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ARCTIC REGIONAL WORKSHOP TO FACILITATE THE DESCRIPTION OF ECOLOGICALLY OR BIOLOGICALLY SIGNIFICANT MARINE AREAS
Helsinki, 3-7 March 2014

DATA TO INFORM THE ARCTIC REGIONAL WORKSHOP TO FACILITATE THE DESCRIPTION OF ECOLOGICALLY OR BIOLOGICALLY SIGNIFICANT MARINE AREAS

Note by the Executive Secretary

1. The Executive Secretary is circulating herewith a background document containing data to inform the Arctic Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas. This document was prepared by the Marine Geospatial Ecology Lab, Duke University, as commissioned by the Secretariat, in support of the Secretariat of the Convention on Biological Diversity in its scientific and technical preparation for the above-mentioned workshop.

2. The document is circulated in the form and language in which it was received by the Secretariat.

Data to inform the CBD Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas in the Arctic

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3 March – 7 March 2014

Prepared for the Secretariat of the Convention on Biodiversity (SCBD)

Marine Geospatial Ecology Lab

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Background

The Marine Geospatial Ecology Lab at Duke University, in conjunction with international partners, has identified and mapped a large number of data sets and analyses for consideration by the Convention on Biological Diversity (CBD) Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas (EBSAs) in the Arctic. Both biological and physical data sets are included. The data are intended to be used by the expert regional workshop convened by the CBD to aid in identifying EBSAs through application of scientific criteria in annex I of decision IX/20 as well as other relevant compatible and complementary nationally and inter-governmentally agreed scientific criteria. Each data set may be used to meet one or more of the EBSA criteria.

Printed maps will be available for annotation at the workshop. Digital versions of these maps are also available online: http://mgel.env.duke.edu/arctic-ebsa

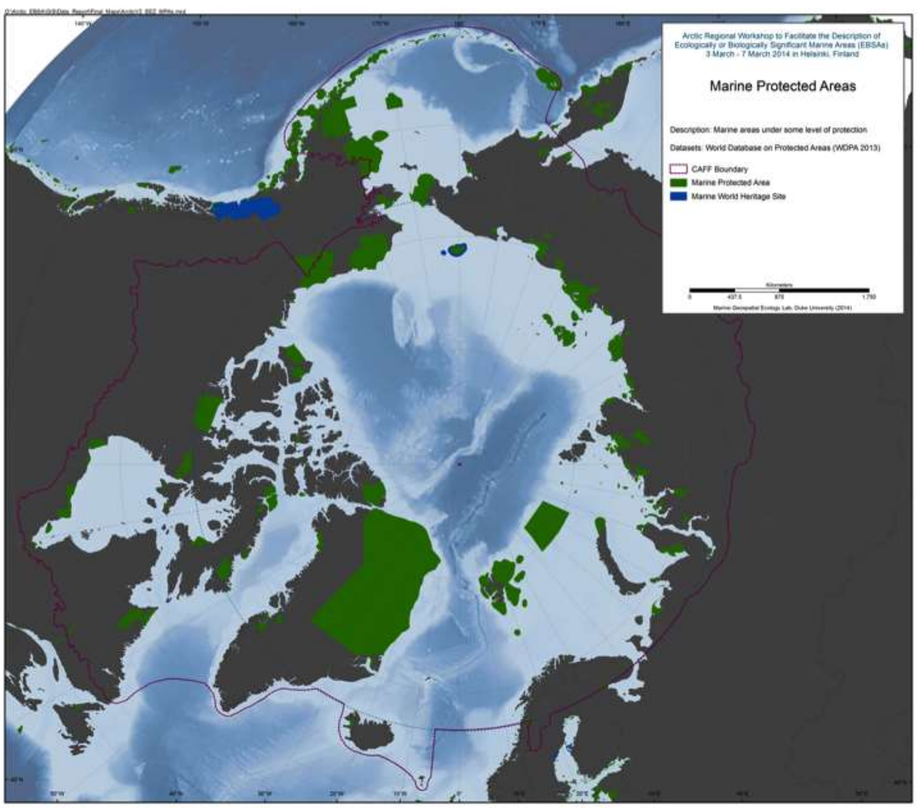


Figure 0.1-1 CAFF Boundary and existing Marine Protected Areas

Biogeographic Classifications

1.1 Global Open Ocean and Deep Seabed (GOODS) biogeographic classification

The classification was produced by an international and multidisciplinary group of experts under the auspices of a number of international and intergovernmental organizations as well as governments, and under the ultimate umbrella of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and its Intergovernmental Oceanographic Commission (IOC). (source: http://ioc-unesco.org/index.php?option=com_content&task=view&id=146&Itemid=76)

Excerpt from executive summary in the full report:

"A new biogeographic classification of the world's oceans has been developed which includes pelagic waters subdivided into 30 provinces as well as benthic areas subdivided into three large depth zones consisting of 38 provinces (14 bathyal, 14 abyssal and 10 hadal). In addition, 10 hydrothermal vent provinces have been delineated. This classification has been produced by a multidisciplinary scientific expert group, who started this task at the workshop in Mexico City in January 2007. It represents the first attempt at comprehensively classifying the open ocean and deep seafloor into distinct biogeographic regions.

The biogeographic classification classifies specific ocean regions using environmental features and – to the extent data are available – their species composition. This represents a combined physiognomic and taxonomic approach. Generalized environmental characteristics of the benthic and pelagic environments (structural features of habitat, ecological function and processes as well as physical features such as water characteristics and seabed topography) are used to select relatively homogeneous regions with respect to habitat and associated biological community characteristics. These are refined with direct knowledge or inferred understanding of the patterns of species and communities, driven by processes of dispersal, isolation and evolution; ensuring that biological uniqueness found in distinct basins and water bodies is also captured in the classification. This work is hypothesis-driven and still preliminary, and will thus require further refinement and peer review in the future. However, in its present format it provides a basis for discussions that can assist policy development and implementation in the context of the Convention on Biological Diversity and other fora. The major open ocean pelagic and deep sea benthic zones presented in this report are considered a reasonable basis for advancing efforts towards the conservation and sustainable use of biodiversity in marine areas beyond the limits of national jurisdiction in line with a precautionary approach. Ongoing work may further refine and improve the classification provided here, however the authors of this report believe that any further refinement to biogeographical provinces need not delay action to be undertaken towards this end, and that such action be supported by the best available scientific information."

Reference:
UNESCO. 2009. *Global Open Oceans and Deep Seabed (GOODS) – Biogeographic Classification*. Paris, UNESCO-IOC. (IOC Technical Series, 84.)

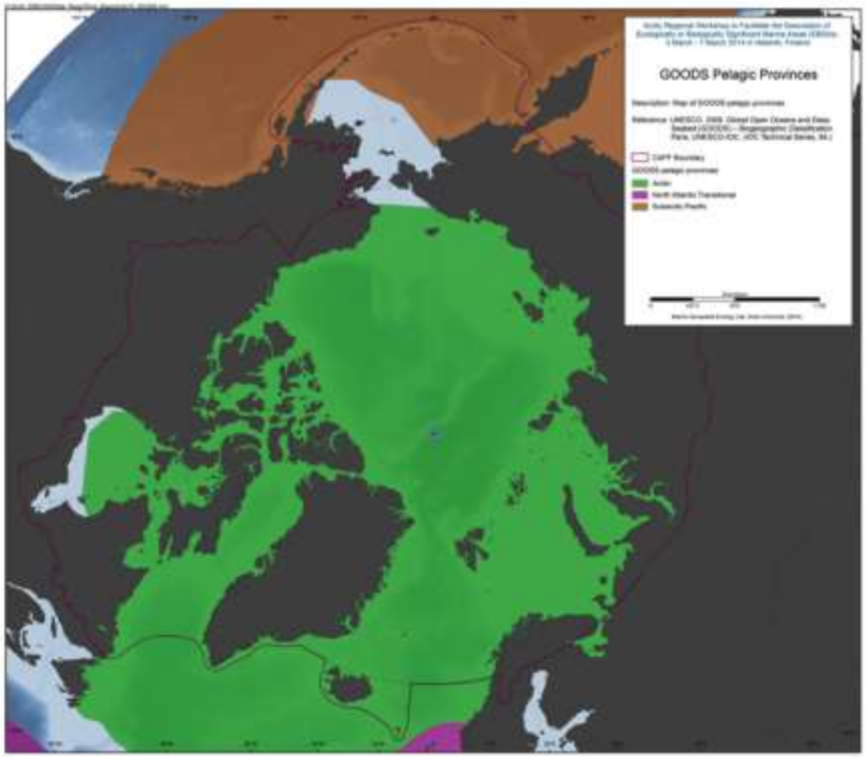


Figure 1.1-1 GOODS Pelagic Provinces

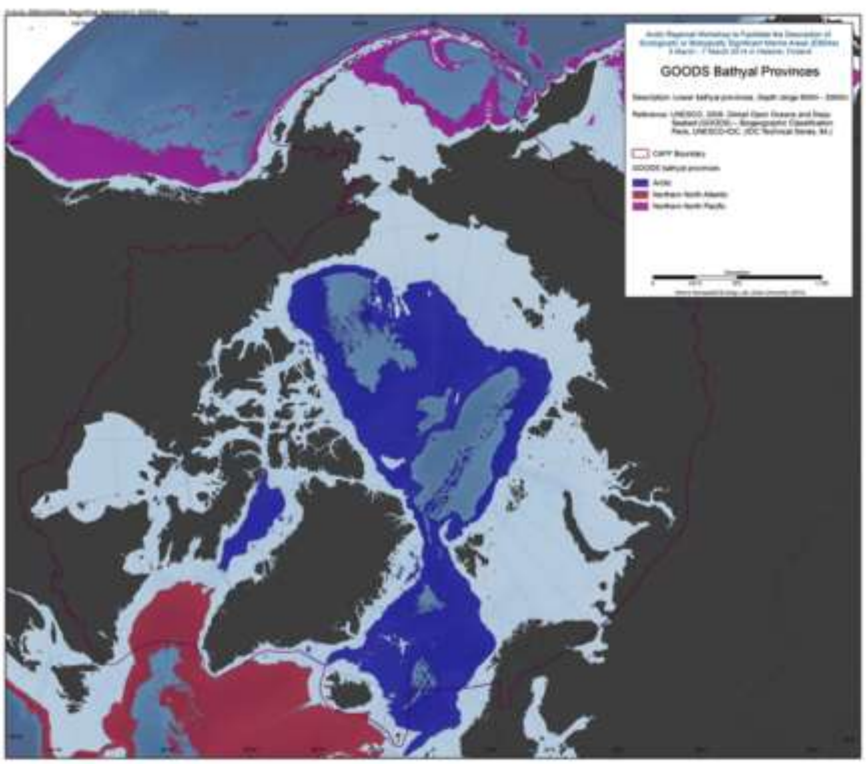


Figure 1.1-2 GOODS Bathyal Provinces

1.2 Marine Ecoregions of the World (MEOW)

"MEOW is a biogeographic classification of the world's coasts and shelves. It is the first-ever comprehensive marine classification system with clearly defined boundaries and definitions and was developed to closely link to existing regional systems. The ecoregions nest within the broader biogeographic tiers of Realms and Provinces.

MEOW represents broad-scale patterns of species and communities in the ocean, and was designed as a tool for planning conservation across a range of scales and assessing conservation efforts and gaps worldwide. The current system focuses on coast and shelf areas (as this is where the majority of human activity and conservation action is focused) and does not consider realms in pelagic or deep benthic environment. It is hoped that parallel but distinct systems for pelagic and deep benthic biotas will be devised in the near future.

The project was led by The Nature Conservancy (TNC) and the World Wildlife Fund (WWF), with broad input from a working group representing key NGO, academic and intergovernmental conservation partners. "
(source: http://www.worldwildlife.org/science/ecoregions/marine/item1266.html)

Reference:
Spalding, M. D. Fox, H. E. Allen, G. R. Davidson, N. Ferdana, Z. A. Finlayson, M. Halpern, B. S. Jorge, M. A. Lombana, A. Lourie, S. A., (2007). Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas. Bioscience 2007, VOL 57; numb 7, pages 573-584.

Data available from: http://www.marineregions.org/sources.php#meow

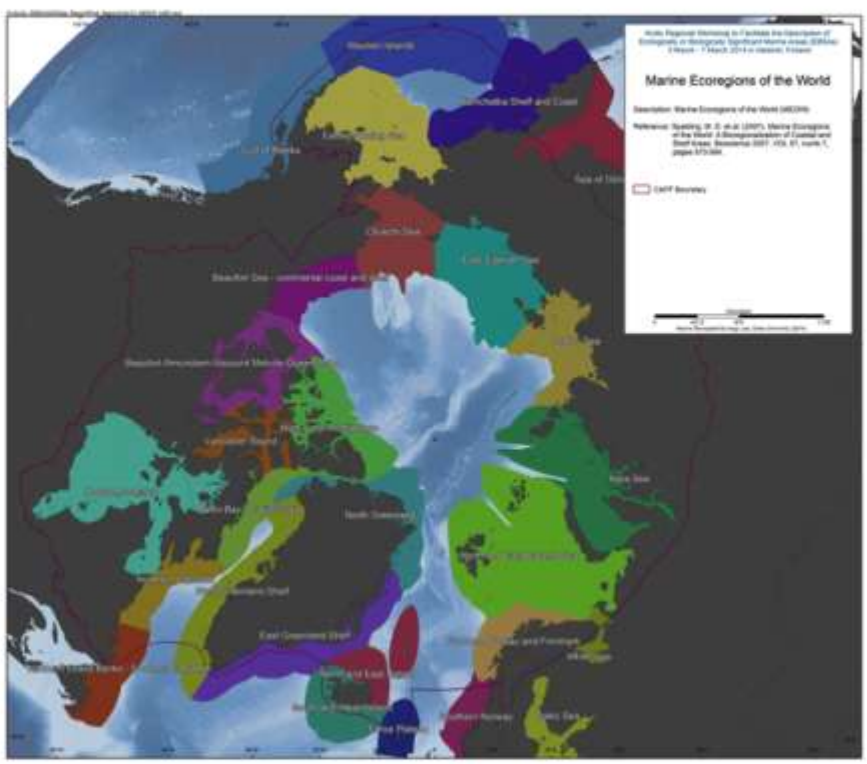


Figure 1.2-1 MEOW Ecoregions

1.3 Large Marine Ecosystems (LMEs)

"Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundary of continental shelves and the seaward margins of coastal current systems. Fifty of them have been identified. They are relatively large regions (200 000 km^2 or more) characterized by distinct bathymetry, hydrography, productivity and trophically dependent populations.

The LME approach uses five modules:

- *productivity module* considers the oceanic variability and its effect on the production of phyto and zooplankton
- *fish and fishery module* concerned with the sustainability of individual species and the maintenance of biodiversity
- *pollution and ecosystem health module* examines health indices, eutrophication, biotoxins, pathology and emerging diseases
- *socio-economic module* integrates assessments of human forcing and the long-term sustainability and associated socio-economic benefits of various management measures, and
- *governance module* involves adaptive management and stakeholder participation."

(source: http://www.fao.org/fishery/topic/3440/en)

Reference:

Sherman, K. and Hempel, G. (Editors) 2009. The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya.

Data available from:

http://www.lme.noaa.gov/

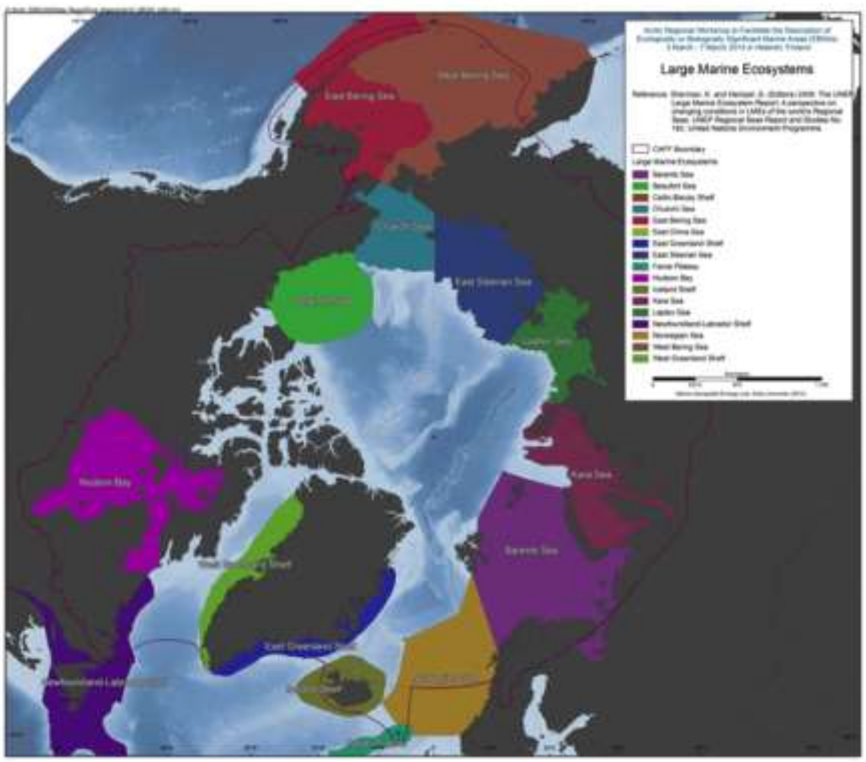


Figure 1.3-1 Large Marine Ecosystems

1.4 Longhurst Marine Provinces

"This dataset represents a partition of the world oceans into provinces as defined by Longhurst (1995; 1998; 2006), and are based on the prevailing role of physical forcing as a regulator of phytoplankton distribution. The dataset represents the initial static boundaries developed at the Bedford Institute of Oceanography, Canada. Note that the boundaries of these provinces are not fixed in time and space, but are dynamic and move under seasonal and interannual changes in physical forcing. At the first level of reduction, Longhurst recognized four principal biomes (also referred to as domains in earlier publications): the Polar Biome, the Westerlies Biome, the Trade-Winds Biome, and the Coastal Boundary Zone Biome. These four Biomes are recognizable in every major ocean basin. At the next level of reduction, the ocean basins are partitioned into provinces, roughly ten for each basin. These partitions provide a template for data analysis or for making parameter assignments on a global scale."

(source: VLIZ (2009). Longhurst Biogeographical Provinces. Available online at http://www.marineregions.org/. Consulted on 2013-01-14.)

References:
Longhurst, A.R. (2006). Ecological Geography of the Sea. 2nd Edition. Academic Press, San Diego, 560p.

Data available from: http://www.marineregions.org/sources.php#longhurst

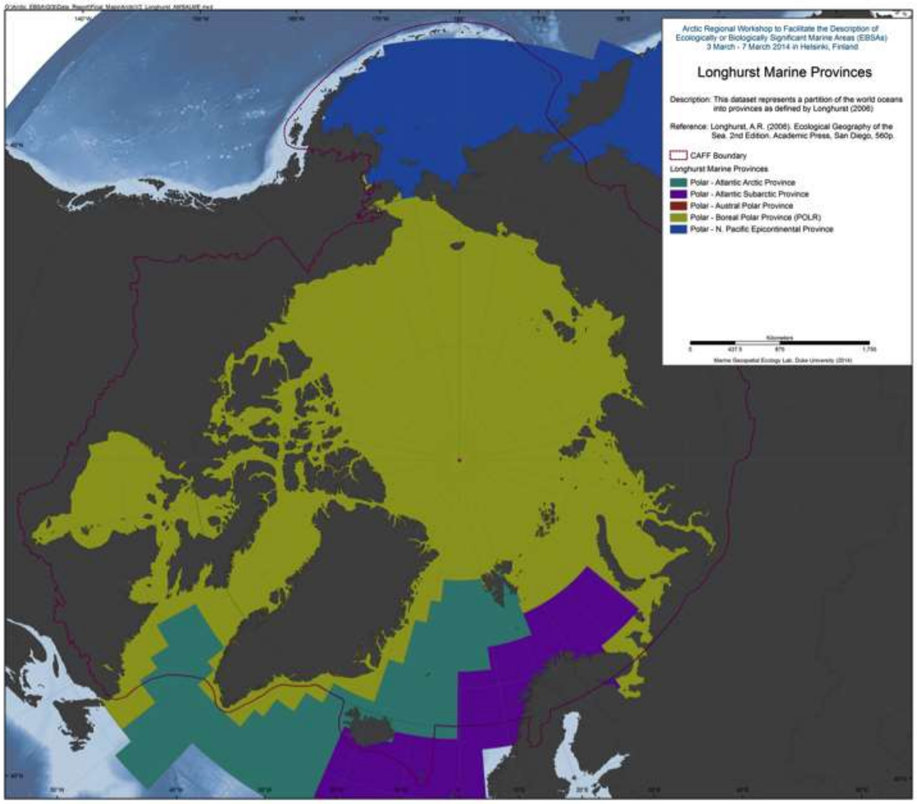


Figure 1.4-1 Longhurst Marine Provinces

Biological Data

1.5 Biological Data from the AMSA II(c) report

Preface:

"The Arctic Council's 2009 Arctic Marine Shipping Assessment (AMSA) 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. 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."

Reference:
AMAP/CAFF/SDWG, 2013. Identification of Arctic marine areas of heightened ecological and cultural significance: Arctic Marine Shipping Assessment (AMSA) IIc. Arctic Monitoring and Assessment Programme (AMAP), Oslo. 114 pp.

Link: http://www.amap.no/documents/doc/Identification-of-Arctic-marine-areas-of-heightened-ecological-and-cultural-significance-Arctic-Marine-Shipping-Assessment-AMSA-IIc/869

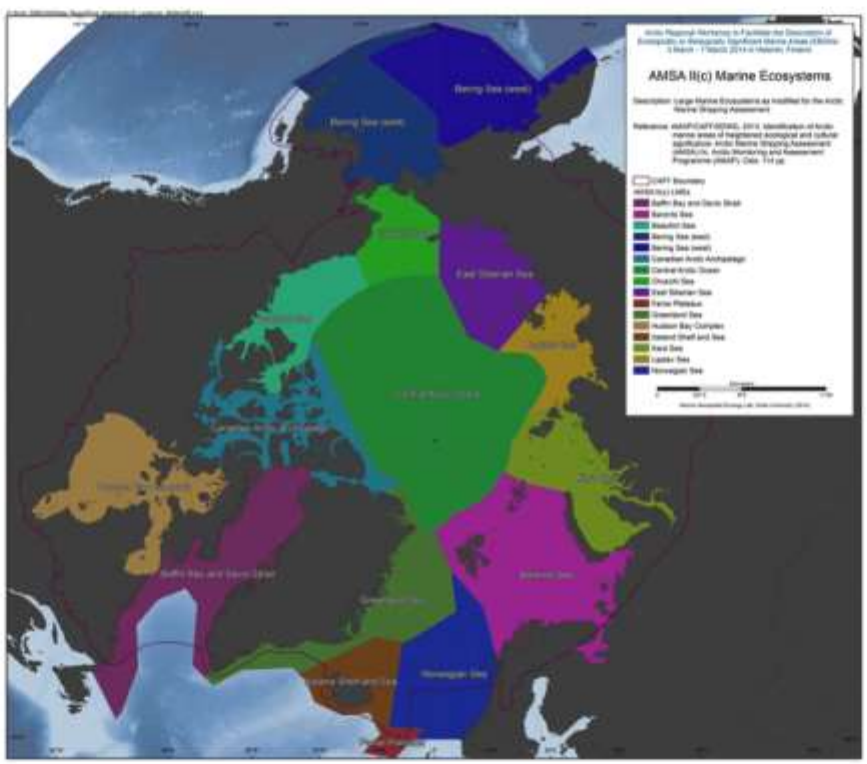


Figure 1.5-1 LMEs from AMSA II(c)

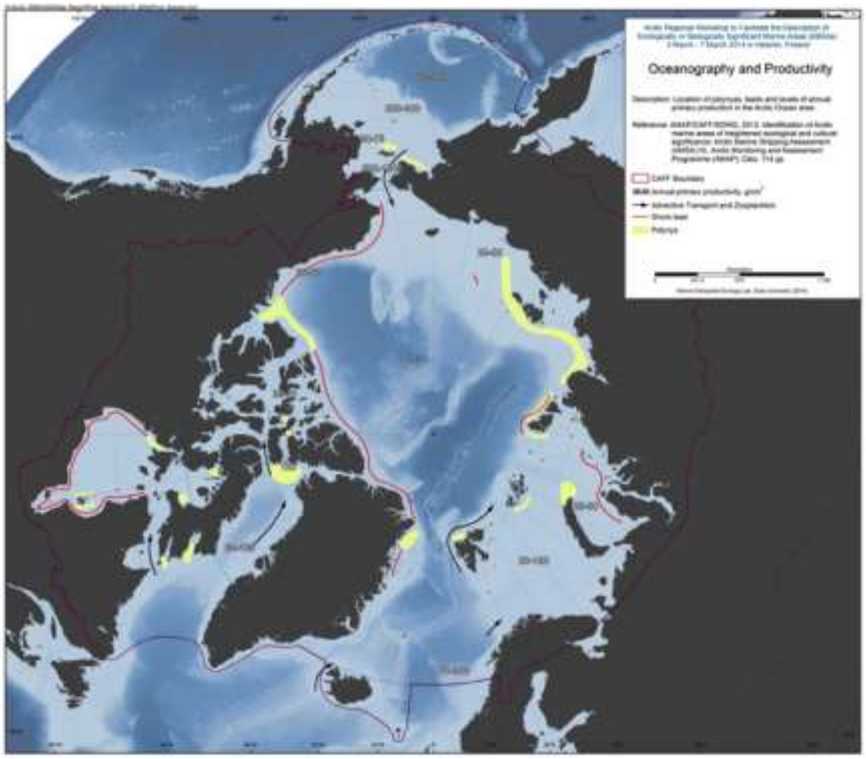


Figure 1.5-2 Productivity from AMSA II(c)

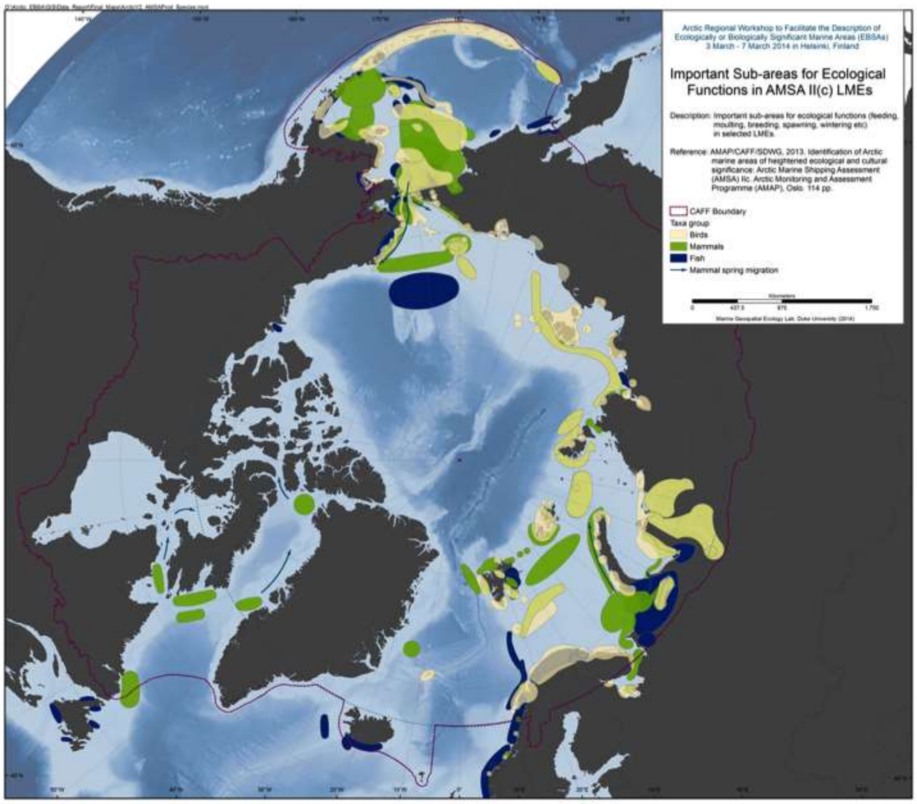


Figure 1.5-3 Important sub-areas for ecological functioning in AMSA II(c) LMEs.

Documentation on sub-area function (breeding, feeding, molting, migration etc) is provided in the report and accompanying GIS dataset.

1.6 Biological Data from the Arctic Biodiversity Assessment

Introduction:
"The Arctic Biodiversity Assessment (ABA) focuses on the species and ecosystems characteristic of the Arctic region and draws together information from a variety of sources to discuss the cumulative changes occurring as a result of multiple factors. It draws on the most recent and authoritative scientific publications, supplemented by information from Arctic residents, also known as traditional ecological knowledge (TEK). The chapters of the ABA have been through comprehensive peer reviews by experts in each field to ensure the highest standards of analysis and unbiased interpretation (see list below). The results are therefore a benchmark against which future changes can be measured and monitored.

The purpose of the ABA, as endorsed by the Arctic Council Ministers in Salekhard, Russia, in 2006 is to *Synthesize and assess the status and trends of biological diversity in the Arctic … as a major contribution to international conventions and agreements in regard to biodiversity conservation; providing policymakers with comprehensive information on the status and trends of Arctic biodiversity* (CAFF 2007). The intent is to provide a much needed description of the current state and recent trends in the Arctic's ecosystems and biodiversity, create a baseline for use in global and regional assessments of Arctic biodiversity and a basis to inform and guide future Arctic Council work. The ABA provides up-to-date knowledge, identifies gaps in the data record, describes key mechanisms driving change and presents suggestions for measures to secure Arctic biodiversity. Its focus is on current status and trends in historical time, where available."

Reference:
CAFF 2013. Arctic Biodiversity Assessment. Status and trends in Arctic biodiversity. Conservation of Arctic Flora and Fauna, Akureyri.

Link: www.arcticbiodiversity.is

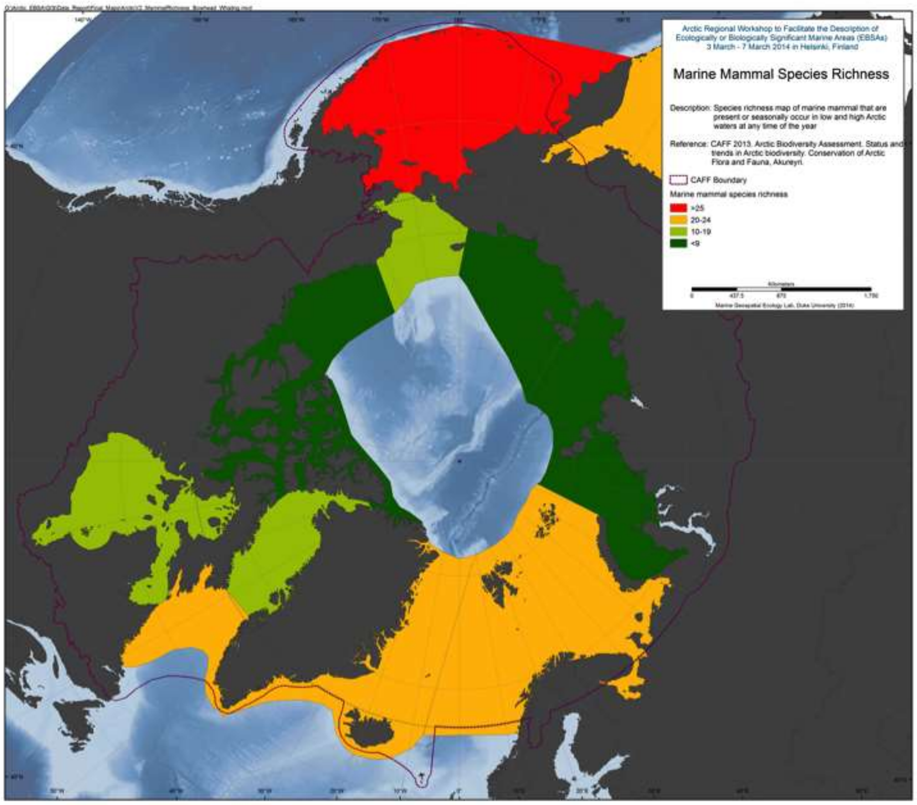


Figure 1.6-1 Marine Mammals Species Richness

[Figure 3.7 from the "Arctic Biodiversity Assessment. Status and trends in Arctic biodiversity."]

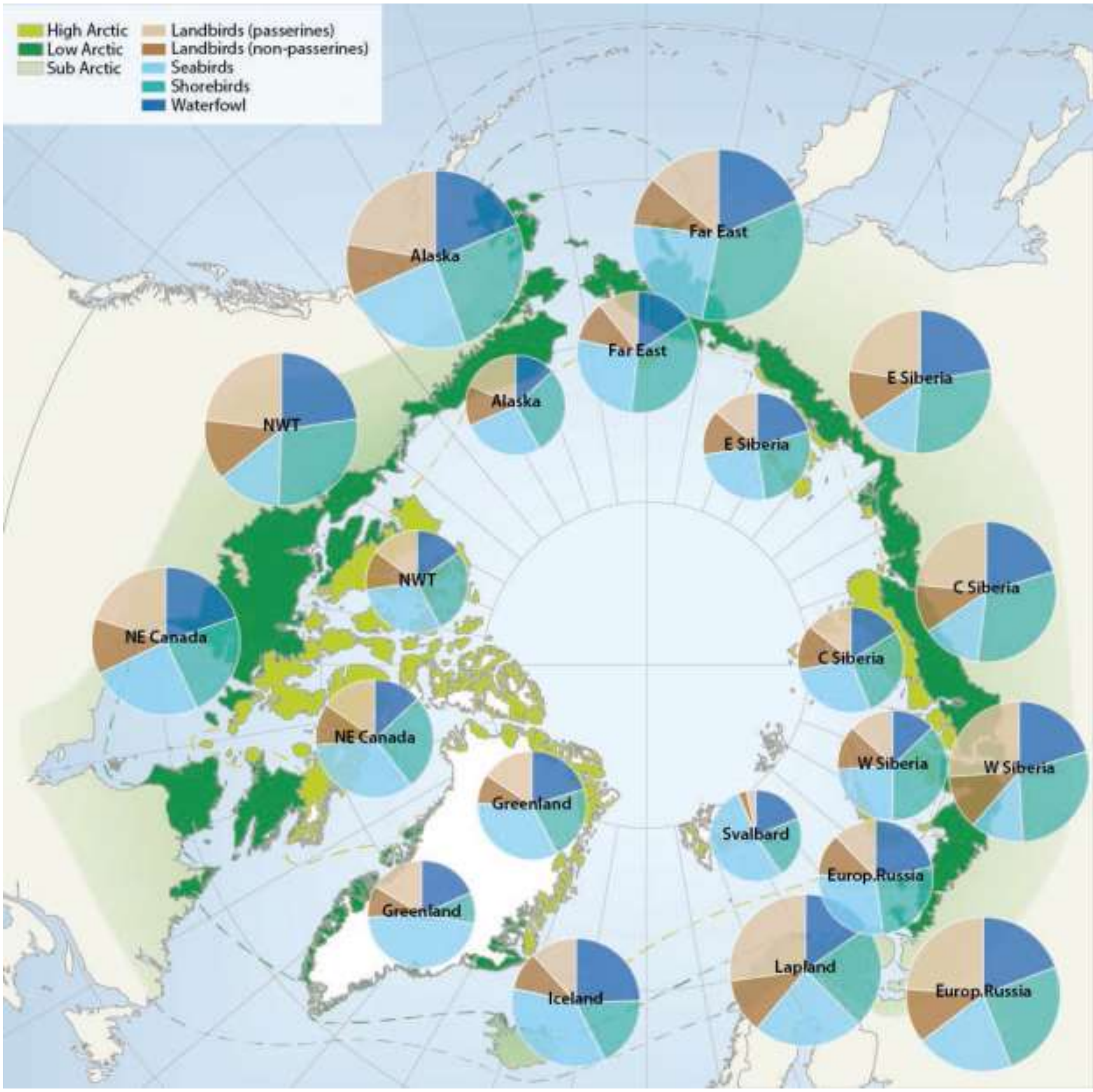


Figure 1.6-2 Avian Biodiversity in Arctic Regions

[Figure 4.1 from the "Arctic Biodiversity Assessment. Status and trends in Arctic biodiversity."]

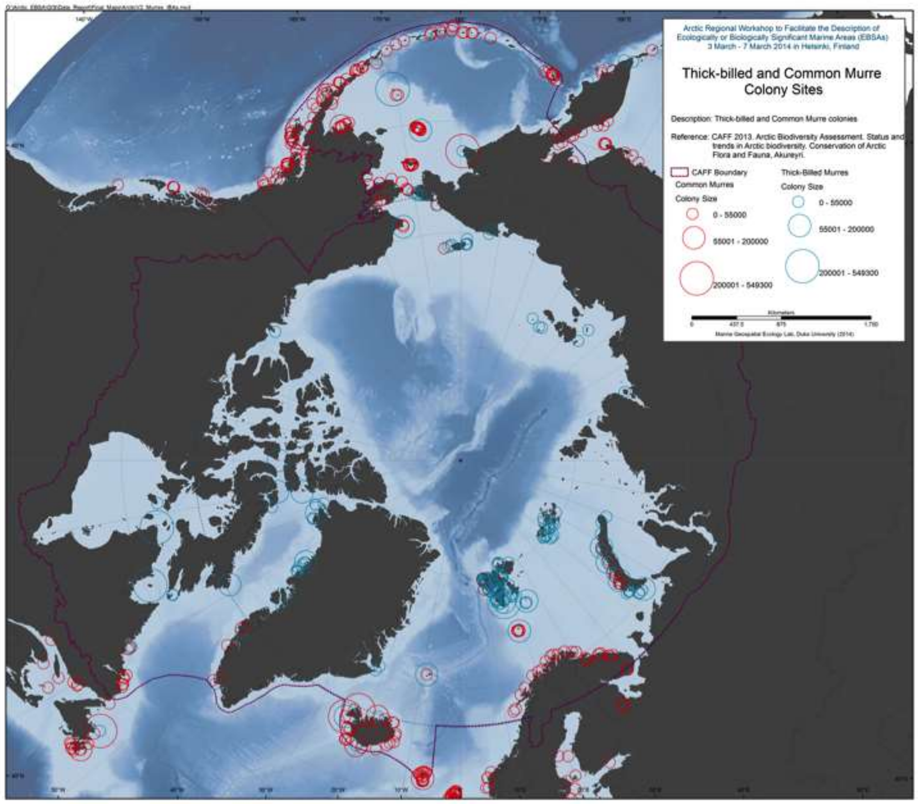


Figure 1.6-3 Murre Colony Sites

[Box 4.3 from the "Arctic Biodiversity Assessment. Status and trends in Arctic biodiversity."]

1.7 Distribution of Endemic Cetaceans

Abstract:
"The Arctic is one of the fastest-changing parts of the planet. Global climate change is already having major impacts on Arctic ecosystems. Increasing temperatures and reductions in sea ice are particular conservation concerns for ice-associated species, including three endemic cetaceans that have evolved in or joined the Arctic sympagic community over the last 5 M years. Sea ice losses are also a major stimulant to increased industrial interest in the Arctic in previously ice-covered areas. The impacts of climate change are expected to continue and will likely intensify in coming decades. This paper summarizes information on the distribution and movement patterns of the three ice-associated cetacean species that reside year-round in the Arctic, the narwhal (*Monodon monoceros*), beluga (white whale, *Delphinapterus leucas*), and bowhead whale (*Balaena mysticetus*). It maps their current distribution and identifies areas of seasonal aggregation, particularly focussing on high-density occurrences during the summer. Sites of oil and gas exploration and development and routes used for commercial shipping in the Arctic are compared with the distribution patterns of the whales, with the aim of highlighting areas of special concern for conservation. Measures that should be considered to mitigate the impacts of human activities on these Arctic whales and the aboriginal people who depend on them for subsistence include: careful planning of ship traffic lanes (re-routing if necessary) and ship speed restrictions; temporal or spatial closures of specified areas

(e.g. where critical processes for whales such as calving, calf rearing, resting, or intense feeding take place) to specific types of industrial activity; strict regulation of seismic surveys and other sources of loud underwater noise; and close and sustained monitoring of whale populations in order to track their responses to environmental disturbance."

Reference:

Reeves RR, Ewins PJ, Agbayani S, et al. (2014) Distribution of endemic cetaceans in relation to hydrocarbon development and commercial shipping in a warming Arctic. Marine Policy 44:375–389. doi: 10.1016/j.marpol.2013.10.005

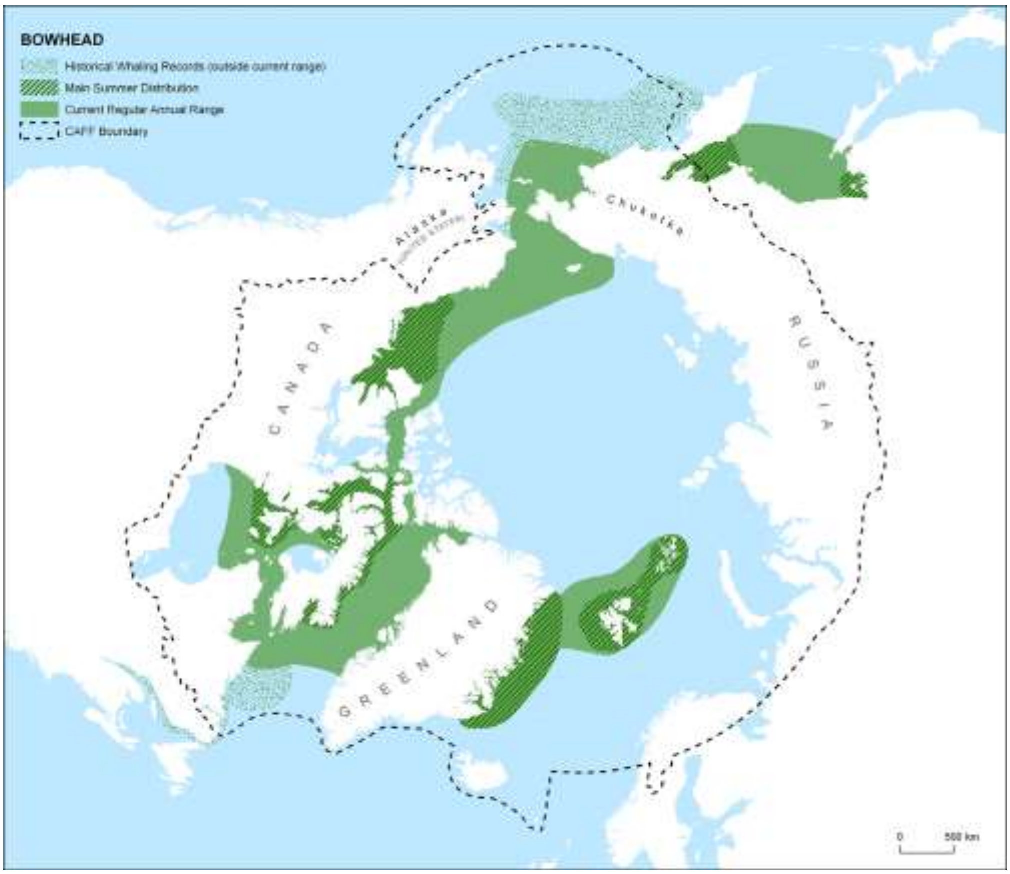


Figure 1.7-1 Circumpolar distribution of bowhead whales

[Fig. 1 from Reeves et al. 2014 "Circumpolar distribution of bowhead whales, showing approximate current range where animals occur regularly during at least part of the year, as well as areas where they tend to occur in highest densities during the summer (July–September, inclusive). Additional stippled areas in the Bering Sea [19] and Labrador Sea/Gulf of St. Lawrence [20,21] represent historical whaling grounds where bowheads were observed during the summer and autumn in the 19th century (Bering Sea) and during various times of year in the 16th–19th centuries (St. Lawrence and Labrador), but where they no longer occur regularly, at least during those seasons."]

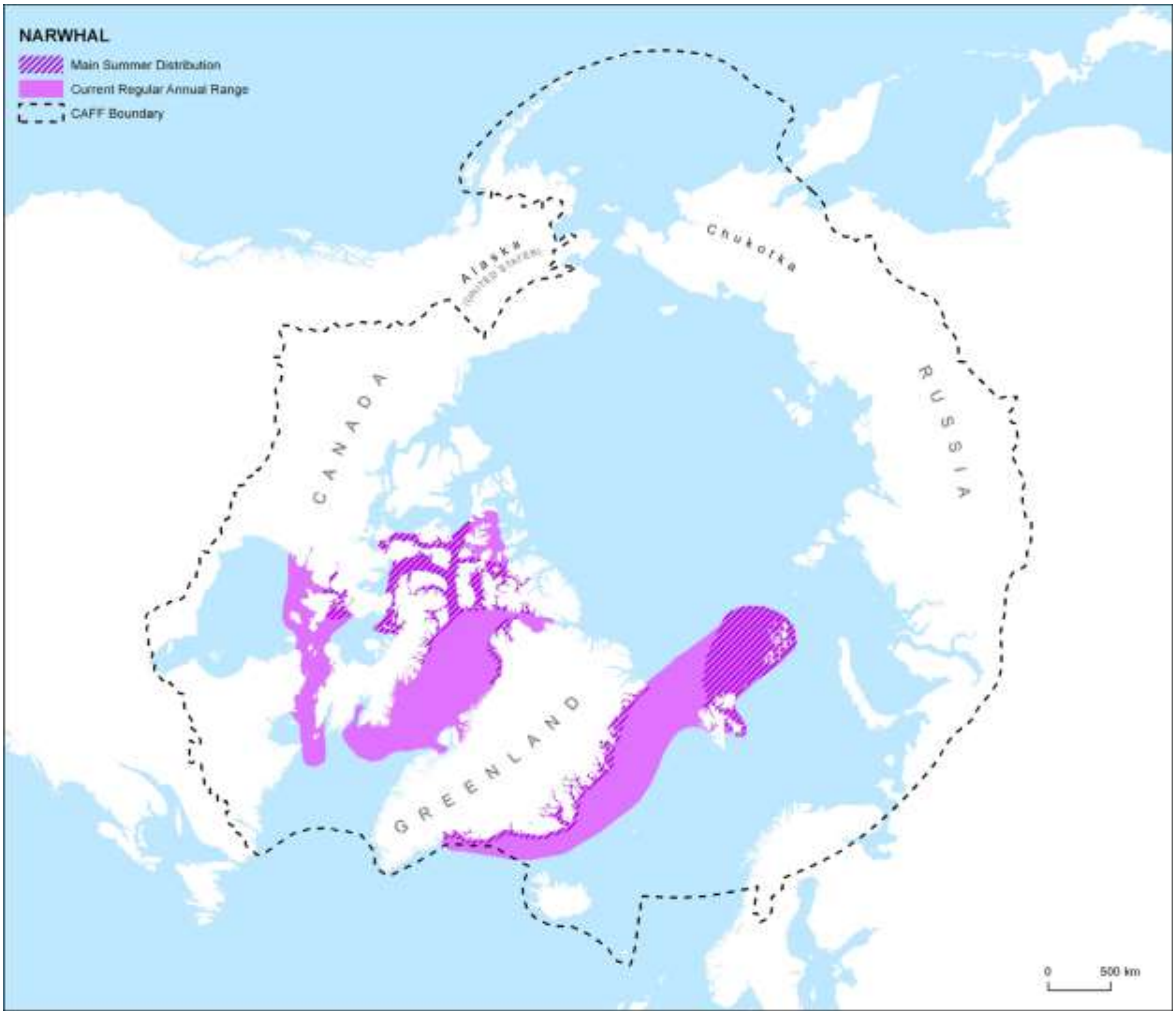


Figure 1.7-2 Circumpolar distribution of narwhal

[Fig. 2 from Reeves et al. 2014 "Circumpolar distribution of narwhals, showing approximate current range where animals occur regularly during at least part of the year, as well as areas where they tend to occur in highest densities during the summer (July–September, inclusive)"]

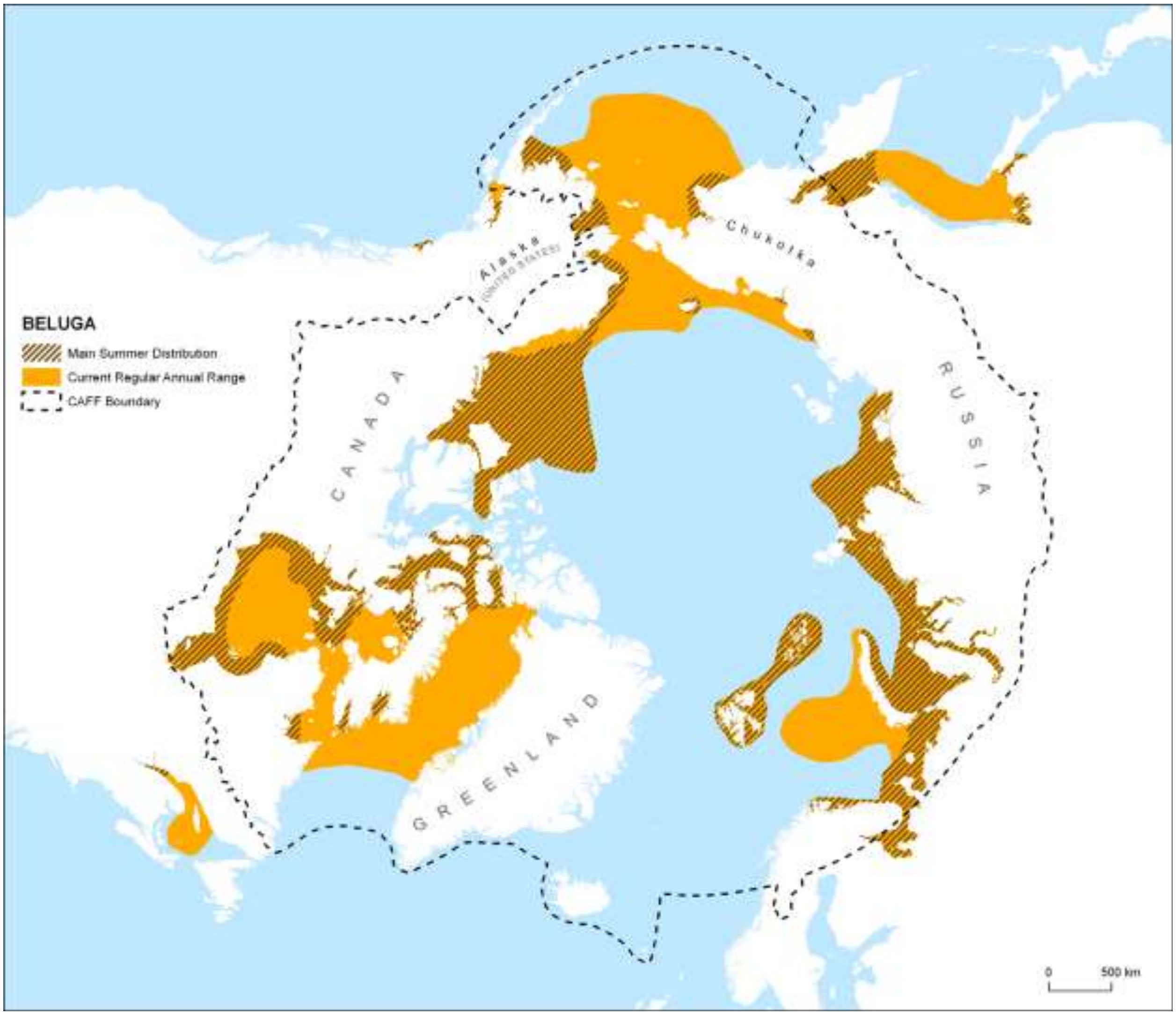


Figure 1.7-3 Circumpolar distribution of belugas

[Fig. 3 from Reeves et al. 2014 “Circumpolar distribution of belugas, showing approximate current range where animals occur regularly during at least part of the year, as well as areas where they tend to occur in highest densities during the summer (July–September, inclusive)”].

1.8 Diversity and Distribution of Endemic Cetaceans

Whale and Dolphin Conservation provided maps that include additional data on cetacean diversity and distribution along with data from Reeves et al. 2014.

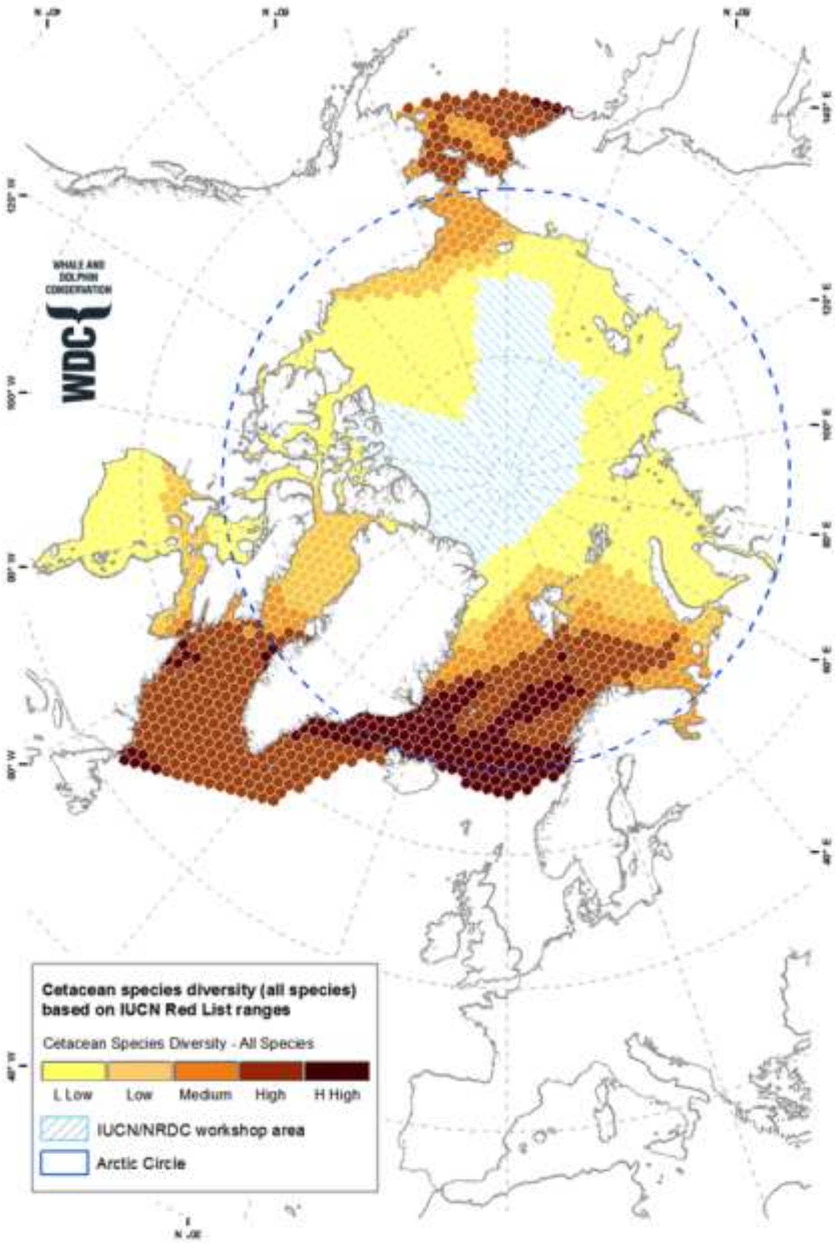


Figure 1.8-1 Cetacean species diversity (all species) based on IUCN Red List ranges

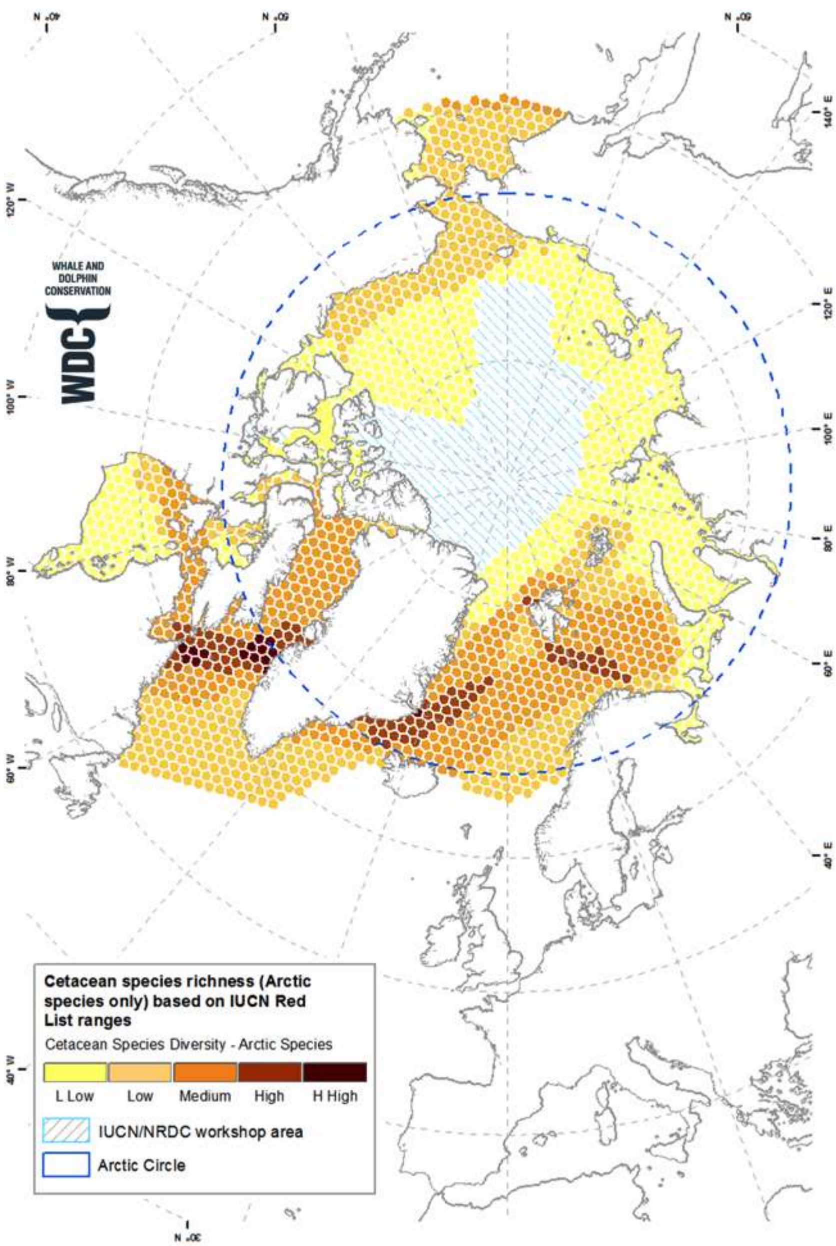


Figure 1.8-2 Cetacean species richness (Arctic species only) based on IUCN Red List ranges

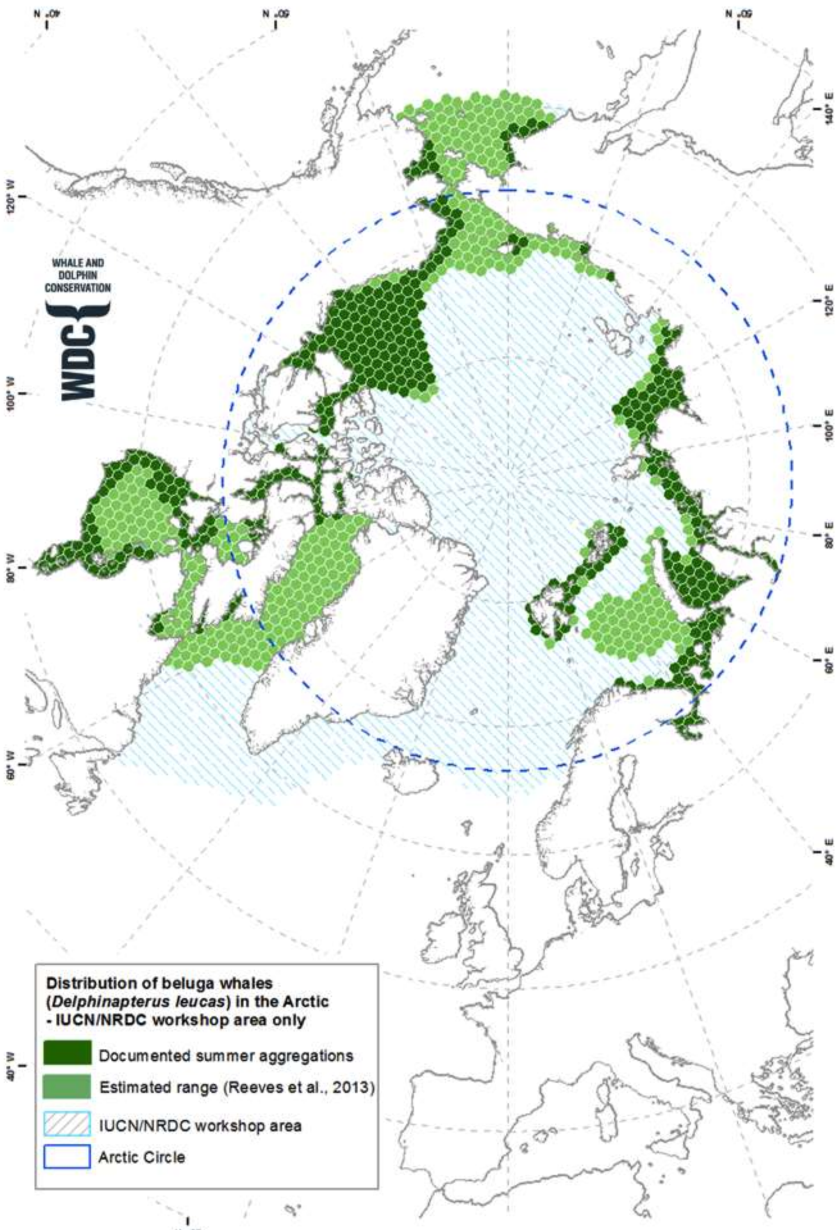


Figure 1.8-3 Distribution of beluga whales in the Arctic

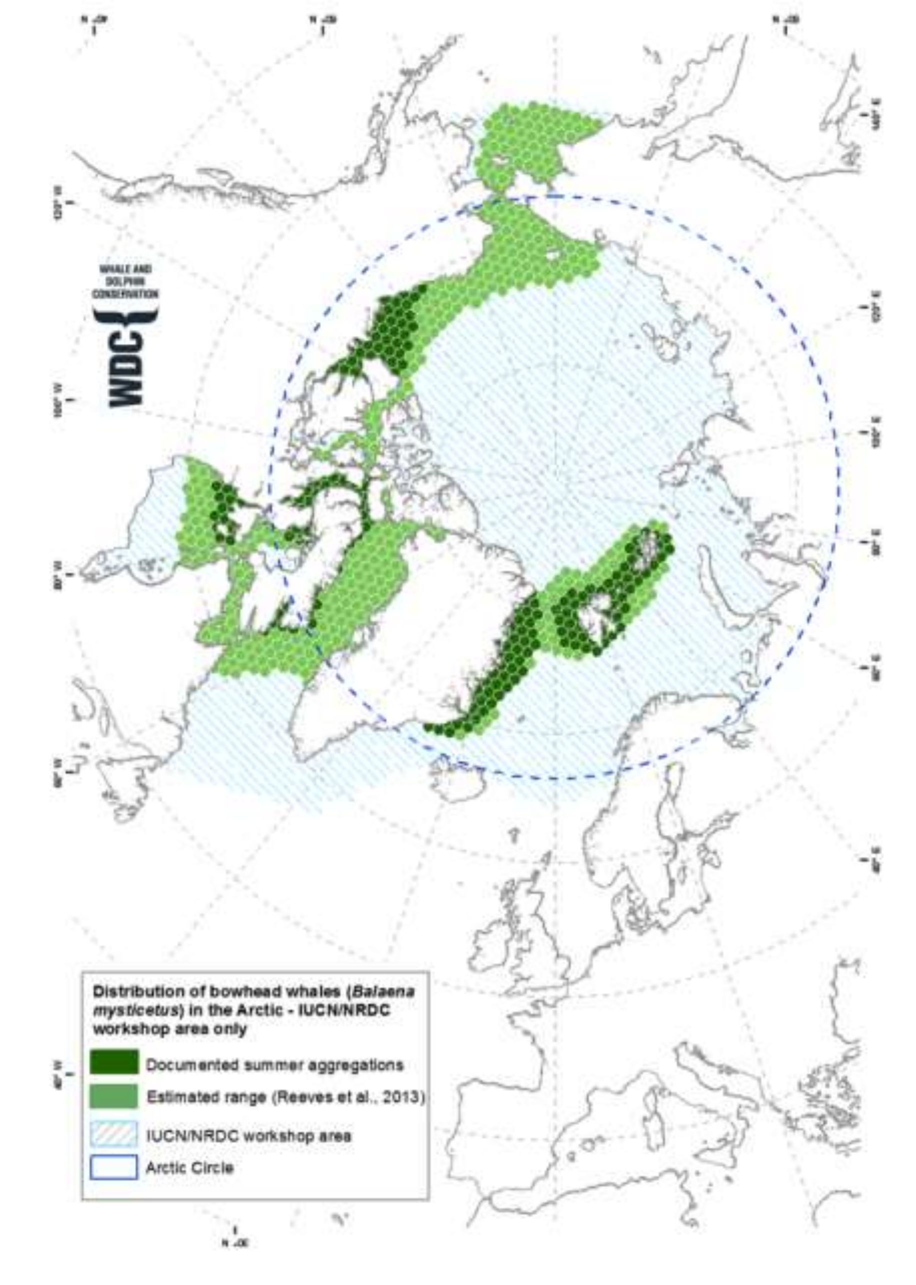


Figure 1.8-4 Distribution of bowhead whales in the Arctic

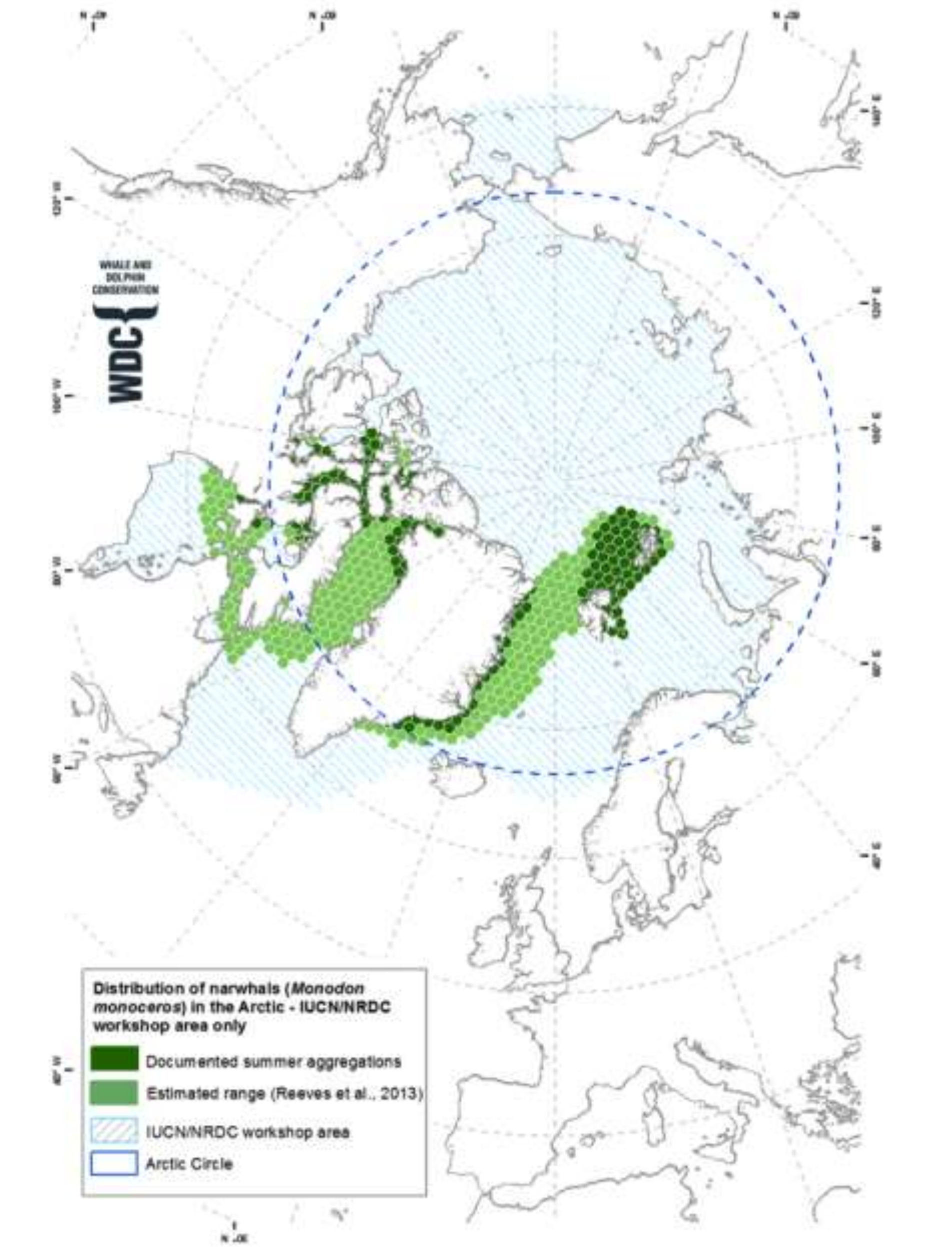


Figure 1.8-5 Distribution of narwhals in the Arctic

1.9 Biologically Important Area for Cetaceans in US Waters

"Biologically Important Areas (BIAs) are defined by the Cetacean Density and Distribution Mapping Working Group (CetMap) as areas and times where migratory species feed, migrate, mate, give birth, or are found with neonates or other sensitive age classes. A separate type of BIA is defined for small and resident populations. The intent of the BIAs is to provide a science-based tool to aid both regulators, such as NOAA, and regulated entities in the studies and planning that are required under multiple US statutes to characterize, analyze, and minimize the impacts of anthropogenic activities on cetaceans and to achieve conservation and protection goals. BIAs were defined for 23 cetacean species in seven regions within the US Exclusive Economic Zone. BIAs were identified through an expert elicitation process. BIAs are not a regulatory designation and have no direct implications for regulatory processes; rather, the BIAs comprise a tool that amalgamates existing published and non-published scientific information into one coherent review document. The information contained in the BIAs will assist scientists, resource managers, and the public in the characterization, analysis, and minimization of anthropogenic impacts on cetaceans. In addition, BIAs may be used to identify information gaps and prioritize future research to better understand cetaceans, their habitat, and ecosystem. "

US Arctic Reference:
Clarke J., Ferguson M., Curtice C., Harrison J. (in prep) Biologically Important Areas For Cetaceans within the US Exclusive Economic Zone - Arctic Region. Mammal Review.

Aleutian Islands and Bering Sea Reference:
Ferguson M., Waite J., Curtice C., Harrison J. (in prep) Biologically Important Areas For Cetaceans within the US Exclusive Economic Zone - Aleutian Islands and Bering Sea Region. Mammal Review.

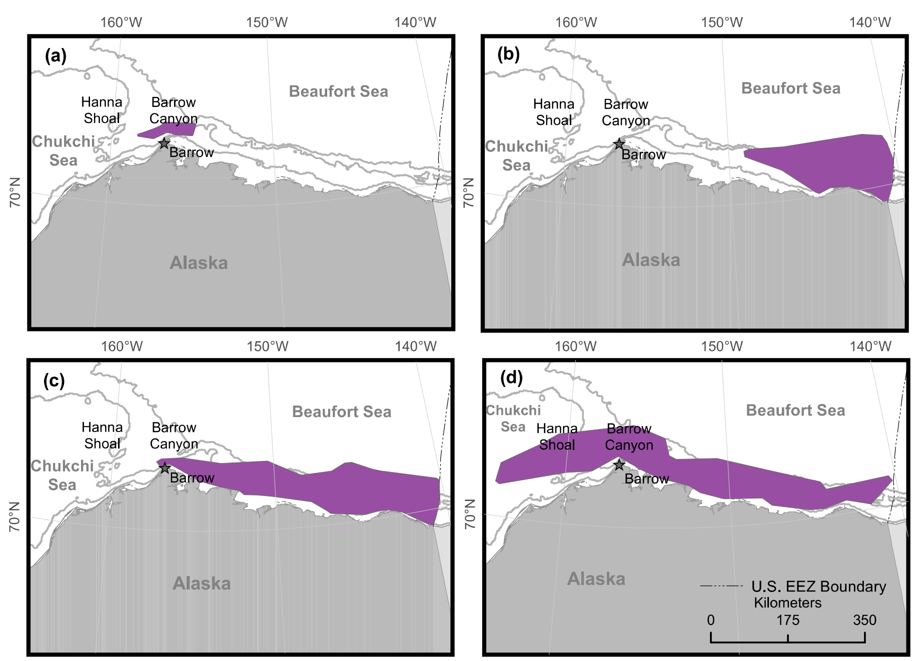


Figure 1.9-1 Bowhead whales cow-calf areas during (a) spring; (b) July through August; (c) September; and (d) October

[Figure 2 in Clark et al. (in prep) "Bowhead whales cow-calf areas during (a) spring; (b) July through August; (c) September; and (d) October, substantiated through extensive aerial and ice-based survey data and expert judgment."]

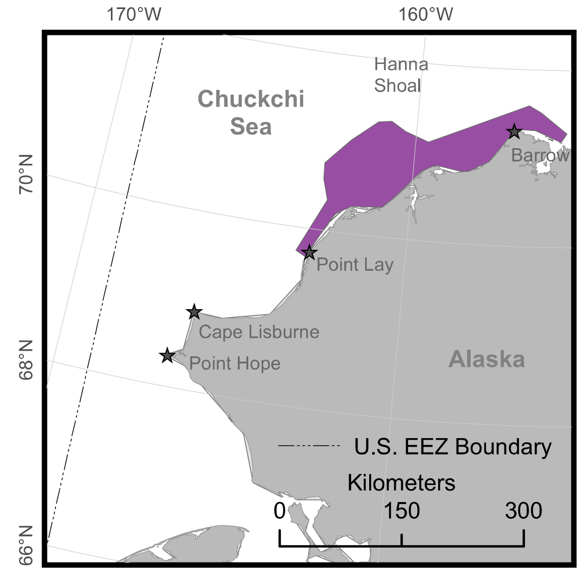


Figure 1.9-2 Gray whale cow-calf areas during June through September

[Figure 8 in Clark et al. (in prep) "Gray whale cow-calf areas during June through September, substantiated through extensive aerial survey data and expert judgment."]

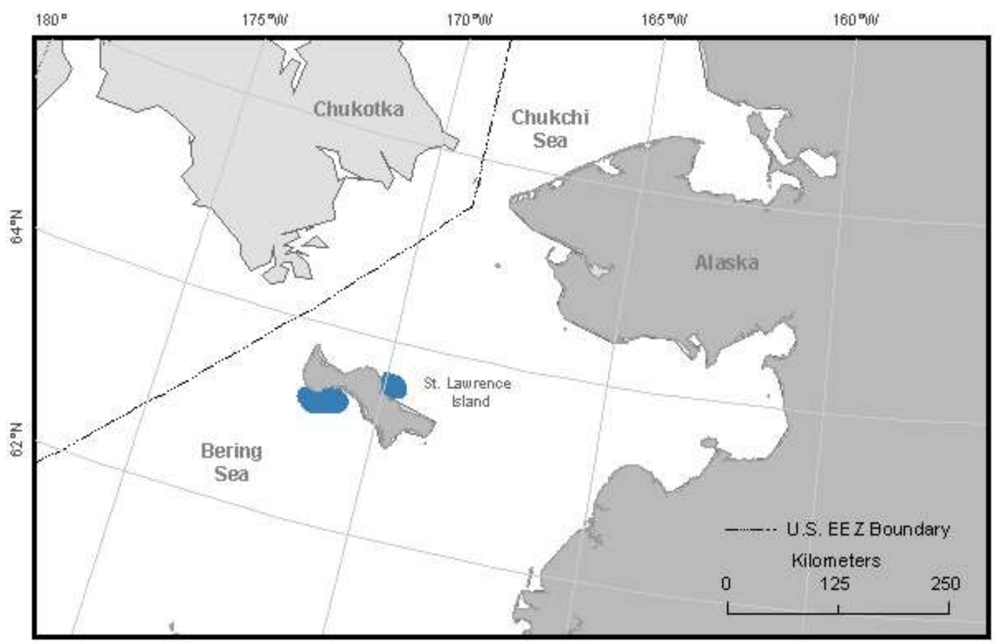


Figure 1.9-3 Bowhead whale feeding Biologically Important Areas around St. Lawrence Island

[Figure 1 in Ferguson et al. (in prep) "Bowhead whale feeding Biologically Important Areas around St. Lawrence Island, substantiated through land-based survey data, stomach content analysis, satellite tagging data and expert judgment. Highest densities of bowhead whales are found in these areas from November through April."]

Figure 1.9-4 Bowhead whale Biologically Important Area for the spring (northbound) migratory corridor through the Bering Sea

[Figure 2 in Ferguson et al. (in prep) "Bowhead whale Biologically Important Area for the spring (northbound) migratory corridor through the Bering Sea. Highest densities are from March through June, substantiated through aerial and land-based surveys, satellite tagging data and expert judgment."]

1.10 Historical Whale Captures

"The Wildlife Conservation Society (WCS) has digitally captured the Townsend Whaling Charts that were published as a series of 4 charts with the article titled "The distribution of certain whales as shown by logbook records of American whale ships" by Charles Haskins Townsend in the journal Zoologica in 1935.

The 4 charts show the locations of over 50,000 captures of 4 whale species; sperm whales (36,908), right whales (8,415), humpback whales (2,883) and bowhead whales (5,114). Capture locations were transcribed from North American ("Yankee") pelagic whale vessel log books dating from 1761 to 1920 and plotted onto nautical charts in a Mercator projection by a cartographer. Each point plotted on the charts represents the location of a whaling ship on a day when one or more whales were taken and is symbolized by month of the year using a combination of color and open and closed circles.

Townsend and his cartographer plotted vessel locations as accurately as possible according to log book records. When plotting locations on an earlier sperm whale chart published in 1931 the cartographer spaced points where locations were very dense, "extending areas slightly" for a number of whaling grounds. However, for charts in preparation at this time, Townsend states that "this difficulty is avoided by omitting some of the data, rather than extend the ground beyond actual

whaling limits." We assumed that this statement refers to the 1935 charts but there is still some question as to whether the cartographer did in fact space locations and thus expand whaling grounds."
(source: http://web.archive.org/web/20070926224128/http:/wcs.org/townsend_charts)

Using a geographic information system (ArcMap 10.x, ESRI, Redlands, CA), capture point locations for each species were aggregated into 1-degree cells.

References:

Smith TD, Reeves RR, Josephson EA, Lund JN (2012) Spatial and Seasonal Distribution of American Whaling and Whales in the Age of Sail. PLoS ONE 7:e34905.

Townsend, C.H. 1931. Where the nineteenth century whaler made his catch. Zoologica 34, No. 6:173-179.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica 19, No. 1:1-50, 4 charts.

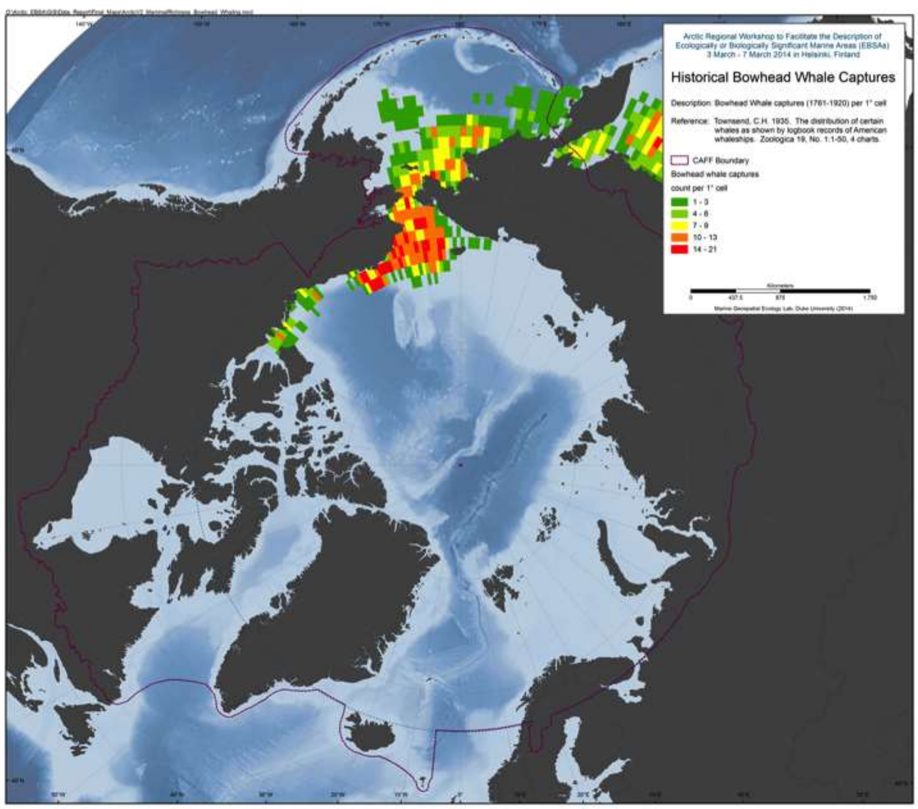


Figure 1.10-1 Historical Bowhead Whale Captures

1.11 Arctic Seabird Distribution Modeling

Abstract:
"We present a first compilation, quantification and summary of 27 seabird species presence data for north of the Arctic circle (>66 degrees latitude North) and the ice-free period (summer). For species names, we use several taxonomically valid online databases [Integrated Taxonomic Information System (ITIS), AviBase, 4 letter species codes of the American Ornithological Union (AOU), The British List 2000, taxonomic serial numbers TSNs, World Register of Marine Species (WORMS) and APHIA ID] allowing for a compatible taxonomic species cross-walk, and subsequent applications, e.g., phylogenies. Based on the data mining and machine learning RandomForest algorithm, and 26 environ- mental publicly available Geographic Information Systems (GIS) layers, we built 27 predictive seabird models based on public open access data archives such as the Global Biodiversity Information Facility (GBIF), North Pacific Pelagic Seabird Database (NPPSD) and PIROP database (in OBIS-Seamap). Model-prediction scenarios using pseudo-absence and expert-derived absence were run; aspatial and spatial model assessment metrics were applied. Further, we used an additional species model performance metric based on the best publicly available Arctic seabird colony location datasets compiled by the authors using digital and literature sources. The obtained models perform reasonably: from poor (only a few coastal species with low samples) to very high (many pelagic species). In compliance with data policies of the International Polar Year (IPY) and similar initiatives, data and models are documented with FGDC NBII metadata and publicly available online for further improvement, sustainability applications, synergy, and intellectual explorations in times of a global biodiversity, ocean and Arctic crisis."

Reference:
Huettmann F, Artukhin Y, Gilg O, Humphries G (2011) Predictions of 27 Arctic pelagic seabird distributions using public environmental variables, assessed with colony data: a first digital IPY and GBIF open access synthesis platform. Mar Biodiv 41:141–179. doi: 10.1007/s12526-011-0083-2

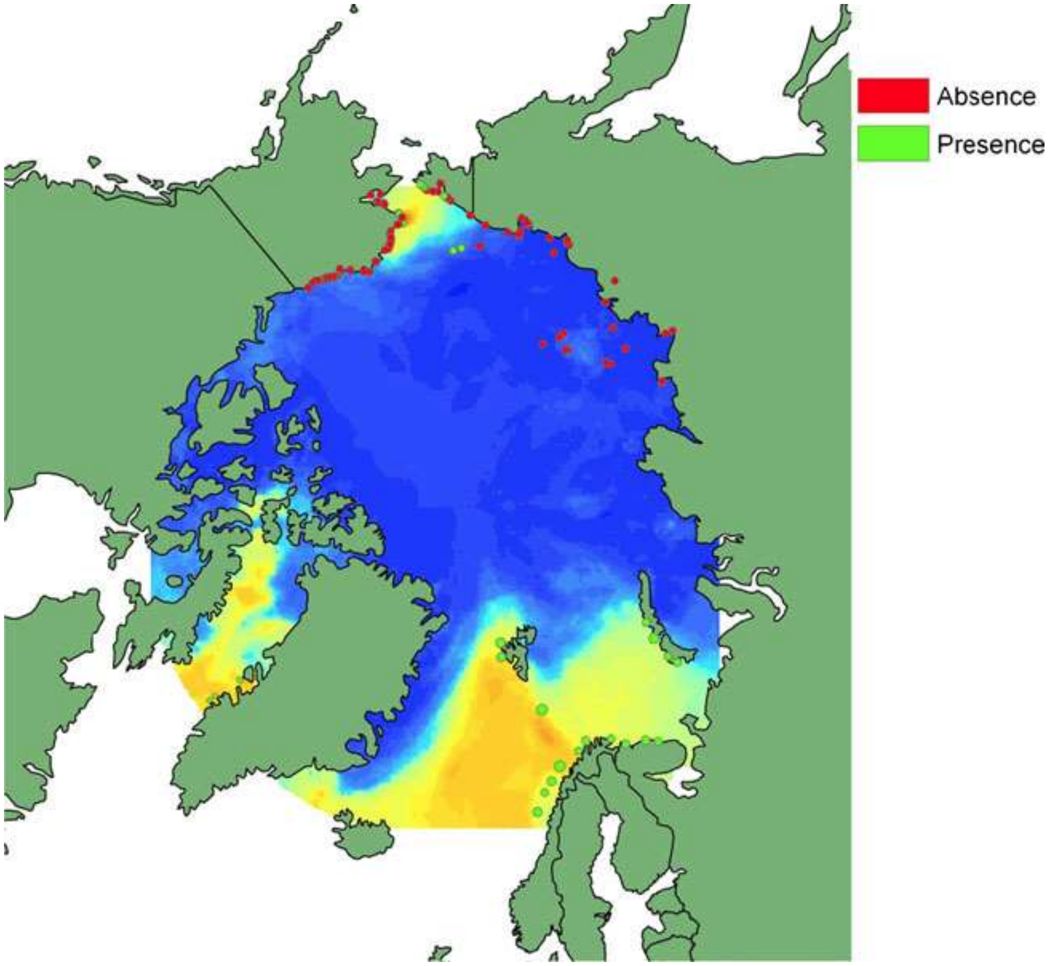


Figure 1.11-1 Predicted distributions for Common Murres

[Figure 3 from Huettmann etal 2011, "Example: Predicted distributions for Common Murres (orange pixels in the prediction surface show presence, yellow intermediate and blue absence. Green dots show known colony sites where murres are present, and red dots predicted absences"]

1.12 Arctic Seabird Biodiversity Modeling

Abstract:
"Aims: To use open access models of predicted seabird distribution data in the Arctic to create rapid assessment biodiversity maps for management purposes and for prioritization of conservation.

Methods: The predicted distributions of 27 species of Arctic seabirds were combined to create a seabird biodiversity map. The GIS layers created were based on peer-reviewed model outputs which were calculated using the random forest algorithm and supplemented with ISO standardized

metadata for quality assurance. We have overlain the species diversity and occurrence maps with known shipping lanes and areas of human activities in the Arctic to highlight areas of potential human conflict with pelagic seabirds.

Results: Entry points to the Arctic Basin for example Baffin Bay, Davis Strait, Chukchi Sea, Greenland Sea and Norwegian Sea are specific conflict zones with mean number of species occurring within 20 km of shipping zones ranging from 17 to 19 (63–70% of modelled species). We also show that these are areas of the highest intensity of human activities in the Arctic (fishing, ship traffic and accident rates).

Main conclusion: These Arctic seabird biodiversity maps can be used to make decisions which take into account ecology and socio-economy (e.g. Marxan analysis and marine protected areas MPAs) and for ecological/economic studies which can help to create a pro-active management scheme. This is particularly important due to the future increase in human impacts in the Arctic (i.e. fishing, tourism and especially shipping). By improving upon these models and further examination into the interactions between seabirds and humans in the Arctic, we can guide important policy decisions to protect Arctic biodiversity."

Reference:

Humphries, R. W. G. & Huettmann, F. (2014). Putting models to a good use: a rapid assessment of Arctic seabird biodiversity indicates potential conflicts with shipping lanes and human activity. *Diversity and Distributions*, 1-13.

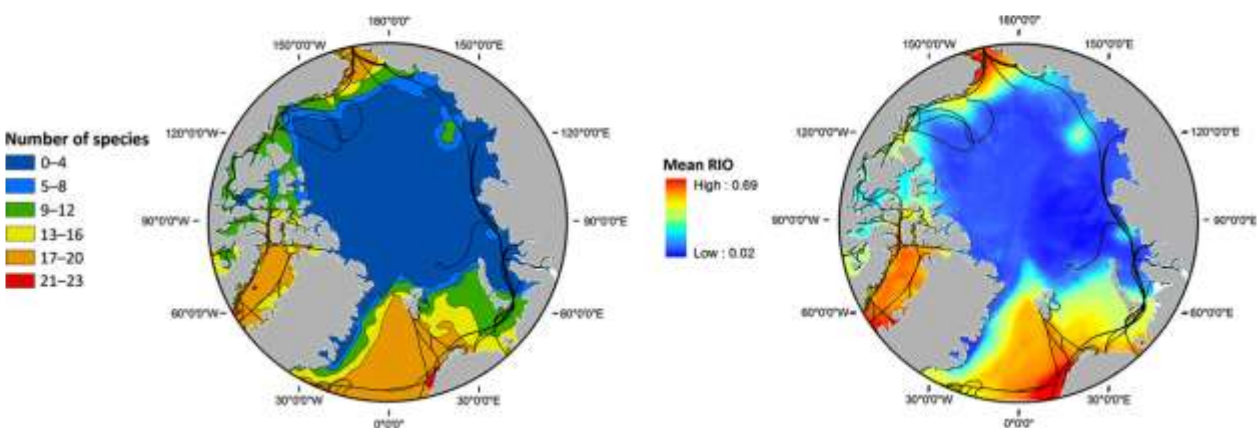


Figure 1.12-1 Seabird species diversity and mean relative index of occurrence

[Figure 2 from Humphries and Huettman 2014 "Seabird species diversity (a) and mean relative index of occurrence (RIO) of 27 modeled seabird species (b) in the Arctic with shipping lanes (www.arcticdata.is) overlain."]

1.13 Important Bird Areas

BirdLife Important Bird Areas (IBAs) have been used to inform the identification of EBSAs in previous EBSA regional workshops. Previously the data provided has been used to either support the designation of an EBSA for a range of taxa and habitats, or to identify EBSAs solely on the basis of bird data.

IBAs have been identified using several data sources:

1. Terrestrial seabird breeding sites are shown with point locality and species that qualifies at the IBA
   – see http://www.birdlife.org/datazone/site/search
2. Marine areas around breeding colonies have been identified based on literature review where possible to guide the distance required by each species. Where literature is sparse or lacking, extensions have been applied on a precautionary basis.
   – see http://seabird.wikispaces.com/
3. Sites identified by satellite tracking data via kernel density analysis, first passage time analysis and bootstrapping approaches.
   - www.seabirdtracking.org

Together these IBAs form a network of sites of importance to coastal, pelagic, resident and or migratory species. EBSA criteria of particular relevance are "important for life-history stages", "threatened species", "diversity" and "fragility". For further information Google "IBAs vs EBSAs".

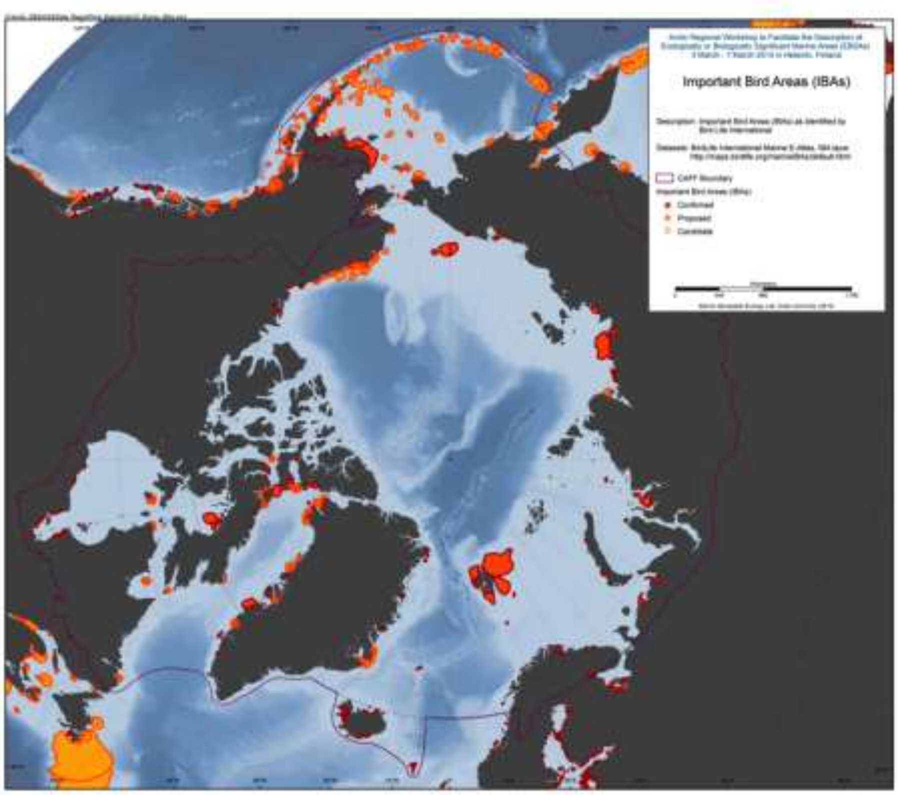


Figure 1.13-1 Important Bird Areas (IBAs)

1.14 Ocean Biogeographic Information System (OBIS) Data

"The Ocean Biogeographic information System (OBIS) seeks to absorb, integrate, and assess isolated datasets into a larger, more comprehensive picture of life in our oceans. The system hopes to stimulate research about our oceans to generate new hypotheses concerning evolutionary processes, species distributions, and roles of organisms in marine systems on a global scale. The abstracts that OBIS generates are maps that contribute to the 'big picture' of our oceans: a comprehensive, collaborative, worldwide view of our oceans.

OBIS provides a portal or gateway to many datasets containing information on where and when marine species have been recorded. The datasets are integrated so you can search them all seamlessly by species name, higher taxonomic level, geographic area, depth, and time; and then map and find environmental data related to the locations. "
(source: http://www.iobis.org/about/index)

The data provided here are summaries of available OBIS data. Species Richness and Hurlbert's Index (ES[50]) data summaries for 1 degree grids are provided for all species, mammals, turtles, shallow species (<100m depth), deep species(>100m depth), and species on the IUCN Red List. Data gaps do exist in OBIS and thus these summaries are not exhaustive.

Reference:

Intergovernmental Oceanographic Commission (IOC) of UNESCO. The Ocean Biogeographic Information System. Web. http://www.iobis.org. (Consulted on 15/01/14)

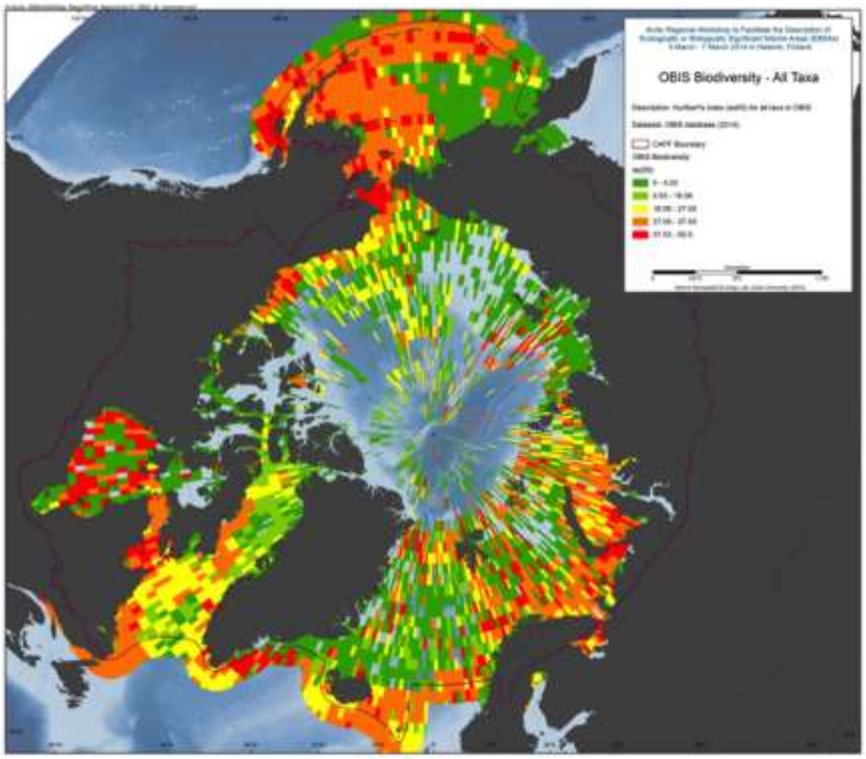
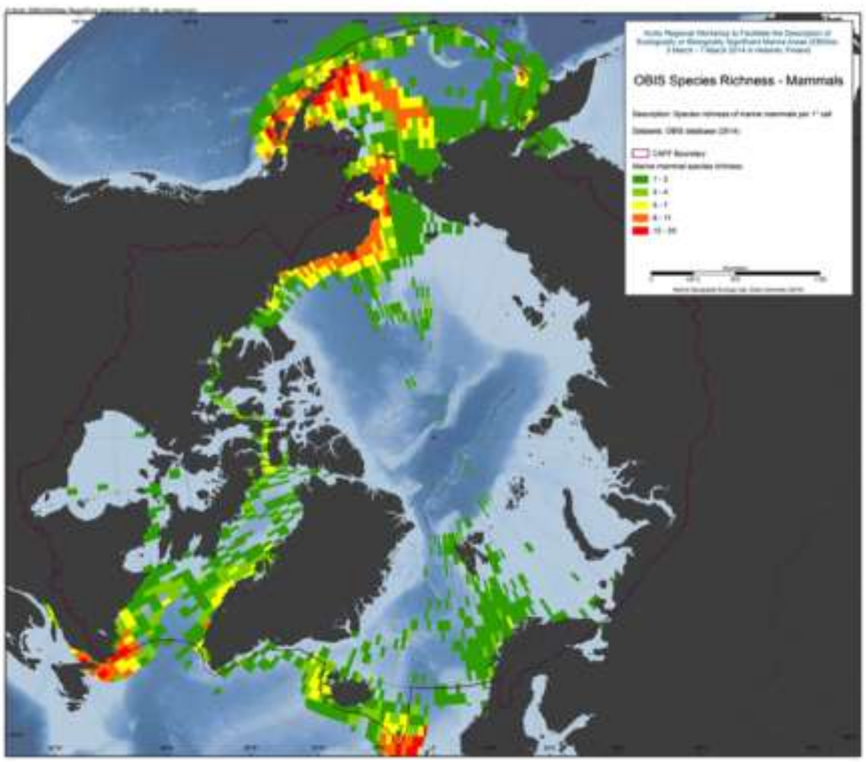


Figure 1.14-1 ES(50) for All



Taxa

Figure 1.14-2 Species Richness for Marine Mammals

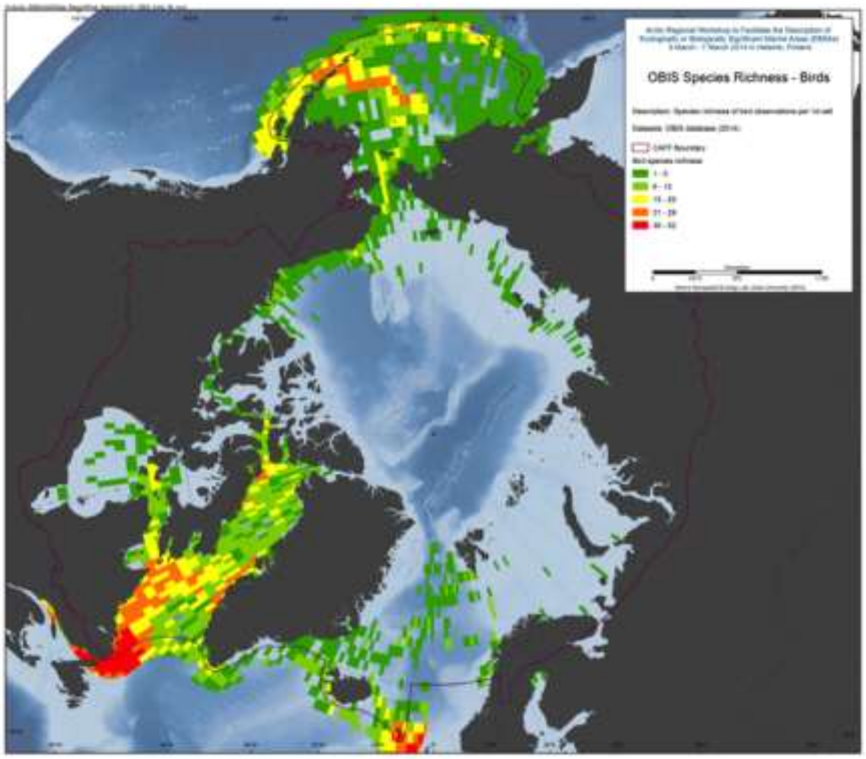
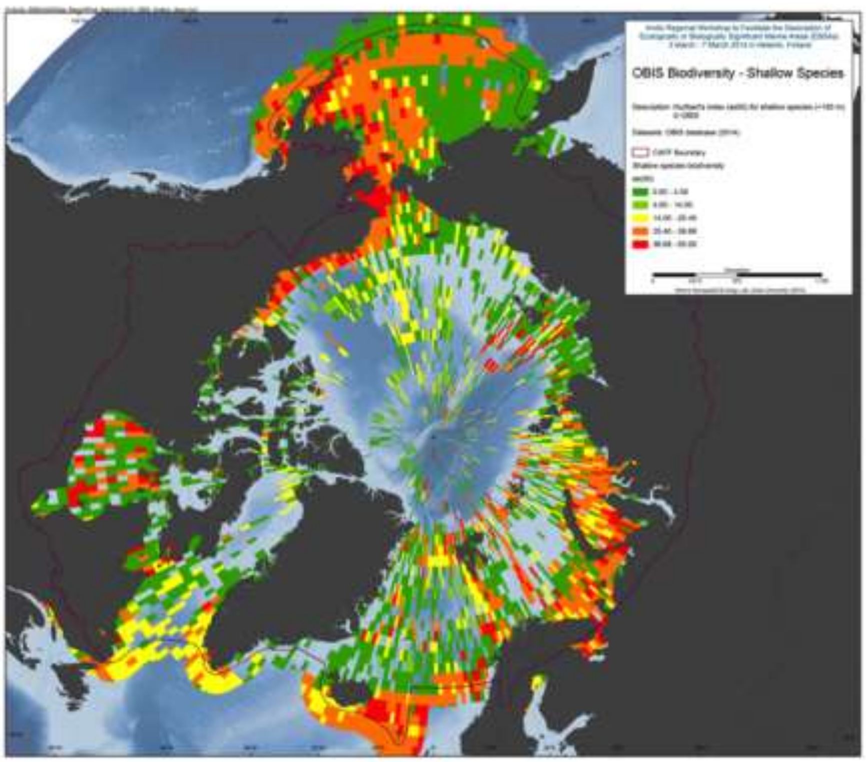


Figure 1.14-3 Species Richness for



Birds

Figure 1.14-4 ES(50) for Shallow Species

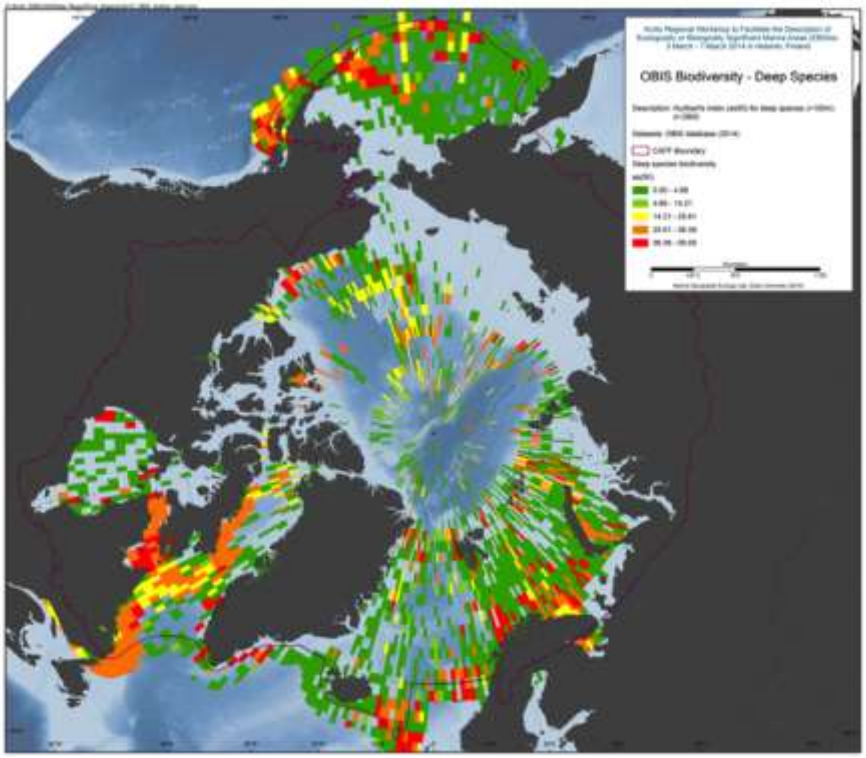
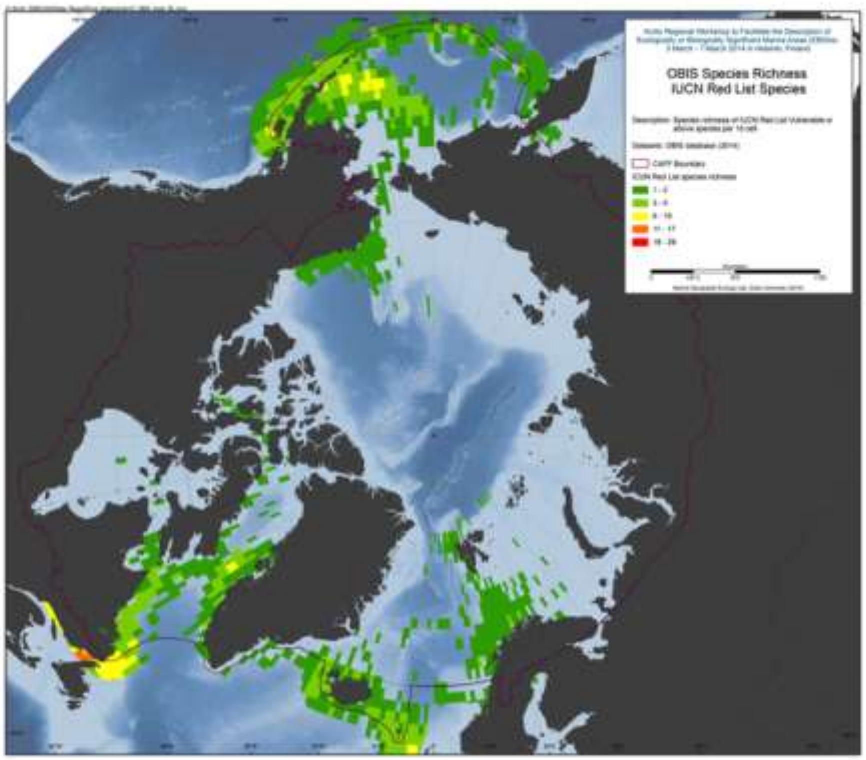


Figure 1.14-5 ES(50) for Deep



Species

Figure 1.14-6 Species Richness for IUCN Red List species

1.15 Predictions of Deep-Sea Octocorals

Abstract:
"Three-quarters of Octocorallia species are found in deep waters. These cold- water octocoral colonies can form a major constituent of structurally complex habitats. The global distribution and the habitat requirements of deep-sea octocorals are poorly understood given the expense and difficulties of sampling at depth. Habitat suitability models are useful tools to extrapolate distributions and provide an understanding of ecological requirements. Here, we present global habitat suitability models and distribution maps for seven suborders of Octocorallia: Alcyoniina, Calcaxonia, Holaxonia, Scleraxonia, Sessiliflorae, Stolonifera and Subselliflorae."

Reference:
Yesson C, Taylor ML, Tittensor DP, Davies AJ, Guinotte J, Baco A, Black J, Hall-Spencer JM, Rogers AD (2012) *Global habitat suitability of cold-water octocorals*. Journal of Biogeography 39:1278–1292.

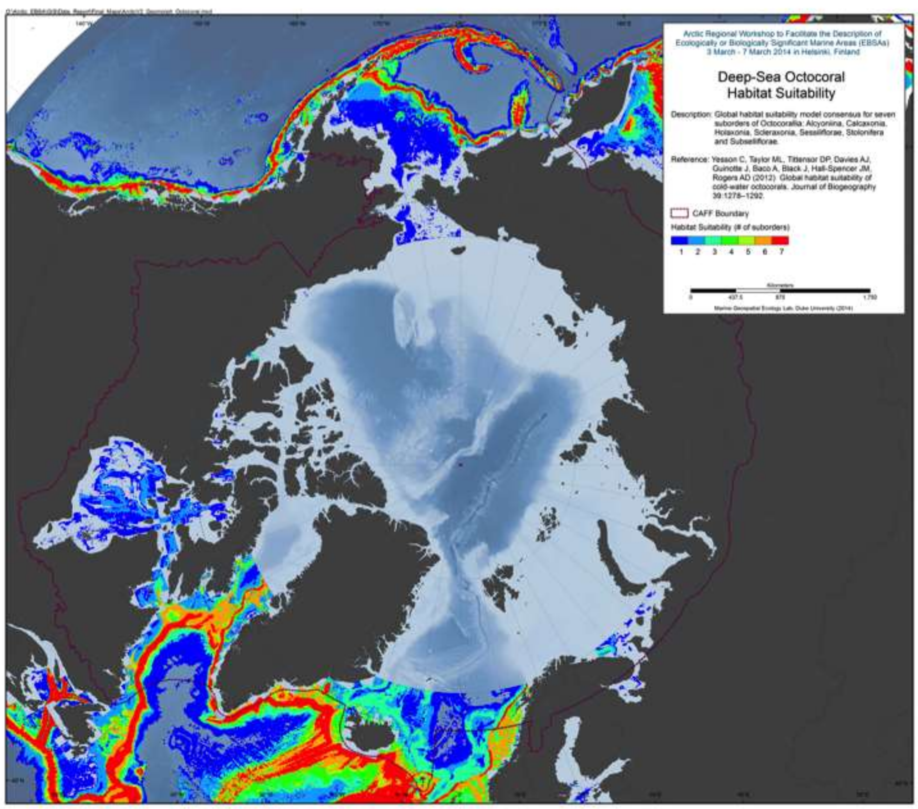


Figure 1.15-1 Deep-Sea Octocoral Habitat Suitability – Consensus

1.16 Distribution of Macrobenthic Organisms the Canadian Artic and Atlantic Waters

Abstract:
"Concentrations of sea pens, small and large gorgonian corals and sponges on the east coast of Canada have been identified through spatial analysis of research vessel survey by-catch data following an approach used by the Northwest Atlantic Fisheries Organization (NAFO) in the Regulatory Area (NRA) on Flemish Cap and southeast Grand Banks. Kernel density analysis was used to identify high concentrations. These analyses were performed for each of the five biogeographic zones of eastern Canada. The largest sea pen fields were found in the Laurentian Channel as it cuts through the Gulf of St. Lawrence, while large gorgonian coral forests were found in the Eastern Arctic and on the northern Labrador continental slope. Large ball-shaped Geodia spp. sponges were located along the continental slopes north of the Grand Banks, while on the Scotian Shelf a unique population of the large barrel-shaped sponge Vazella pourtalesi was identified. The latitude and longitude marking the positions of all tows which form these and other dense aggregations are provided along with the positions of all tows which captured black coral, a non-aggregating taxon which is long-lived and vulnerable to fishing pressures."

Reference:
Kenchington, E., Lirette, C., Cogswell, A., Archambault, D., Archambault, P., Benoit, H., Bernier, D., Brodie, B., Fuller, S., Gilkinson, K., Lévesque, M., Power, D., Siferd, T., Treble, M., and Wareham, V. 2010. Delineating Coral and Sponge Concentrations in the Biogeographic Regions of the East Coast of Canada Using Spatial Analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/041. vi + 202 pp.

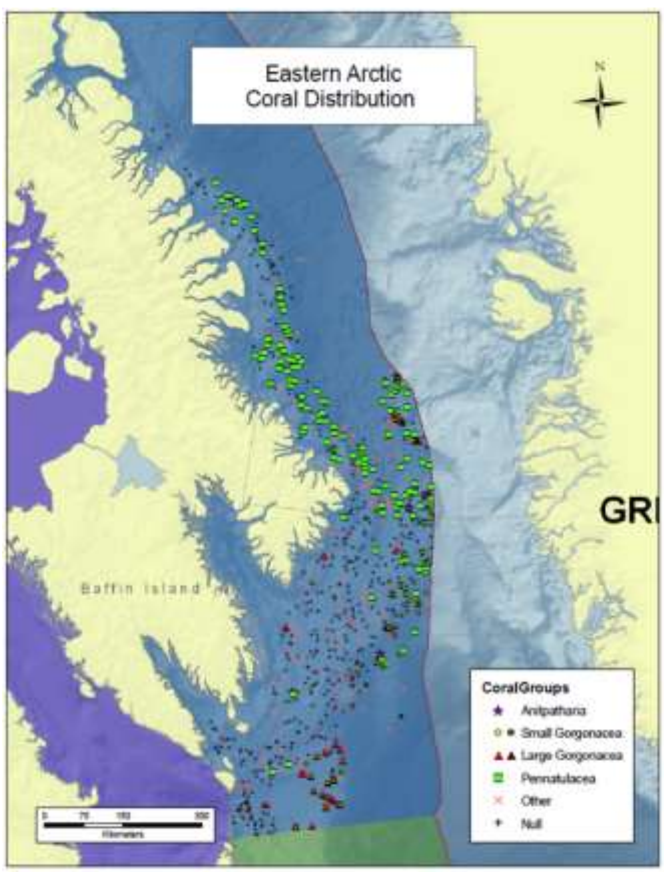


Figure 1.16-1 Distribution of the coral conservation units (sea pens, small gorgonians, large gorgonians and black corals), as well as other corals (soft corals and cup corals) in the Eastern Arctic Biogeographic Zone

[Figure 9 from Kenchington et al. 2010 "Distribution of the coral conservation units (sea pens, small gorgonians, large gorgonians and black corals), as well as other corals (soft corals and cup corals) in the Eastern Arctic Biogeographic Zone. "]

Abstract:
"Benthic communities and their activity are important to ecosystem processes in the polar marine environment. Benthic diversity and production feeds into higher levels of the food chain, benthic remineralization returns nutrients into the water column usable for primary production, and sponge and deep sea coral beds provide structural complexity to habitats and host many associated species. Given the limited spatial coverage of benthic sampling, proxies such as sediment pigment concentration, strong topographic features and polynyas can be used as indicators for benthic production. We used the density of coral and sponge beds, benthic diversity and biomass, benthic remineralization and sediment pigment concentration to identify benthic ecologically and biologically significant areas (EBSA)s in the Canadian Arctic for the Hudson Bay Complex, Eastern Arctic and Western Arctic biogeographic regions. Areas of Hudson Strait have relatively high concentrations of soft corals and sponges compared to other areas within the Hudson Bay Complex, while Baffin Bay-Davis Strait areas in the Eastern Arctic are characterized by large aggregations of sea pens, large gorgonian corals and sponges. In Baffin Bay, particularly important populations of Pennatulacean sea pens are found at the outflow of Lancaster Sound and along the continental slope off Baffin Island. In Davis Strait particularly abundant beds of large gorgonian coral and sponges are found in the Hatton Basin (outflow of Hudson Strait). The Narwhal over-wintering site in Davis Strait has large aggregations of gorgonian corals as well as the rarer black corals. Lancaster Sound and the North Water Polynya areas support high benthic diversity, benthic biomass and high benthic boundary fluxes, as well as still undescribed species such as rare species of enteropneusts. Both polynyas and strong current zones are indicative of high benthic diversity and activity in the Western Arctic, more specifically in Victoria Strait and Franklin Strait. In the Beaufort Sea LOMA, additional benthic EBSAs are suggested in Franklin Bay and the Prince of Wales Strait. There is a large deficiency of data in the Arctic Basin and Canadian Arctic Archipelago, but presence of polynyas in those regions may serve as a proxy of high benthic biodiversity and productivity. "

Reference:
Kenchington, E., Link, H., Roy, V., Archambault, P., Siferd, T., Treble, M., and Wareham, V. 2011. Identification of Mega- and Macrobenthic Ecologically and Biologically Significant Areas (EBSAs) in the Hudson Bay Complex, the Western and Eastern Canadian Arctic. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/071. vi + 52 p.

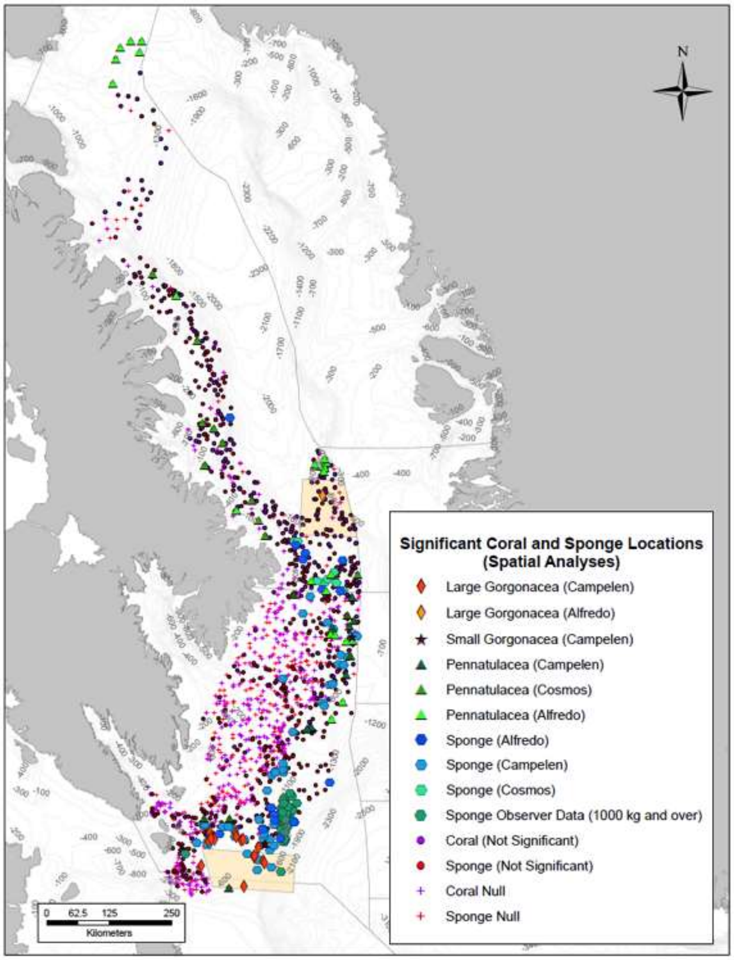


Figure 1.16-2 Location of significant concentrations of gorgonian corals, sea pens and sponges in south and central Baffin Bay and Davis Strait.

[Figure 7 from Kenchington et al. 2011 "Distribution of Location of significant concentrations of gorgonian corals, sea pens and sponges in south and central Baffin Bay and Davis Strait."]

Physical Data

1.17 Seamounts

Abstract:
"Seamounts and knolls are 'undersea mountains', the former rising more than 1000 m from the seafloor. These features provide important habitats for aquatic predators, demersal deep-sea fish and benthic invertebrates. However most seamounts have not been surveyed and their numbers and locations are not well known. Previous efforts to locate and quantify seamounts have used relatively coarse bathymetry grids. Here we use global bathymetric data at 30 arc-second resolution to identify seamounts and knolls. We identify 33,452 seamounts and 138,412 knolls, representing the largest global set of identified seamounts and knolls to date. We compare

estimated seamount numbers, locations, and depths with validation sets of seamount data from New Zealand and Azores. This comparison indicates the method we apply finds 94% of seamounts, but may overestimate seamount numbers along ridges and in areas where faulting and seafloor spreading creates highly complex topography. The seamounts and knolls identified herein are significantly geographically biased towards areas surveyed with shipbased soundings. As only 6.5% of the ocean floor has been surveyed with soundings it is likely that new seamounts will be uncovered as surveying improves. Seamount habitats constitute approximately 4.7% of the ocean floor, whilst knolls cover 16.3%. Regional distribution of these features is examined, and we find a disproportionate number of productive knolls, with a summit depth of o1.5 km, located in the Southern Ocean. Less than 2% of seamounts are within marine protected areas and the majority of these are located within exclusive economic zones with few on the High Seas. The database of seamounts and knolls resulting from this study will be a useful resource for researchers and conservation planners."

Reference:

Yesson, C., et al., The global distribution of seamounts based on 30 arc seconds bathymetry data. Deep-Sea Research I (2011), doi:10.1016/j.dsr.2011.02.004

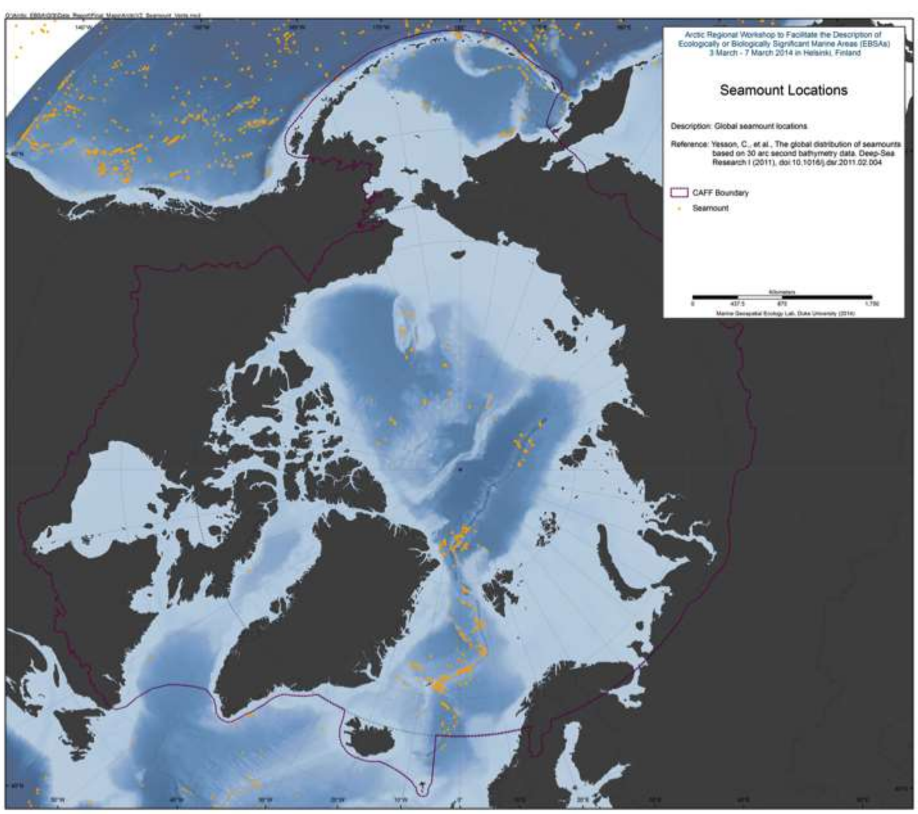


Figure 1.17-1 Seamount Locations

1.18 Vents and Seeps

"ChEss (Chemosynthetic Ecosystem Science) was a field project of the Census of Marine Life programme (CoML). The main aim of ChEss was to determine the biogeography of deep-water chemosynthetic ecosystems at a global scale and to understand the processes driving these ecosystems. ChEss addressed the main questions of CoML on diversity, abundance and distribution of marine species, focusing on deep-water reducing environments such as hydrothermal vents, cold seeps, whale falls, sunken wood and areas of low oxygen that intersect with continental margins and seamounts." (source: http://www.noc.soton.ac.uk/chess/)

"ChEssBase is a dynamic relational database available online since December 2004. The aim of ChEssBase is to provide taxonomical, biological, ecological and distributional data of all species described from deep-water chemosynthetic ecosystems, as well as bibliography and information on the habitats. These habitats include hydrothermal vents, cold seeps, whale falls, sunken wood and areas of minimum oxygen that intersect with the continental margin or seamounts.

Since the discovery of hydrothermal vents in 1977 and of cold seep communities in 1984, over 500 species from vents and over 200 species from seeps have been described (Van Dover et al., 2002. Science 295: 1253-1257). The discovery of chemosynthetically fuelled communities on benthic OMZs and large organic falls to the deep-sea such as whales and wood have increased the number of habitats and fauna for investigation. New species are continuously being discovered and described from sampling programmes around the globe."
(source: http://www.noc.soton.ac.uk/chess/database/db_home.php)

ChEssBase: http://www.noc.soton.ac.uk/chess/database/db_home.php
InterRidge: http://www.interridge.org/irvents/maps

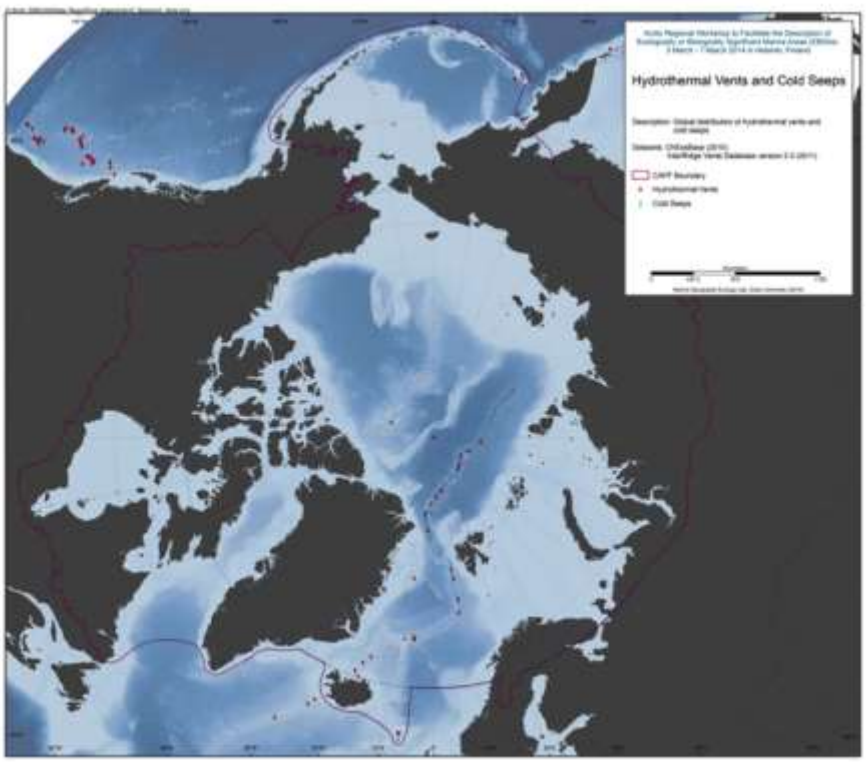


Figure 1.18-1 Hydrothermal Vents and Cold Seeps

1.19 International Bathymetric Chart of the Arctic Ocean (IBCAO), Version 3.0

"The goal of this initiative is to develop a digital data base that contains all available bathymetric data north of 64° North, for use by mapmakers, researchers, institutions, and others whose work requires a detailed and accurate knowledge of the depth and the shape of the Arctic seabed.

IBCAO Version 3.0 represents the largest improvement since 1999 taking advantage of new data sets collected by the circum-Arctic nations, opportunistic data collected from fishing vessels, data acquired from US Navy submarines and from research ships of various nations. Built using an improved gridding algorithm, this new grid is on a 500 meter spacing, revealing much greater details of the Arctic seafloor than IBCAO Version 1.0 (2.5 km) and Version 2.0 (2.0 km). The area covered by multibeam surveys has increased from ~6 % in Version 2.0 to ~11% in Version 3.0. " (source: http://www.ibcao.org)

Jakobsson, M., L. A. Mayer, B. Coakley, J. A. Dowdeswell, S. Forbes, B. Fridman, H. Hodnesdal, R. Noormets, R. Pedersen, M. Rebesco, H.-W. Schenke, Y. Zarayskaya A, D. Accettella, A. Armstrong, R. M. Anderson, P. Bienhoff, A. Camerlenghi, I. Church, M. Edwards, J. V. Gardner, J. K. Hall, B. Hell, O. B. Hestvik, Y. Kristoffersen, C. Marcussen, R. Mohammad, D. Mosher, S. V. Nghiem, M. T. Pedrosa, P. G. Travaglini, and P. Weatherall, The International Bathymetric Chart of the Arctic Ocean (IBCAO) Version 3.0, Geophysical Research Letters, doi: 10.1029/2012GL052219.

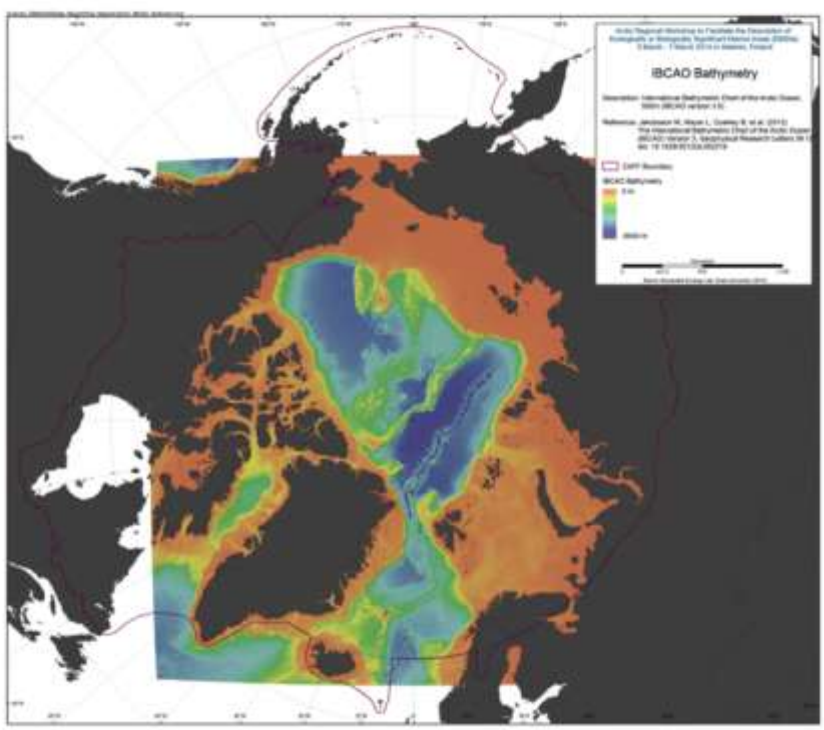


Figure 1.19-1 IBCAO Bathymetry

1.20 Distribution of Large Submarine Canyons

Abstract:
"The aim of this study is to assess the global occurrence of large submarine canyons to provide context and guidance for discussions regarding canyon occurrence, distribution, geological and oceanographic significance and conservation. Based on an analysis of the ETOPO1 data set, this study has compiled the first inventory of 5849 separate large submarine canyons in the world ocean. Active continental margins contain 15% more canyons (2586, equal to 44.2% of all canyons) than passive margins (2244, equal to 38.4%) and the canyons are steeper, shorter, more dendritic and more closely spaced on active than on passive continental margins. This study confirms observations of earlier workers that a relationship exists between canyon slope and canyon spacing (increased canyon slope correlates with closer canyon spacing). The greatest canyon spacing occurs in the Arctic and the Antarctic whereas canyons are more closely spaced in the Mediterranean than in other areas."

Reference:
Harris and Whiteway 2011. Global distribution of large submarine canyons: Geomorphic differences between active and passive continental margins. Marine Geology 285 (2011) 6986. doi:10.1016/j.margeo.2011.05.008

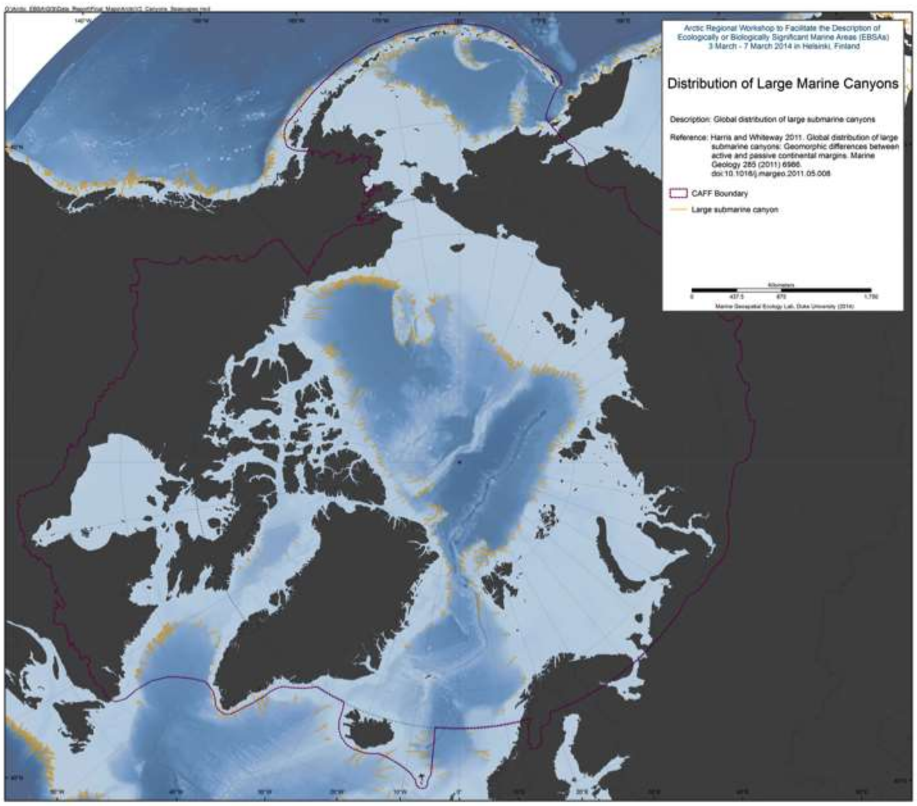


Figure 1.20-1 Large Marine Canyons

1.21 Total Sediment Thickness of the Worlds Oceans & Marginal Seas

“A digital total-sediment-thickness database for the world's oceans and marginal seas has been compiled by the NOAA National Geophysical Data Center (NGDC). The data were gridded with a grid spacing of 5 arc-minutes by 5 arc-minutes. Sediment-thickness data were compiled from three principle sources: (i) previously published isopach maps including Ludwig and Houtz [1979], Matthias et al. [1988], Divins and Rabinowitz [1990], Hayes and LaBrecque [1991], and Divins [2003]; (ii) ocean drilling results, both from the Ocean Drilling Program (ODP) and the Deep Sea Drilling Project (DSDP); and (iii) seismic reflection profiles archived at NGDC as well as seismic data and isopach maps available as part of the IOC's International Geological-Geophysical Atlas of the Pacific Ocean [Udinstev, 2003].

The distribution of sediments in the oceans is controlled by five primary factors:

1. Age of the underlying crust
2. Tectonic history of the ocean crust
3. Structural trends in basement
4. Nature and location of sediment source, and
5. Nature of the sedimentary processes delivering sediments to depocenters

The sediment isopach contour maps for the Pacific were digitized by Greg Cole of Los Alamos National Laboratory, for the Indian Ocean by Carol Stein of Northwestern University, and the South Atlantic and Southern Ocean by Dennis Hayes of Lamont-Doherty Earth Observatory. The digitized data were then gridded at NGDC using the algorithm for "Gridding with Continuous Curvature Splines in Tension" of Smith and Wessel [1990].

The data values are in meters and represent the depth to acoustic basement. It should be noted that acoustic basement may not actually represent the base of the sediments. These data are intended to provide a minimum value for the thickness of the sediment in a particular geographic region. Data are not available for all locations.”
(source: http://www.ngdc.noaa.gov/mgg/sedthick/sedthick.html)

Reference: Divins, D.L., NGDC Total Sediment Thickness of the World's Oceans & Marginal Seas, Data retrieved 25 January 2012, http://www.ngdc.noaa.gov/mgg/sedthick/sedthick.html

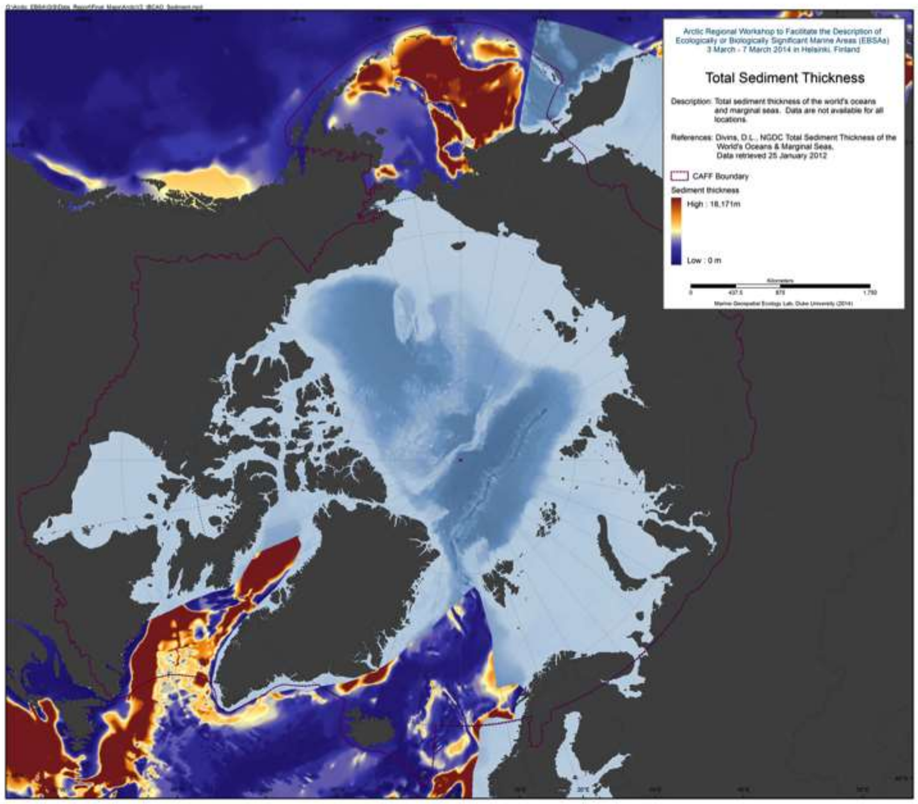


Figure 1.21-1 Total Sediment Thickness

1.22 Global Seascapes

Abstract:
"Designing a representative network of high seas marine protected areas (MPAs) requires an acceptable scheme to classify the benthic (as well as the pelagic) bioregions of the oceans. Given the lack of sufficient biological information to accomplish this task, we used a multivariate statistical method with 6 biophysical variables (depth, seabed slope, sediment thickness, primary production, bottom water dissolved oxygen and bottom temperature) to objectively classify the ocean floor into 53,713 separate polygons comprising 11 different categories, that we have termed seascapes. A cross-check of the seascape classification was carried out by comparing the seascapes with existing maps of seafloor geomorphology and seabed sediment type and by GIS analysis of the number of separate polygons, polygon area and perimeter/area ratio. We conclude that seascapes, derived using a multivariate statistical approach, are biophysically meaningful subdivisions of the ocean floor and can be expected to contain different biological associations, in as much as different geomorphological units do the same. Less than 20% of some seascapes occur in the high seas while other seascapes are largely confined to the high seas, indicating specific types of environment whose protection and conservation will require international cooperation. Our study illustrates how the identification of potential sites for high seas marine protected areas can be accomplished by a simple GIS analysis of seafloor geomorphic and seascape classification maps. Using this approach, maps of seascape and geomorphic heterogeneity were generated in which heterogeneity hotspots identify themselves as MPA candidates. The use of computer aided mapping tools removes subjectivity in the MPA design process and provides greater confidence to stakeholders that an unbiased result has been achieved.

Shallow, continental shelf areas <200 m in depth were excluded from the analysis, since the focus here is on the deep ocean and high sea areas. Also, due to the limited coverage of some data sets, the Arctic Ocean, Mediterranean Sea and a rectangular area south of Japan were also excluded."

Reference:
Harris and Whiteway 2009. High seas marine protected areas: Benthic environmental conservation priorities from a GIS analysis of global ocean biophysical data. Ocean & Coastal Management 52 2238. doi:10.1016/j.ocecoaman.2008.09.009

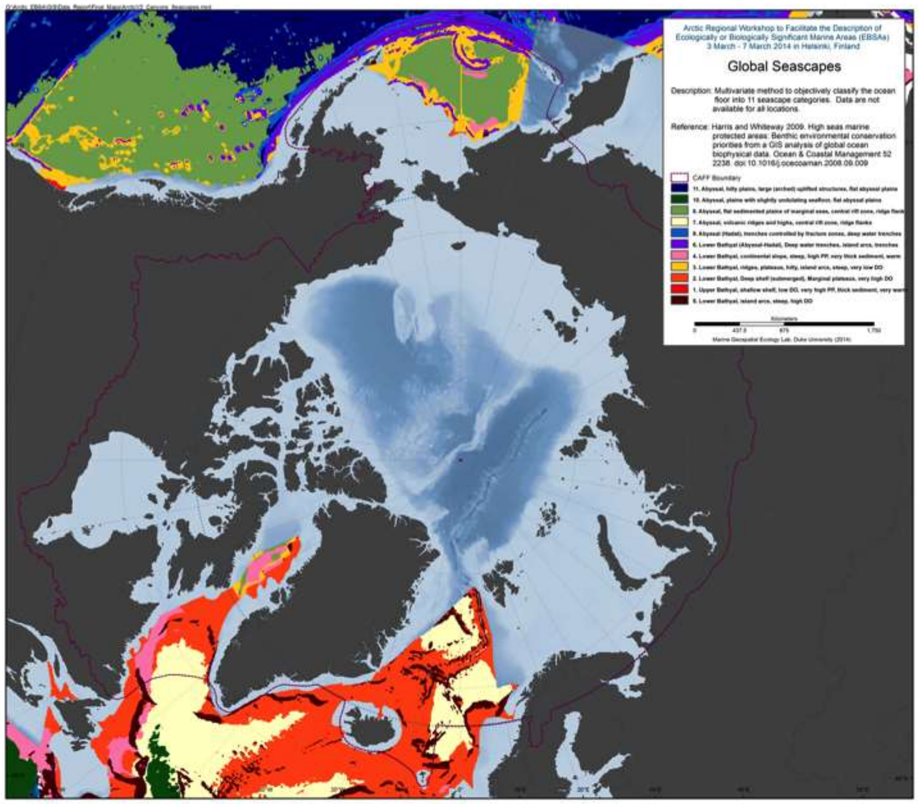


Figure 1.22-1 Global Seascapes

1.23 Seafloor Geomorphology

Abstract:
"We present the first digital seafloor geomorphic features map (GSFM) of the global ocean. The GSFM includes 131,192 separate polygons in 29 geomorphic feature categories, used here to assess differences between passive and active continental margins as well as between 8 major ocean regions (the Arctic, Indian, North Atlantic, North Pacific, South Atlantic, South Pacific and the Southern Oceans and the Mediterranean and Black Seas). The GSFM provides quantitative assessments of differences between passive and active margins: continental shelf width of passive margins (88 km) is nearly three times that of active margins (31 km); the average width of active slopes (36 km) is less than the average width of passive margin slopes (46 km); active margin slopes contain an area of 3.4 million km^2 where the gradient exceeds 5°, compared with 1.3 million km^2 on passive margin slopes; the continental rise covers 27 million km^2adjacent to passive margins and less than 2.3 million km^2 adjacent to active margins. Examples of specific applications of the GSFM are presented to show that: 1) larger rift valley segments are generally associated with slow-spreading rates and smaller rift valley segments are associated with fast spreading; 2) polar submarine canyons are twice the average size of non-polar canyons and abyssal polar regions exhibit lower seafloor roughness than non-polar regions, expressed as spatially extensive fan, rise and abyssal plain sediment deposits – all of which are attributed here to the effects of continental glaciations; and 3) recognition of seamounts as a separate category of feature from ridges results in a lower estimate of seamount number compared with estimates of previous workers."

Reference:
Harris PT, Macmillan-Lawler M, Rupp J, Baker EK Geomorphology of the oceans. Marine Geology. doi: 10.1016/j.margeo.2014.01.011

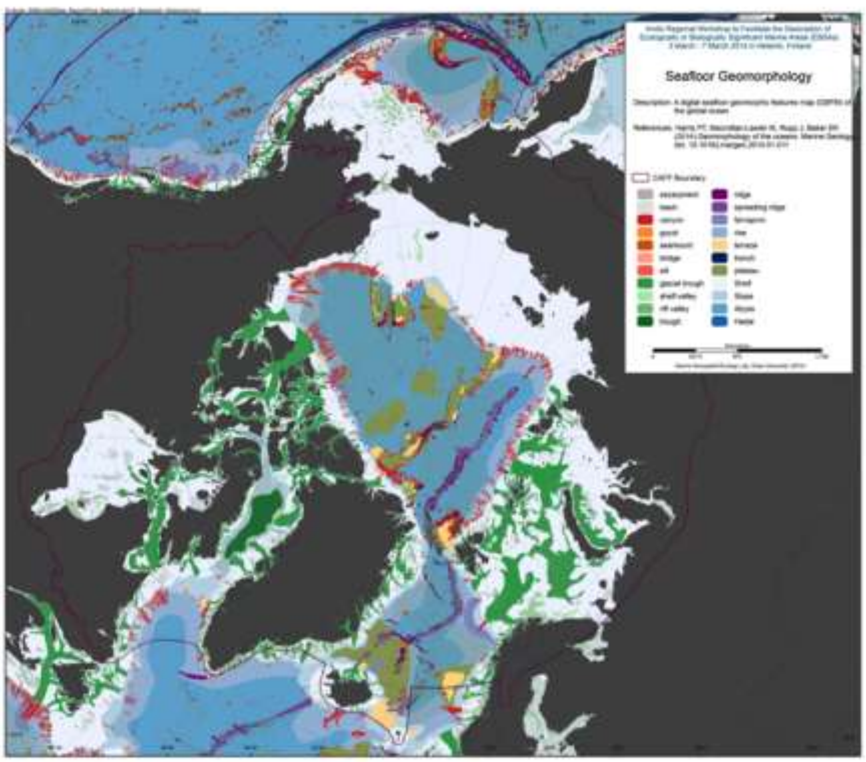


Figure 1.23-1 Seafloor Geomorphology

1.24 Sea Ice Concentration and Occurrence

Abstract:
"The U.S. National Ice Center (NIC) is an inter-agency sea ice analysis and forecasting center comprised of the Department of Commerce/NOAA, the Department of Defense/U.S. Navy, and the Department of Homeland Security/U.S. Coast Guard components. Since 1972, NIC has produced Arctic and Antarctic sea ice charts. This data set is comprised of Arctic sea ice concentration climatology derived from the NIC weekly or biweekly operational ice-chart time series. The charts used in the climatology are from 1972 through 2007; and the monthly climatology products are median, maximum, minimum, first quartile, and third quartile concentrations, as well as frequency of occurrence of ice at any concentration for the entire period of record as well as for 10-year and 5-year periods.

NIC charts are produced through the analyses of available in situ, remote sensing, and model data sources. They are generated primarily for mission planning and safety of navigation. NIC charts generally show more ice than do passive microwave derived sea ice concentrations, particularly in the summer when passive microwave algorithms tend to underestimate ice concentration. The record of sea ice concentration from the NIC series is believed to be more accurate than that from passive microwave sensors, especially from the mid-1990s on (see references at the end of this documentation), but it lacks the consistency of some passive microwave time series."

from http://nsidc.org/data/G02172

Reference:
National Ice Center. 2006, updated 2009. *National Ice Center Arctic sea ice charts and climatologies in gridded format.* Edited and compiled by F. Fetterer and C. Fowler. Boulder, Colorado USA: National Snow and Ice Data Center. http://dx.doi.org/10.7265/N5X34VDB

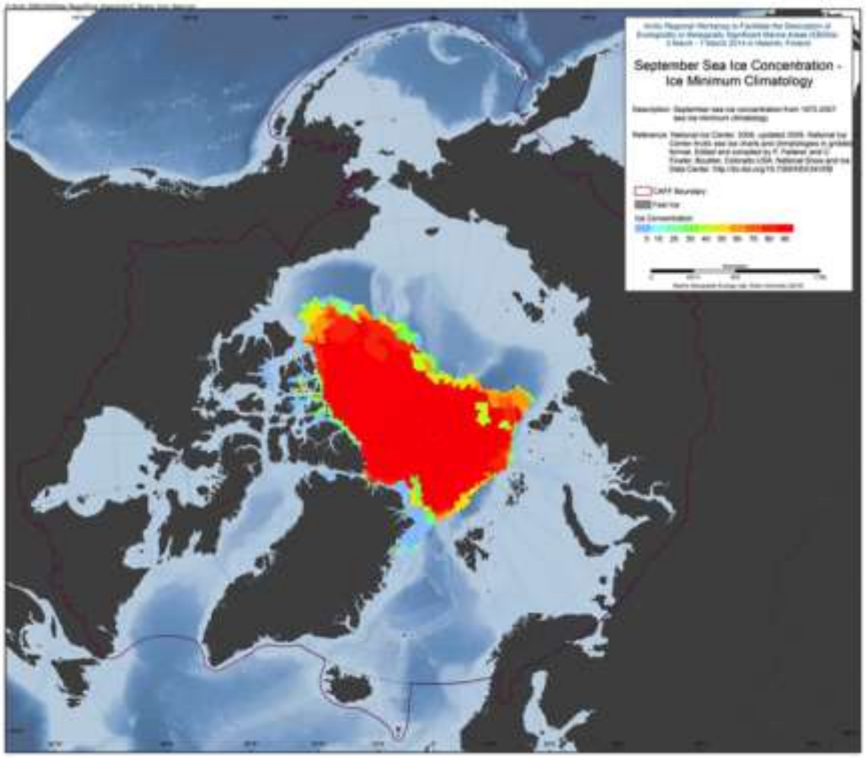


Figure 1.24-1 September Sea-Ice Concentration – Minimum

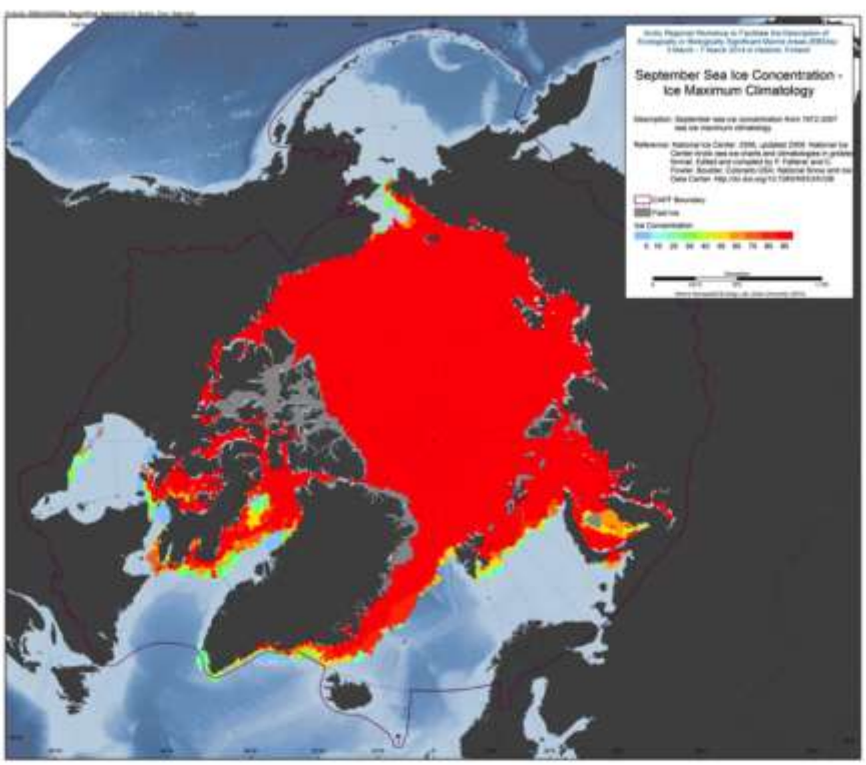


Figure 1.24-2 September Sea-Ice Concentration - Maximum

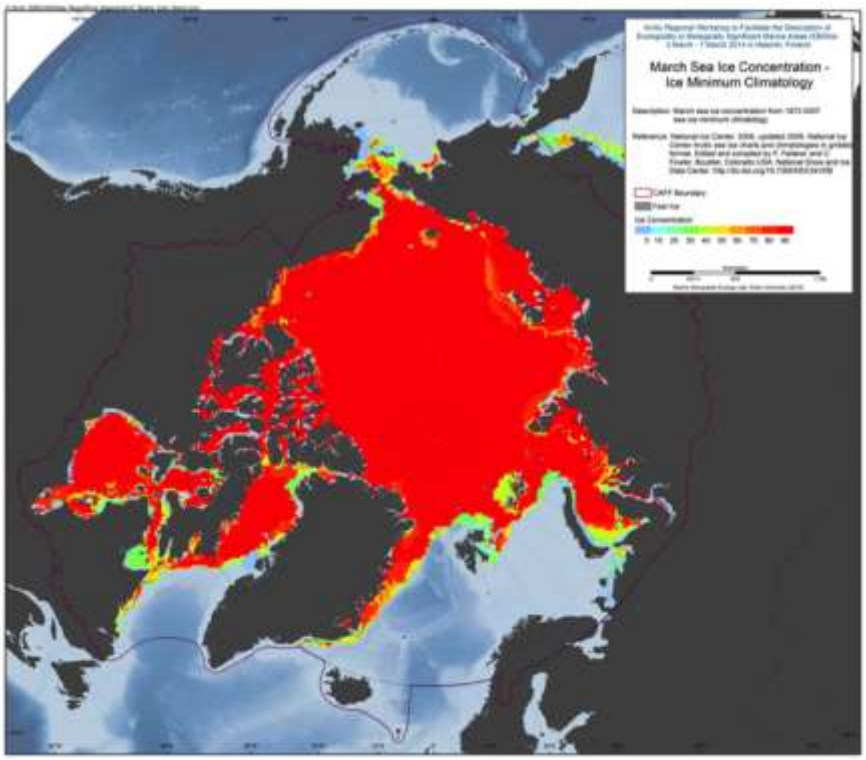


Figure 1.24-3 March Sea-Ice Concentration – Minimum

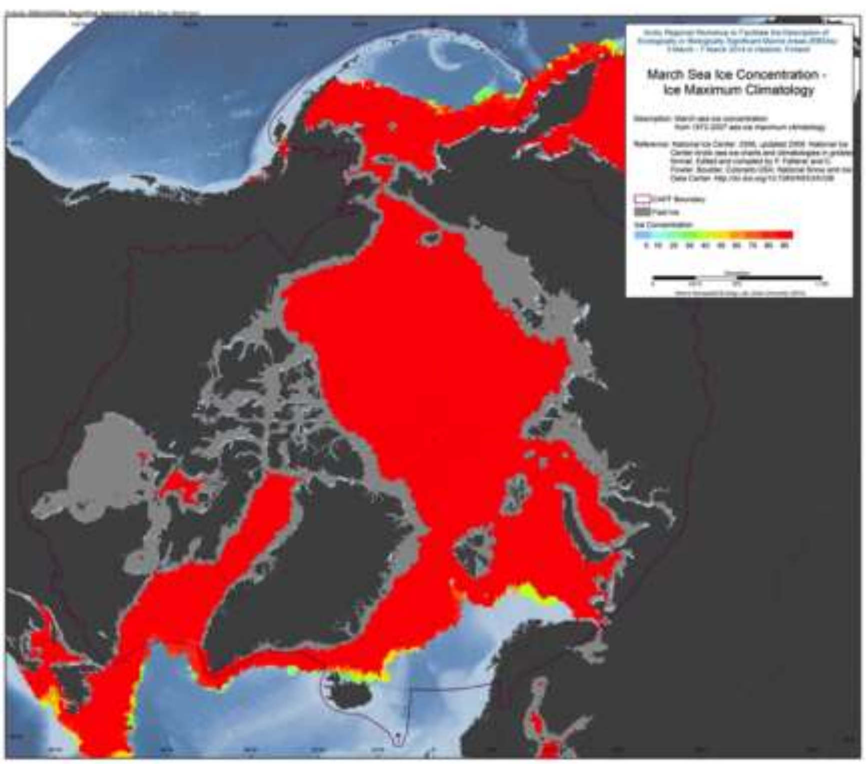


Figure 1.24-4 March Sea-Ice Concentration – Maximum

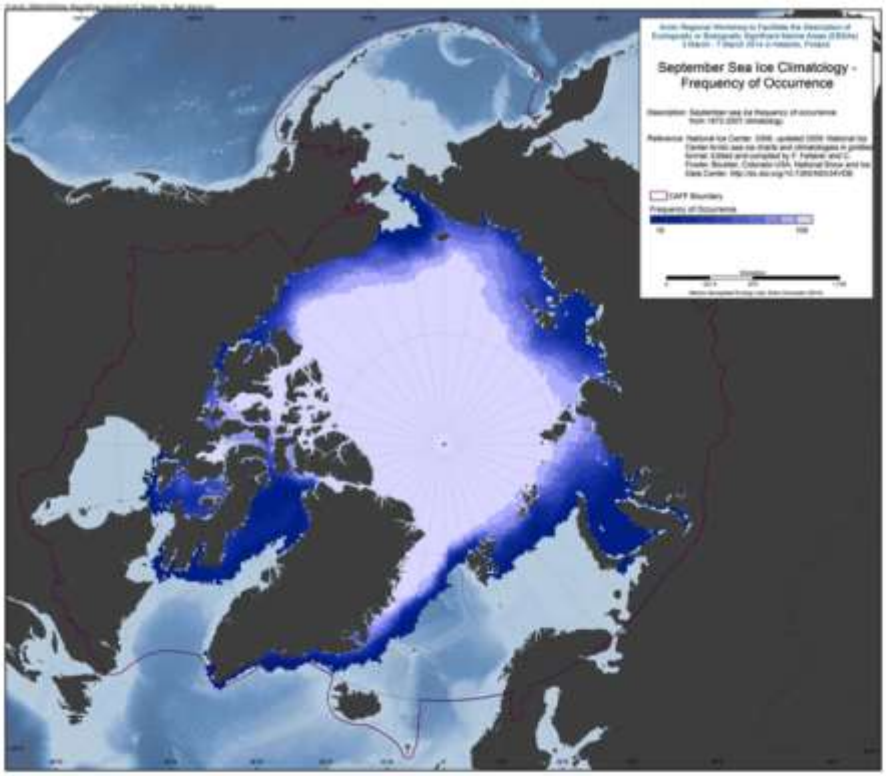


Figure 1.24-5 September Sea-Ice Frequency of Occurrence

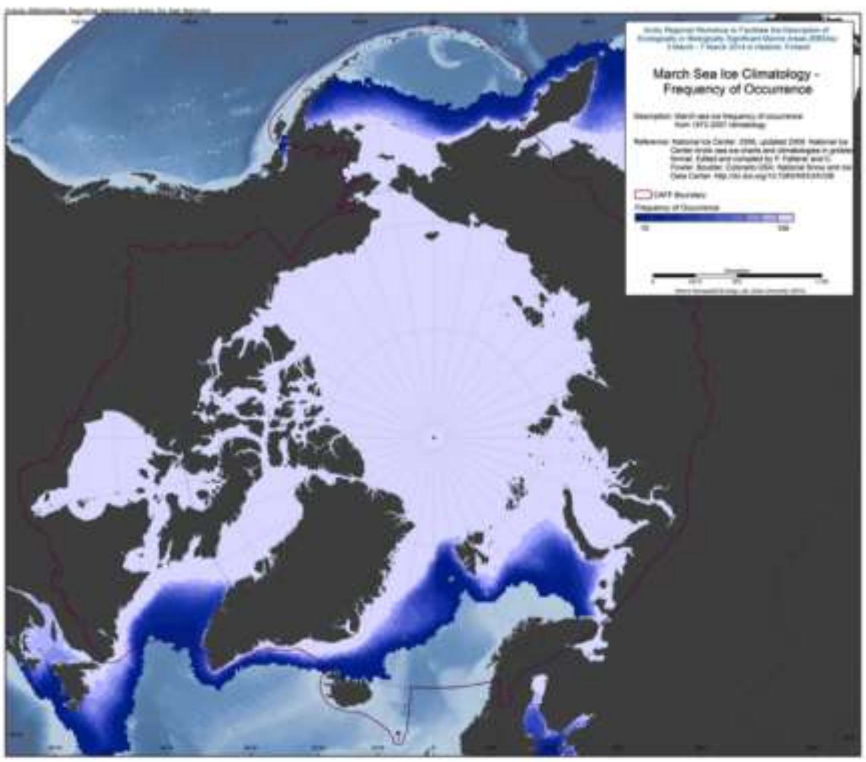


Figure 1.24-6 March Sea-Ice Frequency of Occurrence

1.25 Arctic Regional Climatology

"A set of mean fields for temperature and salinity for the Arctic Seas and environs are available for viewing and downloading.

Area: The area encompassed is all longitudes from 60°N to 90°N latitudes.

Horizontal resolution: Temperature and salinity are available on a 1°x1° and a 1/4°x1/4° latitude/longitude grid.

Time resolution: All climatologies for all variables use all available data regardless of year of measurement. Climatologies were calculated for annual (all-data), seasonal, and monthly time periods. Seasons are as follows: Winter (Jan.-Mar.), Spring (Apr.-Jun.), Summer (Jul.-Aug.), Fall (Oct.-Dec.).

Vertical resolution: Temperature and salinity are available on 87 standard levels with higher vertical resolution than the World Ocean Atlas 2009 (WOA09), but levels extend from the surface to 4000 m.

Units: Temperature units are °C. Salinity is unitless on the Practical Salinity Scale-1978 [PSS].

Data used: All data from the area found in the World Ocean Database (WOD) as of the end of 2011. For a description of this dataset, please see World Ocean Database 2009 Introduction

Method: The method followed for calculation of the mean climatological fields is detailed in the following publications: Temperature: Locarnini et al., 2010, Salinity: Antonov et al., 2010. Additional details on the 1/4° climatological calculation are found in Boyer et al., 2005."

from http://www.nodc.noaa.gov/OC5/regional_climate/arctic/

Reference:
Boyer, T.P., O.K. Baranova, M. Biddle, D.R. Johnson, A.V. Mishonov, C. Paver, D. Seidov and M. Zweng (2012), Arctic Regional Climatology, Regional Climatology Team, NOAA/NODC (www.nodc.noaa.gov/OC5/regional_climate/arctic).

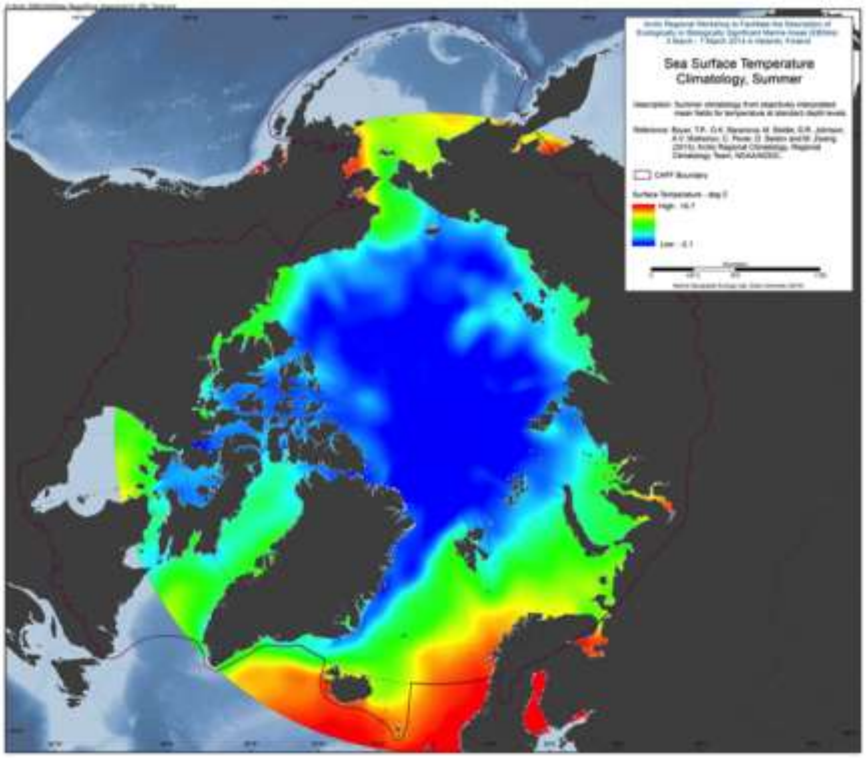


Figure 1.25-1 Arctic Regional Climatology – Summer Surface Temperature

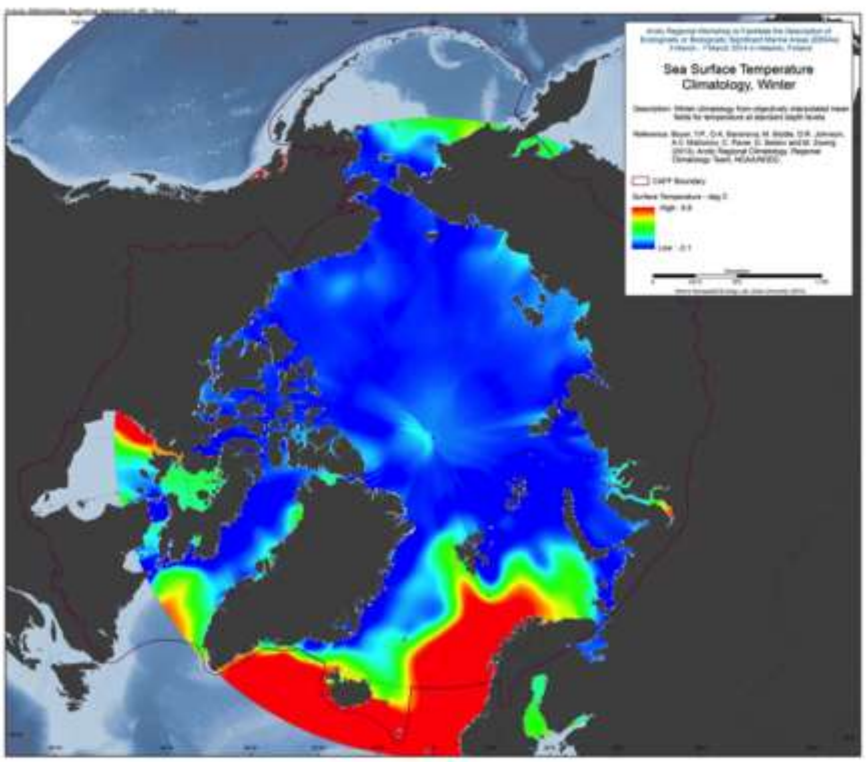


Figure 1.25-2 Arctic Regional Climatology – Winter Surface Temperature

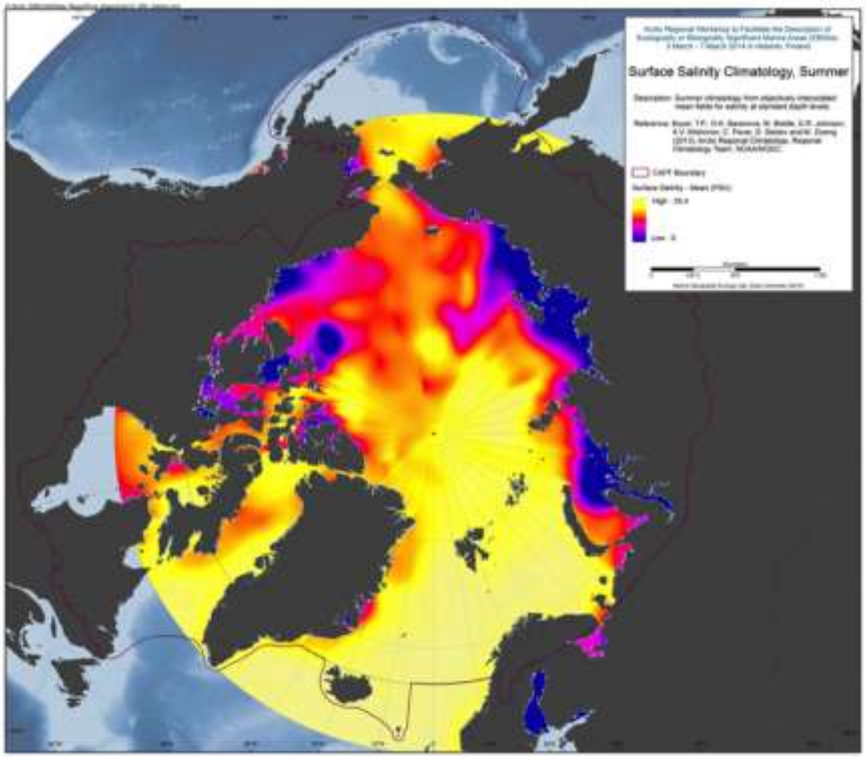


Figure 1.25-3 Arctic Regional Climatology – Summer Surface Salinity

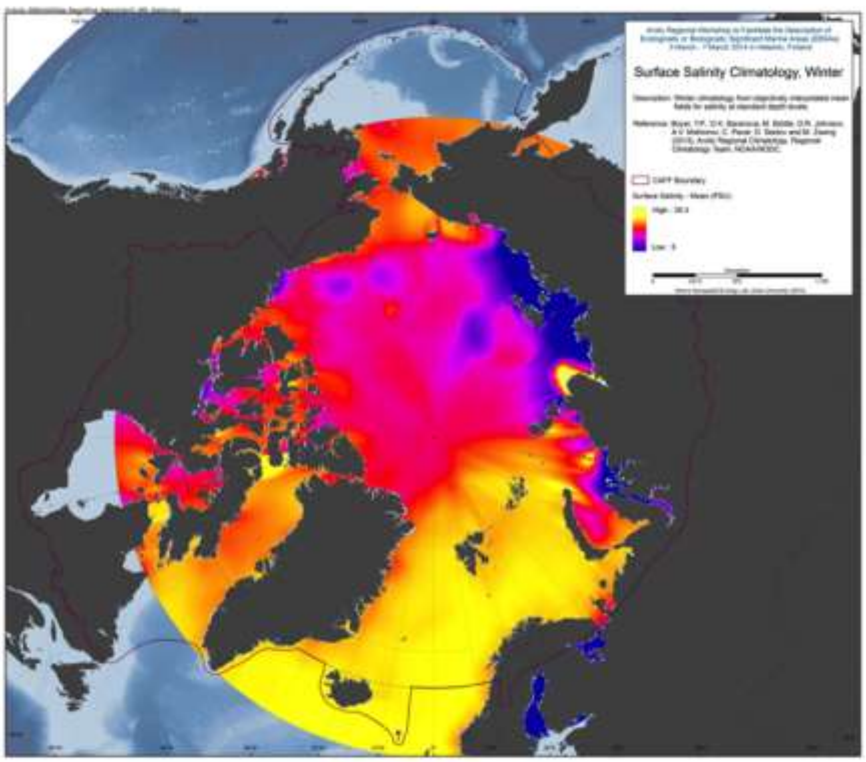


Figure 1.25-4 Arctic Regional Climatology – Winter Surface Salinity

1.26 CSIRO Atlas of Regional Seas (CARS) Physical Ocean Climatologies

For items 4.7.1 through 4.7.6, data were downloaded and processed from the CSIRO Atlas of Regional Seas (CARS).

"CARS is a digital climatology, or atlas of seasonal ocean water properties. It comprises gridded fields of mean ocean properties over the period of modern ocean measurement, and average seasonal cycles for that period. It is derived from a quality-controlled archive of all available historical subsurface ocean property measurements - primarily research vessel instrument profiles and autonomous profiling buoys. As data availability has enormously increased in recent years, the CARS mean values are inevitably biased towards the recent ocean state.

A number of global ocean climatologies are presently available, such as NODC's World Ocean Atlas. CARS is different as it employs extra stages of in-house quality control of input data, and uses an adaptive-lengthscale loess mapper to maximise resolution in data-rich regions, and the mapper's "BAR" algorithm takes account of topographic barriers. The result is excellent definition of oceanic structures and accuracy of point values."
(source: http://www.marine.csiro.au/~dunn/cars2009/)

References:
1. Primary CARS citation:
Ridgway K.R., J.R. Dunn, and J.L. Wilkin, Ocean interpolation by four-dimensional least squares - Application to the waters around Australia, J. Atmos. Ocean. Tech., Vol 19, No 9,1357-1375, 2002

2. Algorithm details:
Dunn J.R., and K.R. Ridgway, Mapping ocean properties in regions of complex topography, Deep Sea Research I : Oceanographic Research, 49 (3) (2002) pp. 591-604

3. CARS seasonal fields and MLD:
Scott A. Condie and Jeff R. Dunn (2006) Seasonal characteristics of the surface mixed layer in the Australasian region: implications for primary production regimes and biogeography. Marine and Freshwater Research, 2006, 57, 1-22.

4. Metadata:
CARS2009 metadata record: MarLIN record: 8539, Anzlic identifier: ANZCW0306008539

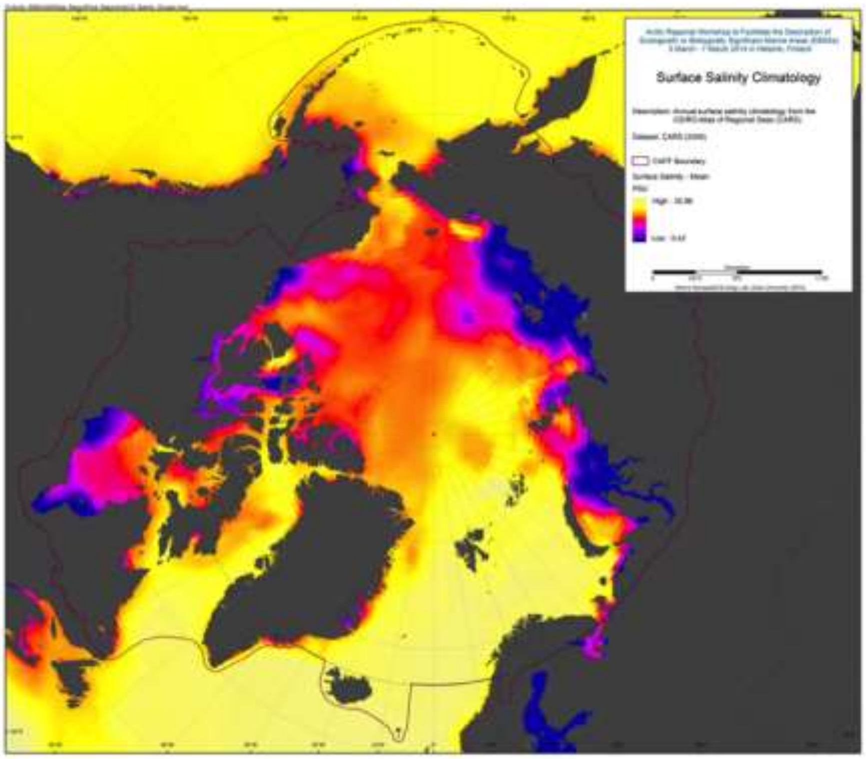


Figure 1.26-1 Surface Salinity Climatology

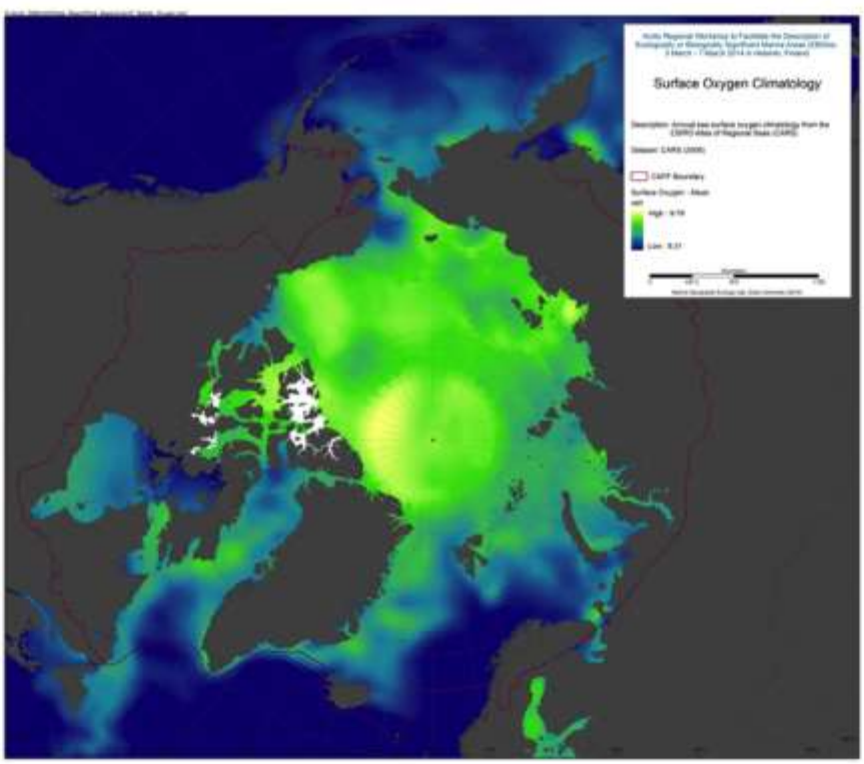


Figure 1.26-2 Surface Oxygen Climatology

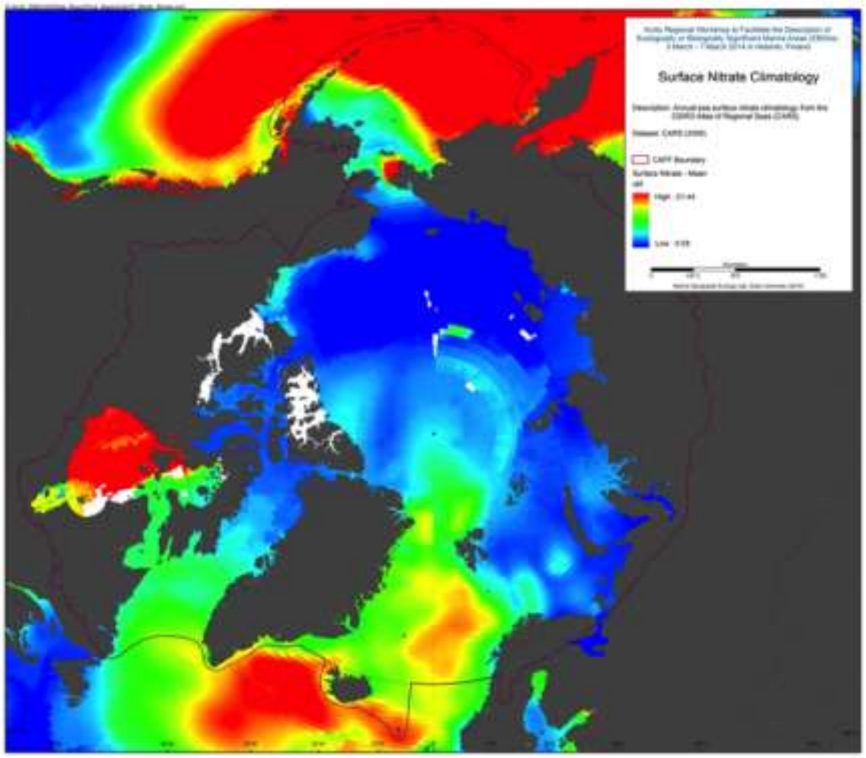


Figure 1.26-3 Surface Nitrate Climatology

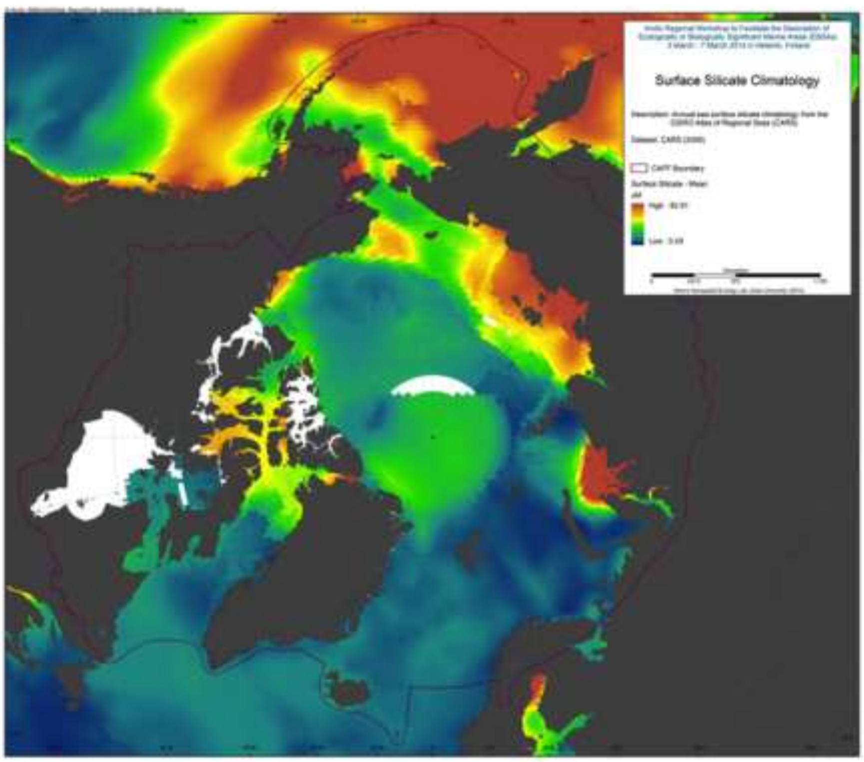


Figure 1.26-4 Surface Silicate Climatology

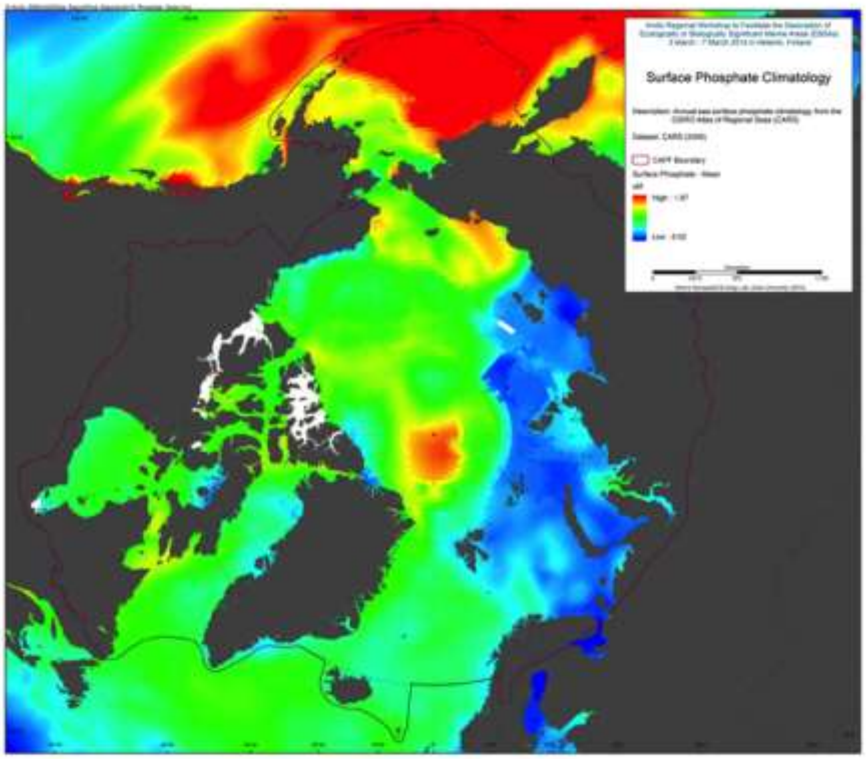


Figure 1.26-5 Surface Phosphate Climatology

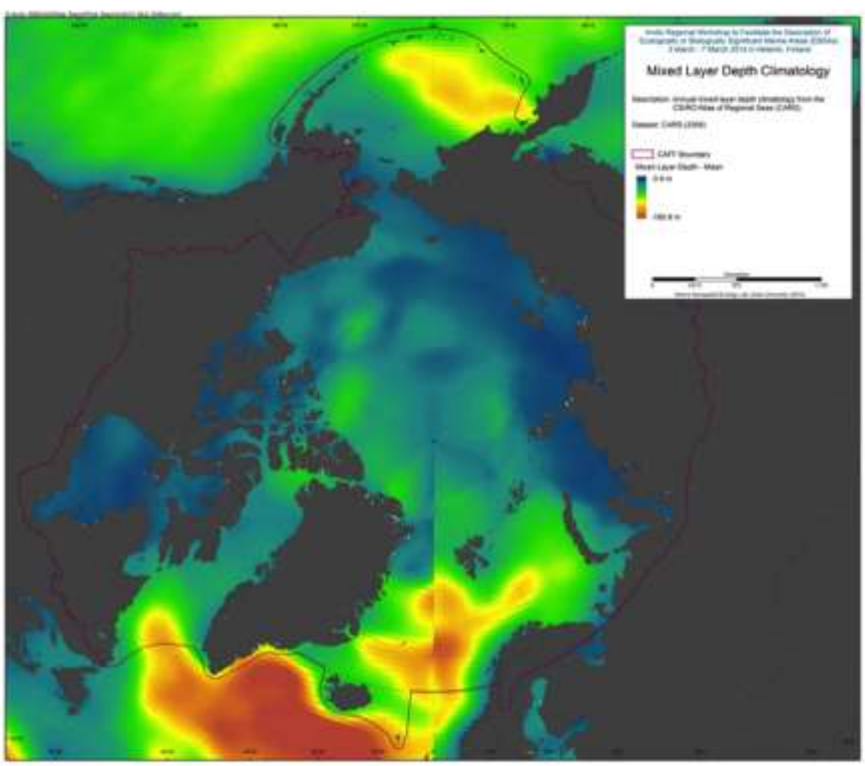


Figure 1.26-6 Mixed Layer Depth Climatology

1.27 Ocean Surface Temperature

The 4k AVHHR Pathfinder dataset, published by the NOAA National Oceanographic Data Center (NODC), provides a global, long-term, high-resolution record of sea surface temperature (SST) using data collected by NOAA's Polar-orbiting Operational Environmental Satellites (POES).

For this effort, monthly cumulative climatologies (1982 - 2009) were created using the "Create Climatological Rasters for AVHHR Pathfinder V5 SST" tool in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010).

References:

Casey,K.S., T.B. Brandon, P. Cornillon, and R. Evans (2010). "The Past, Present and Future of the AVHRR Pathfinder SST Program", in Oceanography from Space: Revisited, eds. V. Barale, J.F.R. Gower, and L. Alberotanza, Springer

Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

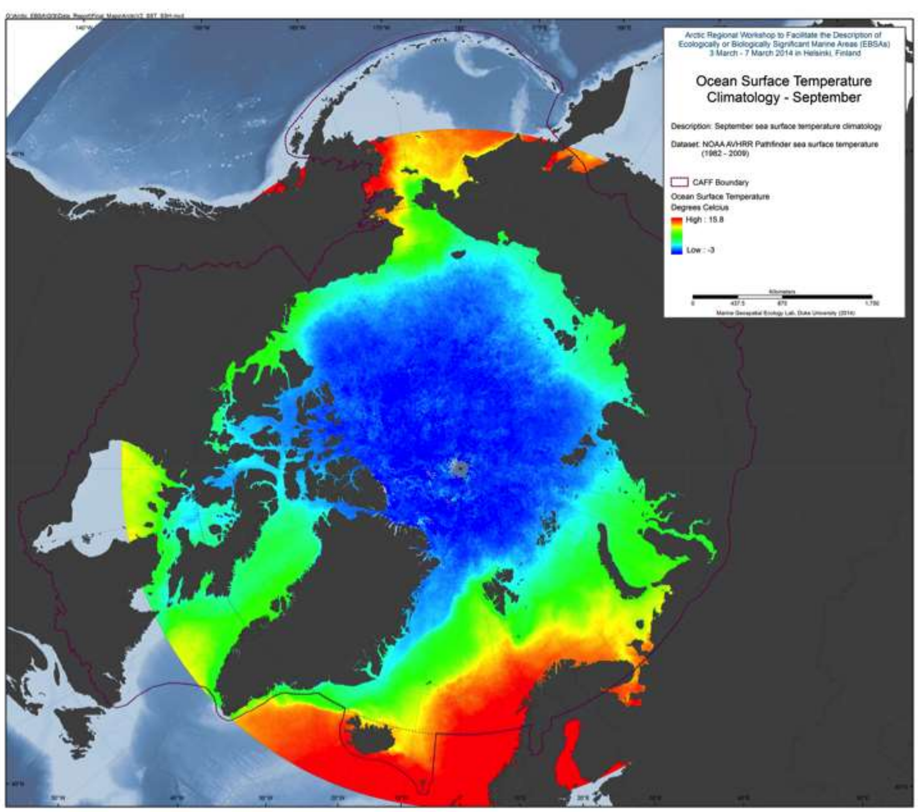


Figure 1.27-1 Ocean Surface Temperature – September Climatology

1.28 Chlorophyll A Climatology

Here, seasonal cumulative (1998-2009) chlorophyll A climatologies were created using the "Create Climatological Rasters for NASA OceanColor L3 SMI Product" tool in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010). This tool uses data from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project. A seasonal climatology was generated for each quarter: January – March, April – June, July – September, October - December.

Reference:
Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

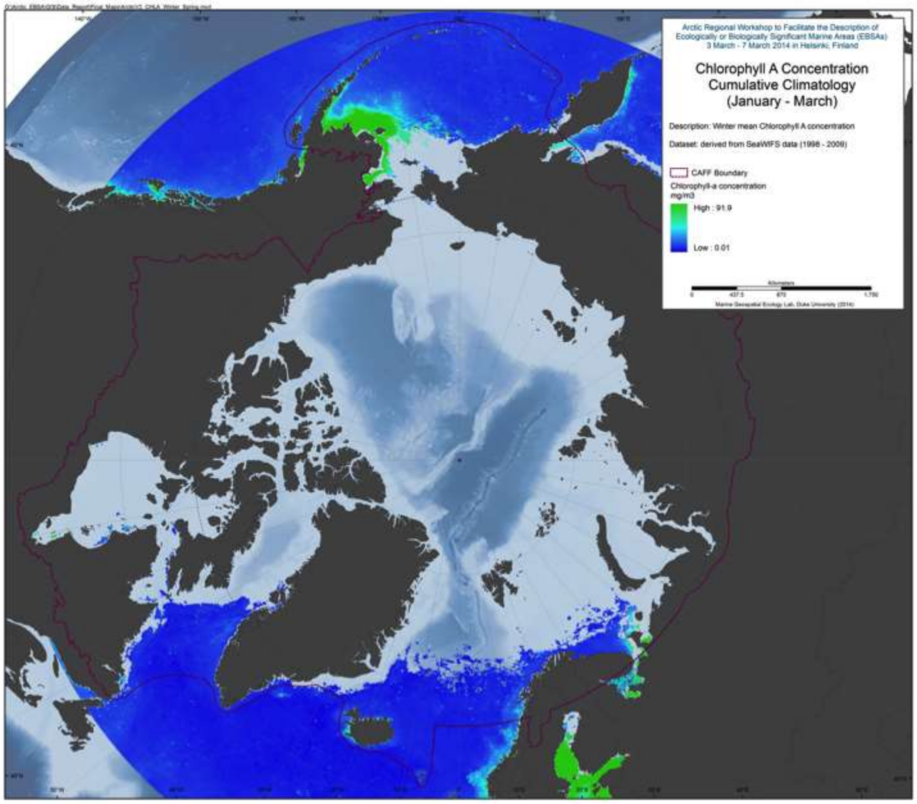


Figure 1.28-1 Chlorophyll A Winter Climatology

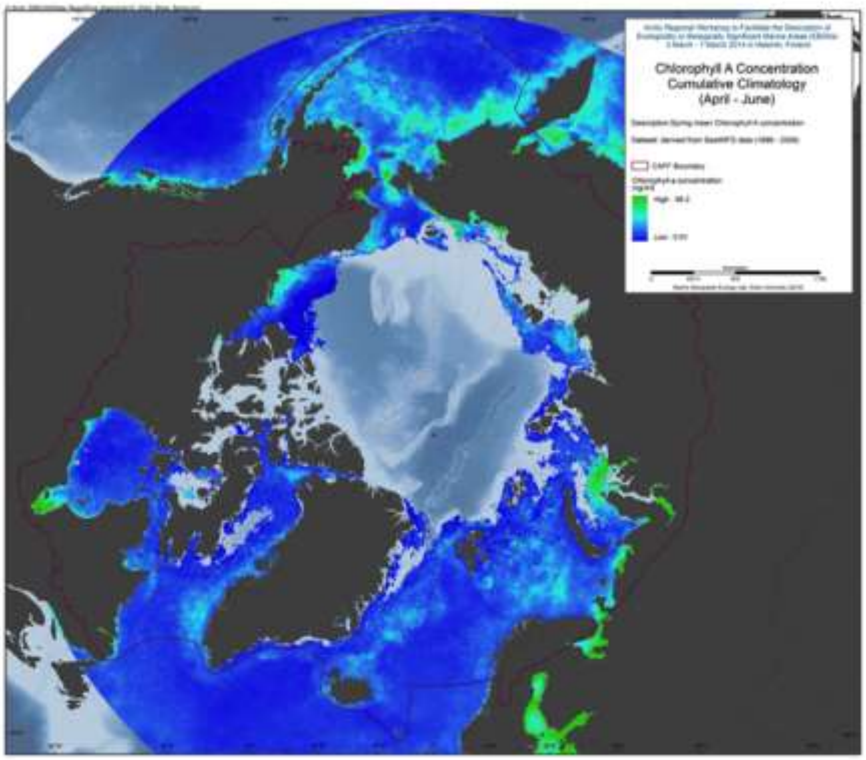


Figure 1.28-2 Chlorophyll A Spring Climatology

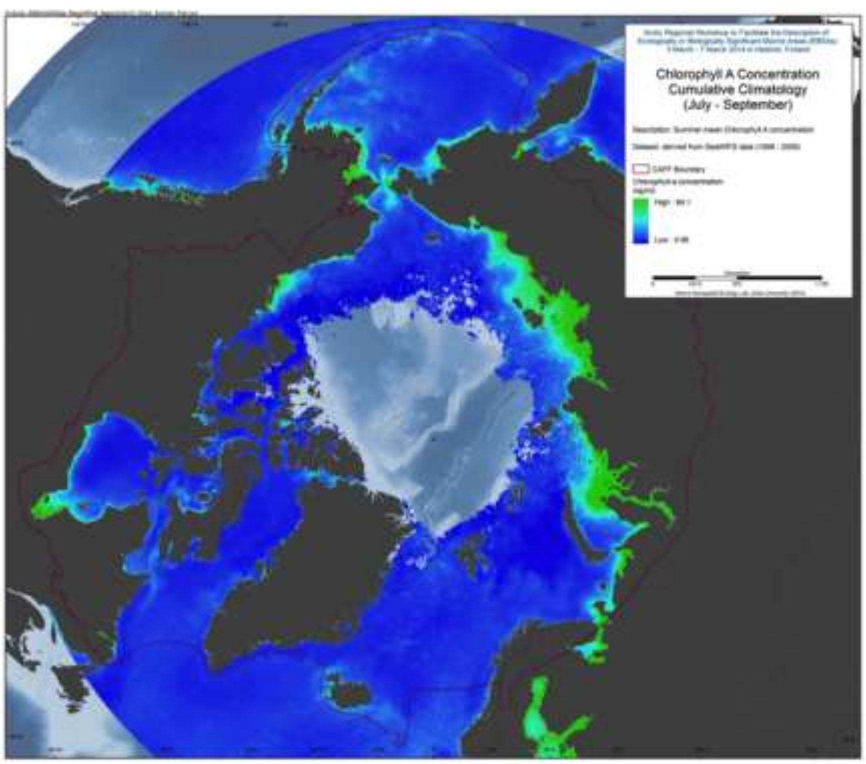


Figure 1.28-3 Chlorophyll A Summer Climatology

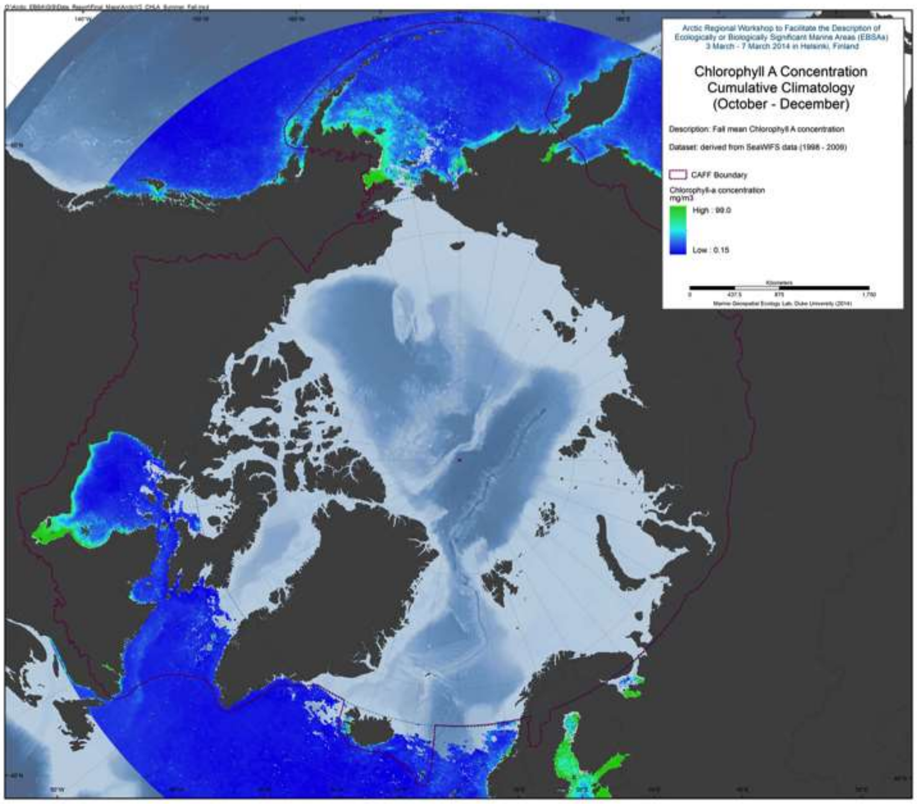


Figure 1.28-4 Chlorophyll A Fall Climatology

1.29 Sea Surface Height

The [Archiving, Validation and Interpretation of Satellite Oceanographic data (AVISO)]() group publishes various products derived from satellite altimetry data, including estimates of sea surface height (SSH), geostrophic currents, wind speed modulus, and significant wave height. To maximize accuracy and spatial and temporal resolution and extent, AVISO merges observations from multiple satellites, including Topex/Poseidon, Jason-1, Jason-2, GFO, ERS-1, ERS-2, and EnviSat. Most Aviso products are one of these "merged" datasets, although a few products are based on observations from a single satellite.
(source: http://code.nicholas.duke.edu/projects/mget)

For this effort monthly climatologies were created from AVISO Global DT-Ref Merged MADT SSH data, from 1993-2011, using the "Create Climatological Rasters for Aviso SSH" tool in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010).

Reference:
Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

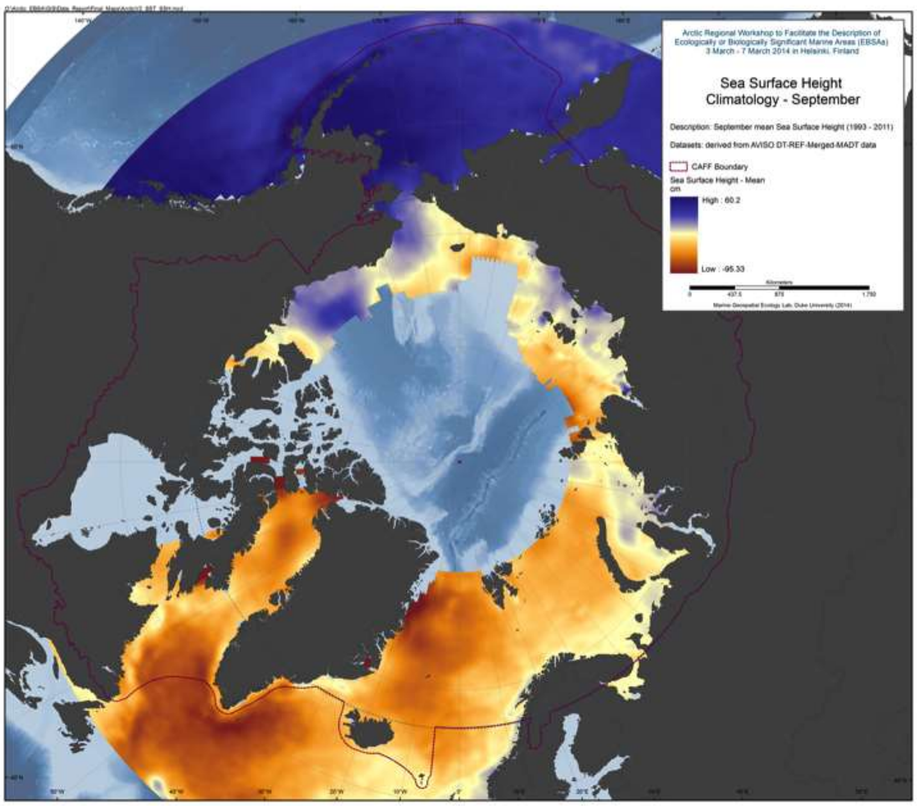


Figure 1.29-1 Sea Surface Height - September Climatology

1.30 Eddy Kinetic Energy

Locations where shear between water masses is high can generate productivity due to mixing. One measure of this mixing is estimated using Eddy Kinetic Energy (EKE). EKE was calculated from the velocity maps based on sea surface height from The Archiving, Validation and Interpretation of Satellite Oceanographic data (AVISO). Using the U and V components from the currents data, EKE is defined as $0.5*(U^2 + V^2)$ and was calculated using AVISO data from 1993-2011, inclusive.

For this effort, a cumulative EKE climatology (1993-2011) was created using the Global DT-Upd Merged Mean Sea Level Anomaly data product in the "Create Climatological Rasters for Aviso Geostrophic Currents Product" tool in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010).

Reference:

Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

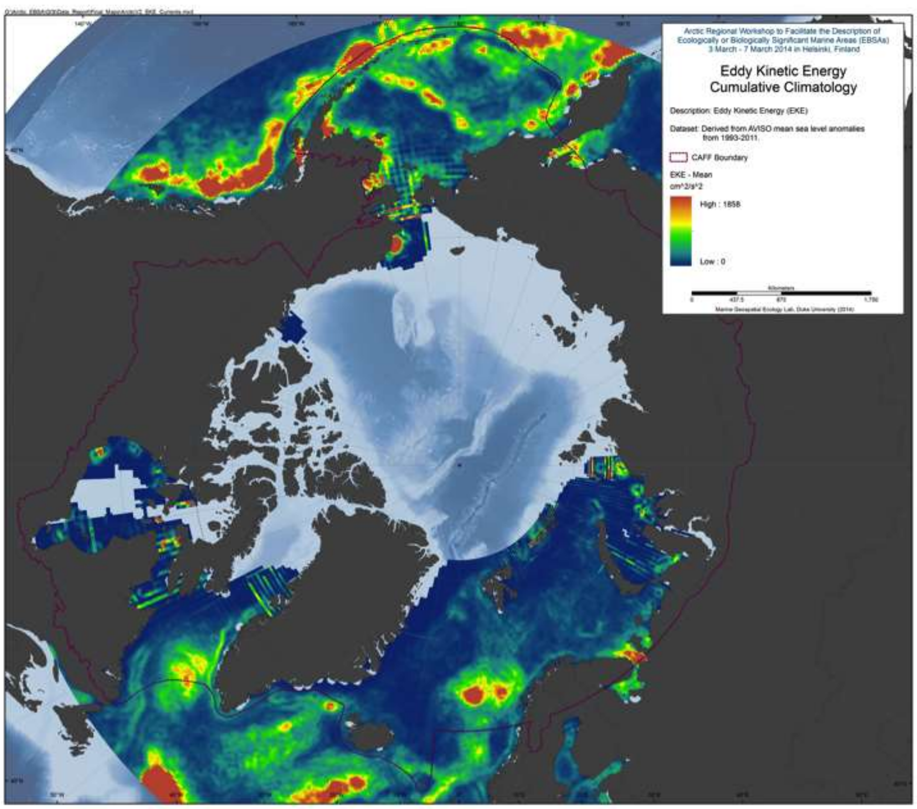


Figure 1.30-1 Eddy Kinetic Energy - Cumulative Climatology

1.31 Drifter Climatology of Near-Surface Currents

"Satellite-tracked SVP drifting buoys (Sybrandy and Niiler, 1991; Niiler, 2001) provide observations of near-surface circulation at unprecedented resolution. In September 2005, the Global Drifter Array became the first fully realized component of the Global Ocean Observing System when it reached an array size of 1250 drifters. A drifter is composed of a surface float which includes a transmitter to relay data, a thermometer which reads temperature a few centimeters below the air/sea interface, and a submergence sensor used to detect when/if the drogue is lost. The surface float is tethered to a subsurface float which minimizes rectification of surface wave motion (Niiler *et al.*, 1987; Niiler *et al.*, 1995). This in turn is tethered to a holey sock drogue, centered at 15 m depth. The drifter follows the flow integrated over the drogue depth, although some slip with respect to this motion is associated with direct wind forcing (Niiler and Paduan, 1995). This slip is greatly enhanced in drifters which have lost their drogues (Pazan and Niiler, 2000). Drifter velocities are derived from finite differencing their raw position fixes. These velocities, and the concurrent SST measurements, are archived at AOML's Drifting Buoy Data Assembly Center where the data are quality controlled and interpolated to 1/4-day intervals (Hansen and Herman, 1989; Hansen and Poulain, 1996). "

Reference:
Lumpkin, R. and Z. Garraffo, 2005: *Evaluating the Decomposition of Tropical Atlantic Drifter Observations*. J. Atmos. Oceanic Techn. I 22, 1403-1415.

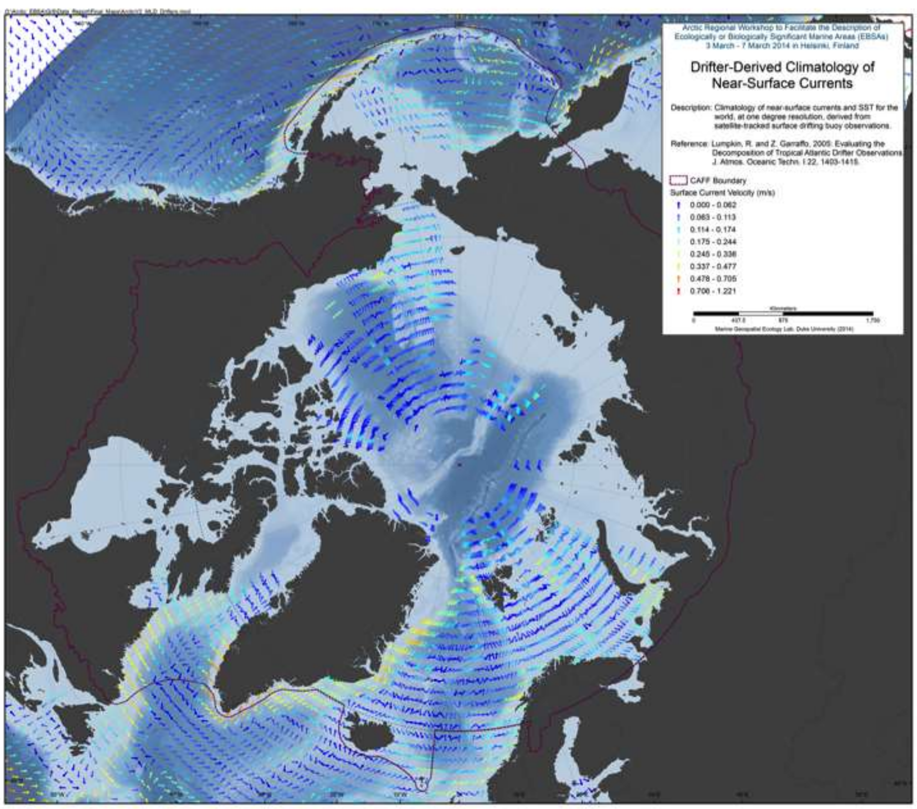


Figure 1.31-1 Drifter-Derived Climatology of Near-Surface Currents

1.32 Surface Current Velocity

The Archiving, Validation and Interpretation of Satellite Oceanographic data (AVISO) group publishes various products derived from satellite altimetry data, including estimates of sea surface height (SSH), geostrophic currents, wind speed modulus, and significant wave height. To maximize accuracy and spatial and temporal resolution and extent, AVISO merges observations from multiple satellites, including Topex/Poseidon, Jason-1, Jason-2, GFO, ERS-1, ERS-2, and EnviSat. Most Aviso products are one of these "merged" datasets, although a few products are based on observations from a single satellite.
(source: http://code.nicholas.duke.edu/projects/mget)

For this effort, cumulative climatologies (1993 - 2011) for ocean current velocity were created using the “Create Climatological Rasters for Aviso Geostrophic Currents Product” tool with the Global DT-Ref Merged MADT product and “mag” (for magnitude) geophysical parameter selected in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010).

References:
Bonjean, F. and Lagerloef, G.S.E. (2002) Diagnostic Model and Analysis of the Surface Currents in the Tropical Pacific Ocean. J. Physical Oceano. 32(10):2938-2954.

Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

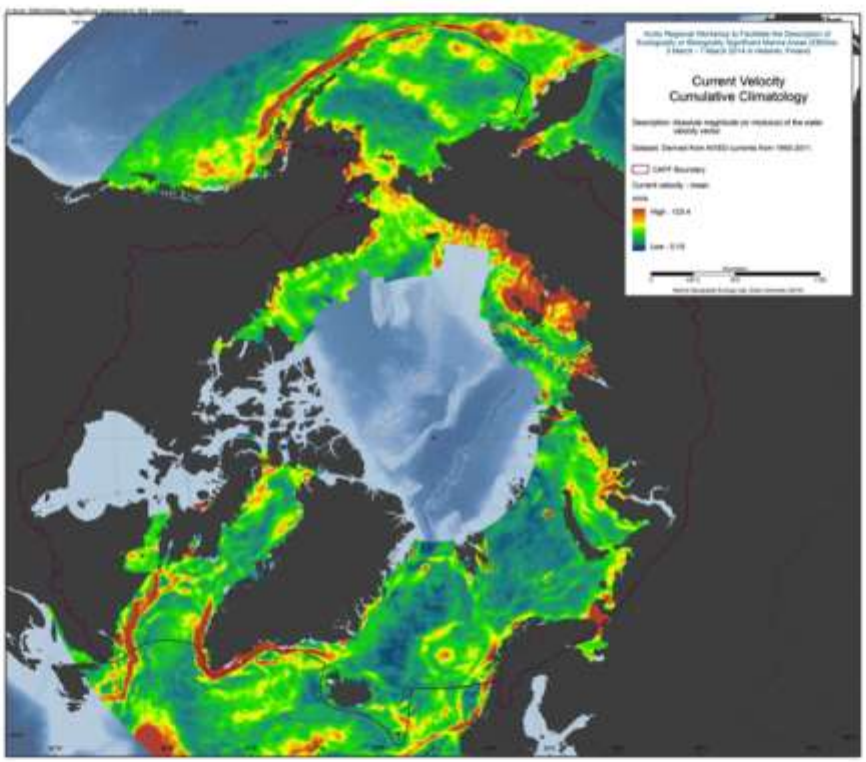


Figure 1.32-1 Surface Current Velocity - Cumulative Climatology

Previous work on EBSA description or similar processes

1.33 Identification of Arctic marine areas of heightened ecological significance

Preface:
"The Arctic Council's 2009 Arctic Marine Shipping Assessment (AMSA) 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. 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."

Reference:
AMAP/CAFF/SDWG, 2013. Identification of Arctic marine areas of heightened ecological and cultural significance: Arctic Marine Shipping Assessment (AMSA) IIc. Arctic Monitoring and Assessment Programme (AMAP), Oslo. 114 pp.

Link: http://www.amap.no/documents/doc/Identification-of-Arctic-marine-areas-of-heightened-ecological-and-cultural-significance-Arctic-Marine-Shipping-Assessment-AMSA-IIc/869

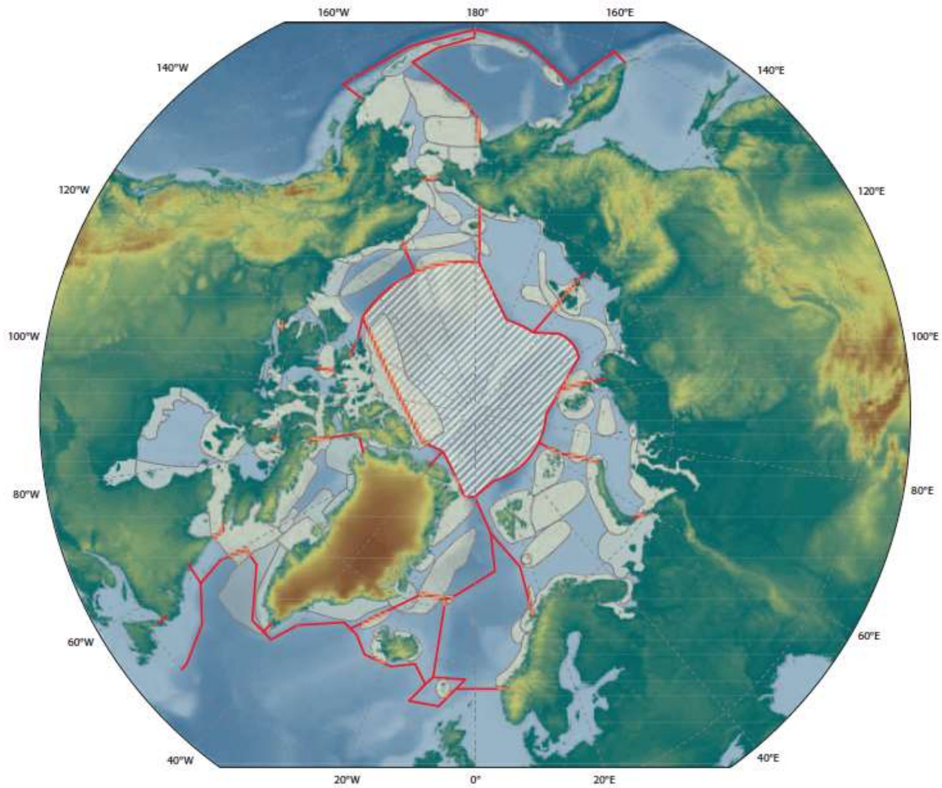


Figure A.17. Map of all the identified Areas of Heightened Ecological Significance in the sixteen Arctic LMEs.

Figure 1.33-1 Areas of heightened ecological significance in the 16 Arctic LMEs

[Figure A.17 from "Identification of Arctic marine areas of heightened ecological and cultural significance: Arctic Marine Shipping Assessment (AMSA) IIc". Documentation on each area is provided in the report and accompanying GIS dataset.]

1.34 IUCN/NRDC Workshop to Identify EBSAs in the Arctic Marine Environment

"The International Union for the Conservation of Nature (IUCN) and the Natural Resources Defense Council (NRDC) have undertaken a project to explore ways of advancing implementation of ecosystem- based management in the Arctic marine environment through invited expert workshops.

The first workshop, held in Washington, D.C. on 16-18 June, 2010, explored possible means to advance policy decisions on ecosystem-based marine management in the Arctic region. Twenty-nine legal and policy experts from around the region participated in the June workshop. The report and recommendations of the June policy workshop can be found here: http://cmsdata.iucn.org/downloads/arctic_workshop_report_final.pdf.

The second workshop, the subject of this report, was held at the Scripps Institution of Oceanography in La Jolla, California on 2-4 November, 2010. The La Jolla workshop utilized criteria developed under auspices of the Convention on Biological Diversity to identify ecologically significant and vulnerable marine areas that should be considered for enhanced protection in any new ecosystem-based management arrangements. A list of participants, the meeting agenda and other relevant documents are attached as appendices to this report."

See http://docs.nrdc.org/oceans/files/oce_11042501a.pdf

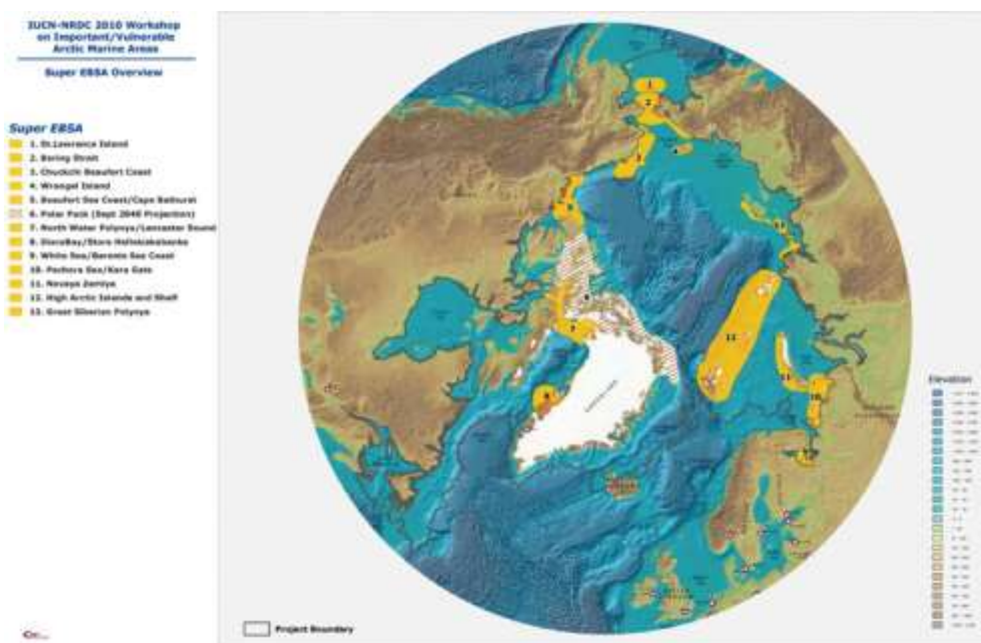


Figure 1.34-1 Super EBSAs as proposed at the IUCN/NRDC Workshop to Identify EBSAs in the Arctic Marine Environment

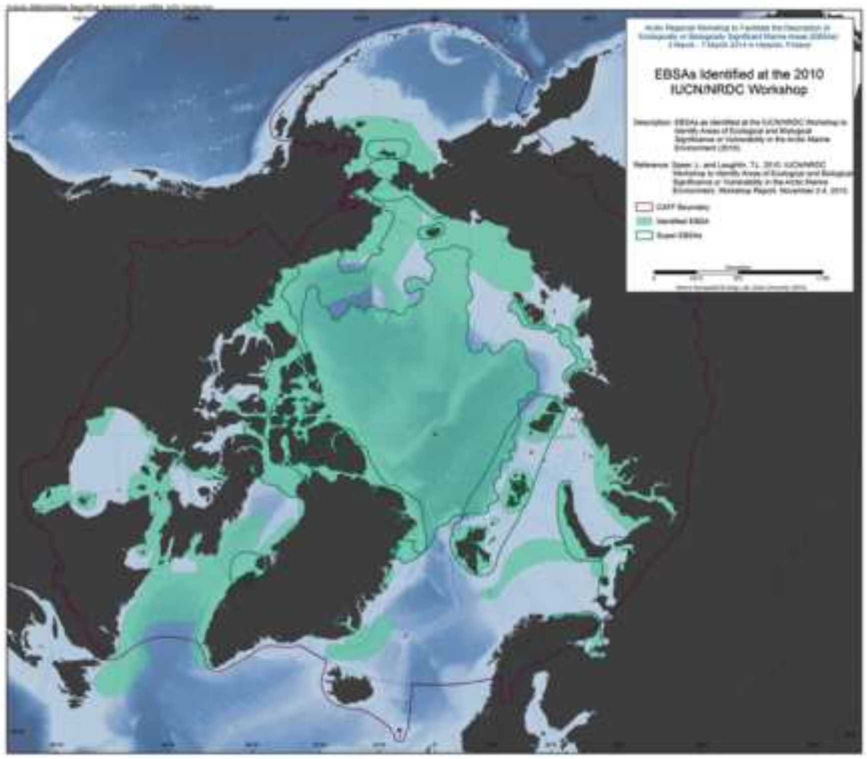


Figure 1.34-2 EBSAs as proposed at the IUCN/NRDC Workshop to Identify EBSAs in the Arctic Marine Environment

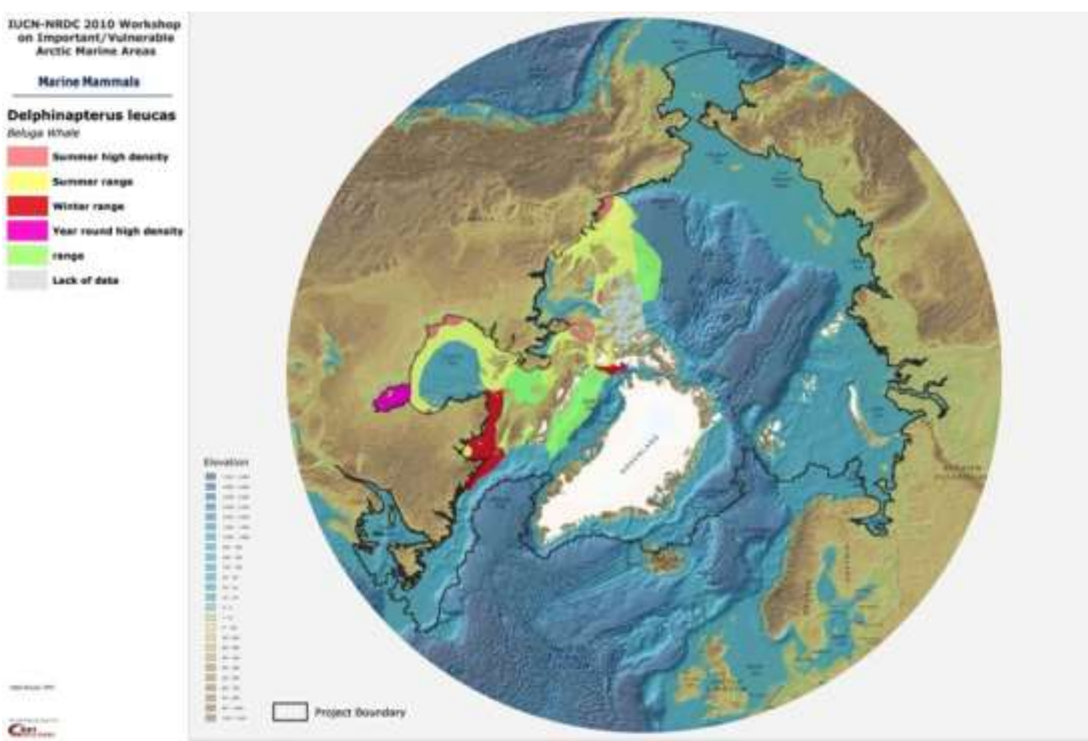


Figure 1.34-3 Beluga whale important areas as prepared for the IUCN/NRDC Workshop to Identify EBSAs in the Arctic Marine Environment

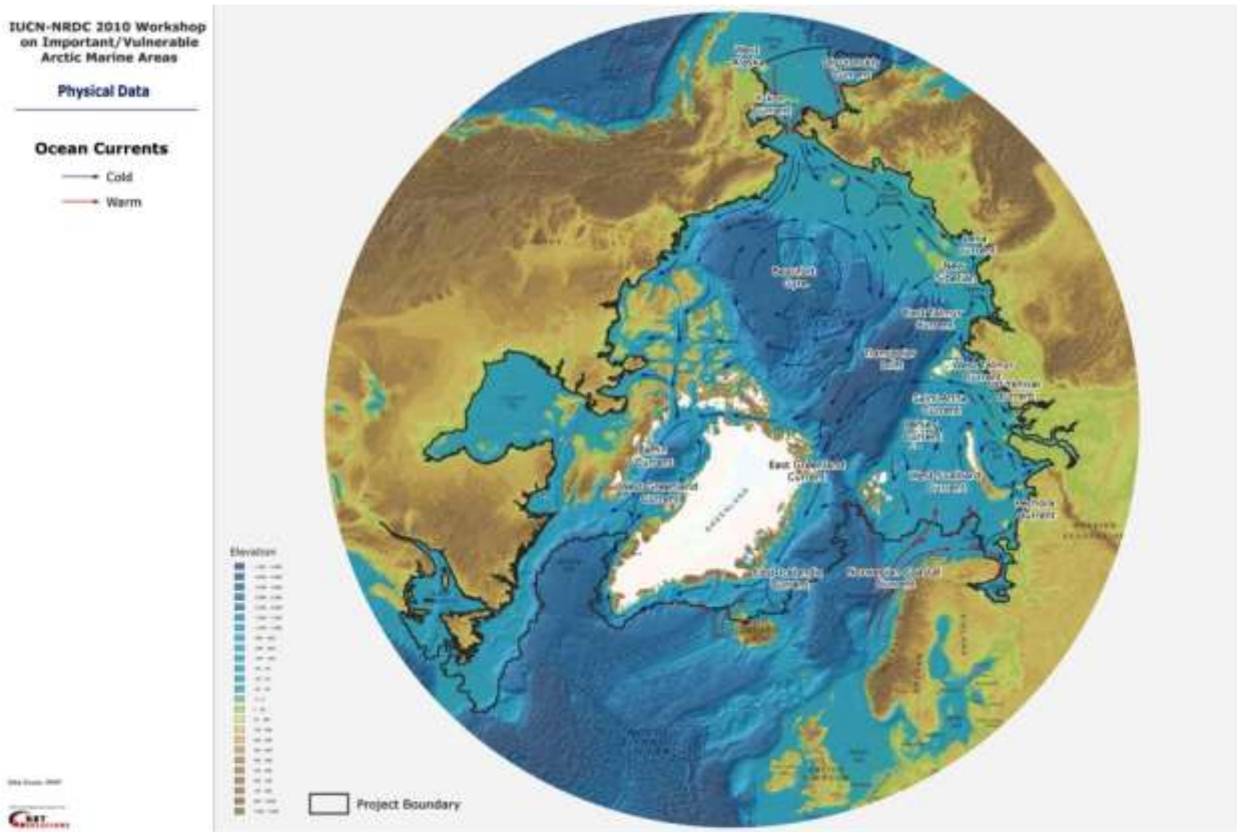


Figure 1.34-4 Ocean currents as prepared for the IUCN/NRDC Workshop to Identify EBSAs in the Arctic Marine Environment

1.35 Identification of Ecologically and Biologically Significant Areas (EBSA) in the Canadian Arctic

"A national Canadian Science Advisory Secretariat (CSAS) science advisory process was held in Winnipeg, Manitoba from June 14-17, 2011 to provide science advice on the identification of Ecologically and Biologically Significant Areas (EBSAs) in the Canadian Arctic based on guidance developed by Fisheries and Oceans Canada. This science advisory process focused on the identification of EBSAs within the following marine biogeographic units: the Hudson Bay Complex, the Arctic Basin, the Western Arctic, the Canadian Arctic Archipelago and the Eastern Arctic. "

Reference:

DFO. 2011. Identification of Ecologically and Biologically Significant Areas (EBSA) in the Canadian Arctic. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/055.

DFO. 2011. Identification of Ecologically and Biologically Significant Areas (EBSAs) in the Canadian Arctic; June 14-17, 2011. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2011/047.

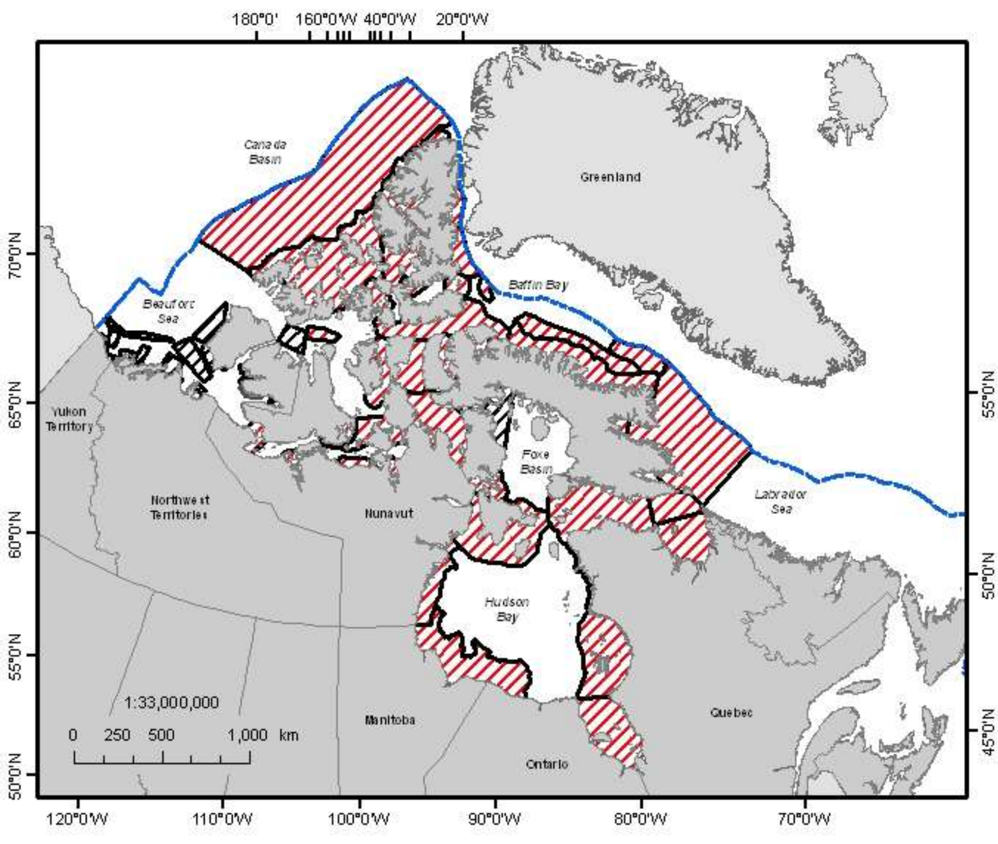


Figure 1.35-1 EBSAs identified within the five Arctic biogeographic regions within Canadian Arctic waters

[Figure 1 from Canadian Science Advisory Secretariat, Science Advisory Report 2011/055]

1.36 Joint OSPAR/NEAFC/CBD Scientific Workshop on the Identification of Ecologically or Biologically Significant Areas (EBSAs) in the North-East Atlantic

“The objective of this scientific workshop was to identify and describe marine areas in the high seas areas in the North-East Atlantic not included in the OSPAR Network of MPAs or the NEAFC Closed Areas but which fulfilled the scientific criteria set out by the CBD (Annex I of CBD Decision IX/20) for Ecologically or Biologically Significant Marine Areas (EBSAs) - with a view to respond to the request by CBD COP 10 (CBD Decision X/29, § 36).”

Reference:
OSPAR/NEAFC/CBD. 2011. Joint OSPAR/NEAFC/CBD Scientific Workshop on the Identification of Ecologically or Biologically Significant Areas (EBSAs) in the North-East Atlantic. Hyeres, France 8-9 September 2011.

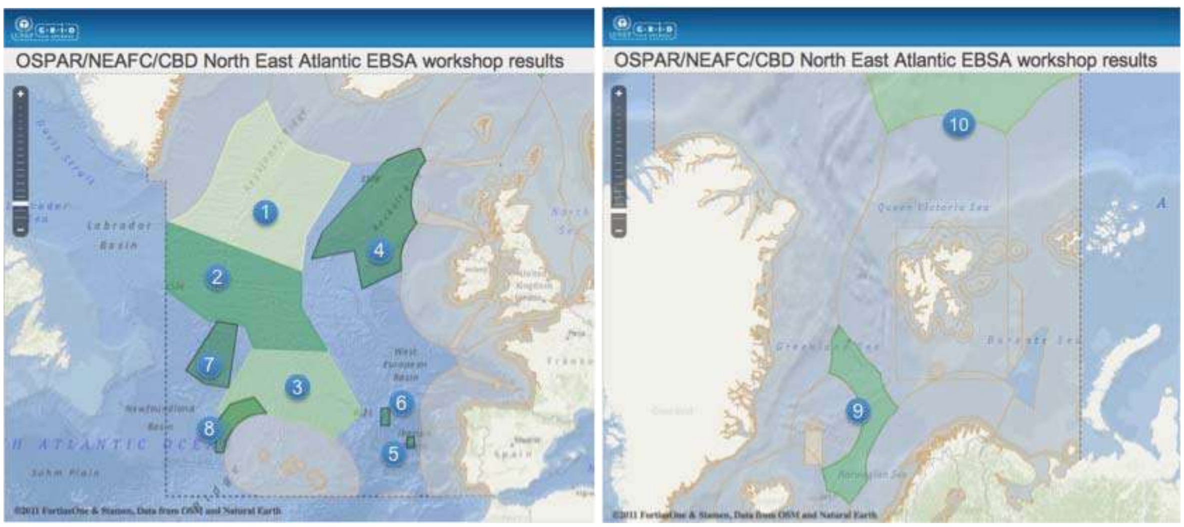


Figure 1.36-1 EBSAs identified in the North-East Atlantic

[Figure 1 from OSPAR/NEAFC/CBD (2011)]

1.37 WWF Important Marine Areas in the Arctic Compilation

"WWF has compiled this document to present much of the available information on description and identification of important marine area in the Arctic.

This document is intended to further facilitate discussions and work within the international community, Arctic Council and among Arctic stakeholders, provide for a full scientific description of important arctic marine areas and help inform the CBD process for the description of EBSAs."

From
http://wwf.panda.org/what_we_do/where_we_work/arctic/publications/?209701/Important-Marine-Areas-in-the-Arctic

Reference:
WWF. 2012. Important Marine Areas in the Arctic. WWF Global Arctic Programme. 24p.

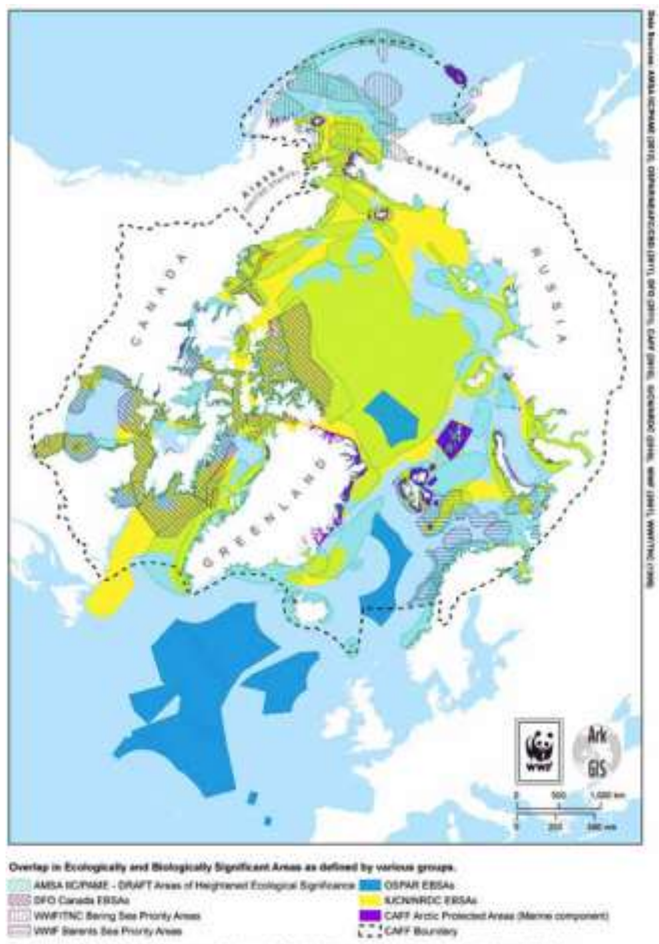


Figure 1.37-1 Overlap in Ecologically and Biologically Significant Areas as defined by Various Groups

[Figure from page 15, WWF (2012)]

Additional Data Resources

Data reports and online resources from several ongoing scientific research programs and planning processes were suggested for the review of workshop attendees.

1.38 Life Linked to Ice: A Guide to Sea-Ice-Associated Biodiversity in this Time of Rapid Change

"*Life Linked to Ice* examines the consequences for biodiversity of the dramatic changes occurring to sea ice. It was prepared by the Conservation of Arctic Flora and Fauna working group (CAFF), and both draws from and builds on Arctic Council assessments in order to present an overview of the state of knowledge about sea-ice-associated biodiversity. The report is intended as a briefing and reference document for policy makers.

Recent changes in Arctic sea ice cover, driven by rising air temperatures, have affected the timing of ice break-up in spring and freeze-up in autumn, as well as the extent and type of ice present in different areas at specific dates. Overall, multi-year ice is rapidly being replaced by first-year ice. The extent of ice is shrinking at all seasons, but especially in the summer. The Arctic Ocean is projected to be virtually ice-free in summer within 30 years, with multi-year ice persisting mainly between islands of the Canadian Arctic Archipelago and in the narrow straits between Canada and Greenland.

The most obvious negative impacts of rapid changes in sea ice are on the species that depend on ice as habitat. They include ice algae, ice amphipods, ringed seals and polar bears. The nature of long-term impacts on species that apparently depend partially on ice is less clear. Examples are the polar cod, the dominant fish of the high Arctic, which is strongly associated with ice but also found in open waters, and seabirds that take advantage of high concentrations of food in the productive ice edge zones for egg laying and chick rearing."

Reference:
Eamer, J., Donaldson, G.M., Gaston, A.J., Kosobokova, K.N., Lárusson, K.F., Melnikov, I.A., Reist, J.D., Richardson, E., Staples, L., von Quillfeldt, C.H. 2013. Life Linked to Ice: A guide to sea-ice-associated biodiversity in this time of rapid change. CAFF Assessment Series No. 10. Conservation of Arctic Flora and Fauna, Iceland. ISBN: 978-9935-431-25-7.

CAFF Website: http://www.caff.is/sea-ice-associated-biodiversity

Download from GRID-ARENDAL (CAFF page was unavailable at time of publication)
http://dev.grida.no/polarweb/Policy/Life_Linked_to_Ice_Oct_2013.pdf

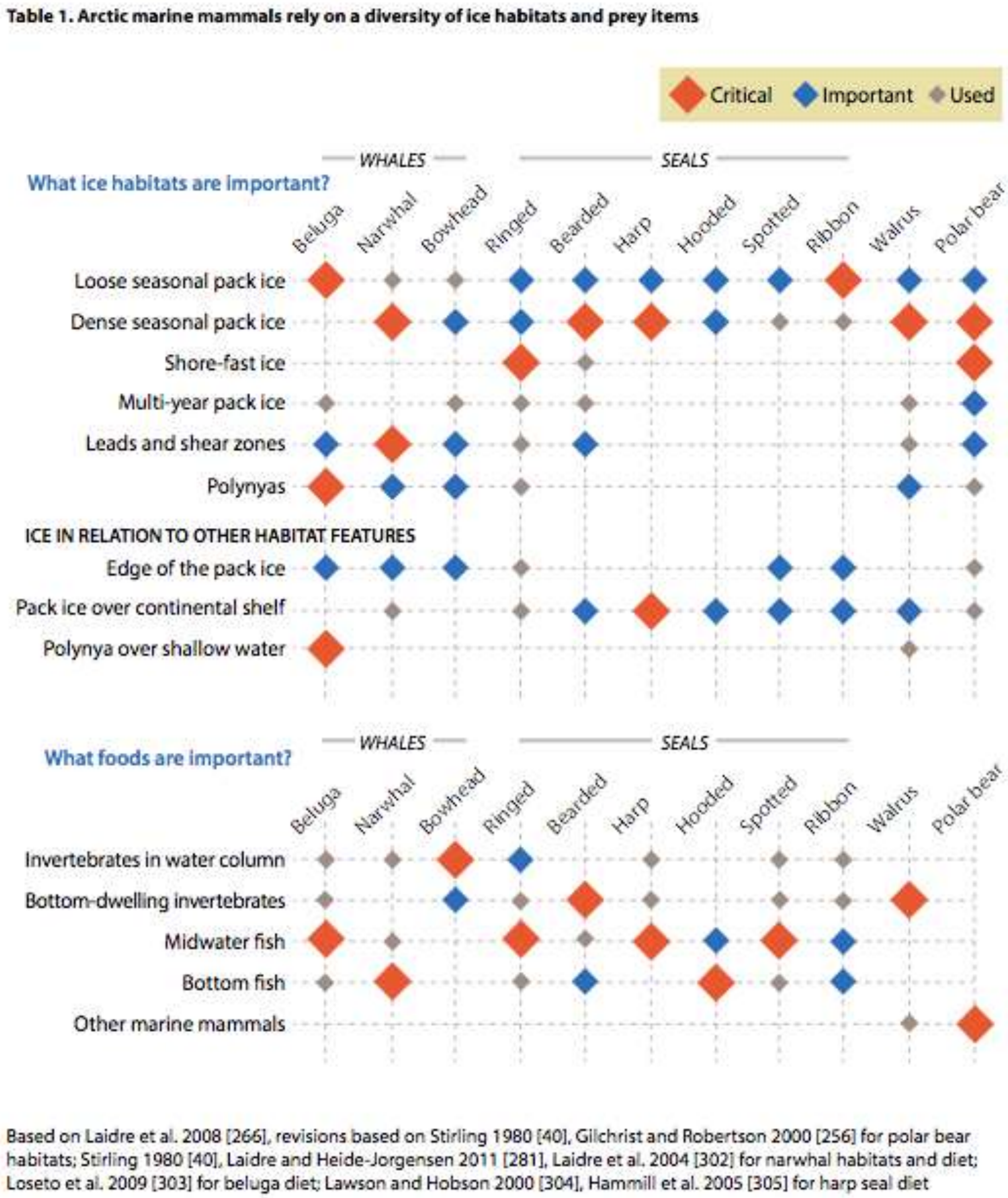


Figure 1.38-1 Ice habitat importance for marine mammals and prey

[Table 1 from Eamer, J. et.al., 2013]

1.39 Arctic Species Trend Index: Tracking Trends in Arctic Marine Populations

“The Arctic Species Trend Index (ASTI) tracks the temporal abundance in 890 populations of 323 vertebrate species. This represents an update of the index first reported on in 2010 (McRae et al. 2010) and shows that average species population abundance in the Arctic has increased over the time period between 1970 and 2007. This pattern, however, is not consistent among regions as vertebrate abundance has increased on average in the low Arctic but not in the high Arctic and sub Arctic. The marine component of the ASTI shows a greater increase – and evidence is presented that the trends in marine species are driving the pan-Arctic index. The marine trend varies according to taxonomic class and ocean basin, among other variables.

Marine mammal populations increased on average but there is a need to interpret the recovery in numbers in the context of the 1970 baseline, as some populations still remain heavily depleted after historical overexploitation. Recent declines were observed in the Bering Sea and Aleutian Islands for seven species: beluga whale, Steller sea lion, harbour seal, sea otter, Pacific walrus, northern fur seal, and gray whale. The reasons for the population declines are not uniform for all species; the associated threats include overharvesting, increased predation, loss of summer sea ice, and depleted prey resource.

Marine bird indices show either stable or declining trends depending on the Arctic region in question. Climate change, exploitation, and invasive species are anthropogenic threats that have been linked with negative trends for some of these populations—but there may also be an influence from natural changes in environmental and foraging conditions, especially affecting piscivorous species, particularly in the Bering Sea and Aleutian Islands.

The fish data set was dominated largely by benthic and commercially fished species from the Bering Sea. Among fish populations there were increases in the Pacific and Arctic basins of the study area, possibly due to increases in sea surface temperatures observed in regions such as the Bering Sea in the 1970s and 1980s. The average trend in seven pelagic fish species showed a variable pattern and was found to have a strong association with similar trends in the Arctic Oscillation.”

Reference:
McRae, L., Deinet, S., Gill, M.& Collen, B. (2012) Tracking Trends in Arctic marine populations. CAFF Assessment Series No. 7. Conservation of Arctic Flora and Fauna, Iceland. ISBN:978-9935-431-15-8.

Link: http://library.arcticportal.org/1665/1/ASTImarine.pdf

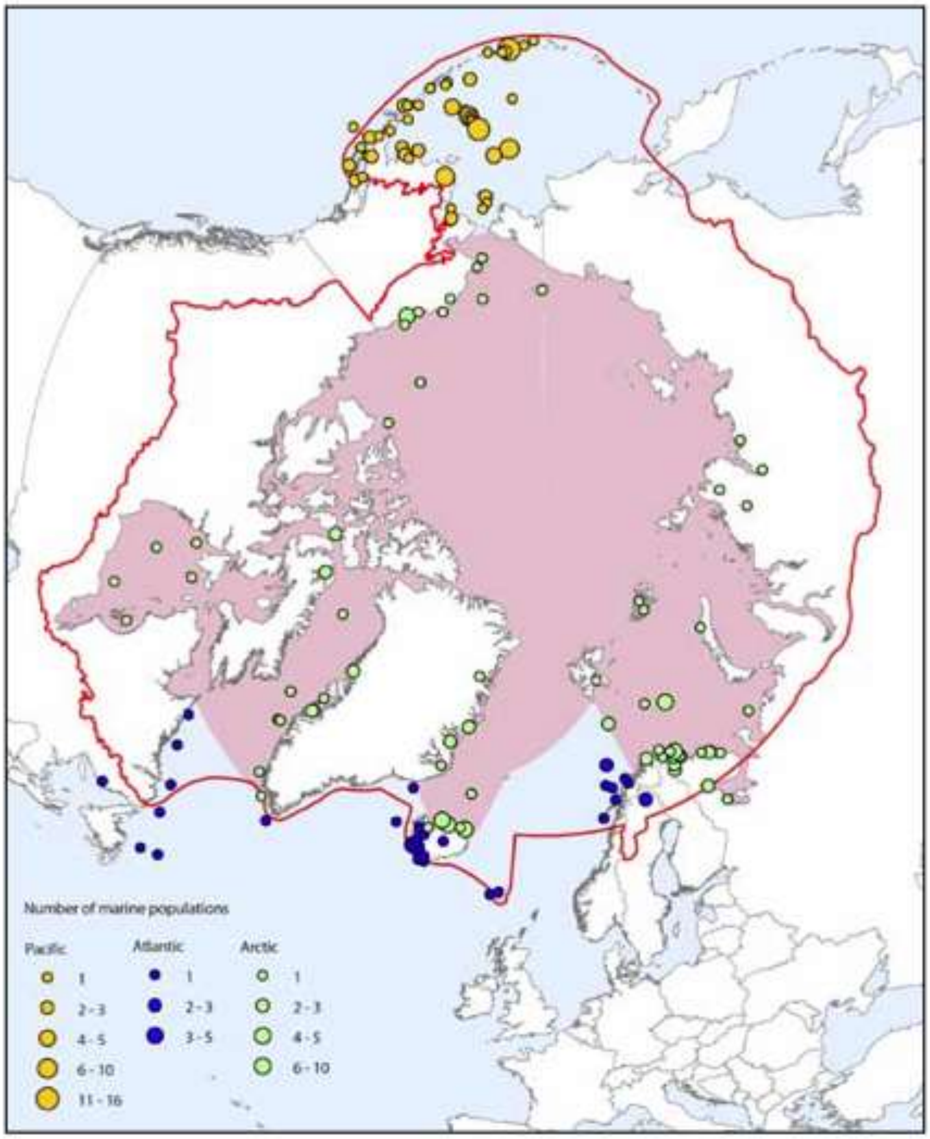


Figure 4. Spatial distribution of marine population data collected
The size of the circle denotes the number of population time series from that location.
For greater clarity in the division of populations by ocean region, the Arctic Ocean base map area used for all analyses is shown in pink.

Figure 1.39-1 Data collection for the Arctic Species Trend Index

[Figure 4 from McRae, L., Deinet, S., Gill, M.& Collen, B. (2012)]

1.40 Assessment 2007: Oil and Gas Activities in the Arctic - Effects and Potential Effects

"This assessment report details the results of the 2007 Assessment of Oil and Gas Activities in the Arctic conducted under the auspices of the Arctic Council and coordinated by the Arctic Monitoring and Assessment Programme (AMAP).

It provides the accessible scientific basis and validation for the statements and recommendations made in the report 'Arctic Oil and Gas 2007' 1 that was delivered to Arctic Council Ministers in April 2008. It includes extensive background data and references to the scientific literature, and details the sources for figures reproduced in the 'Arctic Oil and Gas 2007' report. Whereas the 'Arctic Oil and Gas 2007' report contains recommendations that specifically focus on actions aimed at improving the Arctic environment, the conclusions and recommendations presented in this report also cover issues of a more scientific nature, such as proposals for filling gaps in knowledge, and recommendations relevant to future monitoring and research work, etc."

Reference:
AMAP, 2010. Assessment 2007: Oil and Gas Activities in the Arctic - Effects and Potential Effects. Volumes 1 & 2. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.

A multi-part report on human impacts, the first two sections are currently available:
http://www.amap.no/documents/doc/assessment-2007-oil-and-gas-activities-in-the-arctic-effects-and-potential-effects.-volume-1/776

http://www.amap.no/documents/doc/assessment-2007-oil-and-gas-activities-in-the-arctic-effects-and-potential-effects.-volume-2/100

Appendix 4.3.
Concentrations of petroleum hydrocarbons in marine biota.

Location	Year	Species	Tissue	n	Mean concentration	Units	Remarks	Source
Russia								
Kola Peninsula	2001	*Coregonus* spp. (whitefish)	muscle	–	69	ng/g ww	Σ 5 PAH[a]	AMAP, 2004
Pechora basin	2001	*Coregonus* spp. (whitefish)	muscle	–	79	ng/g ww	Σ 5 PAH[a]	AMAP, 2004
West Taymir	2001	*Coregonus* spp. (whitefish)	muscle	–	112	ng/g ww	Σ 5 PAH[a]	AMAP, 2004
East Taymir	2001	*Coregonus* spp. (whitefish)	muscle	–	106	ng/g ww	Σ 5 PAH[a]	AMAP, 2004
West Taymir	2001	*Coregonus autumnalis* (Arctic cisco)	muscle	–	74	ng/g ww	Σ 5 PAH[a]	AMAP, 2004
East Taymir	2001	*Coregonus nasus* (broad whitefish)	muscle	–	51	ng/g ww	Σ 5 PAH[a]	AMAP, 2004
Chukotka inland	2001	*Coregonus nasus* (broad whitefish)	muscle	–	54	ng/g ww	Σ 5 PAH[a]	AMAP, 2004
Chukotka coast	2001	*Thymallus arcticus* (Arctic grayling)	muscle	–	78	ng/g ww	Σ 5 PAH[a]	AMAP, 2004
Barents Sea	2001	*Gadus morhua morhua* (Atlantic cod)	muscle	25	2	ng/g ww	Σ 9 PAH	Kireeva et al, 2002
Barents Sea	2001	*Gadus morhua morhua* (Atlantic cod)	liver	25	47	ng/g ww	Σ 9 PAH	Kireeva et al, 2002
Barents Sea	2001	*Melanogramus aeglefinus* (haddock)	muscle	25	5	ng/g ww	Σ 9 PAH	Kireeva et al, 2002
Barents Sea	2001	*Melanogramus aeglefinus* (haddock)	liver	25	84	ng/g ww	Σ 9 PAH	Kireeva et al, 2002

Figure 1.40-1 Human impact on marine species data from the AMAP oil and gas assessment

[Figure appendix 4.3 from AMAP, 2010]

1.41 Arctic Climate Issues 2011: Changes in Arctic Snow, Water, Ice and Permafrost

"This report presents a summary of the findings of the Snow, Water, Ice and Permafrost in the Arctic (SWIPA) assessment. This assessment was performed between 2008 and 2011 by the Arctic Monitoring and Assessment Programme (AMAP) in close cooperation with the International Arctic Science Committee (IASC), the World Climate Research Programme / Climate and Cryosphere (WCRP/CliC) Project and the International Arctic Social Sciences Association (IASSA).

AMAP's assessment of the impacts of climate change on Snow, Water, Ice and Permafrost in the Arctic (SWIPA) brings together the latest scientific knowledge about the changing state of each component of the Arctic 'cryosphere'. It examines how these changes will impact both the Arctic as a whole and people living within the Arctic and elsewhere in the world."

Link: http://www.amap.no/swipa/

Reference:
AMAP, 2012. Arctic Climate Issues 2011: Changes in Arctic Snow, Water, Ice and Permafrost. SWIPA 2011 Overview Report.

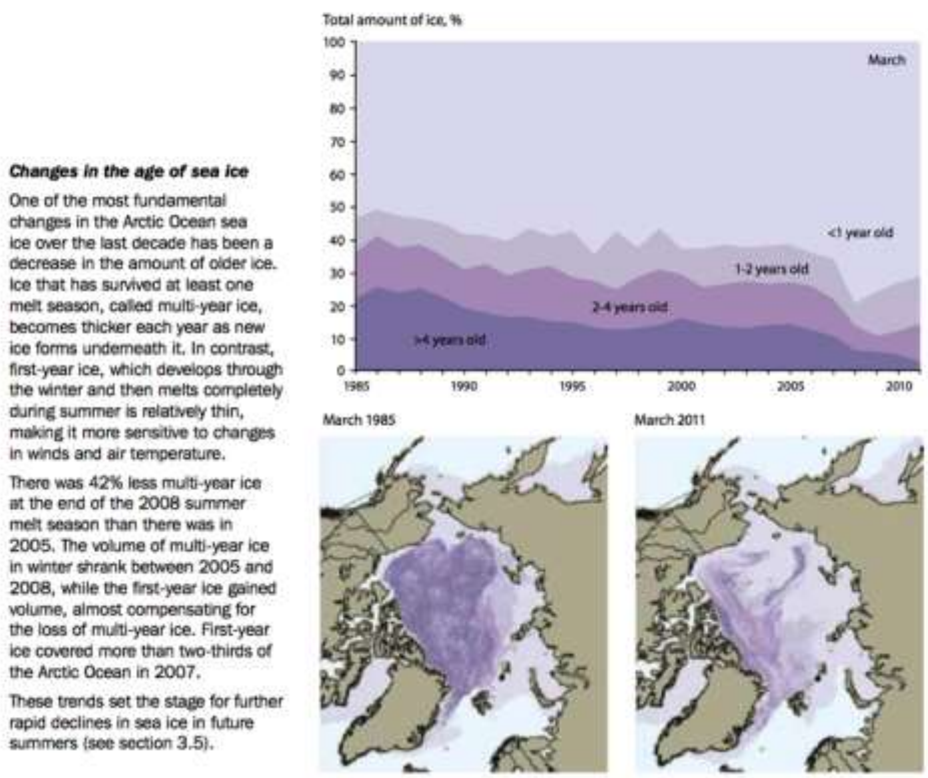


Figure 1.41-1 Changes in multi-year and first-year sea ice from the SWIPA assessment

[Figure from AMAP, 2012]

1.42 Comments from Oceana, Pew, WWF, Audubon, Ocean Conservancy on the Chukchi Call Area, submitted to the Bureau of Ocean Energy Management (US Government)

"BOEM's Outer Continental Shelf (OCS) Oil and Gas Leasing Program for 2012–2017 ("five-year program") recognized the need to take a different approach to oil and gas lease sales in America's Arctic Ocean (Bureau of Ocean Energy Management 2012). For the first time, BOEM acknowledged that areawide leasing was not appropriate in remote Arctic waters, where there are substantial concerns related to food security, ecological values, and the region's difficult environmental conditions. The five-year program called for a "targeted approach" to leasing in the Arctic, in which BOEM will weigh industry interest, oil and gas resource potential, subsistence values, and wildlife and ecological concerns to determine if leasing should take place, and if so, which areas should be open for leasing. In an initial implementation of this approach, the five-year program identified a new exclusion area outside of the city of Barrow, Alaska. "

Reference:
Submitted online via: http://www.regulations.gov, docket # BOEM–2013–0015.

Link:
http://www.scribd.com/doc/189366115/Chukchi-Call-Comments-and-Appendices-3Dec2013

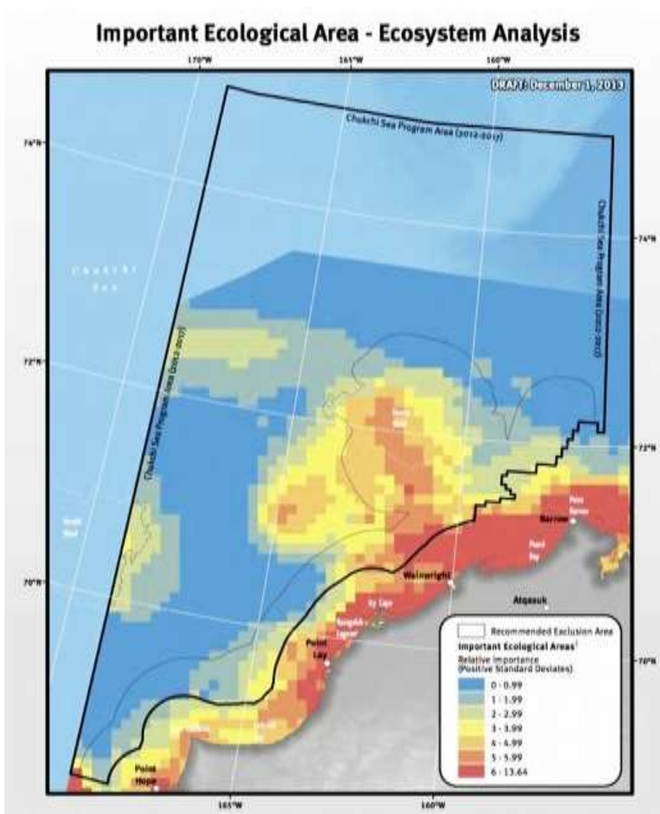


Figure 1.42-1 Draft map of analysis to identify Important Ecological Areas in Chukchi/Point Barrow region

[Map from Chukchi Call Comments, 2013]

1.43 Atlas of Marine and Coastal Biological Diversity in the Russian Arctic

"In this era of climate change and increasing economic activity in the Arctic, this publication, prepared by the specialists of leading scientific institutions of the Russian Academy of Sciences, universities, the Ministry of Natural Resources and Ecology of the Russian Federation, and the Federal Agency of Fishery, provides a crucial foundation for planning conservation activities in the seas and the coastal zone of the Russian Arctic. The Atlas illustrates the distribution of specially protected natural areas in the coastal zone of the Russian Arctic seas, presents schemes of physiographical and biogeographical regionalization, data on species diversity of particular taxonomic groups, biotopes and components of biological diversity which may be used for marine spatial planning in the Russian Arctic, development of protected natural areas network, establishment of fishery refuge zones and areas with special shipping regulations. A particular emphasis is given to the systems of boundary biotopes at interfaces of different environments: sea/sea ice, sea /river discharge, and sea/land and their associated biological diversity."

Reference:
Spiridonov, V.A., Gavrilo, M.V., Krasnova, E.D. and Nikolaeva, N.G., eds. 2011. Atlas of marine and coastal biological diversity of the Russian Arctic. Moscow: WWF Russia and Lomonosov Moscow State University. 64 p.

Link: www.wwf.ru/data/publ/arctic/atlas_biol_ros_arkt-engl.pdf

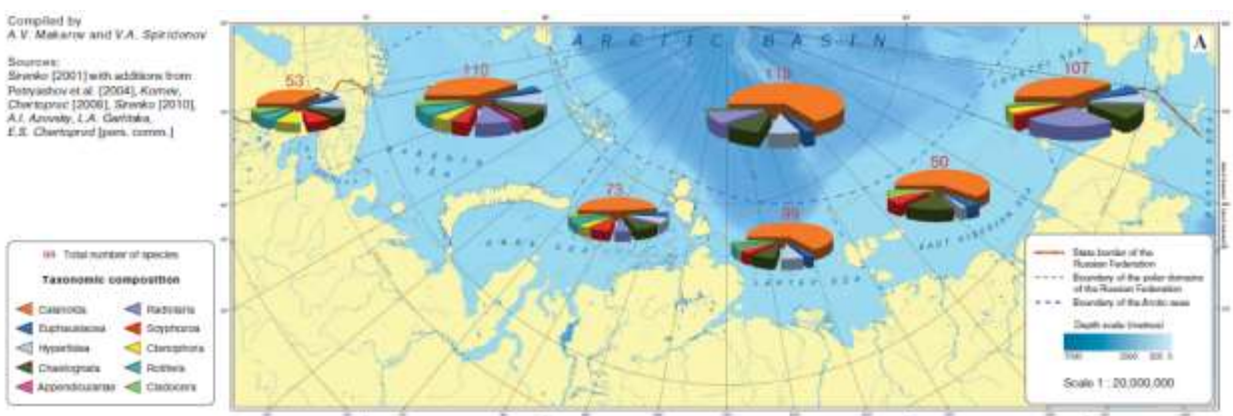


Figure 1.43-1 Species Diversity of Pelagic Animals

[Map 2.3 from Spiridonov, V.A., Gavrilo, M.V., Krasnova, E.D. and Nikolaeva, N.G., eds. 2011]

1.44 Arctic Marine Synthesis: Atlas of Chukchi and Beaufort Seas

"In early 2010, Audubon Alaska, in cooperation with Oceana, completed the Arctic Marine Synthesis: Atlas of the Chukchi and Beaufort Seas. The project area includes the southern Beaufort, southern Chukchi, and northern Bering seas. The atlas provides a holistic look at the dynamic Arctic Ocean ecosystem. This collection of information will be an important tool for scientists and policymakers in setting conservation priorities and designing balanced management plans in this sensitive Arctic region.

The collection of 44 maps contains information on the physical environment, such as sea ice dynamics, the distribution of ice-dependent species including polar bears, and energy development and protected areas. "

Reference:
Smith, M.A. 2010. Arctic Marine Synthesis: Atlas of the Chukchi and Beaufort Seas. Audubon Alaska and Oceana: Anchorage.

Synthesis report and maps available as separate downloads:
http://ak.audubon.org/arctic-marine-synthesis-atlas-chukchi-and-beaufort-seas

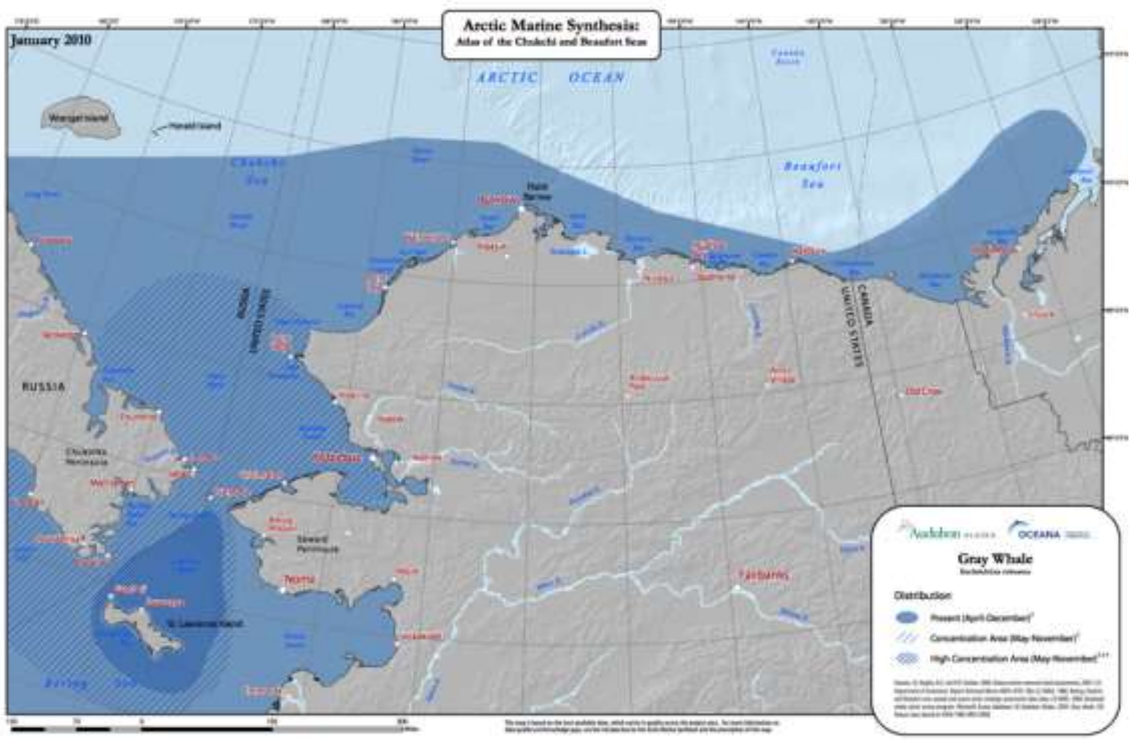


Figure 1.44-1 Seasonal concentration of Grey Whale distribution in Chukchi and Beaufort Seas

1.45 Circumpolar Seabird Data Portal

This online map displays seabird colonies throughout the circumpolar north.

http://axiom.seabirds.net/maps/circumpolar-seabirds/

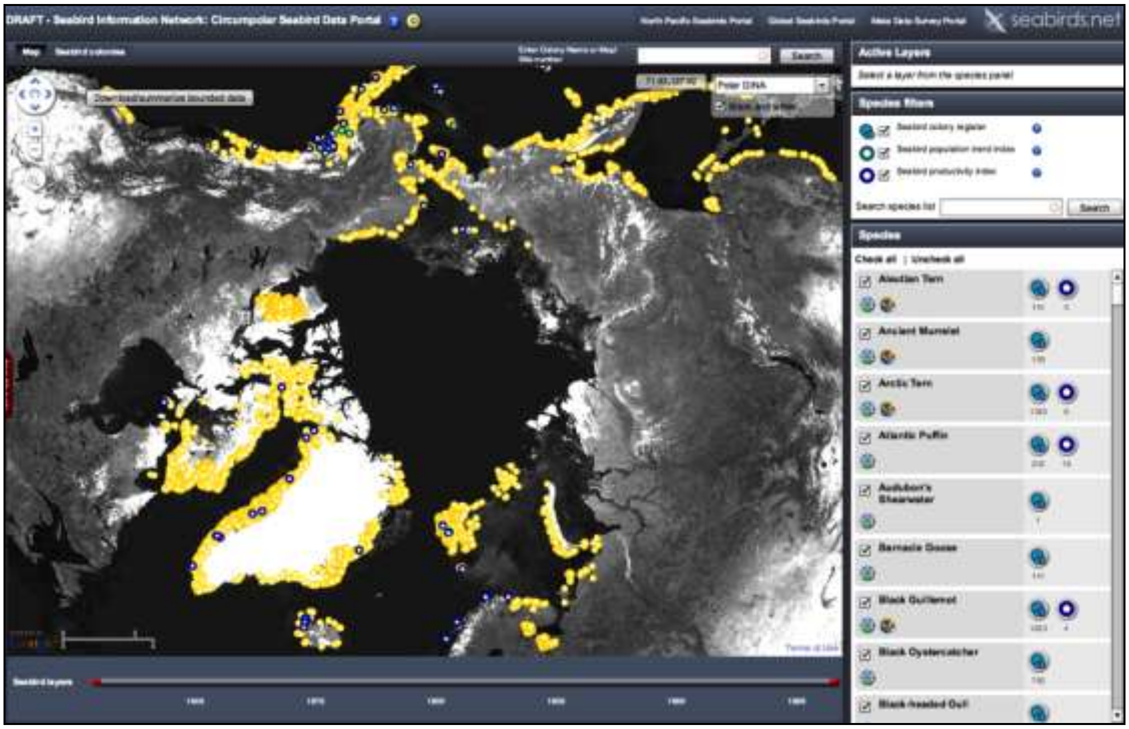


Figure 1.45-1 Screenshot from Circumpolar Seabird Data Portal

1.46 Arctic Geographical Information System (ArkGIS)

"ArkGIS (Arctic Geographical Information System) is a free, interactive mapping platform that combines and integrates existing data about the environment and human activity in the Arctic. The ArkGIS.org web-platform allows any user to download pre-made maps and videos, as well as developing customized maps on their own, using an interactive map service."

http://www.arkgis.org/

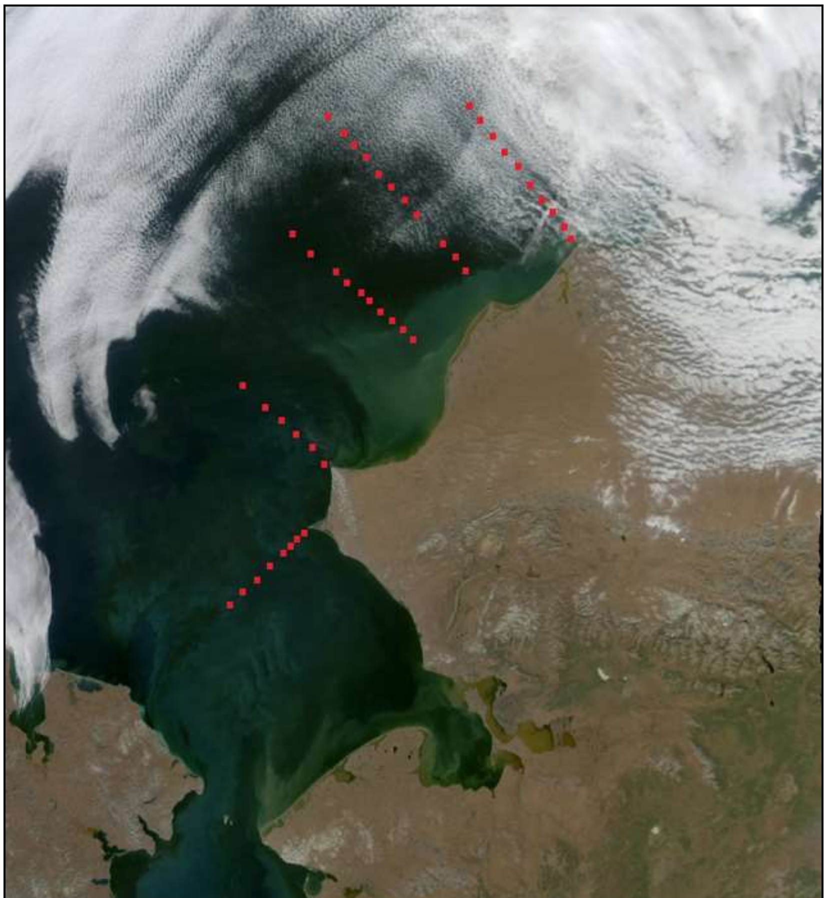
Figure 1.46-1 Screenshot from ArkGIS online data portal

1.47 Synthesis Of Arctic Research (SOAR)

"Our goal is to increase scientific understanding of the relationships among oceanographic conditions, benthic organisms, lower trophic prey species (forage fish and zooplankton), seabirds, and marine mammal distribution and behavior in the Pacific Arctic. The SOAR project is supported by the Bureau of Ocean Energy Management (BOEM), and will assist in their evaluation of oil and gas development in the Arctic.

The SOAR project aims to create a platform for collaboration among scientists and Alaska Arctic residents. The SOAR has the overarching goal of using available data, analytical and modelling approaches to identify and test hypotheses that cross scientific disciplines. The geographic area is the Pacific Arctic, including the northern Bering, Chukchi and Beaufort seas, with time frames extending from days to decades."

http://www.arctic.noaa.gov/soar/index.shtml



Satellite image showing a phytoplankton bloom in the Chukchi Sea and data-collection stations. AOOS image.

Figure 1.47-1 SOAR data collection stations

1.48 Environmental Response Management Application (ERMA)

"The Environmental Response Management Application (ERMA) is a web-based Geographic Information System (GIS) tool that assists both emergency responders and environmental resource managers in dealing with incidents that may adversely impact the environment. ERMA integrates and synthesizes various real-time and static datasets into a single interactive map, thus provides fast visualization of the situation and improves communication and coordination among responders and environmental stakeholders. "

from https://www.erma.unh.edu/arctic/erma.html

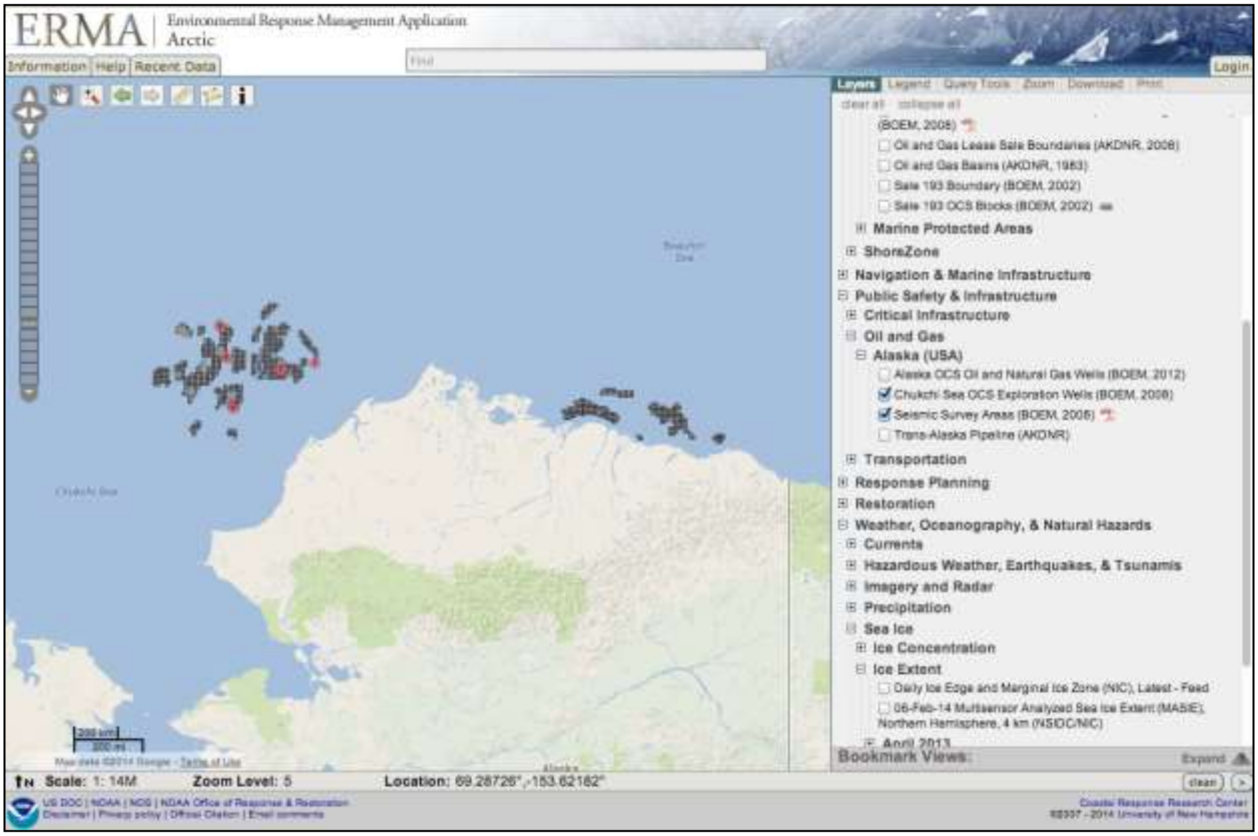


Figure 1.48-1 Screenshot from ERMA online data portal

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Stephan Lutter (WWF)
Martha McConnell (IUCN)
Miles McMillan-Lawler (GRID-Arendal)
Joclyn Paulic (DFO Canada)
Jake Rice (DFO Canada)
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