# WORKSHOP ON ECOLOGICAL VALUING OF AREAS OF THE BARENTS SEA (WKBAR)

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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk



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### Editors


Mariano Koen-Alonso • Adriaan Rijnsdorp • Markku Viitasalo


### Authors


Alexei Bambulyak • Igor Berchenko • Elena Eriksen • John Richard Hansen • Hans Mose Jensen • Lis Lindal Jørgensen • Kit M. Kovacs • Øystein Leiknes • Denis Moiseev • Dmitry Prozorkevich • Jens Rasmussen • Hein Rune Skjoldal • Oleg Titov • Sebastian Valanko



ICES CIEM International Council for the Exploration of the Sea Conseil International pour l'Exploration de la Mer

# Contents

# i Executive summary

ICES WKBAR met to provide the scientific basis to determine the ecological value of areas of the Barents Sea by formulating a definition of ecological value, developing criteria, and a framework to identify areas of special ecological value in the Barents Sea, and exemplify the potential for practical use in management.

Although there is no unique way to define an ecologically valuable area, there is general consensus that areas that (i) are of special importance for life history stages of species, (ii) are essential for threatened, rare of declining species, (iii) contain endemic species or populations, (iv) have high biological and genetic diversity, (v) have particularly high productivity, or (vi) contain unique geomorphological or oceanographic features, are ecologically valuable. Different organizations, such as the Intergovernmental Maritime Organization (IMO) and UN Food and Agricultural Organization (FAO), use slightly different criteria. WKBAR however agreed to use the criteria used by the Convention on Biological Diversity (CBD) to describe Ecologically or Biologically Significant Marine Areas (EBSAs). The CBD criteria are globally accepted, conform with the other sets of criteria, and are specifically meant to be used for highlighting the ecological and biological value of a sea area.

A conceptual framework is described comprising a step-wise approach. First, layers are selected that represent the relevant ecosystem components and ecosystem functions given the criteria for ecological value. Second, the core distribution areas of the selected layers are delineated based on available data and informed by expert knowledge. Third, layers are overlaid and aggregated, and an expert elicitation process is used to delineate the final valuable areas. Component layers are also classified in terms of specific ecological dimensions, allowing the generation of maps representing these dimensions in the Barents Sea. This approach was generally supported by the participants recognising that both numerical data and expert knowledge are required. Additionally, given the seasonality in ecological processes in the Barents Sea there is a need to consider how seasonality would be represented in the data layers.

A list of oceanographic, habitat, and ecological data were compiled, based on earlier monitoring reports, that can be used in the valuation of areas, including information on data source, areal coverage, spatial, and temporal resolution, as well as data holders and contact points. A process of data management is described that can be used to generate the required data layers that is in compliance with the FAIR data policy of ICES.

It proved impossible to test the conceptual framework in practise because only a limited number of data layers were available in the appropriate format, but the available layers were used to inform the discussion and development of several aspects of the conceptual framework.

The results of the workshop provide guidance for compilation and processing of the required data and knowledge layers to map the ecologically valuable areas in the Russian and Norwegian parts of the Barents Sea. Different types of value maps can be produced for different purposes, such as conservation and sustainable use of the sea areas. In a future step the sensitivity of the areas for human activities could also be assessed.

This work is part of the integrated ecosystem assessment which is a core component of the implementation of the Ecosystem Approach to Management of the Barents Sea. WGIBAR could provide a suitable platform for future work.

# ii Expert group information

| | |
|---|---|
| **Expert group name** | Workshop on ecological valuing of areas of the Barents Sea (WKBAR) |
| **Expert group cycle** | NA |
| **Year cycle started** | 2019 |
| **Reporting year in cycle** | 1/1 |
| **Chairs** | Mariano Koen-Alonso, Canada |
| | Adriaan Rijnsdorp, the Netherlands |
| | Markku Viitasalo, Finland |
| **Meeting venue and dates** | 23–24 May 2019, Copenhagen, Denmark (14 participants) |

**WKBAR 2019 participants**

# iii Term of reference

| Term of reference | | Addressed in this report |
|---|---|---|
| a) | Agree definitions. Develop a set of criteria that can be used to identify special/valued areas in the Barents Sea. | Yes |
| b) | Propose a candidate framework. Suggest a framework (or frameworks) for identification of special/valued areas in the Barents Sea. | Yes |
| c) | Exemplify the potential for practical use in management. Showcase data products emergent from the framework expected to be readily usable by ocean/fisheries managers in supporting decision making in the Barents Sea in a Marine Spatial Planning context. | Yes |

# 1 Introduction

ICES has been requested to provide advice on the joint identification and aggregating of data on environmental values in coastal and offshore areas in Norwegian and Russian parts of the Barents Sea. This information will contribute towards further implementation of ecosystem-based management of the Barents Sea, for which Marine Spatial Planning has been recognized as one of the practical tools. In this context, identification and delineation of ecologically special/valued areas of the Barents Sea, as well as their regular updating, constitute key pieces of information for the spatial management of human activities in the area.

Prior to this workshop, a review (Annex 2) within the context of the advice request has been carried out by a review group (RGBAR) of the OCEAN-1 project report (also known as HAV-1) and the report of ICES Working Group on the Integrated Assessment of the Barents Sea (WGIBAR). RGBAR has also been tasked by ICES to chair the WKBAR workshop and to prepare initial draft documents for the workshop. Input from Russian and Norwegian experts, received before and during WKBAR, has been essential to produce this report. This WKBAR report will form the basis of an advice drafting group (ADGBAR) meeting that will be convened in 18–19 June 2019. The expected release of the ICES advice will be on 5 July 2019. The outputs from the whole process (RGBAR Review, WKBAR Workshop Report and ICES Advisory Committee Advice) will be made publicly available on the ICES website.

The purpose of WKBAR was to formulate a definition of ecological value, suggest criteria, and a framework to identify areas of special ecological value, identify data for mapping special/valued areas in the Barents Sea, and exemplify the potential for practical use in management.

In Chapter 2, these definitions and criteria are presented and refined to enable ecosystem-based management approaches for the Barents Sea. In Chapter 3 a proposal for an operational framework for defining and identifying special/valuable areas for the Barents Sea is provided. It needs to be defensible from a scientific standpoint (i.e. reflecting our current understanding of the ecosystem functioning); compliant with international guidelines and supporting national and international initiatives; practical and easy to communicate for local/regional management decision-making; and easily updated by users when new data becomes available. Chapter 4 explores available data, data flows, and data management best practices. A metadata table is also presented, as an inventory for potential information that can be used in assessing the spatial extent of ecologically or biologically valuable sea areas in the Barents Sea.

# 2 Ecological value and criteria

## General introduction to the value of the Barents Sea

The Barents Sea is one of the Arctic shelf seas. It is the major "Atlantic Gateway" to the Arctic Ocean, connecting the Norwegian Sea in the west with the Kara Sea and the White Sea in the north and east. The dynamics of this high latitude sea is influenced strongly by the inflow of warm Atlantic Water and by the markedly seasonal availability of light. Considerable amounts of production (mainly zooplankton) are advected into the region from the south, but locally generated planktonic algae and algae attached to sea ice also contribute to the pulse of summer productivity in the Barents Sea. The ecosystem is also influenced heavily by seasonally occurring sea ice, particularly in the eastern and northern sectors. The marked recent declines in sea ice over the last 3-4 decades are resulting in major changes in the Barents Sea ecosystem. However, currently the region remains an important area for many Arctic endemic species across a broad array of taxa as well as supporting one of the richest fisheries in the world.

Phytoplankton community development in the Barents Sea is typical for a high latitude region; there is a pronounced maximum in both productivity and biomass during the spring and a low during winter. The spring bloom is initiated during the period from mid-April to mid-May, but the exact timing and intensity can vary strongly from area to area and from year to year. The duration of the bloom is typically 3–4 weeks and it is followed by a reduction in phytoplankton biomass mainly due to nutrient exhaustion and grazing by zooplankton. In the fall, increasing winds often mix the upper layers and bring nutrients to the surface, inducing a short secondary (autumn) bloom. However, the timing of phytoplankton development can vary geographically, in accordance with water temperature, sea ice cover etc. The spring bloom in the Atlantic Water domain (without sea-ice) is thermocline-driven; whereas in the Arctic domain (with seasonal sea-ice), stability induced by ice-melt determines when the bloom takes place. Thus, the spring bloom at the ice edge sometimes take place earlier than in the southern parts of the Barents Sea because of early stratification of the water column due to the ice melting.

Mesozooplankton play a key role in the Barents Sea ecosystem by transferring energy from primary producers to animals higher in the foodweb. Geographic distribution patterns of total mesozooplankton biomass show similar patterns over time though some interannual variability does exist in part due to inter-annual variation in ice-cover and variable levels of predation pressure, e.g. from capelin. Two species of Calanus copepods, *Calanus finmarchicus* in the Atlantic water in south and *Calanus glacialis* in Arctic water in north, contribute most of the mesozooplankton biomass (about 70–80% on average). Several species of krill (*Thysanoessa inermis, T. raschii, T. longicaudata, and Meganyctiphanes norvegica*) and amphipods (*Themisto libellula* and *T. abyssorum*) are important components of macrozooplankton that form an important prey base for fish, seabirds, and marine mammals in the Barents Sea ecosystem.

Benthos is an essential and often species-rich component of marine ecosystems. More than 3000 species of benthic invertebrates registered in the Barents Sea. In this region, four distinct zones of benthos occur. These four zones are characterized by temperate species in the southwestern zone, cold-water species in the eastern zone, Arctic species in the northern and north-eastern zone, and an area in the eastern Barents Sea (where the snow crab now occur). Currently, Porifera (mainly the Geodia group) dominate biomass in the west, while Echinodermata (mainly brittle stars) dominate in the east. In the Northeast, Cnidaria (soft corals, such as the sea pen *Umbellula encrinus*, and sea anemones) dominate along with Echinodermata, while Crustacea dominate along with the Echinodermata in the Southeast. Warming conditions have led to migration of temperate species and groups eastwards and northwards. The retreating ice is likely to have quite profound impacts on the amount of biological material reaching the benthos and is likely to reduce benthic biomass. Benthic communities tend to be quite stable spatially and through time, compared to other components of marine ecosystems. However, they can be affected by changing environmental conditions, physical disruption, and via introduced species or invading species exerting new forms of predation pressure. In the Barents Sea examples of the latter are the red king crab and the snow crab, respectively. Natural fluxed in densities in migrating benthic species (predatory and scavenger species such as sea stars, amphipods, and snails with or without sea anemones) can also affect the sedentary fauna.

The principal commercially exploited fish species are the Northeast Arctic cod (*Gadus morhua*), the Northeast Arctic haddock (*Melanogrammus aeglefinus*), the Northwest Arctic saithe (*Pollachius virens*), and the Barents Sea capelin (*Mallotus villosus*). Capelin, polar cod, young herring, and blue whiting constitute the bulk of pelagic fish biomass in the Barents Sea. Zero group fish are important consumers of plankton and are prey of other predators, and, therefore, are important for transfer of energy between trophic levels in the ecosystem. The long-term mean biomass of total 0-group fish species (cod, haddock, herring, capelin, polar cod, and redfish) in the Barents Sea is about 2 million tonnes. Biomass of this group is dominated by cod and herring, which are mostly distributed in western and central parts of the Barents Sea.

Most Barents Sea fish species are demersal; this fish community consists of more than 200 fish species and about 100 regularly occurring species. About 25% are Arctic or mainly Arctic species. The commercial species are all boreal or mainly boreal, except for Greenland halibut (*Reinhardtius hippoglossoides*) that is classified as either Arcto-boreal or mainly Arctic. Saithe occurs mainly along the Norwegian coast and in coastal waters in the southern Barents Sea. Total biomass of cod, haddock and saithe are higher now than some decades ago. Greenland halibut and redfish, in particular *Sebastes mentella*, are important commercial species with large parts of their distribution within the Barents Sea. Other than these main commercial stocks, long rough dab is the demersal stock with the highest abundance. Spawning areas, early-life stage areas and migration/drifting routes and patterns are especially important aspects to include in valuable area planning processes.

The Barents Sea is home to one of the largest concentrations of seabirds in the world. More than 20 million birds, including 40+ species breed in the region at 1600 colonies. The most important species numerically include northern fulmars (*Fulmarus glacialis*) common eiders (*Somateria mollissima*), glaucous gulls (*Larus hyperboreus*), black-legged kittiwakes (*Rissa tridactyla*), common guillemot (*Uria aalge*), Brünnich's guillemots (*Uria lomvia*), razorbills (*Alca torda*), black guillemots (*Cepphus grylle*), little auks (*Alle alle*) and Atlantic puffins (*Fratercula arctica*). Most of the seabirds feed on zero group capelin (*Mallotus villosus*), herring (*Clupea harengus*) and polar cod (*Boreogadus saida*) being key-prey species for many seabirds. Specialists such as the little auk target Arctic species of zooplankton, calanoid copepods being their primary prey. Some of the Arctic species are currently in decline although the causes of the decline are not well understood. Puffins, lesser black-back gulls (*Larus fuscus*), ivory gulls (*Pagophila eburnea*), Steller's eider (*Polysticta stelleri*), black-legged kittiwake and thick-billed murres (*Uria lomvia*) are particular concerns at this time.

The Barents Sea is also one of the most species rich regions in the Arctic with respect to marine mammals. Twenty-three species, including all of the Arctic endemic species that inhabit the North Atlantic Arctic, occur regularly in the region. The resident Arctic species (polar bears *Ursus maritimus*, bowhead whales *Balaena mysticetus*, narwhals *Monodon monoceros*, white whales (or belugas) *Delphinapterus leucas*, ringed seals *Pusa hispida*, bearded seals *Erignathus barbatus*, walruses *Odobenus rosmarus*, harp seals *Pagophilus groenlandicus* and hooded seals *Cystophora cristata*) are tightly ice-affiliated, depending on sea ice habitats for breeding, feeding or both. They are thus vulnerable to climate warming and particularly the sea ice declines that are taking place in the region and warrant special attention when considering species in need of conservation concern. Many of these species are depleted from commercial harvests that started in the Barents Region in the 1600; unsustainable levels of commercial harvest targeting some of these species continued into the 1960s and 1970s (e.g. white whales and polar bears). Harbour seals *Phoca vitulina* and grey seals *Halichoerus grypus* also occupy coastal regions in the Southern Barents Sea and a small population of harbour seals breeds on islands off the west coast of Spitsbergen in Svalbard. Additionally, white-beaked dolphins *Lagenorhynchus albirostris* are common throughout much of the Barents Sea in open-water areas and harbour porpoises *Phocoena phocoena* reside in coastal areas along the mainland of Norway and northwestern Russia. Migratory species include many of the large baleen whales (fin whales *Balaenoptera physalus*, blue whales *Balaenoptera musculus*, humpback whale *Megaptera novaeanglia*, sei whales *Balaenoptera borealis* and minke whales *Balaenoptera acutorostrata*), many of which were also subjected to commercial harvests that resulted in depleted numbers. Several toothed whales also occur throughout most of the Barents Sea in areas with preferred habitats (e.g. killer whales *Orcinus orca*, sperm whales *Physeter macrocephalus*, northern bottlenosed whales *Hyperoodon ampullatus*, long-finned pilot whale *Globicephala melas*). Atlantic white-sided dolphins *Lagenorhnychus acutus* are increasingly common in the southern parts of the Barents Sea. Capelin and polar cod are key-prey species for many marine mammals in the Barents Sea. A few specialist predators, such as benthic feeding walruses that depend on bivalves such as *Mya truncata* and bowhead whales that feed on calanoid copepods, do also occur in the Barents Sea.

## What is value? Ecological value and its role in management

Ecological value is a concept that must be understood in a relative sense. If some areas are identified as being of value for some species, and thereby important for ecosystem functioning, this does not mean that other areas are not important and of low value. It simply means that the identified areas require special management attention, while remaining areas must not be neglected. Every $m^2$ of the seafloor and every $m^3$ of the column of water that flows over it has ecological value. Primary production, generated by a wide array of algal species, is distributed relatively evenly in open water areas within the Barents Sea, and the total ecosystem productivity is based on the primary production integrated over the whole sea area.

Marine spatial management (including marine spatial planning, MSP) is part of the ecosystem approach to management (EA). EA aims to achieve the dual objectives of 'sustainable use of ecosystem goods and services and maintenance of ecosystem integrity' (cfr. definition of EA). This means that scientific and management efforts must be directed to the status of species and habitats within the area intended to be managed. The difference between EA and MSP is that EA also involves non-spatial management measures, such as quotas and gear regulations in fisheries management.

Integrated Ecosystem Assessment (IEA) is a core element of the EA. The purpose of IEA is to evaluate the overall status of the ecosystem, including the status and trends of ecosystem components, which are the species and habitats that make up the ecosystem. Identification of special or valued areas is an activity which is part of (or a preparatory step to) an IEA. A Working Group on Integrated Assessment of the Barents Sea has been established by ICES in 2014.

Ecologically valuable areas, identified according to criteria described below, are also referred to as 'ecological important areas' or 'special areas'. The term 'significant' is sometimes also used, e.g. in the term 'Ecologically or Biologically Significant Marine Area' (EBSA). In the AMSA IIC (AMAP/CAFF/SDWG 2013), the term 'heightened ecological significance' was used.

The ecological value (or values) of an area can be either singular or composite with respect to species and processes involved. A seabird colony, for example, can contain one or several species, and the area identified as valuable would generally include a foraging zone out from the colony, which in turn could contain one or more prey species or production features supporting the colony.

## Criteria to identify 'valuable areas'

The UN Convention on Biological Diversity (CBD) has established a set of criteria to identify Ecologically or Biologically Significant Marine Areas (EBSAs). These criteria were based on a similar set of criteria developed by IUCN to identify potential candidate areas for establishment of Marine Protected Areas (MPAs). A third set of criteria, also based on the IUCN criteria, are used to identifying Particularly Sensitive Sea Areas (PSSAs) by the UN Intergovernmental Maritime Organization (IMO), and finally the UN Food and Agricultural Organization (FAO) uses its own criteria. All these sets of criteria are broadly similar, and although they differ somewhat in style and language and in the level of detail, their core elements are basically similar (see review by Skjoldal and Toropova, 2012).

The seven CBD EBSA criteria adopted to identify EBSAs include:

1. Uniqueness or rarity;
2. Special importance for life history of species;
3. Importance for threatened, endangered or declining species and/or habitats;
4. Vulnerability, fragility, sensitivity, slow recovery;
5. Biological productivity;
6. Biological diversity;
7. Naturalness.

Further information on these criteria, including their definitions, rationale, examples, and considerations with respect to their application are provided in Annex 1 to CBD COP Decision IX/20 (http://www.cbd.int/decision/cop/?id=11663).

Criterion No. 4 on vulnerability, fragility, sensitivity, or slow recovery is common between the EBSA and PSSA criteria but is not part of the IUCN MPA criteria. The concepts of vulnerability, fragility and sensitivity relate to the ecological concepts of resistance and resilience, which are the abilities of species, habitats or ecosystems to withstand pressures and recover from impacts resulting from pressures. This criterion demonstrates the close connection between ecological importance or significance on the one hand and vulnerability or sensitivity on the other.

While considering the benefits for humans is relevant from a policy and decision making perspective, the focus of WKBAR is on the assessment of the ecological value of a sea area without considering its vulnerability or sensitivity for human activities that may compromise the ecological value. Nevertheless, vulnerability and sensitivity may still be relevant to take into account when considering the 'naturalness' of a given area, or in the context of the effects of climate change.

## Ecological components and features

The assessment of ecological value of sea areas from an ecosystem structure and function perspective requires a broad evaluation of biological/ecological components and processes.

Given the wide scope of the inventory required, the compilation on information would benefit from a structured approach. WKBAR considered that the most effective way of organizing the information was through a systematic coverage of structural ecosystem components (e.g. oceanography and physical environment, plankton, fish, sea birds, marine mammals), and identifying relevant features within each one of these components (e.g. frontal zones, areas of biomass concentration, feeding, and spawning areas, etc.). This broad range of ecosystem components and constituting elements (feature layers, see below) will need to be evaluated in terms of representing the structure of the ecosystem as well the ecological functions performed.

For the Barents Sea these structural ecosystem components should at least include the following: all marine mammal species, all seabird species, "major" fish (main commercial and forage fish), zooplankton (*Calanus spp*., krill, amphipods), epibenthic megafauna (sponges, coral), and burrowing infauna. Relevant features within these components would include, for example, areas of high biomass concentration, spawning areas, foraging areas, coral gardens, sponge reefs, etc.

WKBAR agreed that the selection of features within each component to be included in the process of identification and delineation of special/valued areas should be based on the assessment of the feature against the CBD EBSA criteria.

## Ecological dimensions

While the selection of relevant features is based on structural ecosystem components, WKBAR considered that presenting results of the component-driven selection process in terms of general ecological dimensions could also be a useful output.

WKBAR identified four general ecological dimensions: foodweb, habitat, biodiversity, and productivity. The rationale for defining these dimensions is to summarize more general functional aspects of the Barents Sea in a way that is easy to communicate/understand to/by a broad suite of managers and stakeholders. A more detailed description of these general ecological dimensions is provided below.

### Foodweb

This dimension recognizes that food web integrity is key to maintaining ecosystem structure and function, which requires safeguarding of components/functional groups with major roles in energy transfer across trophic levels, and the core locations where these interactions take place. While information on spatially resolved trophic interactions may not be broadly available, data on feeding grounds for important species may exist, and general areas of concentration from scientific surveys can be used as proxy for where key species and/or functional groups are likely to be foraging.

### Habitat

This dimension recognizes that preserving important ecological processes, which are better described through their linkages with specific substrates and/or physical features, requires safeguarding of core areas for benthic processes like biogenic/complex habitats, and habitats defined by oceanographic and physical processes. These areas may provide unique conditions for the survival of specific life history stages which make these habitats a required element for life cycle closure, including breeding (spawning) grounds, nursery grounds, migratory corridors, and/or provide unique geo-morphological or oceanographic features, such as biogenic/complex habitats, ice edge, and Polar Front, that are ecologically relevant.

### Biodiversity

This dimension recognizes that preserving biodiversity in general, as well as focused attention on depleted/endangered species, is key to ecosystem resilience and capacity to adapt to changing conditions, and requires safeguarding of areas with high local diversity, unique species, and/or important areas for depleted/endangered species.

### Productivity

This dimension recognizes that preserving ecological components and processes linked to overall ecosystem productivity is key for ecosystem functioning and persistence. This requires safeguarding of areas linked to core primary and secondary production which form the basis of ecosystem functioning, high overall biomasses (e.g. fish, benthos), and high concentrations of key species for overall ecosystem productivity (e.g. cod, capelin).

## References

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.

Skjoldal, H.R. and C. Toropova 2012. Criteria for identifying ecologically important and vulnerable marine areas in the Arctic. Manuscript prepared as background document for the AMSA IIC report. 18 pp.

# 3 Framework

This Chapter presents a candidate framework for identifying and delineating special/valued areas in the Barents Sea. This framework is not intended as a definitive approach; its aim is to provide conceptual guidance to facilitate the process of identifying special/valued areas in the Barents Sea.

The guiding principles for framework development were: a) to be defensible from a scientific standpoint (i.e. properly reflecting our current understanding of the spatial structure of ecosystem functioning), b) to be consistent/compliant with international guidelines (i.e. its outcomes can inform/support both national and international initiatives), and c) to be practical for local/regional management decision-making (i.e. easy to understand/communicate by/to a broader suite of users, capable of incorporating new data as it becomes available).

## Basic framework structure

The basic idea of this framework is to represent relevant information in the form of georeferenced layers. The identification and delineation of special/valued areas is done by a structured process that relies on the overlap of these information layers onto a common grid, and expert interpretation of these overlaps. The key to this conceptual framework is not the layering of information itself, but the structured process that leads to the selection and production of those information layers. This framework also requires expert input at different entry points in addition to the final delineation of special/valued areas, embedding expert interpretation, feedback, and peer-review of the building blocks as a structural element of the process.

The conceptual framework comprises the structural ecosystem components (e.g. oceanography, plankton, fish, benthos, marine mammals, seabirds) and associated feature layers. EBSA criteria are used to select the feature layers to include in the value assessment. Ecological dimensions are used to summarise the ecological value in terms of a few aspects that encompass the structure and functioning of the ecosystem and that is easy to communicate with stakeholders (Figure 1.1).

| | Criteria (EBSA) | | | | | | | Ecosystem dimension | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Food web | Habitat | Biodiversity | Productivity |
| Ecosystem component | | | | | | | | | | | |
| feature layer | | x | | | | x | | | | x | |
| feature layer | | | | | x | x | | | | x | x |
| feature layer | | | | x | | | | | | | |
| feature layer | | | | x | | x | | | | x | |
| Ecosystem component | | | | | | | | | | | |
| feature layer | | | x | | | x | | | x | x | |
| feature layer | | x | | | | x | | | x | x | |
| feature layer | | x | | x | | | | | x | | x |
| feature layer | | x | | | x | | | | | | x |
| feature layer | | | | | x | | | | | | x |
| feature layer | | x | | | | | | | | x | |
| feature layer | | | | | | | | | | | |

**Figure 1.1. Schematic representation of the framework used to determine ecological value of areas showing the ecosystem components and associated feature layers to be selected according the seven CBD EBSA criteria. Once selected, each feature layer is also classified in terms of four ecological dimensions to allow summarizing general functional aspects of the Barents Sea in a way that is easy to communicate to stakeholders.**

## Ecosystem components

The conceptual framework is organized around structural ecosystem components (e.g. oceanography, plankton, fish, benthos, marine mammals, seabirds). Starting from a list of components, as opposed to simply classifying available layers, allows not only to organize existing information, but also to detect potential gaps and/or uneven coverage of the available information. The final list of components needs to be defined by an expert group with knowledge of the Barents Sea ecosystem and the data sources available.

## Feature layers

Under each ecosystem component, a series of feature layers are identified. These feature layers would range from physical/oceanographic elements like location of sea ice or frontal areas, to core distribution areas for specific taxa, functional groups, habitats, or relevant metrics/proxies for ecosystem process (e.g. spawning areas, feeding areas, etc.). Each candidate feature layer under each component should be assessed against the CDB EBSA criteria to define its relevance for the process and inclusion into the overall analysis. Of particular importance in this step is to ensure that information content is not duplicated across different feature layers to avoid "double counting" problems, and to ensure that each feature layer displays core areas and not full distributions of the feature being considered (e.g. areas that have consistently contained high densities of a key species or functional group) (Figure 1.2). The selection (i.e. the feature itself and what constitutes a core area for that feature), review, and assessment of feature layers need to be done by an expert group with knowledge of the Barents Sea ecosystem and the data sources available.

All feature layers should be constructed in such a way to allow for their overlap onto a common grid. Ideally, the grid size should permit preserving the resolution of the highest resolved feature layer and/or be practical for effectively informing management decisions. The precise grid size should be agreed by an expert group with knowledge of the Barents Sea ecosystem and the data sources available.

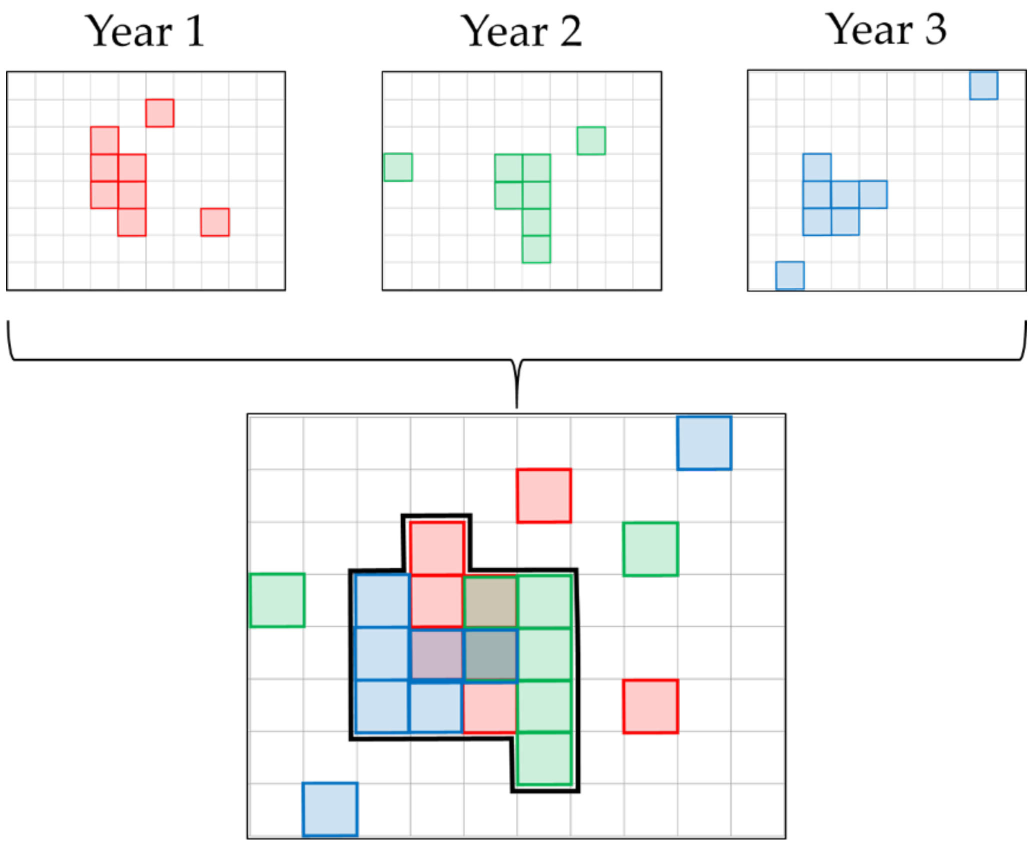


**Figure 1.2. Schematic representation of the construction of a base feature layer from yearly distributions of core areas. From each yearly full distribution map for the target feature, core areas containing the top percentiles (e.g. top 10%) can be identified (top small maps in the figure). These core area yearly maps can be overlapped to defined a general area that has consistently contained high densities of the feature within the targeted period of time (bottom map, with base core area delineated by the thick black line). This general area of consistent presence of high densities is identified as the base feature layer and included as such for the overall analysis. While this procedure emphasizes areas with consistent presence of high density of the feature under consideration, those locations with records in only one year could also be included in the base feature layer if expert knowledge so indicates. The exemplified procedure helps identifying hot spots, but the actual boundary of the base feature layer is defined by the expert interpretation of these results.**

## Ecological dimensions

Once selected and defined, each base feature layer would also be classified as contributing to four general ecological dimensions: food web, habitat, diversity, and productivity. These general ecological dimensions are easy to communicate/understand to/by a broad suite of managers and stakeholders, and this a posteriori classification of each accepted base feature layer would allow the production of maps displaying how different areas in the Barents Sea are contributing to these general ecological dimensions. This a posteriori classification should be done by an expert group with knowledge of the Barents Sea ecosystem.

## Integration of information: Identification and delineation of special/valued areas

Once all the components and feature layers are defined, the identification and delineation of special/valued areas should be done by overlapping the selected layers, and expert interpretation of these overlaps. This process is analogous to the one depicted in Figure 1.2, but where the layers being considered are the base feature layers for all the components included in the analysis. This final integration of layers and identification of areas would be expected to be done in a workshop setting, and with the participation of the experts that contributed to the development of the components and feature layers. The result of this exercise would be a network of special/valued areas for the Barents Sea, against which changes of these areas over time can be compared. As it was the case for each component and base feature layer, each identified special/valued area needs to be described in terms of the underlying feature layers that led to its identification and delineation, and the overall rationale used for the delineation. This description is the essential metadata for each special/valued area identified.

### The concept of special/valued areas

Within this framework, areas can be considered special/valued for very different reasons, and any given area can be special/valued for multiple biological/ecological reasons. This also means that special/valued areas are unlikely to be substitutable by one another; they are not intrinsically comparable. An area containing a single unique feature (e.g. a threatened species) is not intrinsically more or less special/valued than another one that concentrates multiple similar features (e.g. high biomasses of multiple key species like cod and capelin) or combines structurally different features (e.g. contains coral reefs, nursery areas, and core primary production locations). All these areas are important because they inordinately contribute to one or more of the features already selected as relevant for the identification and delineation of special/valued areas.

From a spatial organization perspective, maintaining overall ecosystem structure and function would requires maintaining the integrity of the network defined by these special/valued areas. Such a network is, from a purely ecological processes perspective, an artificial construct; it does not represent a specific ecological process or flow. However, from a management perspective it represents the network of locations where a suite of important ecological/biological functions/traits are concentrated, and hence, higher than usual risk aversion to ecological impacts would be expected in decision-making.

### The role of experts

Expert input is an integral part of this framework; it provides informed input and peer-review at each one of the key steps of the framework. As indicated above, the precise list of components and features to be included in the Barents Sea analysis would need to be defined by an expert group with knowledge of the ecosystem and the data sources available. Similar level of expert engagement and input is also required for the proper integration and interpretation of information that leads to the identification and delineation of special/valued areas.

The task of such expert group is not only to carry out the delineated steps, but also properly document the decisions made along the way. Those descriptions are an essential piece of the metadata for each component, base feature layer, and special/valued area. This expert group can be ICES WGIBAR, which already brings together Norwegian and Russian scientific experts on a regular basis, and/or a group purposely constituted for these tasks (e.g. dedicated workshops).

## Classes of layers

The base feature layers within this conceptual framework are providing information on the spatial distribution of important locations of the target features. The information summarized in these layers can be generated through direct analysis of specific data sources (e.g. fish density derived from specific research surveys), or it can be derived from general scientific knowledge (e.g. spawning areas delineated by experts on the basis of multiple sources and analyses). This difference in the nature of the information content allows recognizing two different classes of layers:

- Data layers: built from direct integration/summary of data collection programs (e.g. research surveys, remote sensing). These layers provide a direct metric or proxy for the feature; they may require expert examination for quality control, but they do not typically integrate multiple sources of information. The benefit of this class of layer is that allows for straightforward updating and comparison with prior results, but this strength is also its weakness. It depends on the availability of data with proper spatial resolution and coverage, and its updating requires that the monitoring programs that collected the data remain active and within similar operational parameters.

- Knowledge layers: built through expert elicitation processes. These layers represent our current understanding on a specific topic/feature, and typically consider and integrate a multiplicity of sources and analyses. The knowledge layers represent the cumulated knowledge arising from data collection through years and decades of research and monitoring. The knowledge is reflected and documented in scientific papers, reports, and books, and is operationally available in networks of scientists and other experts working in and with a specific ecosystem. Unless already available through previous exercises (e.g. AMAP/CAFF/SDWG, 2013), development of knowledge layers may require targeted processes (e.g. expert workshops or working groups). The benefit of this class of layer is that provides an overarching integration of all/many sources of available information regardless of their coverage and resolution to represent the feature in space, but a potential weakness is that it does not allow for simple and straightforward updating and comparisons with prior results.

While both classes of layers have their advantages and disadvantages, the more procedural construction of the data layer class may make them a preferred option, but the monitoring programs of many important ecological features do not have the required coverage and resolution to generate adequate data layers. On the other hand, the knowledge layer class is a natural way for incorporating local, traditional, and indigenous knowledge, which is typically very difficult to capture within the data layer class. All in all, both classes of layers are valid ways of bringing information about selected features into the framework.

## Spatial and temporal variability

The different ecosystem features considered for the identification and delineation of special/valued areas can typically vary in space and time, e.g. reflecting the migratory dynamics of populations of fish, birds, and marine mammals, or the annual cycle in light and production. As much as possible the information layers used to describe these components should ideally reflect this variability. In this context we can distinguish:

1. Spatially continuous, temporally dynamic features. These are features that have a continuous distribution in space without well-defined natural boundaries, and which will be changing dynamically over time. Examples of these features include species distributions and derived metrics from these (e.g. diversity). These features are incorporated into the framework by defining core areas within the distribution, where the inter-annual variability is reflected in the final delineation of the base feature layer (Figure1.2).
2. Spatially discrete features. These are features that have relatively well defined natural boundaries, and where these boundaries can be reasonably described using a polygon. These include, for example, benthic habitats like coral gardens and oceanographic features like the Polar Front. These spatially discrete features can be stable or variable over time:
   a) Temporally stable discrete features. These would typically correspond to biogenic benthic habitats that do not show significant changes in location and extent within management horizons. Their base feature layers only need to be defined once, and after that will remain constant within the framework.
   b) Temporally dynamic discrete features. These features can be oceanographic structures (e.g. Polar Front position, sea ice edge), or biological variables (e.g. the core area of the spring bloom from satellite imagery), but they share two basic character-

istics: a) a reasonably well defined spatial extent that can be adequately approximated with a polygon, even if it is geographically large, and b) a location that is seasonally and/or annually variable. Their base feature layers can be delineated using a procedure analogous to the one depicted in Figure 2, with the only difference that the annual core areas are directly the polygons describing the feature location in each year.

Constructing base feature layers for temporally dynamic features, both spatially continuous and discrete, would require defining the period of time that will be considered in the analysis (e.g. 3 years in the schematic example depicted in Figure 1.2). While data availability would likely be an important constraint in this decision, it is important to consider the implications of using different time windows. Using all data or very large time windows (e.g. many decades) has the benefit of covering a broader set of ecosystem states and configurations, and hence showcases the full range of variability of the target feature. However, using shorter, more recent time windows (e.g. the last 10 years) can provide a more accurate depiction of current special/valued areas, which may be more relevant for management applications.

Hybrid approaches could also be considered, for example, defining the base feature layer base on a recent time window and using the full extent of the time series to define a buffer zone around the areas in base feature layer. While these hybrid approaches can be appealing, careful consideration needs to be given to the fact that many base feature layers are going to be overlapped in the process of identifying special/valued area, and if many of these base feature layers come with buffers, the full process could become unwieldly rather quickly. Initial explorations of the framework may benefit from trying simpler options first.

## Monitoring and updating special/valued areas

The conceptual framework as described so far allows for the use of structural ecosystem components, and their related base feature layers, to identify and delineate special/valued areas. However, the Barents Sea ecosystem is currently experiencing important directional changes associate with climate change. Consequently, the geographical location of today's special/valued areas may not necessarily remain stable over time. Furthermore, depending on the differential effects of climate change on the features that define any given special/valued area, not only the area can change location, but its composition of features can also change. Locations that today are not identified as special/valued areas can become one, and current special/valued areas can no longer be few years from now.

In this context of change, monitoring and updating special/valued areas is a necessary element for the conceptual framework. If we consider the special/valued areas resulting from the initial implementation of the conceptual framework as the base special/valued areas, maintaining an up-to-date inventory of special/valued areas in the Barents Sea requires considering two different processes: a) regular monitoring of changes from base special/valued areas, and b) review of the entire framework through a benchmark process on a regular basis.

A special/valued area would typically be defined by several base feature layers, some of these layers will be stable in time, and others will be dynamic. Regular monitoring would require regular (e.g. annual) updating of the base feature layers associated with dynamic features. Within regular monitoring, the overlay of these updates on the base special/valued area would inform on how some of the dynamic component features are changing (or not) in space (Figure 1.3). This level of tracking is expected to be particularly useful for informing ongoing management decisions.

After a pre-determined number of years (e.g. 5-10 years), the full framework should be reviewed, its components and feature layers examined and updated, and the special/valued areas re-delineated. Since this would be a major undertaking, precise schedules will need to be defined by experts on the Barents Sea ecosystem and its monitoring programs, as well as by managers making use of the products of the implemented framework.

The schedule of the monitoring and updating cycle would also be expected to inform the appropriate time windows to be considered for the construction of base feature layers. For example, if the benchmark process is scheduled every 5 years, a time window of 10 years for the base feature layers would imply that at every benchmark process the first 5 years within the period used to define the base feature layers would be dropped, and the results from the last 5 years of monitoring would be added to the set of years to be used for constructing the updated base feature layers. A process scheduled like this would render special/valued areas updated with information from the previous 10 years every five years.

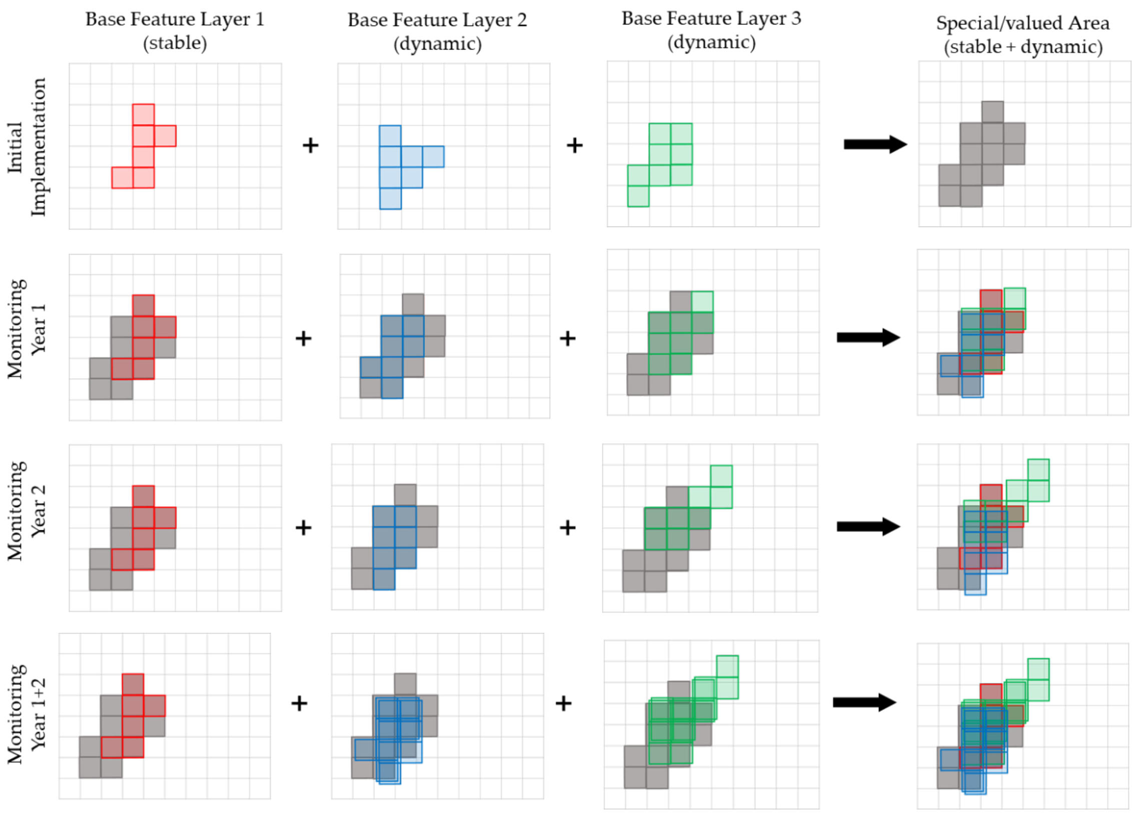


**Figure 1.3. Schematic representation of the initial delineation of a special/valuable area from three base feature layers, one of the stable in time (#1, red), and the other two dynamic (#2, blue, and #3, green), and the subsequent monitoring. The first row represent the generation of the special/valued area form the individual base feature layers. Rows 2 and 3 show the changes in the feature layers with respect to the base special/valued area; Year 1 does not show a major change from the initial delineation, but Year 2 indicates a potential drift in feature #3. The last column and bottom row show the cumulative marginal across features and years; the dynamic feature layers in these marginal maps have been off-set to facilitate visualization.**

## Scoring

This conceptual framework is based on the premise that all base feature layers included in the analysis already represent important properties/traits, and or important levels of these. Furthermore, these characteristics are not intrinsically comparable, so all feature layers are given equal weighing. For overlap exercises the base feature layers can be normalized, or given a nominal value of 1 to the locations in each feature layer actually containing the feature of interest. The counting of how many base feature layers' overlap in a given grid cell can be used as an index to focalize the attention of the experts doing the identification and delineation analysis on hot spot areas. The bottom line is that there is no ecologically meaningful scoring scheme that can be applied in a blanket manner to such diverse set of features.

Implementation of scoring schemes is simply a matter of scaling base feature layers with specific pre-determined weights, and calculating averages/sums over all layers. One specific variation on scoring used in other exercises on identification and delineation of special/valued areas is the use of scores against the different CBD EBSA criteria, allowing those feature layers that qualify under multiple criteria to have higher weights in the analysis. Regardless the specific scheme, the important issue with scoring is not implementation, but the rationale behind the implementation. If a credible justification is provided to highlight some components or features over others in the identification and delineation of special/valued areas, nothing within this framework prevents from applying weighing factors to these base feature layers to implement such rationale.

While scoring schemes to emphasize some features over others is probably the most common use of scoring, scoring schemes can also be implemented to reflect the uncertainty associated with a given base feature layer. If layers are scored according to the level of confidence we have about the information they convey, a suitable scoring scheme (e.g. 0.1, 0.5, 1.0 for low, medium and high confidence) could be applied to incorporate our confidence level on the underlying information into the process of identifying and delineating special/valuable areas. These confidence scores do not have to be applied in a blanket manner to an entire base feature layer. If such layer is based on a composite of multiple sources, some of them with higher confidence levels than others, nothing prevents from applying spatially disaggregated confidence scores. Of course, more complex scoring schemes would imply a more complex implementation, so the value added to the final identification and delineation of special/valued areas need to be evaluated against the increased procedural complexity in the implementation of the framework.

## Coverage

The assumption so far is that all base feature layers actually cover the entirety of the Barents Sea area. However, that is not always the case, some sources of information only offer a partial coverage to the Barents Sea, and careful examination needs to be given to the value of including/excluding base feature layers with partial coverage. The notion of coverage is different whether one considers 'data layers' or 'knowledge layers'. In the latter case, the cumulative scientific knowledge may be less influenced by spatial coverage than if working with specific layers of data. 'Coverage' needs also to be seen in context with the geographical distribution of a biological component or feature. Thus, information about distribution of ivory gulls or walruses would be relevant only for the northern ice-covered parts of the Barents Sea and not for the open water areas in the south which are not inhabited by these species (apart for some stray individuals or vagrants).

In a general sense, since the conceptual framework relies on overlapping multiple layers, it is clear the incorporating too many layers with partial coverage can severely impact the ability of the framework to provide a comparable view of all areas in the Barents Sea. For this reason, incorporation of layers with partial coverage would in principle be discouraged. However, information on some important features may only be partially available, and their exclusion from the framework may pose more risks than the ones associated with the distorted perspective generated by layers with partial coverage.

Several options were briefly discussed at WKBAR as potential ways of dealing with partial coverage issues, but no specific approach was recommended. Some of the options discussed included: a) simply discarding all base feature layers with partial coverage, b) include layers with partial coverage, but scaling the aggregated grid cell metrics to the actual number of base layers covering the grid cell (e.g. if the metric were the count of layers actually occurring in a grid cell, then divide that value for the number of potential layers in that grid cell) , and c) calculate aggregate cell metrics with all layers and only with layers with full spatial coverage and map the difference between the two to identify areas where data coverage may be influencing the evaluation of special/valued areas.

Regardless of the specific approach taken, if layers with partial coverage are included, generating maps of coverage (i.e. maps showing how many base feature layers are actually present in each grid cell) would be useful. These coverage maps would provide a quick point of comparison with the overlap of base feature layers to evaluate the potential influence of coverage on the location of hot spots.

## Seasonality

Many of the important ecological properties/traits that will be relevant for the identification and delineation of special/valued areas possess a clear seasonal cycle1. This implies that some special/valued areas may only be ecologically important during some fraction of the year, or at last some of its constituent features will only be present at certain times of the year. This seasonality effects on the nature of special/valued areas can be of particular importance for management applications in terms of potentially regulating human activities taking into account the seasonality of features in special/valued areas.

While the merit of considering seasonality within the conceptual framework is without question, the practical aspects of incorporating seasonality present very real constraints especially when working with data layers. In the Barents Sea there are two major research surveys within a year, so from a purely data perspective, only two blocks within a year could be directly based on survey data. This would affect most layers describing core areas in fish distributions, and derived layers (e.g. diversity layers). Some other features derived from remote sensing or oceanographic models could be represented by monthly layers, while some knowledge layers (e.g. fish spawning areas, sea birds breeding and feeding areas) may be represented as blocks of months were the feature is present/active based on well understood seasonal cycles. Figure 1.4 depicts these different seasonal resolutions on base feature layers, and shows how, if the assumptions made to generate these seasonal blocks are somewhat reasonable, it is possible to represent seasonality within the framework.

1 Estimates of the start and end of the season are available from http://atmospheric-circulation.ru/about-us/

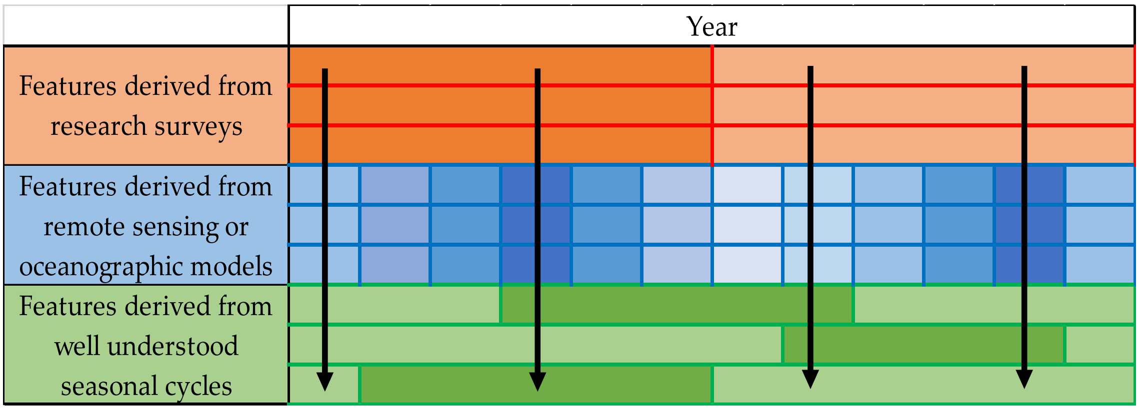


**Figure 1.4. Schematic representation of the seasonal resolution of different base feature layers derived from different sources. Each arrow exemplifies the combination of potential values for overall overlap at different points of the seasonal cycle.**

We cannot assume that spatial distributions at two times of the year are static and representative of wider blocks of time. On the contrary, we know that the mapped distributions are dynamic features reflecting large scale seasonal migrations by fish and transport with water of plankton (including fish larvae). This illustrates the limitations and challenges associated with representing seasonality when working with data layers. A potential solution to this lack of resolution could be the implementation of spatial models to estimate the seasonality of these layers. However, before such modelling is implemented, it is necessary to demonstrate that the models actually perform well in predicting seasonal cycles.

Working with knowledge layers, as was done in the AMSA IIC report, it is feasible to include information on seasonality for each of the identified special or valued areas. Thus, for seabird colonies, fish spawning areas, spring and autumn staging areas for birds, migration corridors for marine mammals, etc., there should be linked metadata with information on when the areas are used for the identified purposes. Maps can then be either annual or seasonal, showing the mapped features with information provided on when the areas are used and important. These are some plausible strategies to consider seasonality within the framework, but which one is better will depend on the precise resolution of the base feature layers, the level of seasonal detail truly required for management purposes, and the cost-benefit analysis associated with the implementation of a more complex framework. These decisions need to be evaluated both by experts with knowledge on the Barents Sea and the data sources available, as well as by managers with experience on the specific activities and projects expected to be managed using the products generated by the framework.

## Framework products and general management context

This conceptual framework describes a general approach that can be used to guide the process of identification and delineation of special/valued areas in the Barents Sea. However, many of the details in the actual implementation require input, review, and interpretation by experts with knowledge on the Barents Sea as well as input and considerations from managers expected to be end users of the results. Depending on the decisions made during the actual implementation process, some of the expected products may change.

In general terms, this framework would be expected to render:

- A series of maps of base features in the Barents Sea, and associated descriptive metadata.
- A series of maps showcasing the contribution of the base features to the four ecological dimensions: food web, habitat, biodiversity, and productivity.
- A full overlap map of all base feature layers in the Barents Sea, and associated descriptive metadata.
- A map of special/valued areas in the Barents Sea, with the associated description of each area and indicating the contributing base layers.

In terms of interactive tools, all these maps, associated base layers, metadata and descriptions would be expected to be implemented in a web-based GIS-capable portal, where the different base layers, overlaps, and special/valued areas can be explored and turn on/off by the user. This portal would also be expected to provide the platform for displaying the monitoring of the dynamic layers contributing to the special/valued areas. The Norwegian Environment Agency's web portal www.havmiljo.no provides a good example for the type of portal and functionality that would be required for this framework.

In terms of management applications, this framework needs to be thought within the broader scope of integrated ecosystem assessments, and where the identification and delineation of special/valued areas is a core component of the implementation of ecosystem-based management of the Barents Sea.

## References

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.

# 4 Data

## Data management best practices

Assuring both the quality of underlying data and the transparency of an assessment process is vital. It will ensure scientific credibility of the process aiming to identify ecologically valuable areas, to be used reliably by managers for decision-making purposes. WKBAR noted the recently established ICES manual for data management best practices (see ICES, 2019), which centres on the FAIR principles, ensuring that all data are:

- Findable (through documentation and metadata)
- Accessible (through clarity on licensing, formats and the ICES data policy)
- Interoperable (through extended use of shared reference systems and services)
- Reusable (by having known data quality and good documentation)

WKBAR noted that a large part of the data that can be used for describing valuable areas of the Barents Sea is already collected within Norwegian/Russian joint monitoring. ICES WGIBAR also regularly conducts some quality checking and standardizing of data. Some challenges however remain. WKBAR noted that there are inherent differences in data management between national institutes and between countries. Norway has an open data policy, while Russian data can be shared after request only. Further there are differences in how data is aggregated and in the units used. This has implications for both storing the data and how it can be extracted to carry out a joint assessment. Ideally, joint standards and workflows, as well as a common open database for all Barents Sea data would be recommended. A common database would make it easy to produce value maps over the whole Barents Sea area and to verify they have been delineated following the same principles. Currently, however, it is only possible to agree upon common criteria and methods for the description of valuable areas, and to produce the value maps through joint workshops and expert networks, such as WKBAR and WGIBAR. The difficulties can however be diminished by agreeing upon data management 'best practice guidelines' with predefined workflows and routines. In doing so, the following points are important:

- Use existing standards and formats to describe data wherever possible, making adaptations only where necessary (i.e. avoid making new standards/formats)
- Create documentation (ideally ISO meta-data) on the origin of the data you are using in the process
- Verify /double check by a second expert, following the "four-eyes principle"
- Have a clear understanding of the level of temporal and spatial resolution at which data are used in the process
- Agree upon methods on how aggregation of data is done – and document how this has happened
- Iterate the assessment process and get feedback for improvement over a number of reporting cycles (of data)

The aim of the best practice guidelines is to standardize and enhance quality assurance for all data submitters. Potential issues and potentially erroneous results in the submitted and aggregated data can be identified early in the process. By assuring the quality of underlying data and the scientific credibility and transparency of the assessment process, any subsequent joint data products can reliably be disseminated as web-based map products for decision-makers in Norway and Russia and for others it may concern.

## Data flows

The process from collecting data to producing maps of environment values for the Barents Sea is described in Figure 5. It is suggested to use existing data sets from the joint annual IMR-PINRO ecosystem surveys of the Barents Sea and other established surveys and monitoring programs. It is suggested that WGIBAR together with invited experts on e.g. seabirds and sea mammals could be given the terms of reference that will compile spatial and aggregated maps for the features within each ecosystem component (e.g. oceanography, plankton, fish, etc.). These aggregated maps (base feature layers in the context of the framework) are then aggregated by ecological dimensions (food web, habitat, biodiversity, productivity) to provide synoptic value maps for these easily communicated dimensions. The full aggregation of all base feature layers renders the overall ecological and biological value map for the Barents Sea, which will serve as basis for the expert-driven delineation of special/valued areas.

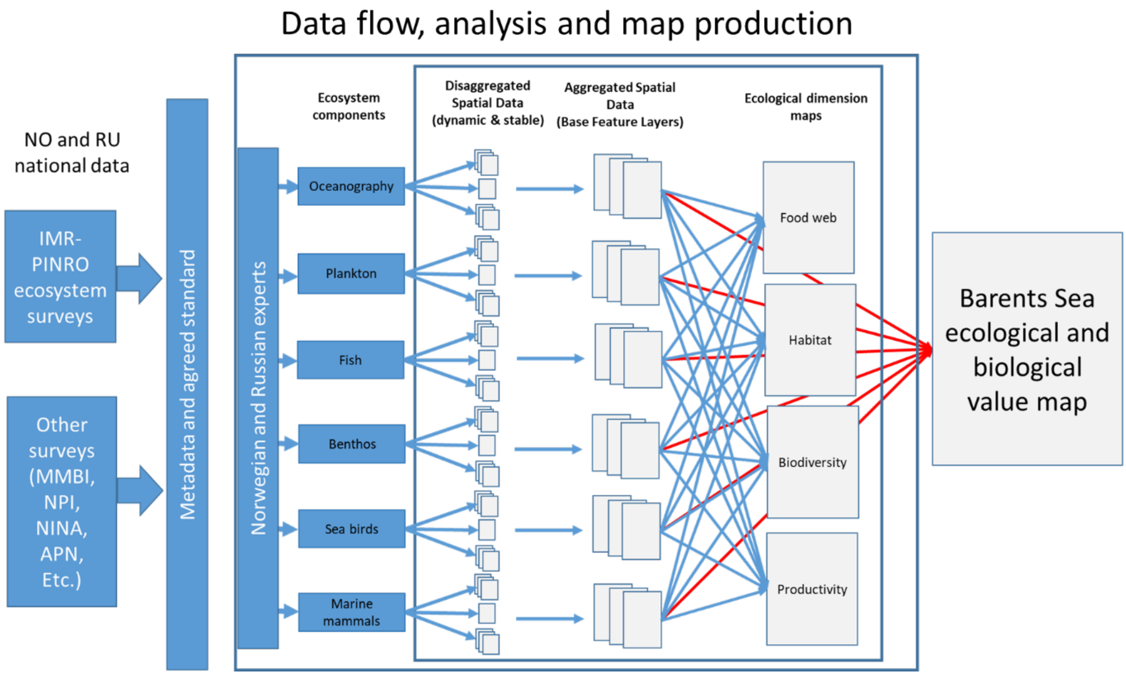


**Figure 5. Flow chart of the data collection (left side) to standardization of data per ecosystem component to the spatial mapping and further to the aggregated maps by ecological dimensions and to the Barents Sea ecological and biological value map (right side). This overall Barents Sea ecological and biological value map is the one used to identify and delineate special/valued areas.**

## Metadata

WKBAR compiled a metadata table (based Korneev *et al.*, 2015) for an overview of known data sources that could be considered within an assessment process to identify ecologically and biologically valuable areas for the Barents Sea. This metadata table is present in Annex 2.

## References

Korneev, Oleg & Titov, Oleg & van der Meeren, Gro & Arneberg, Per & Tchernova, Julia & Jørgensen, Nina. 2015. Final Report 2012-2015 Joint Russian-Norwegian Monitoring Project - Ocean 3.

ICES. 2019. ICES User Handbook: Best practice for Data Management. 12pp. http://doi.org/10.17895/ices.pub.4889

# Annex 1: List of participants

| Name | Institute | E-mail |
|---|---|---|
| Adriaan Rijnsdorp (chair) | Wageningen University & Research, the Netherlands | adriaan.rijnsdorp@wur.nl |
| Mariano Koen-Alonso (chair) | DFO, Canada | Mariano.Koen-Alonso@dfo-mpo.gc.ca |
| Markku Viitasalo (chair) | Finnish Environment Institute, Finland | markku.viitasalo@ymparisto.fi |
| Alexei Bambulyak | Akvaplan-niva, Tromsø, Norway | Alexei.Bambulyak@akvaplan.niva.no |
| Denis Moiseev | Murmansk Marine Biological Institute | Denis_Moiseev@mmbi.info<br>denis_moiseev@mail.ru |
| Dmitry Prozorkevich | PINRO, Russia | dvp@pinro.ru |
| Elena Eriksen | IMR, Norway | Elena.eriksen@hi.no |
| Hein Rune Skjoldal | IMR, Norway | hein.rune.skjoldal@hi.no |
| Igor Berchenko | MMBI, Russia | berchenko@mmbi.info |
| Jens Rasmussen | Marine Laboratory, UK | jens.rasmussen@gov.scot |
| John Richard Hansen | Norwegian Polar Institute, Norway | john.richard.hansen@npolar.no |
| Kit M. Kovacs | Norwegian Polar Institute, Norway | kit.kovacs@npolar.no |
| Lis Lindal Jørgensen | Institute of Marine Research | lis.lindal.joergensen@hi.no |
| Oleg Titov | PINRO, Russia | titov@pinro.ru |
| Øystein Leiknes | Norwegian Environment Agency | Oystein.Leiknes@miljodir.no |
| Sebastian Valanko | International Council for the Exploration of the Sea (ICES) | sebastian.valanko@ices.dk |
| Hans Mose Jensen | International Council for the Exploration of the Sea (ICES) | hans.jensen@ices.dk |

# Annex 2: Overview table of the existing spatial inventories and other data useful for producing value maps for the Barents Sea.

Note: The table does not encompass all data; it lists data that are easily available – mostly derived from the monitoring report.

| Parameter level 1 | Parameter level 2 | Spatial coverage / area covered (information not complete) | Temporal resolution (if any) (information not complete) | The CBD EBSA criteria adopted to identify EBSAs in the Barents Sea | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Uniqueness or rarity | Special importance for life history of species | Importance for threatened, endangered or declining species | Vulnerability, fragility, sensitivity, slow recovery | Biological productivity | Biological diversity | Naturalness | |
| Phytoplankton | Net primary productivity | | | | | | | | | | |
| | Chlorophyll a / Total PPL biomass | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Phytoplankton species abundance | | | | | | | | | | Temporally and spatially limited data |
| | Phytoplankton diversity | | | | | | | | | | Temporally and spatially limited data |
| Zooplankton | Zooplankton species, abundance and biomass | BS | | | | | | | | | |
| | Krill abundance | | | | | | | | | | |
| | Jellyfish biomass | | | | | | | | | | |
| Pelagic invertebrates | Shrimp | BS | Annual | | | | | | | | |
| Macroalgae | Distribution and coverage of macroalgal species | | | | | | | | | | Fragmented info for NO coast; collected by research institutes and algae farming industry |
| Benthos | Total benthos biomass (grab sampling) | | | | | | | | | | Temporally and spatially limited data |
| | Benthos species, abundance and biomass (grab sampling) | | | | | | | | | | Temporally and spatially limited data |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Megafauna (trawl sampling):<br>abundance, biomass | | | | | | | | | | |
| Pelagic fish | Species: Blue whiting, BS capelin, polar cod, NSS herring<br>-0-group & adult abund. / biomass<br>-spawning areas | BS | 1-2 times a year | | | | | | | | |
| Demersal fish | Beaked redfish, NEA haddock, NEA cod, Greenland halibut<br>-0-group and adult abund./biomass<br>-spawning areas | BS | 1-2 times a year | | | | | | | | |
| Seabirds | Seabird assemblages at sea (from aerial and ship-based surveys) | | | | | | | | | | |
| | Seabird colony locations | | | | | | | | | | |
| | Breeding populations: numbers in selected colonies (9 species) | | | | | | | | | | |
| | Seabirds' reproductive success | | | | | | | | | | 10 species for RU, 1 species for NO |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| Mammals | Whales (minke, fin, humpback) and white beaked dolphins:<br>-abundance<br>-distribution | NO, RU | | | | | | | | | |
| | Harp seal:<br>-population size<br>-distribution<br>-reproductive rate | | | | | | | | | | |
| | Ringed seal:<br>-population size<br>-reproductive rate | | | | | | | | | | |
| | Walrus: population size | | | | | | | | | | |
| | Polar bear:<br>-denning areas<br>-reproductive success | NO | | | | | | | | | |
| Vulnerable and endangered species (VES) | VES fish: Number of VES; their relative abundance and population trends | BS | Annual | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bowhead whale: relative abundance | | | | | | | | | | |
| | Harbour seal and grey seal: abundance on BS coast | | | | | | | | | | |
| Non-indigenous species | Red king crab, snow crab distribution | NO-EEZ, RU-EEZ | | | | | | | | | More NIS = lower naturalness |
| Biodiversity | Demersal fauna biodiversity indicator | | | | | | | | | | |
| Geology | Distribution of different bottom substrates (mud, sand, gravel, boulders, rock etc.) | | | | | | | | | | Covered by MAREANO project for NO |
| Sea ice | Sea ice<br>-area<br>-extent<br>-concentration | BS | daily-weekly | | | | | | | | |
| | Number of icebergs observed | BS | daily-weekly | | | | | | | | |
| Oceanography / physics | Sea surface temperature (satellite) | BS | daily-weekly | | | | | | | | |
| | Salinity, in situ (50 m and bottom) | BS cruises, whole area maps | 3-4 per year | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area of water masses (calculated from salinity and temperature) | | | | | | | | | | |
| | Frontal Zones / sharpness and location (satellite) | BS | annually | | | | | | | | |
| Water chemistry | Nutrients, in situ (whole area maps; 50 m and bottom) | BS | | | | | | | | | |
| | CDOM (satellite) | BS | | | | | | | | | |

# Annex 3: Technical minutes from the Ecological Valuing of Barents Sea Review Group (RGBAR)

**RGBAR**

By correspondence 1– 19 April, 2019

Participants: Adriaan Rijnsdorp, Chair (NL), Markku Viitasalo (FIN) and Mariano Koen-Alonso (CAN) and Sebastian Valanko (ICES Secretariat)

Review was conducted within the context of NOR-RUS request to, "*provide advice on the joint identification and aggregating of data on environmental values in coastal and offshore areas in Norwegian and Russian part of the Barents Sea*."

Review material:

Magnus Aune, Alexei Bambulyak, Kjetil Sagerup, Ana Sofia Aniceto, Denis Moiseev, Pavel Vaschenko, Olga Kalinka, Georgy Dukhno. 2017. Report OCEAN-1: Valuable areas in the Barents Sea Phase 1. Akvaplan-niva AS 2017. Rapport 8328. 68 pp.

ICES. 2018. Interim Report of the Working Group on the Integrated Assessments of the Barents Sea (WGIBAR). WGIBAR 2018 REPORT 9-12 March 2018. Tromsø, Norway. ICES CM 2018/IEASG:04. 210 pp.

## Review

To provide a better basis for the managing of the marine areas in the Barents Sea, the OCEAN-1 project has been initiated by the Joint Norwegian Commission on Environmental Cooperation to compare methods and criteria used for identifying valuable areas in the Norwegian and Russian part of the Barents Sea. The Phase-1 report presents the findings of a joint research team on the analysis of approaches used in Norway and Russia, describes the status of data and provides recommendations for mapping valuable areas in the Barents Sea. Information on available data is also provided in the Report of WGIBAR. Both reports are reviewed by ICES. The review is given below.

## General considerations

There is no unique way of defining and identifying special/valuable areas in an ecosystem. There are several international processes like CBD EBSAs and FAO VMEs, which come with their own set of criteria and guidelines, as well as national initiatives like Canada's C-EBSAs, or Norway's and Russia's processes to define special areas in the Barents Sea (see OCEAN-1 below). The processes do not strictly share a common set of criteria nor follow identical steps to identify them, but the level of overlap among the criteria is typically high. Their results, if they were applied to a common ecosystem, would probably be fairly consistent.

The criteria all typically highlight the functionality, high biodiversity, rarity and sensitivity, as well as level of human interference in the system, and can be measured and assessed using various biotic parameters or indicators (Table 1).

**Table 1. The CBD-EBSA and FAO-VME criteria**

| | CBD-EBSA | FAO-VME |
|---|---|---|
| 1 | uniqueness or rarity | uniqueness or rarity |
| 2 | special importance of an area for a life history stage of a species | Functional significance of habitat |
| 3 | importance for the threatened, endangered or declining species and/or habitats | fragility |
| 4 | vulnerability, fragility, sensitivity, or slow recovery | Life history attributes of species |
| 5 | biological productivity | Structural complexity |
| 6 | biological diversity | |
| 7 | naturalness | |

# OCEAN-1 Phase-1

## Norway

In Norway, the value of 10x10 km grid cells is assessed based on the monthly distribution maps of a selection of species, life stages and habitat types for four ecosystem components: benthos, fish, birds and marine mammals. For the value assessment only species were included that are confined in space and time. Hence, evenly distributed species of life stages were not taken into account. No details were provided on how the confinement in space was estimated and used for species selection. Value was estimated semi-quantitatively in a stepwise approach. In the first step a value score of 0 (lowest value) to 3 (highest value) was assigned to each of the selected species for a number of CBD-EBSA criteria (Table 2) and the mean species score was determined over the CBD-EBSA criteria. In the second step the highest of the mean species scores was determined and assigned as the score for the ecosystem components. In the third step, the highest ecosystem components score was determined and assigned as the value score for the area. The value scores reflect the habitat value for the species with the most constraint spatial distribution and threat status within the species group assessed.

**Table 2. CBD-EBSA criteria used to determine the value assessment of the different groups (ecosystem components)**

| Ecosystem component | CBD-EBSA criteria | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Habitat types | x | x | | x | | x | |
| Fish | x | x | | | x | | |
| Seabirds | | x | x | | | | |
| Marine mammals | | x | x | | | | |

In addition, several larger areas were defined as particularly valuable areas by expert judgement based on the importance with regard to biological diversity and production and where disturbance potentially may induce long-lasting or irreversible damage (Olsen & von Quillfeldt, 2003). Four criteria were used that are related to biological diversity (i.e., particularly high biodiversity, living area for particular species or populations, particular nature or habitat types, and borderlines where species have their distribution limits), and two criteria were used that are relevant for biological production (i.e., high biological production, and high concentrations of species or individuals). These criteria match the 5th and 6th criterion of the EBSA. Table 3 presents the justification of the particular valuable areas designated in the Norwegian part of the Barents Sea.

Monthly maps of environmental value, derived by combining the valuable and particularly valuable areas, are provided on a web portal of the Norwegian Environmental Agency together with background information on which of the major group and the species are determining the value. It is unclear how the monthly maps were derived given the available survey data are generally confined to specific survey periods.

**Table 3. List of Particularly Valuable and Vulnerable areas**

| Particularly valuable area | Justification |
|---|---|
| Lofoten to Tromsøflaket, including Eggakanten | Narrow shelf area with high concentrations of species at all trophic levels, where important aspects of species' life histories occur, including overwintering, reproduction, juvenile stages, feeding and resting. |
| Vestfjorden/Vesterålen | High biological production, and historically important areas for NEA cod and NSS herring. |
| 50 km coastal zone from Tromsøflaket to the order to Russia | Productive and biologically diverse area, where species at all trophic levels area found. |
| The variable ice edge | Short and intense primary production, which is exploited by species at all higher trophic levels. Occasionally very dense concentrations of foraging species. |
| Bear Island | Important with regard to biological production and diversity, with major colonies of breeding seabirds. |
| The Polar Front | High biological production, many seabirds, and attractive feeding area for species at several trophic levels. |

## Russia

In Russia several approaches have been used to define valuable areas in relation to the sensitivity for oil spills. The OCEAN-1 Report does not provide details on the different methods, but describes the key elements. One approach published by WWF Russia is expert-based and uses information on abundance or presence-absence of relevant biota (benthos, fish, birds, sea mammals) on a seasonal (quarterly) basis. No information is given how the maps of the various biota are combined into a habitat value map. Another approach, building on earlier work done in Russia and Norway, proposed to map existing nature conservation areas, areas of spawning and feeding and fishing as well as areas with high seasonal concentration of birds and marine mammals (Zemplyanov, 2013). Finally, Kornev (2015), following the UNESCO IOC Manual and Guide on MSP and the Norwegian 'Integrated Management Plan for the Barents Sea', developed an integrated management plan for Russian seas. CBD-ESBA criteria were used to assess the values for the selected biota. Habitat value was estimated as the rank of the biomass distribution for two levels of the trophic chain: 1) plankton and zoobenthos; 2) fish, marine mammals and seabirds.

In total four EBSAs are designated in the Russian part of the Barents Sea (Murman coast and Varanger Fjord), shallow parts of the Pechora Sea, coast of western and norther Novaya Zemlya, northeastern Barents – Kara Sea).

## Towards a common methodology

Because of the differences in methodology, the results of the Norwegian and Russian assessments are not directly comparable. Most assessments combined information of several groups of biota (ecosystem components), acknowledged the fact that habitat value may vary seasonally, and used criteria set by international organizations such as the CBD. Differences occurred in the criteria and in the selection of species and species groups used, as well as in the scoring system and in the way the habitat scores were aggregated over species and ecosystem components. Benthos, fish, seabirds and marine mammals were included by both countries but Russia also included phytoplankton and zooplankton. Finally there was a difference in the resolution of the time steps to take account of seasonal changes in value.

In order to map valuable areas in the Norwegian and Russian part of the Barents Sea in a standardised way, an agreed definition of value and a common valuation methodology is needed. Although there are differences in the methodology applied by Norway and Russia, their methods show similarities in the ecosystem components considered and the criteria used to determine value. The biggest difference appears to be in selection of species and the way the value scores were determined and aggregated over ecosystem components.

Building on these similarities, and informed by the experiences from other exercises around the world (e.g. C-EBSAs in Canada), a candidate framework (Annex 2) was developed for consideration at the WKBAR workshop.

## Data types and data availability

The OCEAN-1 report provides an overview of data sources that can be used for the value assessment. Table 4 presents a list of species and life stages for which distribution maps have been compiled. Most data layers are based on monitoring programmes such as the MAREANO project (habitat types) and the Joint IMR-PINRO Ecosystem Survey.

A comprehensive list of references is provided to survey data sources, fish spawning sites and larvae data, cod research (*skreitokt*), marine mammals and habitat types. In addition, literature references are provided on species, species distributions and the Barents Sea ecosystem, and on methods and approaches elaborated in Russia. Finally, references to the EBSAs designated in the Russian part of the Barents Sea are provided.

**Table 4. List of ecosystem components and associated biota and life stages for which monthly distribution maps have been compiled as used in the value assessment in Norway.**

| | | | | | |
|---|---|---|---|---|---|
| **Habitat** | | **Distribution** | | | |
| | Demospongia sponge communities | x | | | |
| | Hexactinellid sponge communities | x | | | |
| | Umbellula communities | x | | | |
| | Sea-pen communities | x | | | |
| | Coral gardens | x | | | |
| | Coral reefs | x | | | |
| **Fish** | | **Feeding** | **Spawning** | **Larvae** | **0-group** |
| | Greenland halibut | x | x | | |
| | BS capelin | x | x | x | x |
| | NEA haddock | x | x | | |
| | NEA saithe | x | x | | |
| | NEA cod | x | x | x | x |
| | NSS herring | x | x | x | x |
| | Beaked redfish | x | x | | |
| | Deepwater redfish | x | x | | |
| | Polar cod | x | x | | |
| **Seabirds** | | **Feeding** | | | |
| | Razorbills | x | | | |
| | Little auk | x | | | |
| | Herring gull | x | | | |
| | Yellow-billed loon | x | | | |
| | Northern fulmar | x | | | |
| | Gannets | x | | | |
| | European Storm-petrel | x | | | |
| | Barnacle goose | x | | | |
| | Ivory gull | x | | | |
| | Black-legged kittiwake | x | | | |
| | Goosander | x | | | |

| | | | |
|---|---|---|---|
| Common guillemot | x | | |
| Atlantic puffin | x | | |
| Brünnich guillemot | x | | |
| Glaucous gull | x | | |
| Brent goose | x | | |
| Arctic tern | x | | |
| Sabine gull | x | | |
| Ste’ler's Eider | x | | |
| Great skua | x | | |
| Great Cormorant | x | | |
| Great black-backed gull | x | | |
| Black guillemot | x | | |
| Common shag | x | | |
| Common eider | x | | |
| **Marine mammals** | **Feeding** | **Pupping Molting** | **Haul out Resting** |
| Harbour seal | x | x | x |
| Bearded seal | x | x | |
| Ringed seal | x | x | |
| Walrus | x | | x |
| Harp seal | x | x | |
| Beluga | x | | |
| Narwhal | x | | |
| Hooded seal | x | x | |
| Grey seal | x | | |
| Polar bear | x | x | |
| Whales | x | | |

## WGIBAR

The Working Group on the Integrated Assessments of the Barents Sea (WGIBAR) report provides an update of the changes in the status of the Barents Sea ecosystem and the oceanographic conditions. WGIBAR distinguishes 15 subareas based on topography and oceanography. Information is presented on primary production, phytoplankton, zooplankton (mesozooplankton and krill), benthos, shellfish, pelagic fish, demersal fish, marine mammals and seabirds. Information on biogenic habitats (such as coral reefs, sponge gardens) from the MAREANO project has not been fully integrated in the report.

The report shows that the Barents Sea appears to be changing rapidly. The air and water temperatures are higher than average and ice coverage is reduced. Spatially integrated net primary production has increased over the years. An increase in ice-free areas, and length of the growing season, provide improved habitat for phytoplankton growth. These changes will affect the food web and are likely to affect the distribution and abundance of biota, and hence the ecological value of areas.