersed. Ringed seal construct a lair in snow drift where the whelp is nursed. Harp, hooded, spotted and ribbon seals gather in specific whelping areas in the southern extent of winter ice where they give birth to the young.

Whale calves and seal pups are borne relatively large, with a length of around a third the length of the mother. Thus a bowhead calf is about 4 m long and weighs a tonne, a beluga calf is about 1.5 m, a walrus calf is 1.2 m (about 60 kg), and ringed seal whelp is about 0.5 m. The young are fed very rich milk and grow fast. Whale and walrus calves suckle their mothers for up to a year or more. In contrast, the seal whelps of harp, hooded, spotted and ribbon seals that have a rich wooly pelt to keep them warm, are nursed on the ice for a few weeks only before being abruptly weaned and left by their mothers. The hooded seal is the most extreme case where the 'bluebacks' are nursed for only four days, during which time they drink 10 liters of milk (60 % fat) and put on 7 kg of weight per day.

An important feature in the biology and ecology of whales relates to their mode of reproduction. In the long nursing period, the young calves swim with their mother on the annual migration from wintering and calving grounds to the summer feeding grounds at higher latitudes. In this way they learn a particular migration route from their mothers which is the basic mechanism for the matrilineal structure of whale populations. This is particularly well studied with humpback whales that can be individually recognized by the color pattern on their flukes and bodies (photo id). This has shown that individual whales have a high degree of site fidelity, returning each summer to the same summer feeding grounds even if they mix on a common wintering and breeding ground (in the West Indies region for North Atlantic populations).

Populations and conservation status

Marine mammals often occur in relatively well-defined and discrete populations. The separation between the Atlantic and Pacific sectors of the Arctic and adjacent boreal areas is often expressed in genetically distinct forms. Thus, separate subspecies are recognized for walrus, harbor porpoise, minke whale, and possibly also fin and blue whales. Harbor seal has four subspecies within the Arctic area; two in the North Atlantic and two in the North Pacific. However, even within Atlantic or Pacific sectors of the Arctic, several populations are often recognized that are more or less separated by geographical distance and biological mechanisms (such as referred to above for whales). These population units are often called stocks as practical management units for whales, or subpopulations in other cases, such as for polar bear.

Bowhead whale has four recognized populations (the Okhotsk Sea, Bering Sea, Eastern Canada-West Greenland, and Spitsbergen stocks). The Bering and Eastern Canada-West Greenland stocks are relatively large (each of the order of 10 000 individuals), while the Spitsbergen stock may number in the tens of individuals and is considered to be 'Critically Endangered'. Bowhead whale as a species is no longer considered a Threatened species by IUCN (and is assessed to be in the 'Least Concern' category).

Beluga has 20 or more subpopulations, each with separate summering grounds although some may mix in the wintering areas. Many of the subpopulations are small (hundreds to a few thousand) and remain in ice-free sub-Arctic waters in summer. Four of the stocks or subpopulations are large (numbering in the range of 20 000–50 000 individuals) and are migratory to summer feeding grounds in the Low and High Arctic. These are the Bering-Chukchi-Beaufort, Western Hudson Bay, Eastern High Arctic-Baffin Bay, and Karskaya subpopulations. The total population of beluga numbers about 200 000 individuals and it is assessed by IUCN as being 'Near Threatened'. This is also the case for narwhal that occurs with at least two populations, the largest in Baffin Bay (total population over 80 000 individuals).

Pacific walrus has one large migratory population that winters in the northern Bering Sea and summers (females and juveniles) in the Chukchi and East Siberian seas. The size of the population is not well known but was previously estimated to be of the order of 200 000. Atlantic walrus has eight subpopulations, totaling only about a tenth of the numbers for Pacific walrus. At the species level, walrus is assessed by IUCN to be 'Data Deficient' due to the uncertainty about population size and the threat from climate change.

The large whales were severely depleted by former whaling. North Atlantic (*Eubalaena glacialis*) and North Pacific (*E. japonica*) right whales are estimated to number about 400 and 500 individuals, respectively, and are assessed by IUCN to be 'Endangered' (they should possibly be considered Critically Endangered given their precariously low populations). Blue whale, fin whale and sei whale are also considered to be 'Endangered' although their global populations are much higher (10 000–100 000). Sperm whale is assessed to be 'Vulnerable'.

Sea otter in the Bering Sea is assessed to be 'Endangered' due to a previous strong decline to near extinction. Steller sea lion has been undergoing decline in recent decades but is now assessed by IUCN to be 'Near Threatened'. Northern fur seal is listed as 'Vulnerable' as is hooded seal in the Atlantic sector. The ice-associated spotted seal and ribbon seal in the Bering Sea are assessed by IUCN to be 'Data deficient' due to uncertainty about their situation. Polar bear is listed as 'Vulnerable' by IUCN due to the threat of climate change and overharvesting.

Marine and coastal birds

Types of birds

There is a great variety of birds that occur in marine and coastal areas in the Arctic, with a total of about 200 species (Table A.22). Many terms are used to classify birds, such as seabirds, waterbirds, waterfowl, and shorebirds. 'Waterbird' is a term used by Wetlands International and the Ramsar Convention for birds that occur in wetlands. In this use, 'waterbirds' include traditional waterfowl such as ducks, geese and swans, divers, grebes, shorebirds, cranes, and some forms of seabird such as gulls, terns and cormorants.

Seabirds contain a variety of types or families of birds including auks, gulls, terns, skuas, cormorants, storm-petrels, petrels and

Table A.22. Overview of the types and numbers of species of Arctic marine and coastal birds.

Bird type	Families/ subfamilies/ tribes	Number of species[1]		
		Arctic	Sub-Arctic[2]	Total
Seabirds	Albatrosses		3	3
	Petrels and shearwaters	1	7	8
	Storm-petrels		3	3
	Cormorants	1	4	5
	Gannets		1	1
	Skuas	3	2	5
	Gulls	8	12	20
	Terns	2	4	6
	Auks	7	13	20
	Total	22	49	71
Waterfowl[3]	Swans	1	2	3
	Geese	10	3	13
	Seaducks	6	10	16
	Diving ducks	2	5	7
	Dabbling ducks	1	10	11
	Divers or loons	4	-	4
	Grebes		3	3
	Total	24	33	**57**
Shorebirds	Lapwings		1	1
	Plovers	7	3	10
	Woodcocks		1	1
	Snipes and dowitchers	1	6	7
	Godwits and curlews	5	6	11
	Shanks		13	13
	Turnstones	1	1	2
	Sandpipers (calidrine)	23	1	24
	Phalaropes	2	1	3
	Oystercatchers		2	2
	Total	39	35	**74**
	Overall total			202

[1] Including inland (or mainly inland) species; [2] number of bird species that are restricted to the sub-Arctic parts of the Arctic area, which are broadly the open water areas south of the seasonal sea ice in the marine environment and forested areas south of the tundra on land; [3] including divers and grebes which are usually not considered to be in this group.

shearwaters, gannet (one species), and albatrosses. A total of about 70 species of seabird may be found within the Arctic area, most of them (about 50 species) restricted to the sub-Arctic region. Auks and gulls are the two most dominant families in terms of number of species (about 20 each), with seven to eight species breeding in the true Arctic. Among the auks, thick-billed (*Uria lomvia*) and common (*U. aalgae*) murres are abundant species that breed in seabird colonies on cliffs around the circumpolar Arctic. The smaller dovekie or little auk (*Alle alle*) is very numerous in the High Arctic of the Atlantic sector, while black guillemot (*Cepphus grylle*) is widely distributed around the coasts and islands of the Arctic. Among the gulls, glaucous gull (*Larus hyperboreus*) is a large species with an Arctic circumpolar distribution. Herring gull (*L. argentatus*) also has a wide distribution, extending into the Low Arctic. Black-legged kittiwake (*Rissa tridactyla*) is the most numerous of the gull species, extending the breeding range into the Low Arctic both in the Atlantic and Pacific sectors. The Iceland gull (*Larus glaucoides*) breeds in the Arctic in northeastern Canada. The Ivory gull (*Pagophila eburnea*) is a High Arctic species and is among the few birds that remain in the Arctic during winter.

Other seabirds include northern fulmar (*Fulmarus glacialis*) which is a petrel with a wide distribution in Low Arctic and boreal areas of both the Atlantic and Pacific sectors. Other petrels and shearwaters, storm-petrels, and three North Pacific species of albatross are found north into the sub-Arctic zone. This is also the case for cormorants, where pelagic cormorant (*Phalacrocorax pelagicus*) in the Bering Sea region and great cormorant (*P. carbo*) in the north-western Atlantic extend their breeding ranges into the Low Arctic.

Waterfowl (used in a narrow sense) is a segment of waterbirds that include the family of swans, geese and ducks. *Seaducks* are a group of ducks (tribe Mergini) that include four species of eider that are prominent and conspicuous members of the Arctic fauna. Common (*Somateria mollissima*) and king (*S. spectabilis*) eiders have wide circumpolar breeding distributions, while spectacled eider (*S. fischeri*) is found in the Pacific sector of the Arctic. Steller's eider (*Polysticta stelleri*) breeds in northern Russia with a western (Atlantic) and an eastern (Pacific) population. Long-tailed duck (*Clangula hyemalis*) is another abundant and widespread seaduck in the Arctic.

Geese are to a large extent an Arctic group of birds with about ten species breeding in the true Arctic. These are found mainly inland and away from the coasts. The most Arctic and marine of the species is brent goose (*Branta bernicla*) that has (with different subspecies) a circumpolar distribution. Snow goose (*Chen caerulescens*) and Ross's goose (*Anser rossii*) breed in Arctic Canada (and on Wrangel Island for snow goose) and they occur to some extent in coastal habitats. Emperor goose (*C. canagica*) occurs in the Bering Sea and is very much a coastal species with a breeding distribution north to the Bering Strait region. *Dabbling ducks* tend to be largely associated with freshwater wetlands, and about ten species are found in sub-Arctic areas. Northern pintail (*Anas acuta*) is a numerous species with a circumpolar breeding distribution north in the Low Arctic zone, and the mallard (*A. platyrhynchos conboschas*) in Greenland constitute a true Low Arctic subspecies.

Divers or loons occur with four (or five) species which all breed in the true Arctic. Red-throated (*Gavia stellata*), black-throated (*G. arctica*) and white-billed (*G. adamsii*) divers have wide circumpolar or holarctic distributions, while great northern diver (*G. immer*) is largely a North American species. Divers utilize the marine environment during post-breeding and migration, for example, staging in coastal polynyas before lakes inland become free of ice.

Shorebirds or waders are generally smaller and more slender birds with long legs and beaks which allow them to wade and feed along shorelines. About 70 species occur within the Arctic area, with almost 40 of them breeding in the true Arctic. There are two families of birds that comprise the majority of shorebirds. The *plover* family includes the Eurasian, Pacific and American golden plovers which are conspicuous species on Arctic tundra but with limited use of Arctic coastlines. The family of snipes, sandpipers and phalaropes is more diverse. *Shanks* and *snipes* are medium-sized birds that are found mainly in the boreal zone with breeding ranges that extend north into the sub-Arctic zone for several species.

Godwits and *curlews* are relatively large shorebirds. Whimbrel (*Numenius phaeopus*) is a common curlew species with a circumpolar breeding distribution in the Low Arctic. Bar-tailed godwit breeds on tundra and wetlands across northern Eurasia. Eskimo curlew (*N. borealis*) was once a numerous species breeding in northern Canada but may now be extinct.

Sandpipers are a subfamily of mostly small shorebirds where the majority breeds in the true Arctic. Red knot (*Calidris canutus*) and dunlin (*C. alpina*) are diverse species (many subspecies recognized) with circumpolar breeding distributions. Purple (*C. maritima*) and rock (*C. ptilocnemis*) sandpipers occur in the Atlantic and Pacific sectors, respectively, and are species with strong association with Arctic coasts. Spoon-billed sandpiper (*Eurynorhynchus pygmeus*) is a species with restricted breeding range along the coasts of the Chukchi Peninsula. This is probably the most threatened bird species in the Arctic, now believed to exist with fewer than 1000 individuals and declining. Phalaropes are small swimming birds which mainly breed in freshwater habitats, but outside the breeding season they are strictly associated with the marine environment usually far offshore. Red (*Phalaropus fulicarius*) and red-necked (*P. lobatus*) phalaropes are abundant species with Arctic circumpolar breeding distributions.

Arctic breeding birds

The great majority of birds in the Arctic stays there only during the summer season and migrates south to spend the winter at lower latitudes or even in the southern hemisphere. Many of the birds, such as geese and shorebirds, use the Arctic primarily as a breeding ground and are more appropriately considered to be Arctic breeding birds. Among the group of seabirds, however, there are several species that are true Arctic birds although most of them move south to spend the winter in the sub-Arctic zone or beyond in the adjacent boreal zone. This is the case for many auks (e.g., common and thick-billed murres, black guillemot, little auk, least auklet *Aethia pusilla*) and some gulls such as glaucous, ivory and Ross's (*Rhodostethia rosea*) gulls. However, the sub-Arctic shelf waters off West Greenland are very important winter habitat for thousands of seabirds: auks, gulls, cormorants and seaducks.

There are two broad patterns or strategies for reproduction used by the Arctic or Arctic-breeding birds. Some species breed on cliffs or remote islands or islets that are free from and/or inaccessible to terrestrial predators such as the Arctic fox (*Vulpes lagopus*). Many auks, notably common and thick-billed murres and little auk, kittiwakes and northern fulmar typically breed in large colonies on cliffs. Murres and northern fulmar lay single eggs on narrow cliff ledges where they are incubated in shifts by both parents. Other species that breed in colonies place their eggs in crevices, cracks or among rocks in scree slopes and boulder fields (e.g., many auklets), or in excavated burrows in the turf on talus slopes (e.g., puffins). Large colonies of seabirds depend on the coincidence of two factors: availability of suitable breeding habitat and access to a sufficient food supply that allows the parents to feed and raise their chicks. The feeding range from the colonies may be from 10 to 200 km or more dependent on the species. Zooplankton (copepods, krill, amphipods) is the main food for several species of auk such as little auk, and auklets, while small fish (e.g., herring, capelin, polar cod, sand lance/sandeels), or a combination of small fish and zooplankton, comprise the diet for many seabirds such as common and thick-billed murres, kittiwakes, terns, and some gulls. Large gulls, such as glaucous gull, are partly top-predatory and take eggs and chicks of seabirds and other birds, as well as adults of small species that they are able to catch.

The other breeding pattern is to use the vast space of Arctic tundra and wetlands as the breeding ground and to spread out in a highly dispersed manner which makes it more difficult for predators to locate many of the nests. This is a pattern used by most of the shorebird species, divers, and many ducks and geese. Even among the seaducks, most of the species breed dispersed inland and away from the coasts. This is the case for king, spectacled and Steller's eiders, long-tailed duck, and the species of scoters and mergansers. Common eider is the exception and breeds in colonies on coastal habitat on inaccessible islands or islets. Seaducks, and many species of shorebirds, other ducks, geese and divers move to coastal habitats after breeding where they feed and prepare for the autumn migration. Eiders and other seaducks molt their flight feathers and are flightless for a period of about three weeks. During this period they usually aggregate in specific molt areas where they have access to food and are relatively safe from predators. Geese also have a flightless period during molt when they aggregate near water. Brent, barnacle and emperor geese are species that molt and spend the non-breeding season in the marine coastal zone. Many species of auk have a similar molt period after breeding when they occur flightless at sea.

The broad patterns of feeding ecology are that shorebirds generally feed on insects at their breeding grounds while they change to feed more on invertebrates in coastal habitats during the post-breeding period. Seaducks (except mergansers which are fish-eaters) feed on insects and aquatic invertebrates at the inland breeding areas and feed on bivalves, crustaceans and other invertebrates in the coastal and marine habitats after breeding. Geese are largely plant-eaters and feed variously on terrestrial and aquatic vegetation. Divers eat mainly fish both in freshwater and marine habitats.

The life-history characteristics vary across the different types and species of Arctic or Arctic-breeding birds. The number of eggs produced is a good reflection of the mortality experienced by the different types. Most species of auk and some other seabirds such as northern fulmar lay only one egg. They are long-lived species and typically reproduce over many years. Gulls and terns usually lay two to three eggs, while most shorebirds lay four eggs. Geese lay around five eggs which is also the typical clutch size for eiders. Many ducks lay around ten eggs, with the largest clutch sizes found among the dabbling and diving ducks. This pattern reflects the high predation on ducks and geese; on eggs and chicks by a range of terrestrial (e.g., Arctic fox) and bird predators (notably large gulls), and also on adults, particularly for ducks, by birds of prey.

A special adaptation among Arctic-breeding birds is a shortening of the incubation period and the time from hatching to fledging by the chicks. The incubation period may be as short as three weeks (22-24 days for king eider) and the time from hatching to fledging may be shorter than three weeks for some of the small sandpipers. The shortening of the breeding period to two months or less allows these species to breed during the short Arctic summer and be ready to fly out in time before the onset of harsh conditions in autumn. Many of the migratory birds also arrive early in the season to be able to start breeding as soon as the local conditions allow access to the breeding grounds and feeding areas.

Migrations and flyways

Each spring large numbers of birds arrive on the Arctic breeding grounds and leave with a new generation of chicks at the end of the season. Many of these migrations are long. Arctic tern migrates to spend the winter in the Antarctic. Many species of shorebird have similar long migrations to wintering areas in the southern hemisphere, as far south as the pampas of Argentina and Tierra del Fuego for some species. Skuas and phalaropes migrate south to upwelling regions off South America and Africa. Geese, ducks and gulls typically have shorter migrations to warmer latitudes in the northern hemisphere. Auks tend to be the most Arctic and northern of the birds and several species migrate south to winter in the sub-Arctic zone, as do some seaducks such as eiders.

There are some broad patterns in the geography of the migrations along what has been termed ‘flyways’. Birds from the Barents Sea region migrate south to winter in western Europe and western Africa. However, millions of auks and some gulls from Svalbard move across the North Atlantic to the waters off southwestern Greenland and Newfoundland. Birds from western and central Siberia migrate south to winter in eastern Africa, the Middle East and South Asia. Birds from eastern Siberia migrate south on the Pacific side to wintering areas in East and Southeast Asia and Australasia. Birds from Alaska tend to migrate south along the Pacific coast to winter in the western Americas. Birds from northwestern and central Arctic Canada and also partly from northern Alaska migrate south via inland routes east of the Rocky Mountains to wintering areas from the southern USA to South America. Birds from eastern Canada and western Greenland migrate south on the Atlantic side to the Caribbean area and eastern and southern South America.

The migrations are energetically costly. The fuel consumption of brent geese is about 1 g of fat per 10 km and they burn about 0.5 kg fat (about a third of their body weight) to fly 5000 km from Alaska to California. Smaller shorebirds are highly adapted physiologically to long migrations and put on a fat reserve of 50 % or more of the body weight for the flight. Bar-tailed godwits (*Limosa lapponica*) have been logged to fly non-stop for more than 10 000 km over the ocean between northern breeding grounds and wintering areas in the southern hemisphere. The long-range migratory birds depend very much on favorable feeding and staging areas to put on the necessary ‘fuel’ for the flight and also for reproduction when they return north in spring. Many of these staging areas are in the temperate zone south of the Arctic, such as Copper River Delta in southern Alaska, Delaware Bay in eastern USA, Bay of Fundy in maritime Canada, the Wadden Sea in Western Europe, and the Yellow Sea area in China. Important staging areas within the Arctic include lagoons on the north side of the Alaska Peninsula and the Yukon-Kuskokwim Delta in the eastern Bering Sea, the Anadyr Gulf region in the northwestern Bering Sea, western Hudson Bay and James Bay in Canada, estuaries and intertidal areas in Iceland, and coastal wetlands, in particular river deltas and estuaries and coastal shallows, along the Siberian coast and the Pechora and White Sea region in Russia.

Species diversity and conservation status

The migrations and migratory behavior have driven a diversification of species related to the site fidelity of the birds. This is expressed as a high degree of use of the same breeding, staging and wintering grounds along specific migratory routes by individual birds. The routes are learned by young birds that follow their parents during the flights, or are evidently ‘learned’ evolutionary in the genes of birds where the juveniles are left behind by the parents to find their own way south from the breeding grounds. A result of this site fidelity and use of fixed migratory routes is the differentiation into different forms or subspecies, usually with distinct morphological and genetic characteristics. For species with wide circumpolar (or amphi-boreal) distributions, a common pattern is that they are represented with different subspecies in North America and Eurasia, or in the Atlantic and Pacific sectors. Several species occur with more than two subspecies recognized. Thus, common eider has about six subspecies, dunlin (a small shorebird species) is recognized with eight to ten subspecies, while cackling goose (*Branta hutchinsii*) occurs with four species (after its ‘divorce’ from Canada goose (*B. canadensis*) which has seven subspecies).

The subspecies level is important from a conservation and management perspective since they are distinct units with geographical connection through the site fidelity associated with migrations. At the species level (see Table A.5), 12 of the about 200 species of seabirds, waterfowl and shorebirds that occur in the Arctic area, are listed as ‘Threatened’ by IUCN, with another nine species listed as 'Near Threatened'. Two of the species are listed as 'Critically Endangered': Kittlitz's murrelet (*Brachyramphus brevirostris*) and spoon-billed sandpiper, both of which occur in the Bering Sea region. In addition, Eskimo curlew is listed as 'Critically Endangered/Possibly Extinct'. Two of the species are listed as 'Endangered': marbled murrelet (*B. marmoratus*) and red-breasted goose (*Branta ruficollis*). Among the seven species listed as 'Vulnerable' (which is the least serious category of 'Threatened') are black-footed albatross (*Phoebastria nigripes*), Steller's eider, red-legged kittiwake (*Rissa brevirostris*) and bristle-thighed curlew (*Numenius tahitiensis*).

At the subspecies level, some are red-listed nationally although the species is not listed as 'Threatened' by IUCN. This is the case for subspecies *rufa* of red knot which is listed as 'Endangered' in Canada. Rock sandpiper (*Calidris ptilocnemis*) occurs with four or five subspecies with restricted range in the Bering Sea area. Subspecies *ptilocnemis* which breeds on the Pribilof Islands is listed as being of 'high conservation concern' in the United States, while subspecies *kurilensis* (provisional) which breeds on the tip of Kamchatka, is included in the Red data book of Russia.

Frits Steenhuisen

Part B

Areas of Heightened Cultural Significance

Henry Huntington, Camilla Brattland, Aleut International Association, Sami Council,
Dennis Thurston and Martin Magne

Cultural setting, impacts, and sensitivity

The Arctic is of global cultural, archeological, and historical importance. The Arctic was a major migration path and settlement area for the movement of people northward in Eurasia and from Asia to the Americas during and after the last ice age. The Vikings led the transatlantic migration of peoples from Europe, reaching Iceland in the 9th century and Greenland soon after, encountering Inuit who reached there two centuries later. Explorers and commercial whalers sailed the fringes of the Arctic in the 16th, 17th and early 18th centuries. There were many 19th century discovery expeditions, commercial whaling operations, mining booms and frequent disasters, and in the mid-20th century military activities left their imprint and legacy.

Today, the Arctic's indigenous peoples continue traditional ways of life, including hunting, fishing, and gathering of marine resources, in addition to extensive travel on the ocean in summer and on sea ice in winter. Along the coasts and on islands, the marine environment plays a central role in food, housing, settlement patterns, and cultural practices and boundaries. Other settlers in the region have brought their own cultures, practices, and life ways. Many of these also involve the marine environment, for example through commercial fishing, but also through other economic and recreational activities.

Not surprisingly, the human presence and legacy in the Arctic is often found where fish and marine mammals are abundant, and where transportation is easiest. Thus, when it comes to commercial vessel traffic, the potential for interaction and conflict is high. Oil spills and disturbances related to shipping or the construction and operation of shore-based facilities may affect marine subsistence hunting and fishing. Shipping lanes adjacent to the village coasts may increase the number of visitors to small communities. Increased ship-based tourism may place cultural heritage sites at greater risk of looting, vandalism of other kinds, and various forms of physical deterioration from pedestrian, boat and other vehicular traffic. Small boats launched from larger cruise ships can enter narrow inlets and access difficult to reach locations, and can operate largely undetected in remote areas. Ships and their anchors and the construction of underwater infrastructure such as pipelines and dock footings may destroy submerged archeological sites.

Shipping also has the potential to benefit Arctic communities, through greater awareness of cultural values and heritage, and through economic opportunities related to resource development and trade (PAME, 2009). Educational programs and tourism initiatives will be able to harness that increased awareness to create benefits for those communities where cultural heritage sites are found. An inter-play of awareness and education will result in proactive protective strategies, actions, and reports, of which the present report is an initial example. At the same time, activities associated with or facilitated by shipping, such as port development or resource extraction, bring their own risks and benefits above and beyond vessel traffic itself (e.g., Baffrey and Huntington, 2010).

The Arctic Marine Shipping Assessment (known as the 'AMSA Report': PAME, 2009), noted the importance of identifying and protecting culturally important areas from impacts due to increased vessel traffic in the Arctic (see Table B.1). At present, the information needed to assess the entire Arctic for cultural significance and sensitivity is not available. The information that exists is often fragmented, incomplete, and inconsistent across jurisdictions. More work is needed to create a more thorough assessment of culturally important areas throughout the Arctic.

Thus, a comprehensive catalog of areas of heightened cultural significance cannot yet be compiled. Instead, Part B takes a first step towards such a catalog. It begins by describing types of areas of heightened cultural significance, then provides examples of each in the form of case studies from around the North, and concludes by discussing approaches to protecting such areas in the context of vessel traffic.

Table B.1. Examples of potential impacts to areas of heightened cultural significance from various types of vessel traffic in the Arctic.

Increased shipping activity	Effect	Potential negative impacts	Potential positive impacts
Shipping activity in general	Oil spills, waste water, rubbish, development of harbors and other infrastructure, ice breaker activity	Negative visual effect and impact on archeological sites Workforce influx resulting in demographic and cultural change Social and health issues Change or loss of natural resource base Loss of traditional knowledge	Improved access to goods and services, including medical Economic opportunity
Cruise tourism	Increased number of visitors to heritage sites	Impact on surface, rubbish, vandalism, amateur surveys and excavations, unauthorized memorial plaques, etc.	Employment/income opportunities Increased awareness about heritage in the wider society Stimulus to research and financial support
	Increased number of boat and helicopter landings	Impact on surface and increased erosion	
	Infrastructure on the shore	Visual impact, site destruction	
	On-site accidents	Destruction of sites and objects	
	Use of underwater equipment, building of platforms, pipes, ports, etc	Direct impact on shoreline and submerged sites Loss of heritage sites and historic properties on land	Discovery of underwater sites Funding for cultural resource surveys
	Bottom trawling	Damage to underwater heritage and historic properties	
Shipping associated with prospecting and exploitation	Building of infrastructure	Direct impact on shoreline and underwater sites	Employment, infrastructure
Fishing activity	Operations	Damage to and destruction of underwater sites Disruption of coastal fisheries by large-scale fisheries	New opportunities for fishing, selling fish
Military activity	Operations	Restrictions on local use	

The Arctic Marine Shipping Assessment and Arctic peoples

The AMSA Report (PAME, 2009) reconfirmed that the marine environment and marine resources have long sustained Arctic communities. Thus, Arctic settlement patterns demonstrate a strong marine influence. Local Arctic residents today depend heavily on marine resources for subsistence and the local economy. A combination of over-the-ice travel (i.e., using ice as a platform and means of travel for hunting and fishing) and boat transport (i.e., for fishing, hunting and travel) allows the use of large Arctic marine areas during much of the year. Life in the Arctic is dependent on movement and sea ice is integral to this movement in the High Arctic. Remote indigenous coastal communities are especially vulnerable to marine accidents as they risk losing not only their vital marine resources, but the natural foundation of their cultures and way of life (PAME, 2009). Among the findings of the AMSA Report are the following:

- Marine shipping is one of many factors affecting Arctic communities, directly and indirectly. The variety of shipping activities and the range of social, cultural and economic conditions in Arctic communities mean that shipping can have many effects, both positive and negative.
- While economic effects of marine shipping may be positive, there are many concerns expressed by Arctic coastal communities about social, cultural and environmental effects.
- There is insufficient information to identify with any precision the likely effects of marine shipping for most Arctic coastal communities. No current database exists for indigenous use in local Arctic waterways that could be used to develop multiple use management measures and potential mitigation strategies.
- The costs and benefits of marine shipping will be unevenly distributed among and within communities and regions.
- Constructive engagement of local residents at the earliest opportunity in a planned Arctic marine development project can help reduce negative impacts, assist in a smooth interaction and increase positive benefits from marine shipping.
- AMSA town hall meetings revealed that Arctic residents think about shipping, not by itself, but in a broader context of economic, environmental, political and social change. Shipping did not appear to be a cause of great hope or fear; rather, as an additional factor that would influence the future of Arctic communities in various ways.

Classification and identification of areas of heightened cultural significance

Three types of areas are considered here: communities, archeological and historical sites, and traditional use areas.

Communities include all human settlements in the Arctic. Their cultural assets may vary depending on history and other factors, but all require some degree of protection from the impacts of vessel traffic. Such impacts may be physical, in terms of disturbance to coastal zones where ships may offload or where ship wakes may cause erosion or damage. Or the impacts may be social, due to the arrival of vessel crews, economic opportunity, and other changes to local societal patterns. Communities are relatively easy to identify, since they are shown on maps and clearly visible from nearby. Their sensitivities may be harder to determine from a distance, and further information is likely to be needed to help translate the simple presence of humans along a coastline to an understanding of the cultural significance and spatial extent of their interactions with the marine environment. Traditional use areas, described below, are a particular aspect of communities that requires careful attention.

Archeological and historical sites are more widespread, including the many locations and areas where people have been over the past several thousand years of human presence in the Arctic. Much has happened in the Arctic, and a great deal of that history and prehistory is of considerable interest to many people, in addition to being the cultural patrimony of Arctic peoples. There are upward of 120 ships greater than 12 meters in length that lie beneath Arctic waters in North America alone. There are many archeological and historical sites around the Arctic and only a proportion have been identified to date. In some cases, local communities may not want to share details about old settlements or grave sites, lest these places become targets for those seeking archeological or historical treasures. In other cases, a great deal of effort has gone into identifying sites of interest to avoid impacts from coastal development and other activities. Much of the Arctic coast, especially locations that are or were well-drained, has the possibility of holding a historical or archeological site and thus should be approached with care. In the case of responding to an emergency, priority protection should be given to places that have already been identified while also attempting to minimize damage to other areas.

Within the category of archeological and historical sites are those locations that have been designated for their cultural value, including historic properties, monuments, and some protected areas. They are distinct from historical and archeological sites in the degree of recognition they are given and the efforts made to protect them from disturbance or damage. These designated sites may commemorate an ancient village site, or a specific historical event, or less tangible connections between humans and their surroundings. Many areas that are protected for ecological reasons (see Part A of this report) also encompass cultural legacies that enrich the merits of the protected area. Since these sites are already recognized, identifying them is relatively straightforward.

Traditional use areas go beyond the specific sites where people have lived or left signs of their passage, and include the areas that are used for hunting, fishing, travel, and other purposes. These areas can be vast, covering thousands of square kilometers for a single person or almost the entire Arctic when the use areas for all communities are considered together. In Canada, for example, the Inuit Land Use and Occupancy Project (Freeman, 1976) documented that all of the Canadian Arctic was used by people, with the exception of remote northwestern areas of the Canadian Arctic Archipelago. Traditional use areas have been documented for some parts of the Arctic, but in many instances the documentation is now years or decades old. Use patterns are changing with improved transportation technology and also in response to changes in fish and wildlife distribution resulting from climate change and increased human presence in the Arctic. Information about traditional use areas is valuable for determining where overlaps with vessel traffic and other uses may occur, and thus where conflicts are most likely. Disturbance to traditional use areas may affect hunting and fishing success and, more importantly, human safety. Special precautions may be appropriate within traditional use areas, especially in the most intensively used places within the overall use area. Effective communication is also important so that vessels and locals are aware of one another.

Examples of areas of heightened cultural significance

As noted above, information to map and describe all three types of culturally significant area is not yet available for the entire Arctic. It is thus premature to attempt a complete review of areas of heightened cultural significance at anything approaching a circumpolar scale. In some countries, much of the information needed is indeed readily available for most categories of cultural area, although it can also be out of date. This section provides case studies as examples of the different types of area, drawing on information from a specific country for each section.

Communities: Norway

Many ports and fishing communities are found on the Arctic coast of Norway. The offshore marine environment in the Barents Sea is managed according to the Integrated Management Plan for the Barents Sea and Lofoten Area (Norwegian Government, 2006). The management plan sets up a framework for long-term management of spatial conflicts between marine use forms and sustainable management of marine ecosystems. Much knowledge has therefore already been acquired in terms of governing shipping activities in Arctic Norway and assessing the potential impacts of oil spills and other risks.

The management plan is based on a thorough analysis and identification of valuable and vulnerable areas in terms of how important the areas are for biological production and biodiversity (Olsen and von Quillfeldt, 2003). A similar assessment of socially vulnerable and valuable areas has however not been conducted for the coastal communities and social-ecological systems in Arctic Norway, although recent government publications have reported on the socio-economic development patterns for the area (KRD, 2010).

The International Maritime Organization (IMO) criteria are 'sea areas where the use of living marine resources are of particular social or economic importance, including fishing, recreation, tourism, and the livelihoods of people who depend on access to the area' (see also Page 115). In the Norwegian context, the social and economic importance of the valuable sea areas in the Barents Sea are mainly connected to their function as a basis for commercial fisheries activities. Of a population of 460 000 in northern Norway, around 20 000 or 4.7% are employed in or connected to marine industries (KRD, 2010). In addition to the importance of these fishing fields to the fisheries industry in northern Norway, they are also important to foreign fishers from the south of Norway and from EU countries and Russia.

Mapping of 'communities' can be done in various ways; identifying the physical location of the settlements is the simplest but perhaps least informative. Other methods display more information about the relationship of the community to the surrounding lands and waters.

In Arctic Norway, human dependency areas are defined as areas where Saami traditional industries are prioritized by the Saami Parliament (see Figure B.1). This means that fishers and farmers who are settled in the priority area are eligible

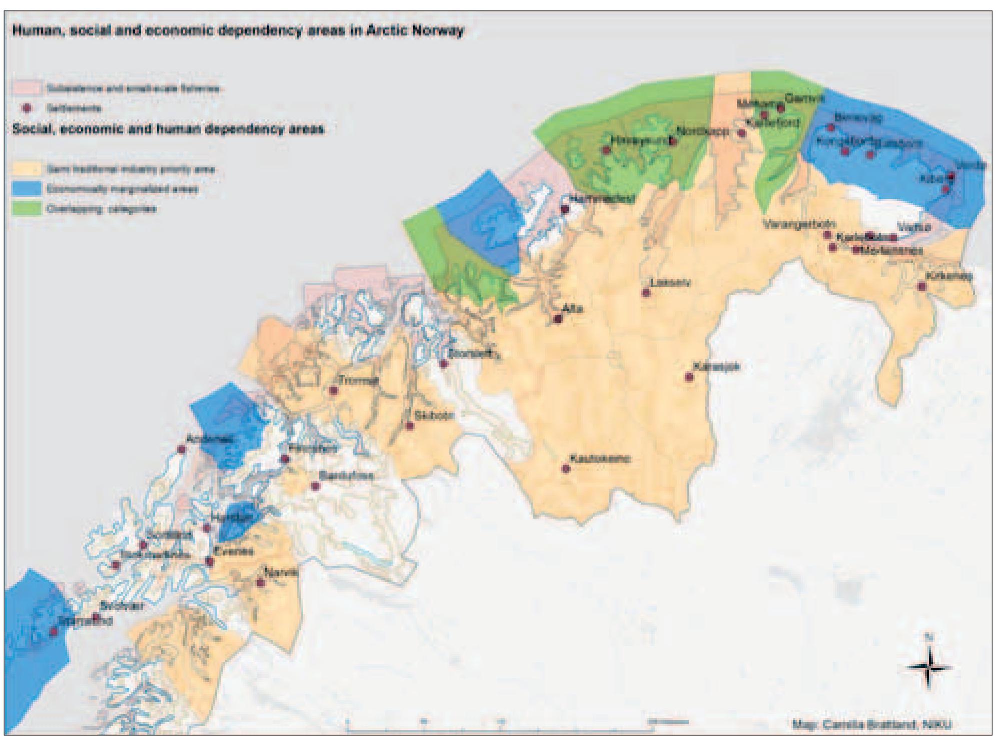


Figure B.1. Overview of coastal sea areas of Arctic Norway important in social, economic and human dependency terms. Source: Norwegian Institute for Cultural Heritage Research (NIKU).

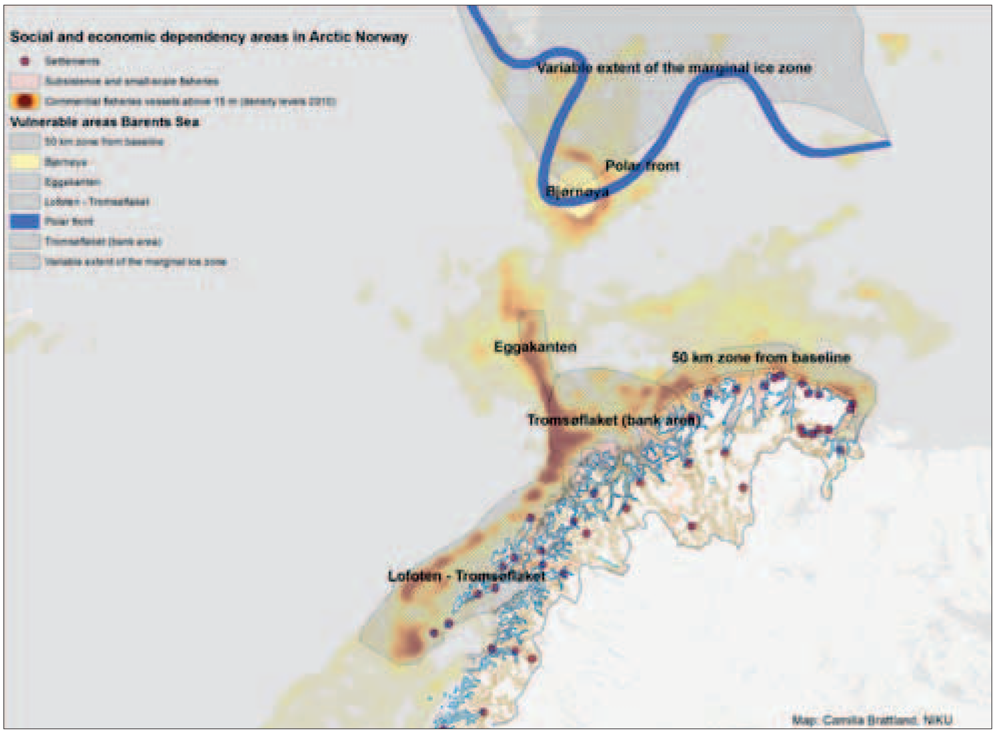


Figure B.2. Valuable and vulnerable areas in the Barents Sea. Source: Norwegian Ministry of the Environment, Directorate of Fisheries, Norwegian Map Authority.

for support from Saami Parliament funds, as well as other targeted social and economic support measures. These areas form the basis for yearly statistical assessments of the state of Saami society. These areas are also the target areas for special measures and governance regulations issued by the Norwegian Government, thus making these areas subject to the criterion on human dependency under the IMO (see Page 115).

Identifying the locations of economically valuable areas is another way of considering the community presence on the sea, related in part to traditional use areas (see Page 112). In the Barents Sea, the valuable areas largely overlap with areas where a majority of the commercial fisheries activity takes place. Coastal fisheries are mainly conducted by the local fishing fleet, whose activities are limited by the fishing vessels' range and fishers' settlement patterns.

The locations of the valuable and vulnerable areas in the Barents Sea relative to commercial fisheries activities (based on the Fisheries Directorate's density mapping for 2010) and subsistence and small-scale fisheries in the coastal zone (red hatched lines) are shown in Figure B.2. The seascape made visible through the mapping of fishing activities can be compared to a social landscape in the marine environment. The Tromsøflaket bank area (toward Lofoten, Eggakanten) as well as areas off the coast of Finnmark and Bjørnøya are identified as important for social and economic dependency by the local population. Both for their biological value and social values, they represent areas where the use of fish resources is of particular social and economic importance for commercial and small-scale fisheries.

Archeological and historical sites: Canada and Greenland

Archeological and historical sites are found in all Arctic countries. A small percentage are designated in some way as cultural and historical sites, and thus recognized and protected for their cultural, archeological, or historical value. This designation gives them greater visibility, making them easier to protect in the event of an accident, but may also attract more attention and visitors. Undesignated sites are far more common, and no doubt many remain to be identified. The Canadian case study examines the general category of archeological and historical sites, followed by a case study from Greenland focusing specifically on designated areas.

Canada

Canada has a great wealth of archeological and historical sites. Within 100 meters of the 161 800 km of shoreline in Canada's Arctic, over 3835 archeological and historical sites have been recorded to date that relate to indigenous and Euro-Canadian culture and history. Based on a common understanding of the effects and potential impacts of increased shipping in the Arctic, this discussion provides a general assessment of the potential impacts of various types of increased shipping activity in Arctic Canada.

Site data compiled for this exercise were obtained from, and with the consent of, the territorial governments of Yukon, Northwest Territories, and Nunavut. Table B.2 lists the types of cultural heritage site found (as of 2011) that relate to indigenous and European peoples. The locations of the known cultural heritage sites along the shorelines of the three territories are illustrated in Figure B.3. A comparison with shipping routes shown in Figure B.4 illustrates the

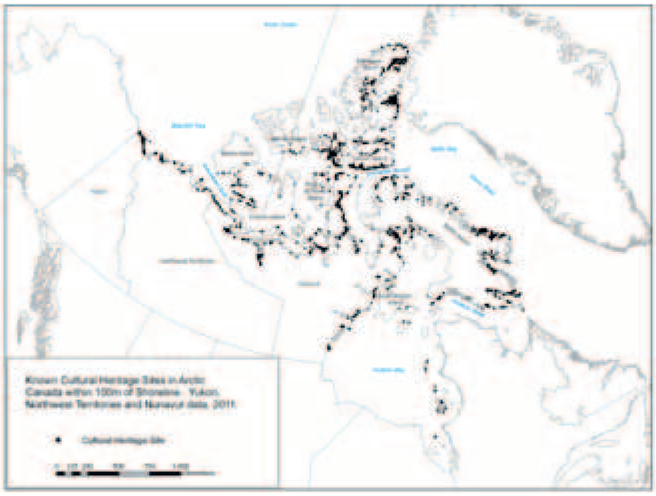


Figure B.3. Locations of known archeological and historical sites in Arctic Canada within 100 meters of the shoreline.

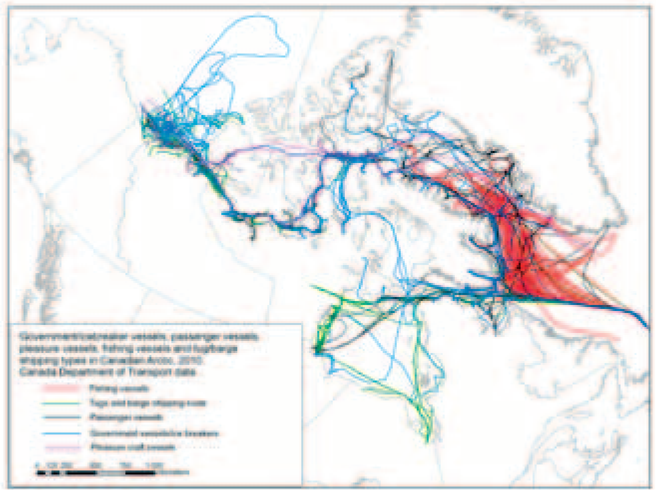


Figure B.4. Government/icebreaker, passenger, fishing, and tug/barge routes in the Canadian Arctic, 2010.

considerable overlap between sea routes used for vessel traffic and coastlines with archeological and historical sites.

Areas of heightened cultural significance – based solely on the density of sites – are evident along Yukon's shore of the Beaufort Sea, the east central coast of Ellesmere Island, the central east coast of Baffin Island, and on the southern shores of Devon Island along Lancaster Sound, among others. Areas on Figure B.3 with no apparent archeological and historical sites principally reflect areas where ground investigations have not been intensively undertaken, rather than a complete lack of past human activity. Increased human activity in these areas, such as resource prospecting or extraction and exploration, may bring greater attention to these areas, leading to further discovery of important archeological and historical sites. Even at the scale under discussion here, the shipping routes illustrated on Figure B.4 indicate that areas such as Lancaster Sound, the northern shores of the Northwest Territories and Yukon, and the eastern shores of Baffin Island can be assessed as being at high levels of potential impact.

Table B.2. Types of cultural heritage sites near Canada's Arctic shorelines in 2011 (Yukon, Northwest Territories, and Nunavut).

Aboriginal heritage sites	European heritage sites
Villages	Explorers' camps
Campsites	Whaling stations
House depressions	Shipwrecks
Tent rings	Trading posts
Sod houses	Historic monuments
Cabins	Depots
Tent frames	Missions
Ice houses	Cabins
Dog houses	Graves
Caches	
Graves	
Stone artifact scatters	
Stone quarries	
Hunting blinds	
Kill sites	
Drivelanes	
Lookouts	
Isolated finds	

The effects and potential impacts of increased shipping on archeological and historical sites in the Canadian Arctic may be varied. Direct erosional effects from heightened wave activity will vary depending on local topography and bathymetry. For example, sites on unstable banks or on low-relief shorelines near areas of shallow water may be subject to greater erosional effects than sites on stable, elevated shores. Icebreaking activities will increase in frequency and be of longer duration, resulting in magnified open water conditions that exacerbate effects due to climate change, and thus lead to possible additional erosional impacts. Similarly, variation in effects from oil spills and other forms of contamination will also be in large part determined by local geography, marine qualities, and ice conditions.

Effects arising from increased shipping activity may result from developments that are ancillary to shipping itself. Many of these ancillary developments may be inland. Resource developments require infrastructure, exploration areas may expand and intensify, access corridors may extend for considerable distances from resource extraction areas to ports and communities, and communities may increase in population and geographic size. Underwater routing of cables and pipelines may impact underwater shipwrecks and other types of submerged archeological and historical sites. Construction of new ports and/or expansion of current ones have very high potential to damage significant archeological and historical sites because they tend to be situated in areas of long-term human habitation.

The potential effects of increased shipping activities on archeological and historical sites in the Canadian Arctic are compounded by the potential physical effects of climatic change on those resources. Essentially, not only will rising atmospheric and marine temperatures allow for increased shipping, but changes to the sites will also occur through melting, permafrost changes, increased biological activity at macro- and microscopic levels, and chemical alterations to the constituent parts of the cultural heritage resources. Archeological and cultural sites will also be subject to longer annual periods of such impacts. In addition, higher sea levels and greater storm surges would have negative effects, again possibly magnified by local topography and changes in sea-ice conditions. In effect, Arctic archeological and cultural sites will become more fragile and at the same time more accessible. Since many of the *in-situ* resources in Arctic sites are organic and perishable (bone, wood, hide), very high rates of deterioration will occur in relation to typical archeological and historical sites in more southern areas.

Greenland

In Greenland, there are several protected areas, some of which include sites of high cultural significance that are protected either in their own right or as part of a larger ecological and cultural area. Figure B.5 shows the locations of some of these areas around Greenland. In other jurisdictions, protection may be designated nationally or by local authorities. Information on the location of cultural heritage sites may thus be divided among different agencies or levels of government.

At least six protected areas in Greenland also include cultural heritage components, which makes these areas especially significant and worthy of protection (see Figure B.5). These areas include:

C Ilulissat Icefjord is a UNESCO World Heritage Site protected for its natural historical value. The protected area includes two heritage sites comprising cultural layers from the first inhabitants of West Greenland to recent times, one of which contains well preserved, 4000 year old, organic artifacts from the first Paleoinuit cultures of Eastern Arctic.

D Arnangarnup Qoorua/Paradisdalen nationally designated area, comprising both natural and cultural historical values. The cultural heritage sites are related to Inuit seasonal inland hunting.

F The National Park of North- and East Greenland is an IUCN category V or VI protected area. The vast area comprises many natural and cultural historical values.

G Kuussuaq/Austmannadalen is nationally protected for both its natural and cultural historical values. The heritage sites in the area are related to the Norse settlers.

I Ivittuut and Kangilinnguit is nationally protected for both its natural and cultural historical values.

K Uunartoq is nationally protected for both its natural and cultural historical values.

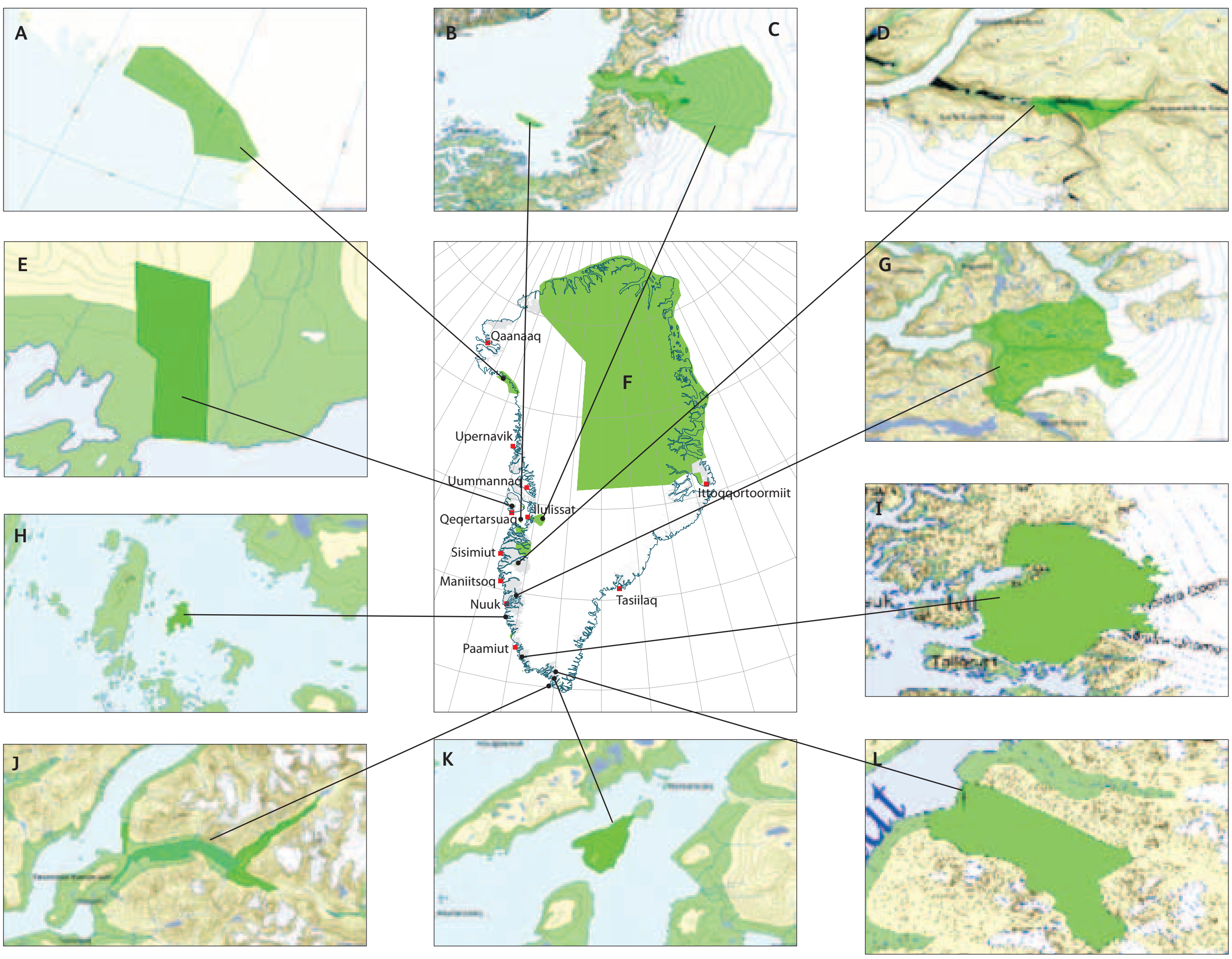


Figure B.5. Overview of protected areas in Greenland. Areas C, D, F, G, I and K also include cultural heritage components. Source: Ministry of Housing, Nature and Environment.

Traditional use areas: Alaska, USA

Much work has been done in Alaska to map traditional use areas around the state. In Alaska, 'subsistence' is used to describe traditional hunting, fishing, and gathering activities, which supply a large proportion of the food for people in villages across northern Alaska and St Lawrence Island, where whaling is at the center of indigenous cultures, particularly the hunting of the bowhead whale. Any vessel activity at times and places where bowhead whales migrate or feed is likely to disturb traditional hunting and have significant cultural impacts. It is therefore important to be aware of the subsistence use areas at times when subsistence hunts and fishing are taking place.

However, potential impacts are not restricted to bowhead whale hunting. Walrus, beluga, seals, salmon, herring and other fisheries in northern Alaska and along the Bering Sea coast and the Aleutian Islands provide critical resources to coastal peoples and in many cases result in long-distance travel along the coast or into the open ocean. Salmon and seals and small whales also migrate up the Yukon, Kuskokwim, and other large rivers, providing important resources for people living far from the coasts in the Alaska interior. Oil spills and disturbances related to shipping may also impact people living in these regions.

Although much mapping work has been done in Alaska, the methods and dates have varied, making it difficult to compile a statewide map of the collective traditional use areas. Furthermore, maps of lifetime use areas typically provide little information about intensity or seasonality of use. A recent project conducted in some Bering Sea communities in Alaska and Russia provides some information on the dynamic nature of subsistence use. Because there is high variability in use patterns, and because climate change is likely to alter those patterns further, future use areas may differ from past ones. To provide resilience for coastal communities, vessel traffic should be managed so as to allow flexibility in use patterns to reflect changing conditions.

The following areas are representative and do not include all use areas for all villages and local communities. With a more thorough inventory and location map of all villages and local communities the examples here can help guide mitigation and avoidance measures. Figure B.6 shows the lifetime subsistence use areas of the eight communities on the North Slope of Alaska, illustrating that the entire coastline is part of the collective use area in the region. (The coastline southeast of Point Hope in the lower left of the graphic is used by Kivalina and other communities not included in this mapping exercise, and thus is not an area with no use.)

The Bering Sea Sub-Network (BSSN), a project conducted by the Aleut International Association in the Bering Sea, provides another view of subsistence use areas. In this case, individuals were interviewed twice a year regarding harvests that had occurred during the previous six-month period, the results were mapped showing both seasonal patterns and the intensity of use across the use area. Figure B.7 shows the results from Togiak, Alaska, on the north shore of Bristol Bay. This displays harvest areas for important marine species, including fish and marine mammals, for discrete time periods. The overall use area is relatively compact, especially when compared with other subsistence mapping techniques that display lifelong use areas.

For Gambell, Alaska, on St Lawrence Island in the northern Bering Sea, marine mammals especially walrus and bowhead whales, are the main subsistence species. The use areas are vast (see Figure B.8), even in winter. Note in this case that the use area encompasses the Anadyr Strait (between St Lawrence Island and the Russian mainland), through which a great deal of vessel traffic moves on its way to or from the Bering Strait just to the north. The potential for conflict with shipping is thus much higher for Gambell than for Togiak, where hunters and fishers do not go far from the coast and intercept no shipping lanes except for re-supply vessels going to Togiak itself.

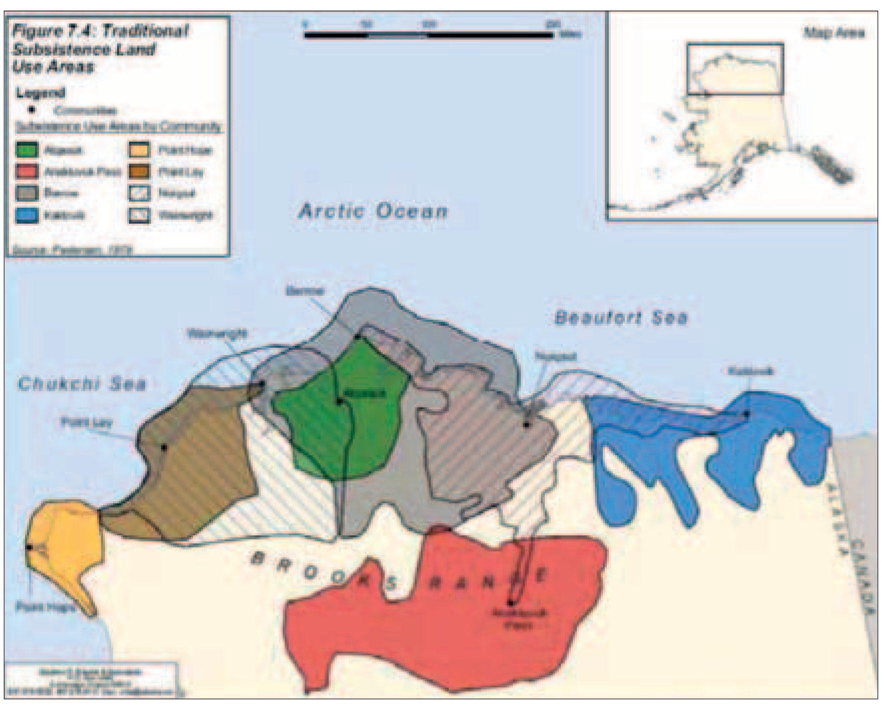
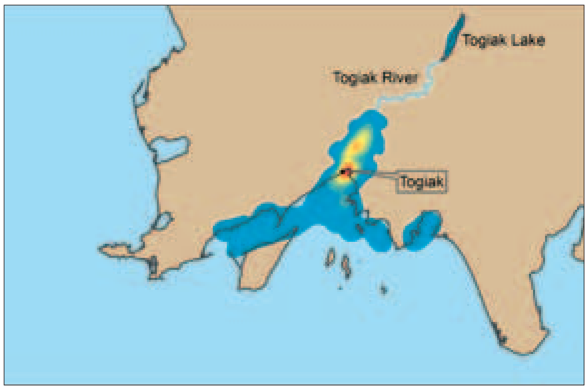
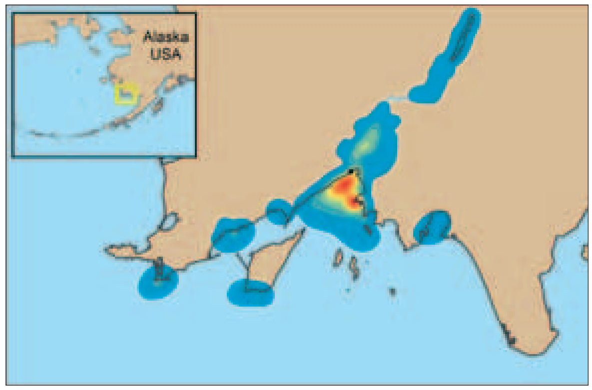


Figure B.6. Traditional land use areas by community on the North Slope of Alaska. Source: after Braund and Kruse (2009).

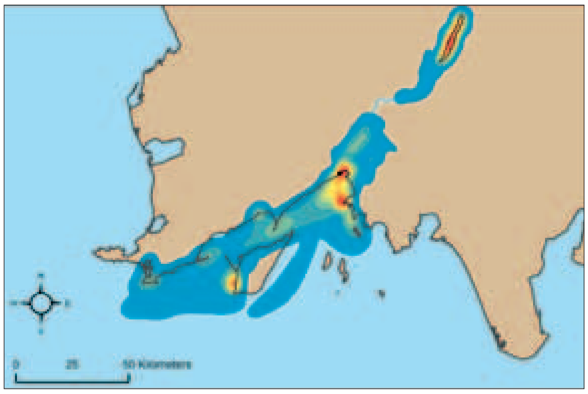
Spring. March, April, May 2009 (n = 85)



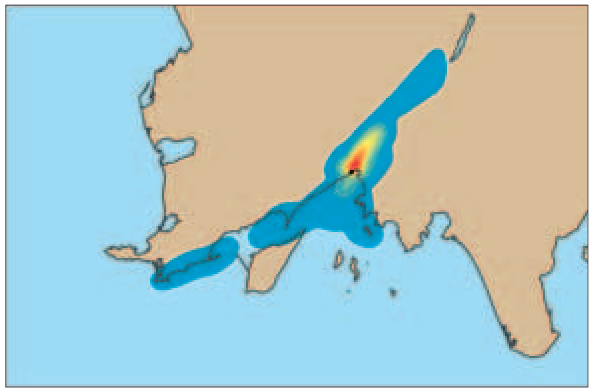
Summer. June, July, August 2009 (n = 62)



Fall. September, October, November 2009 (n = 39)



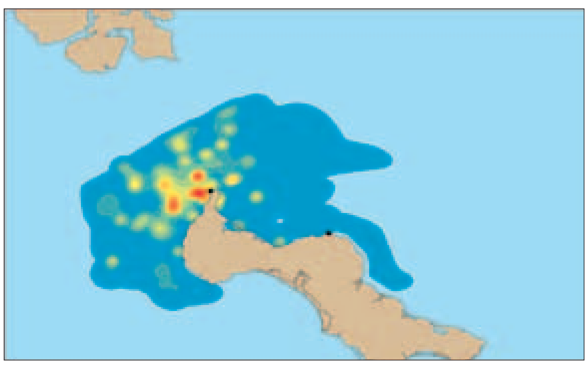
Winter. December 2009, January, February 2010 (n =33)



Low High

Figure B.7. Seasonal subsistence use areas for spring, summer, autumn, and winter 2009/10 in Togiak, Alaska (Bering Sea Sub-Network: BSSN). Source: Aleut International Association (2011).

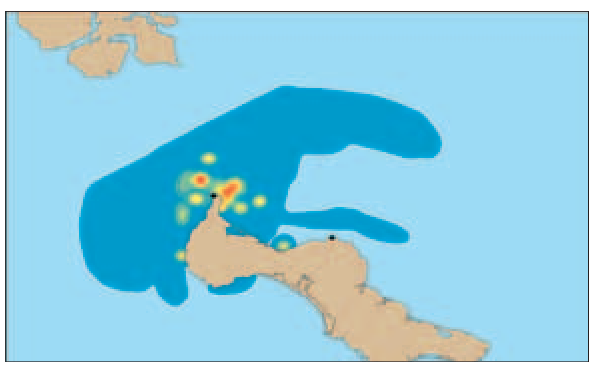
Spring. March, April, May 2008 (n = 41)



Summer. June, July, August 2009 (n = 67)

Fall. September, October, November 2009 (n = 38)

Winter. December 2009, January, February 2010 (n =17)



Low High

Figure B.8. Seasonal subsistence use areas for spring, summer, autumn, and winter 2009/10 in Gambell, Alaska (Bering Sea Sub-Network (BSSN). Source: Aleut International Association (2011).


B&C Alexander / ArcticPhoto

Environmental protection and cultural protection

Many protected areas, and certainly the large ones, are designated for environmental reasons. They may still, however, encompass all three categories of areas of heightened cultural significance, and thus can protect cultural values as well as environmental ones. There are 1127 protected areas in the Arctic consisting of about 3.5 million km^2 (CAFF, 2010), over 40 % of which have a coastal component. There are few marine protected areas in the Arctic, however.

According to CAFF (2002), there are various cultural and societal reasons for establishing protected areas:

Cultural and Heritage values can include the importance of protected areas in representing the characteristics that formed a society's distinct character and the historical importance of a site in shaping a society or people; spiritual values attributed to a site are also included.

Recreation values can include the worth of a site for consumptive (i.e., sport hunting) or non-consumptive (hiking, camping, photography, etc.) activities.

Societal values can include the importance of a protected area to a society at large often reflected in the funding or political priority attached to the site.

Landscape values can include the visual characteristics and their relative importance to local communities, nations or internationally.

Educational values can include the use of a site to train or teach people and make them aware of their physical and natural surroundings and its biodiversity.

Scientific and research values can include the importance of a site in contributing to an overall understanding of the natural environment and the consequences of natural vs. human-caused, or anthropogenic, changes.

Each protected area is likely to reflect a differing mix of these values, together with basic environmental protection. Protected area designation, however, does not necessarily mean that cultural values will actually be protected. Accidents and oil spills do not stop at the edge of a protected area. Attracting more visitors can have benefits and risks, as discussed earlier (see Table B.1). Protection on land may do nothing to limit vessel traffic offshore, which may interfere with traditional practices or disturb cultural heritage sites through pollution, wave action from ship wakes, or other forms of disruption.

Nevertheless, the fact that there are many protected areas in the Arctic can provide some protection, even if it is incidental, to culturally significant areas of different kinds. An assessment of priority needs for cultural area designation and protection should take into account the degree to which some areas and some sites are already protected, to avoid redundant effort. Furthermore, an evaluation of the cultural importance of existing protected areas should be communicated to the managers of those areas, because in many cases the cultural values may not be fully recognized and may deserve extra attention. For example, an undocumented archeological or historical site may attract souvenir hunters if additional protective measures are not taken to preserve the integrity of the site and its artifacts.

Protecting areas of heightened cultural significance

There are various mechanisms for protecting areas of heightened cultural significance. Designation as a cultural heritage site is one such approach, and the inclusion of cultural areas within larger protected areas is another. This section describes first the application of IMO criteria for cultural values to Arctic areas, using Alaska and Norway as examples. It then outlines potential next steps to gather more information about areas of heightened cultural significance around the Arctic and to protect those areas in advance of further increase in vessel traffic and related potential disruptions.

IMO social, economic, human, and cultural criteria

Specific to shipping, the IMO uses social, cultural, and economic criteria (among others) to identify and set regulations for particularly sensitive sea areas (PSSAs) (IMO, 2002). Getting the PSSA designation for an area, however, is not simple. In most cases, the area must be experiencing a demonstrated, immediate threat from shipping. In other cases, the IMO has taken precautionary action, but only in response to national measures already in place. Thus, while the IMO system for assessing cultural values is useful for evaluating Arctic locations, the simple fact of meeting IMO criteria does not mean that IMO action will follow. The IMO criteria are:

4.4.12 Social or economic dependency – An area where the environmental quality and the use of living marine resources are of particular social or economic importance, including fishing, recreation, tourism, and the livelihoods of people who depend on access to the area.

4.4.13 Human dependency – An area that is of particular importance for the support of traditional subsistence or food production activities or for the protection of the cultural resources of the local human populations.

4.4.14 Cultural heritage – An area that is of particular importance because of the presence of significant historical and archeological sites.

Applying these criteria to Arctic Alaska using the information presented above, the entire coastline meets Criterion 4.4.14: Cultural heritage, due to the long-term habitation of the entire region by indigenous peoples. Much of the area, including most of the existing protected areas, meets all three criteria (see Table B.3). It is clear from this example that the basic threshold of cultural significance is easily met in much of the Arctic. But, it is also highly unlikely that the entire region will be designated as a PSSA, nor is it clear that such a designation would provide additional protection for culturally significant areas. Inclusion of cultural significance and awareness thereof in a potential IMO Polar Code[1] may make more mariners aware of the cultural values at stake along the routes they follow, but formal protection is another matter.

The same criteria have been applied to Norway's Arctic coastline, creating in this case a map showing the areas that meet one or more of the IMO criteria listed above (see Figure B.9). As is the case with Alaska, there are few if any areas that do not meet at least one of the criteria. At the same time, this analysis must be taken in light of a lack of more detailed knowledge of cultural, social and economic conditions related to the marine environment in Arctic Norway. In general, the overlap between the three IMO categories on the coast of Finnmark is a result of the inclusion of coastal municipalities in Finnmark in the Saami traditional industry priority area, the areas' economic dependency on marine industries, the importance of the Finnmark sea areas for subsistence, small-scale and commercial fisheries, and the locations of cultural heritage sites. Since the abundance of cultural heritage sites is dense in the coastal zone, the entire coastal zone is regarded as a cultural heritage zone. Until further information on these topics is collected and digitized, it is however challenging to make a thorough description of sensitive sea areas in social and economic terms.

Similar if not greater challenges apply to other Arctic countries.

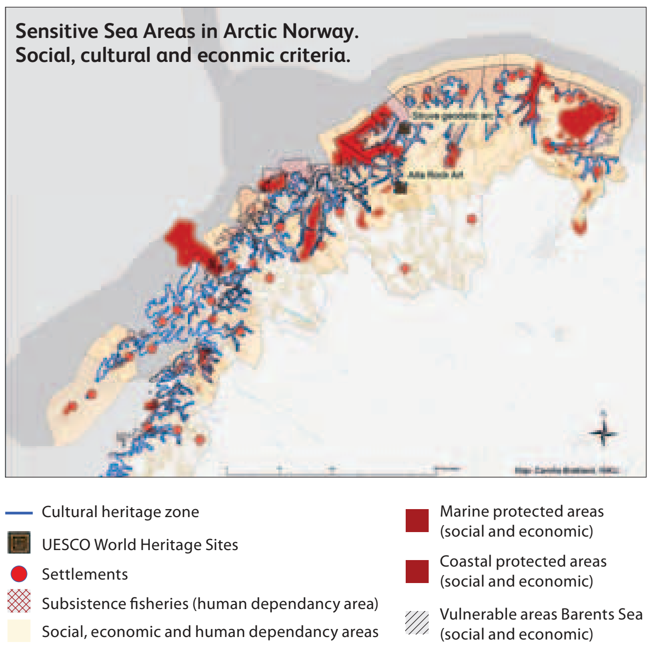


Figure B.9. Culturally significant areas of the coastline in Arctic Norway that meet one of more of the IMO's social, economic and cultural criteria for particularly sensitive sea areas. Source: Norwegian Institute for Cultural Heritage Research (NIKU).

[1] The IMO is currently developing a draft international code of safety for ships operating in polar waters (the 'Polar Code'), which would cover the full range of design, construction, equipment, operational, training, search and rescue and environmental protection matters relevant to ships operating in the inhospitable waters of the Arctic and Antarctic.

Table B.3. Areas of cultural significance on the coastline of Arctic Alaska and the extent to which these meet the IMO's social, economic and cultural criteria for particularly sensitive sea areas.

Area	Cultural attributes	4.4.12: Social or economic dependency	4.4.13: Human dependency	4.4.14: Cultural heritage
The entire coastline of Arctic Alaska including the Bering Sea, Bering Strait, Chukchi Sea, and Beaufort Sea.	Arctic Alaska is important for the understanding of prehistoric human occupation of and migration to North America in late Pleistocene and Holocene epochs when sea level was 60 m lower than today. All well-drained coastal areas contain known sites or have the potential to contain unknown but significant resources.			×
Shallow waters (< 200 m) of the Bering Sea, Chukchi Sea, and Beaufort Sea shelves and Bering Strait.	These seas have drowned the continental shelf which was used in human migration across the vast exposed Bering Sea Land Bridge between Asia and North America during the late Pleistocene and early Holocene epochs when sea level was about 60 m below present. All formerly habitable terrestrial landforms on the shelf that have not been destroyed or significantly altered may contain significant prehistoric archeological resources. The Bering Shelf has potential for prehistoric cultural resource sites in waters up to 60 m deep, where drowned landforms exist that have not been extensively altered by erosion or ice gouging. The Chukchi Shelf has potential for prehistoric cultural resource sites in waters up to 60 m deep, where drowned landforms exist that have not been extensively altered by erosion or ice gouging. The Beaufort Shelf has potential for prehistoric cultural resource sites in waters up to 20 m deep, where drowned landforms exist that have not been extensively altered by erosion or ice gouging.	×		×
Seafloor of the Bering Sea, Bering Strait, Chukchi Sea and Beaufort Sea	Shipwrecks are documented in Arctic Alaska coastal and offshore waters. Many of these may be of historic significance, particularly the sunken vessels of the 19th century New England whaling fleet along the Chukchi Sea coast from Bering Strait to Pt Barrow and the sunken and fetched up vessels and aircraft of the Aleutian Campaign of the Pacific Theatre of WWII near Attu and Kiska Islands. The locations of many shipwrecks are not known except last position and general area.			×
Chukchi Sea coast and coastal waters; All marine areas and coastal segments around villages and coastal communities	Local community subsistence uses, subsistence economy, cultural significance and transportation.	×	×	×
Beaufort Sea coast and coastal waters; All marine areas and coastal segments around villages and coastal communities	Local community subsistence uses, subsistence economy, cultural significance and transportation.	×	×	×
Bering Sea coast and coastal waters including the Bering Strait and the Aleutian Islands: All marine areas and coastal segments around villages and coastal communities	Local community subsistence uses, subsistence economy, cultural significance, and transportation.	×	×	×
Aleutian Islands coast and coastal waters; All marine areas and coastal segments around villages and coastal communities	Local community subsistence uses, subsistence economy, cultural significance and transportation.	×	×	×
Arctic National Wildlife Refuge	Local community subsistence uses, subsistence economy, cultural significance and transportation; National significance for unique wilderness and recreation values.	×	×	×
Selawik National Wildlife Refuge	Local community subsistence uses, subsistence economy, cultural significance and transportation.	×	×	×
Yukon Delta National Wildlife Refuge	Local community subsistence uses, subsistence economy, cultural significance and transportation.	×	×	×
Togiak National Wildlife Refuge	Local community subsistence uses, subsistence economy, cultural significance and transportation.	×	×	×
Izembek National Wildlife Refuge	Local community subsistence uses, subsistence economy, cultural significance and transportation.	×	×	×
Alaska Maritime National Wildlife Refuge	Local community subsistence uses, subsistence economy, cultural significance and transportation.	×		

Area	Cultural attributes	4.4.12: Social or economic dependency	4.4.13: Human dependency	4.4.14: Cultural heritage
Cape Krusenstern National Monument and Archeological District	A series of 114 marine beach ridges, formed at an average of perhaps 60 years each since the time of the highest post-glacial sea level, the district contains the remains of peoples who have inhabited these beaches for 5000 or more years. Adjacent to the ridges on unglaciated uplands in the Iguchuk Hills are surface deposits that extend the record backward to the time of the end of the Pleistocene. Cape Krusenstern beach ridges place in a broad, horizontal stratigraphy virtually all phases of cultural history known in northwest Alaska and have made possible the identification of several new phases previously unknown.			×
Bering Land Bridge National Preserve	Established to: Protect and interpret examples of arctic plant communities, volcanic lava flows, ash explosions, coastal formations, and other geologic processes; Provide for archeological and paleontological study, in cooperation with Native Alaskans, of the process of plant and animal migration between North America and the Asian Continent; and Provide for outdoor recreation and environmental education activities at Serpentine Hot Springs; also Local community subsistence uses, subsistence economy, cultural significance and transportation	×	×	×

Next steps

The Arctic has extensive, valuable cultural sites and practices along nearly its entire coastline. Readily available information makes the extent of this cultural legacy clear, but details are lacking. This report has presented as examples a subset of the information available about communities and their interactions with the sea, about heritage sites, about archeological and historical sites, and about traditional use areas. While this information is incomplete from an Arctic perspective, it is nonetheless sufficient to begin work to determine how best to reduce negative impacts from increasing vessel traffic in the region. At the same time, it is important to fill in the gaps in knowledge so that important sites or activities are not neglected through ignorance.

The potential impacts of shipping on areas of heightened cultural significance have not yet been evaluated to determine which are most damaging and most widespread. The specific threats are likely to vary with each area and its characteristics, but an overall evaluation of the relative severity of each type of threat should nonetheless be possible at this stage.

This evaluation would lead to an assessment of protective measures and their application to vessel traffic around the Arctic, again to determine widely shared approaches that can be refined according to the specific conditions at each site or in each region. Such protective measures should of course be evaluated in connection with their relevance for ecological protection, as many approaches may serve both goals. Preparedness for accidents and emergencies should be part of this exercise. The desirability of IMO action, either for PSSAs or as part of the Polar Code, should also be included.

Better documentation of areas of heightened cultural significance is also needed throughout the Arctic. Traditional use areas have been recorded in some areas, but in others they are missing or decades out of date. Assessing the ways in which use areas are changing due to climate change as well as technological advances is also necessary, to avoid limiting protection to areas that are not sufficient for current or future needs.

Archeological and historical sites are known in many places, but often only superficially, and other regions simply have not been surveyed to determine what is there. Priorities should of course be in areas where vessel and other activity is already occurring or expected soon. The designation of more heritage sites will increase the visibility of this cultural legacy, but such action can only be expected for the best known or more important sites. Many other sites will require other forms of protection, not least the greater awareness of Arctic visitors that much of the coastline reflects a long history of human habitation.

Finally, compiling information is the starting point for a more thorough analysis of the cultural values located along Arctic coastlines and farther out to sea. The analysis of the significance of these areas and their relationship with environmentally and economically important areas is also essential to determine where conflicts are most likely to occur and to point the way to potential resolutions of such conflicts. The Arctic has much potential for resource development and for shipping, but there is also a wealth of cultural legacy and current practice equally deserving of attention, recognition, and protection.

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