CBD

Convention on Biological Diversity

Distr.
GENERAL

CBD/EBSA/WS/2018/1/3
6 February 2018

ENGLISH ONLY

REGIONAL WORKSHOP TO FACILITATE THE DESCRIPTION OF ECOLOGICALLY OR BIOLOGICALLY SIGNIFICANT MARINE AREAS IN THE BALTIC SEA AND TRAINING SESSION ON ECOLOGICALLY OR BIOLOGICALLY SIGNIFICANT MARINE AREAS
Helsinki, 19-24 February 2018

DATA TO INFORM THE REGIONAL WORKSHOP TO FACILITATE THE DESCRIPTION OF ECOLOGICALLY OR BIOLOGICALLY SIGNIFICANT MARINE AREAS IN THE BALTIC SEA

Note by the Executive Secretary

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

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

Data to Inform the CBD Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas (EBSA) in the Baltic Sea

20 February - 24 February 2018
Helsinki, Finland

Jesse Cleary, Sarah DeLand, Ben Donnelly, Patrick Halpin
Marine Geospatial Ecology Lab, Duke University

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

Inquiries should be addressed to:

Jesse Cleary
Marine Geospatial Ecology Lab, Duke University
Durham, NC, USA
Telephone : +1 919-684-3660
Email : jesse.cleary@duke.edu
Web : http://mgel.env.duke.edu

Important Notice

Information contained in this publication comprises general statements based on scientific research. The Marine Geospatial Ecology Lab (MGEL) advises the reader to note that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, MGEL (including its employees and consultants) excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it. Additionally, some data sets used herein require permission from the data providers for use.

Contents

Figures

1 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 Baltic Sea. Biogeographic, 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 dataset may be used to meet one or more of the EBSA criteria.

Printed map posters and map books will be available for review at the workshop. Digital versions of these maps are also available online:
https://duke.box.com/s/3vbex0wdeno5uxx9qarz6okfy4ikoxar

1.1 Data Collection Scope

Data and supporting documents for this report were collected and collated for the Baltic Sea. The exact geographic focus of the workshop will be established by the workshop attendees at the meeting.

Figure 1.1-1 Data collection scope

2 Biological Data

2.1 Ocean Biogeographic Information System (OBIS)

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 researchers 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 0.1 degree grids are provided for all species, mammals, shallow species (<100m depth), and deep species (>100m depth). 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 01/03/17)

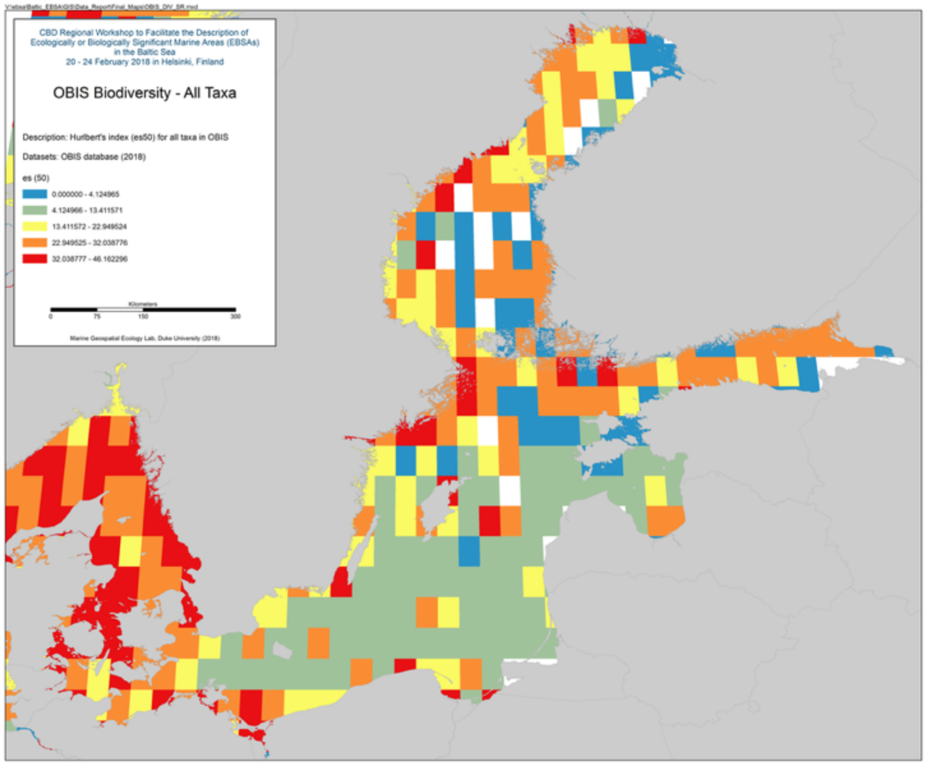


Figure 2.1-1 Biodiversity ES(50) for All Taxa

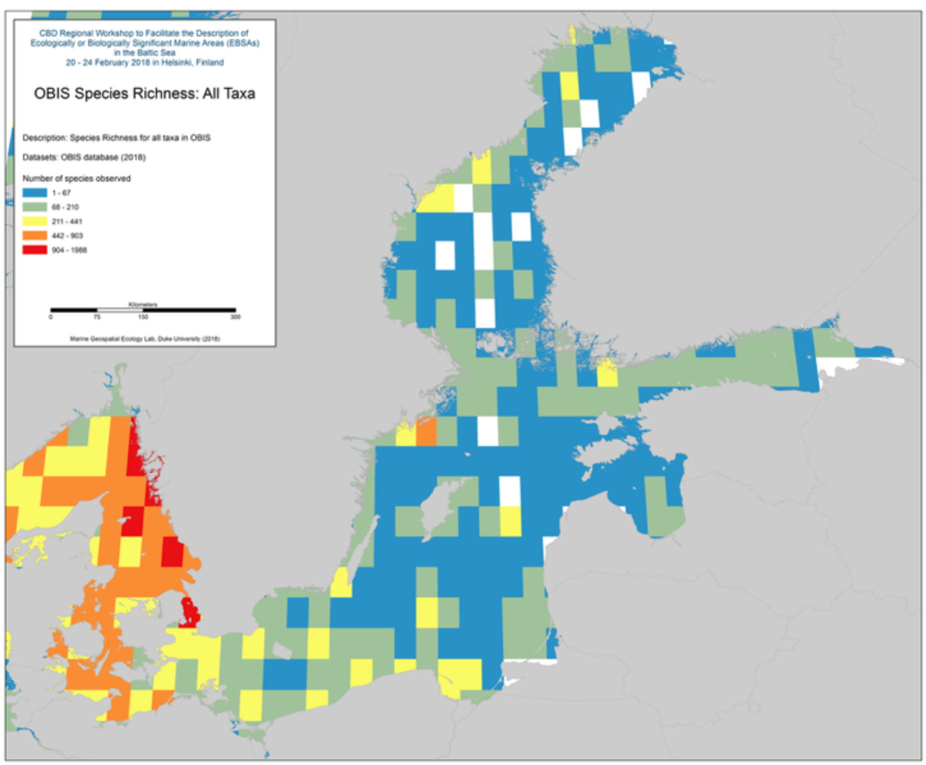


Figure 2.1-2 Species Richness for All Taxa

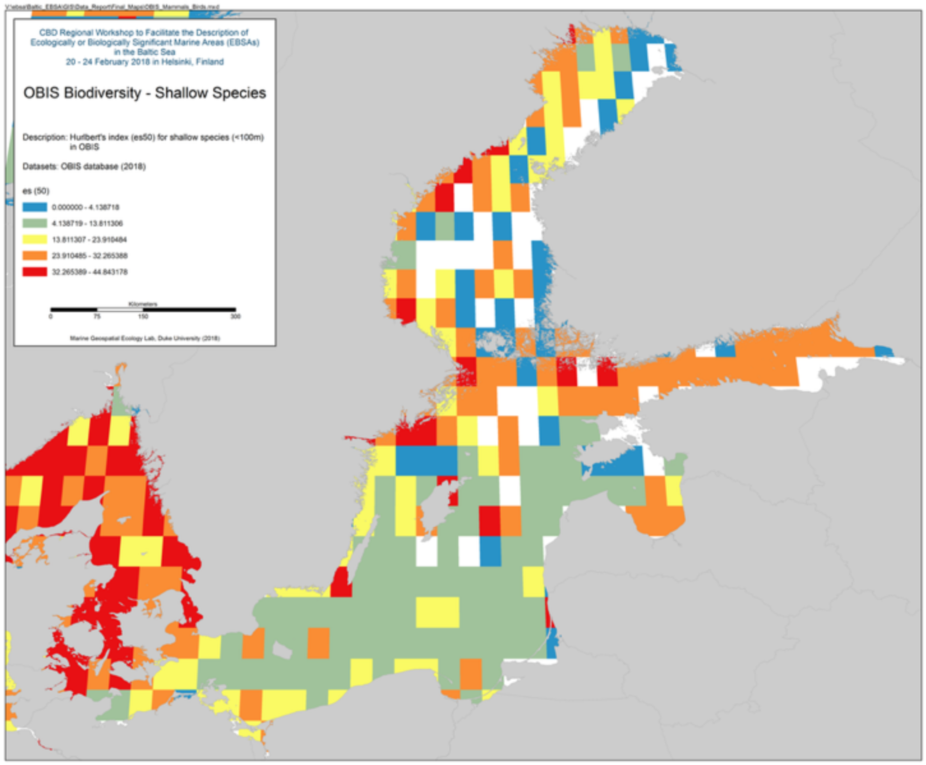


Figure 2.1-3 Biodiversity ES(50) for Shallow Species

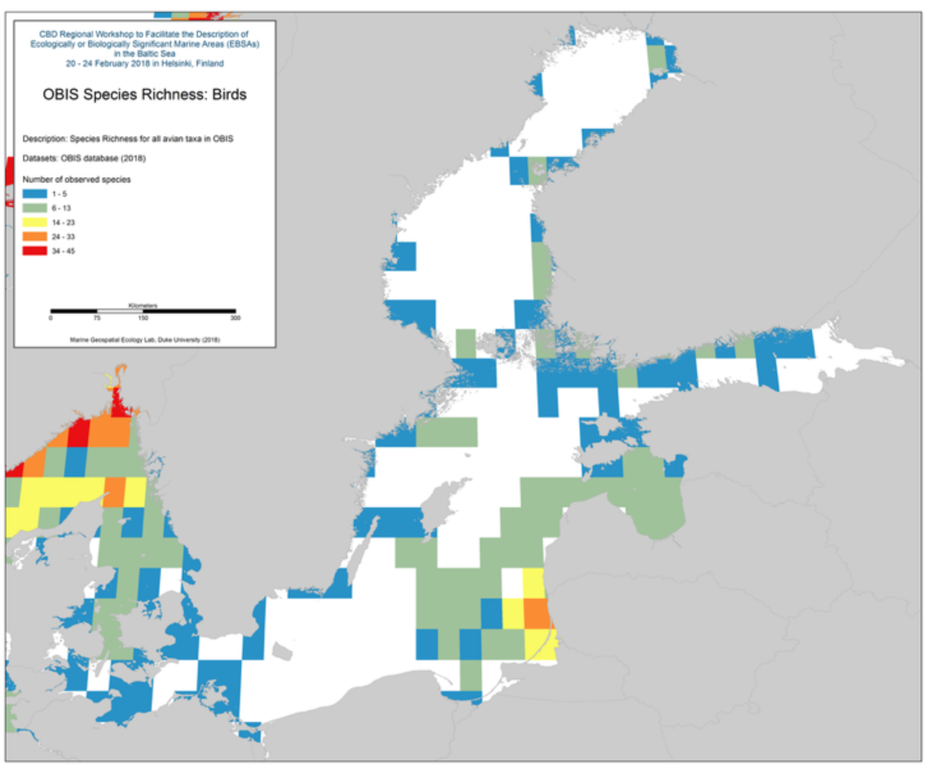


Figure 2.1-4 Species Richness for all Avian taxa

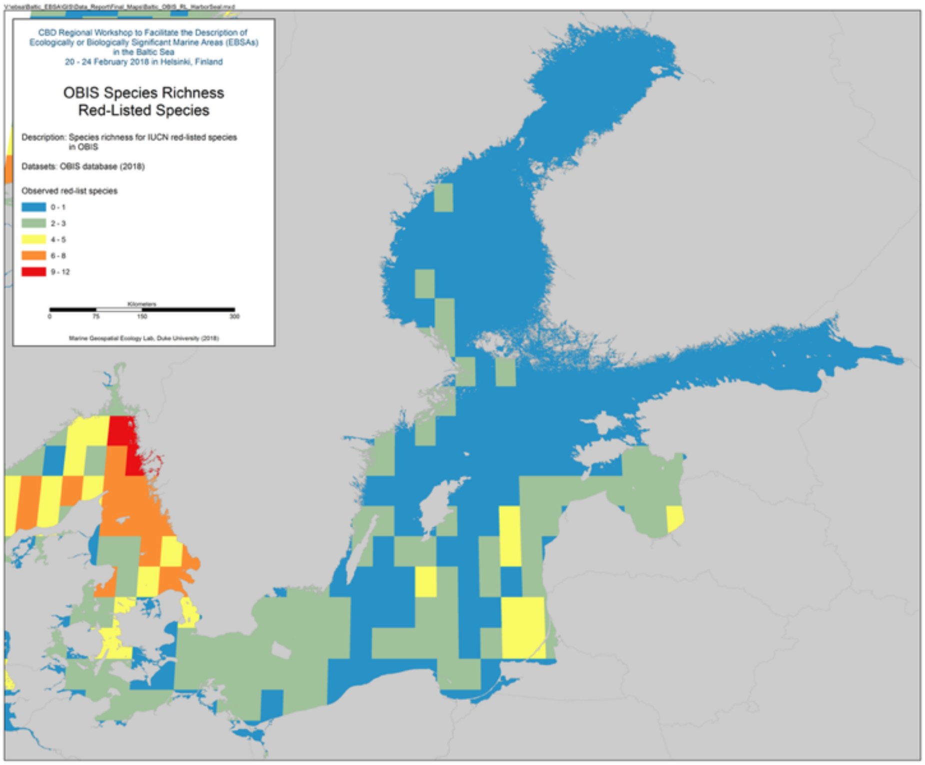


Figure 2.1-5 Species Richness for Red-Listed Species

2.2 BirdLife International Important Bird Areas (IBAs)

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 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".

Dataset:
BirdLife International Marine E-Atlas, prepared by BirdLife International January 2018

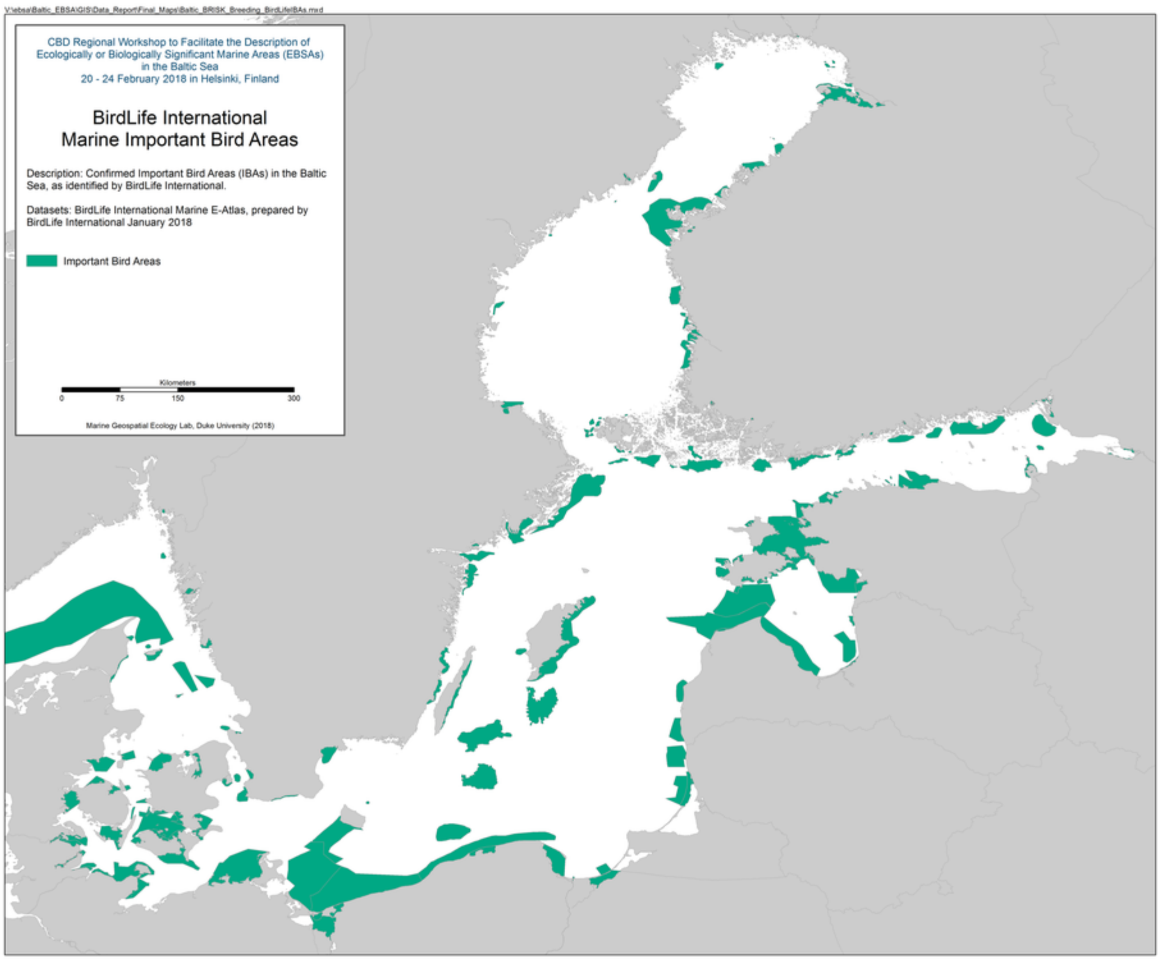


Figure 2.2-1 BirdLife International Important Bird Areas (IBAs)

2.3 Bird breeding areas (BRISK)

"The data set is indicating important spots where sea- and shore birds breed in the Baltic Sea area. This dataset depicts breeding areas of birds as polygon regions used for the BRISK project (Sub-regional risk of spill of oil and hazardous substances in the Baltic Sea, http://www.brisk.helcom.fi/). This dataset has been produced by COWI (http://www.cowi.dk). Based on data collected from Baltic sea countries (Denmark, Estonia, Finland (Finnish data Copyright: SYKE, The Finnish data is lacking small bays of the Finnish coastline. These bays are important for birds), Germany, Latvia, Poland, Russia, Sweden). The dataset includes data provided by the BRISK Project Partner organisations from various Baltic Sea countries. The detailed documentation of what partner provided what data is given in the Annex of the document: 70618-3.1.2.2 Data Collection Report."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/ceced767-2d09-498f-9481-d2933467551f

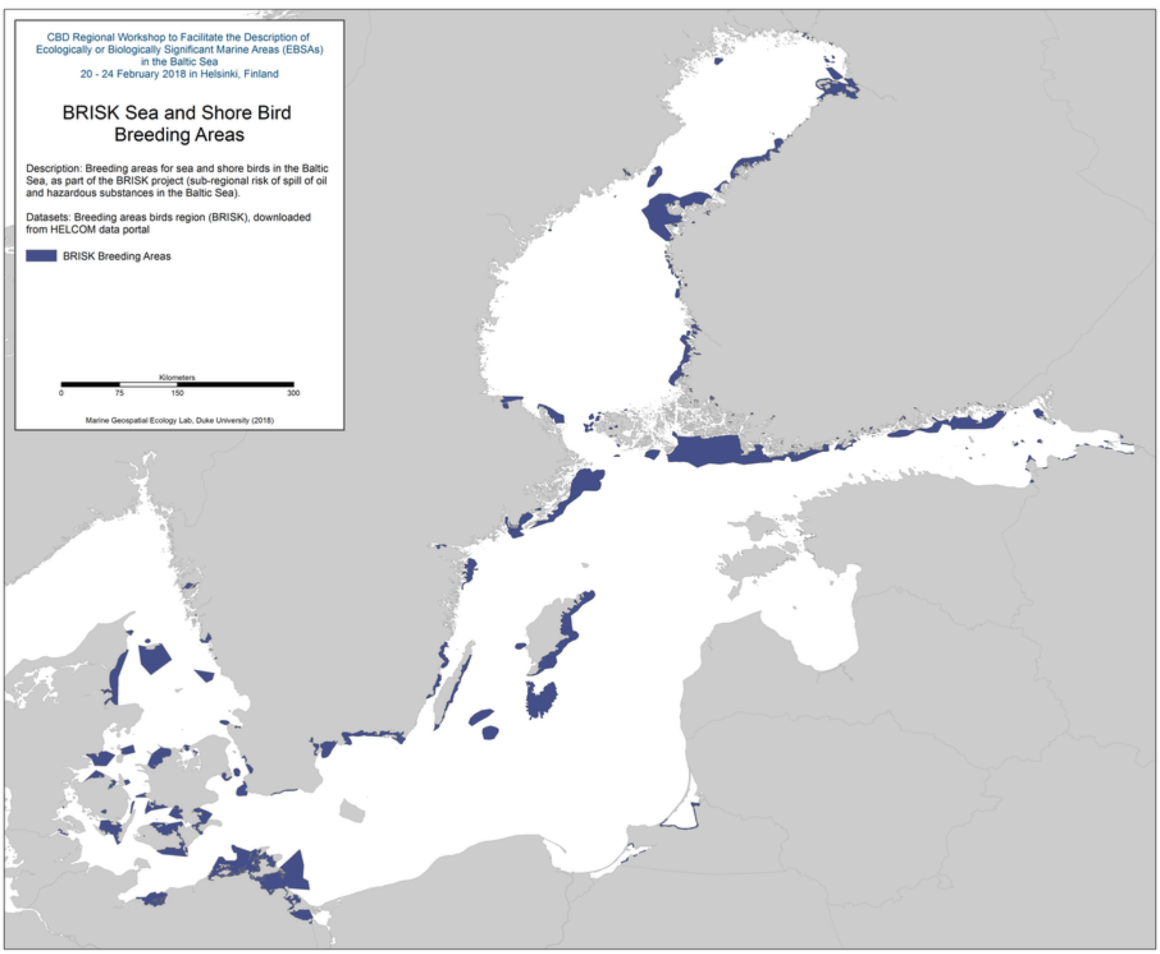


Figure 2.3-1 Bird breeding areas (BRISK)

2.4 Wintering areas for sea and shore birds (BRISK)

"The data set is showing wintering areas for sea and shore birds in the Baltic Sea area as polygons used for the BRISK project (Sub-regional risk of spill of oil and hazardous substances in the Baltic Sea, http://www.brisk.helcom.fi/). This dataset has been produced by COWI (http://www.cowi.dk) based on data collected from HELCOM, Finland (Copyright: SYKE), Latvia, Lithuania, Poland, Russia and Sweden. The dataset includes data provided by the BRISK Project Partner organisations. The detailed documentation of what partner provided what data is given in the Annex of the document: 70618-3.1.2.2 Data Collection Report."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/534b3be6-a14e-42c6-9372-7231f9d32aac

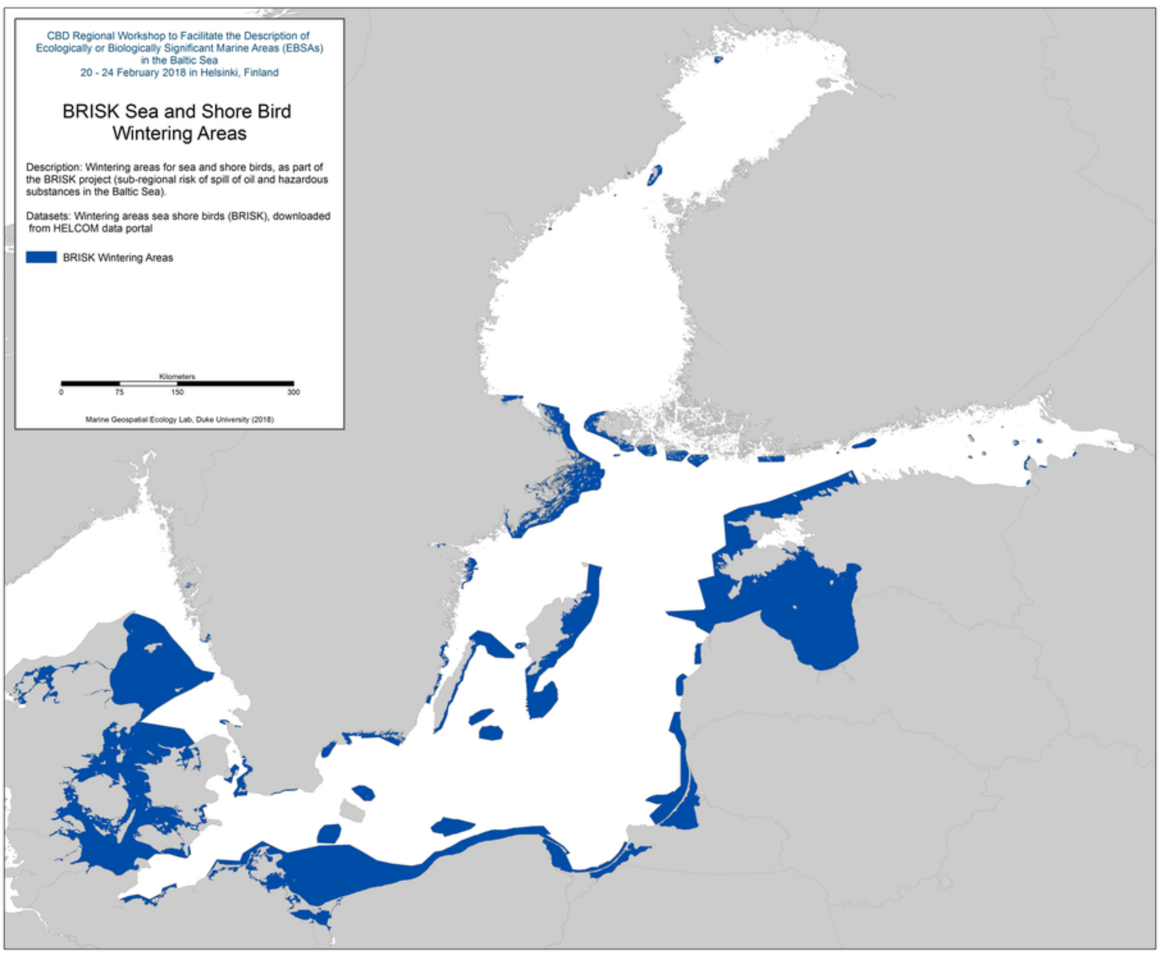


Figure 2.4-1 Wintering areas for sea and shore birds (BRISK)

2.5 Staging areas for migrating sea and shore birds (BRISK)

"The data set is showing staging areas for migrating sea and shore birds in the Baltic Sea area as polygons used for the BRISK project (Sub-regional risk of spill of oil and hazardous substances in the Baltic Sea, http://www.brisk.helcom.fi/). This dataset has been produced by COWI (http://www.cowi.dk) based on data collected from Baltic Sea countries (Denmark, Estonia, Finland (Copyright: SYKE), Germany, Latvia, Poland, Russia, Sweden). The dataset includes data provided by the BRISK Project Partner organisations. The detailed documentation of what partner provided what data is given in the Annex of the document: 70618-3.1.2.2 Data Collection Report."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/d0303ad2-560d-4b78-80d5-24f67b388dce

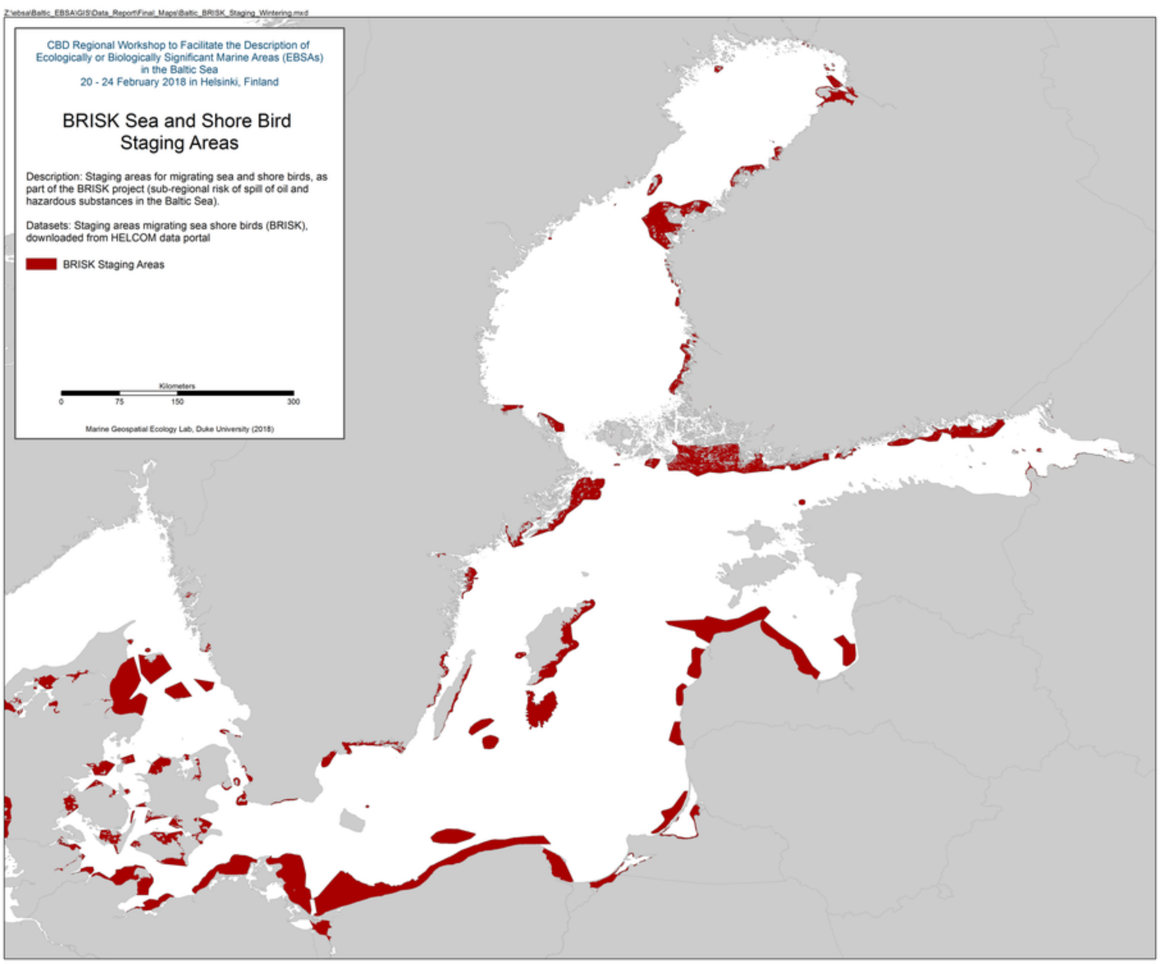


Figure 2.5-1 Staging areas for migration of sea and shore birds (BRISK)

2.6 Spawning areas for fish with demersal or pelagic eggs (BRISK)

“The data set is spawning areas for fish with demersal eggs in the Baltic Sea area as polygon areas used for the BRISK project (Sub-regional risk of spill of oil and hazardous substances in the Baltic Sea, http://www.brisk.helcom.fi/). This dataset has been produced by COWI (http://www.cowi.dk) based on data collected from Poland and Russia and by COWI from polygons created from 10 m depth curve. The dataset includes data provided by the BRISK Project Partner organisations. The detailed documentation of what partner provided what data is given in the Annex of the document: 70618-3.1.2.2 Data Collection Report.”

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/2b40b23a-c46c-4258-a209-6279b12548a7

“The data set is showing spawning areas with pelagic fish eggs in the Baltic Sea area as polygons used for the BRISK project (Sub-regional risk of spill of oil and hazardous substances in the Baltic Sea, http://www.brisk.helcom.fi/). This dataset has been produced by COWI (http://www.cowi.dk) based on data from HELCOM and COWI.”

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/380bf6c2-a018-4a1c-bdea-39d9ced25ba4

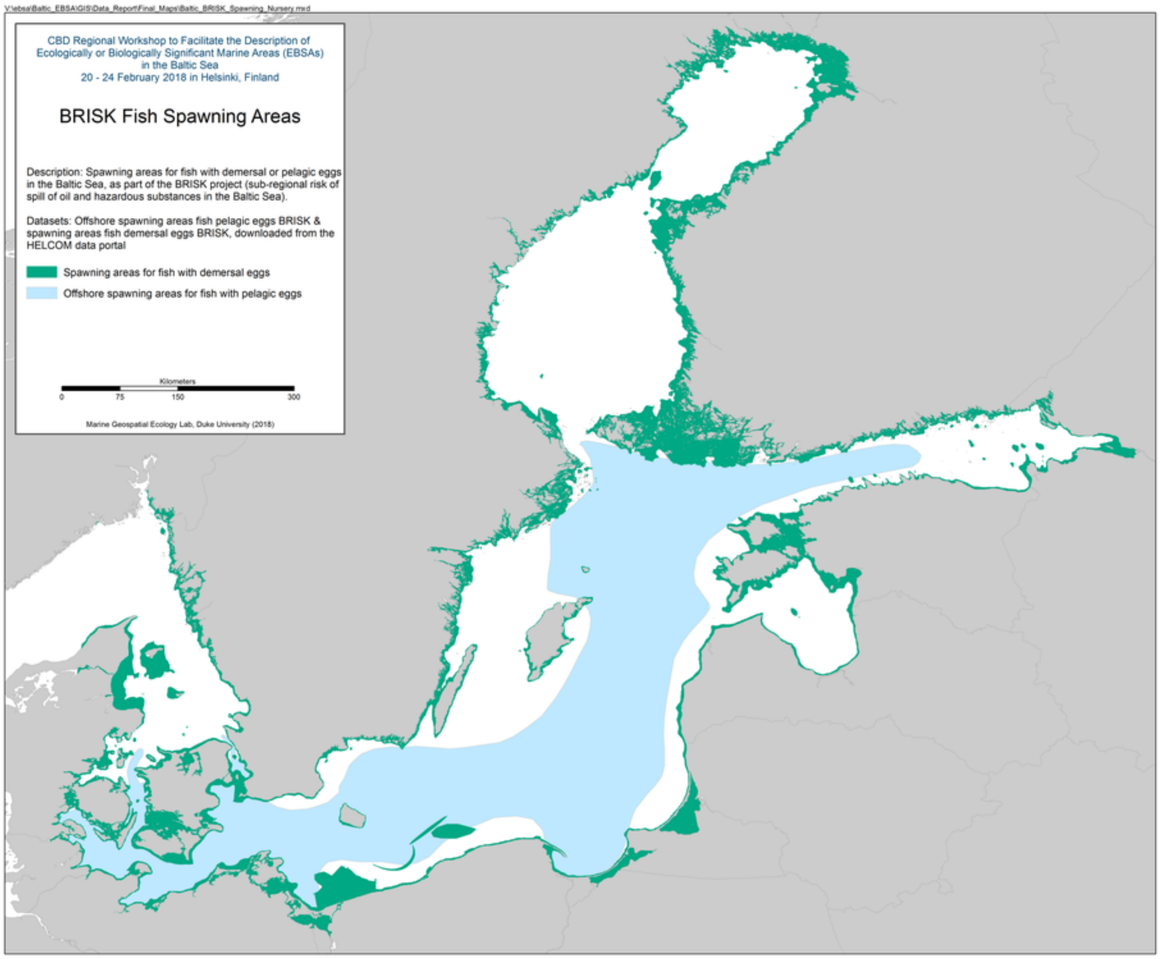


Figure 2.6-1 Spawning areas for fish with demersal or pelagic eggs (BRISK)

2.7 Nursery areas for fish in shallow water (BRISK)

"The data set is showing nursery areas for fish in the shallow waters of the Baltic Sea area as polygons used for the BRISK project (Sub-regional risk of spill of oil and hazardous substances in the Baltic Sea, http://www.brisk.helcom.fi/). This dataset has been produced by COWI (http://www.cowi.dk) based on data collected from Poland and Russia and by COWI from polygons created from 10 m depth curve. The dataset includes data provided by the BRISK Project Partner organisations. The detailed documentation of what partner provided what data is given in the Annex of the document: 70618-3.1.2.2 Data Collection Report. Shallow water areas are nursery areas for a long list of fish. Particularly during summer these areas are vulnerable."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/219845d1-11a4-429f-a4c4-60b734d41e18

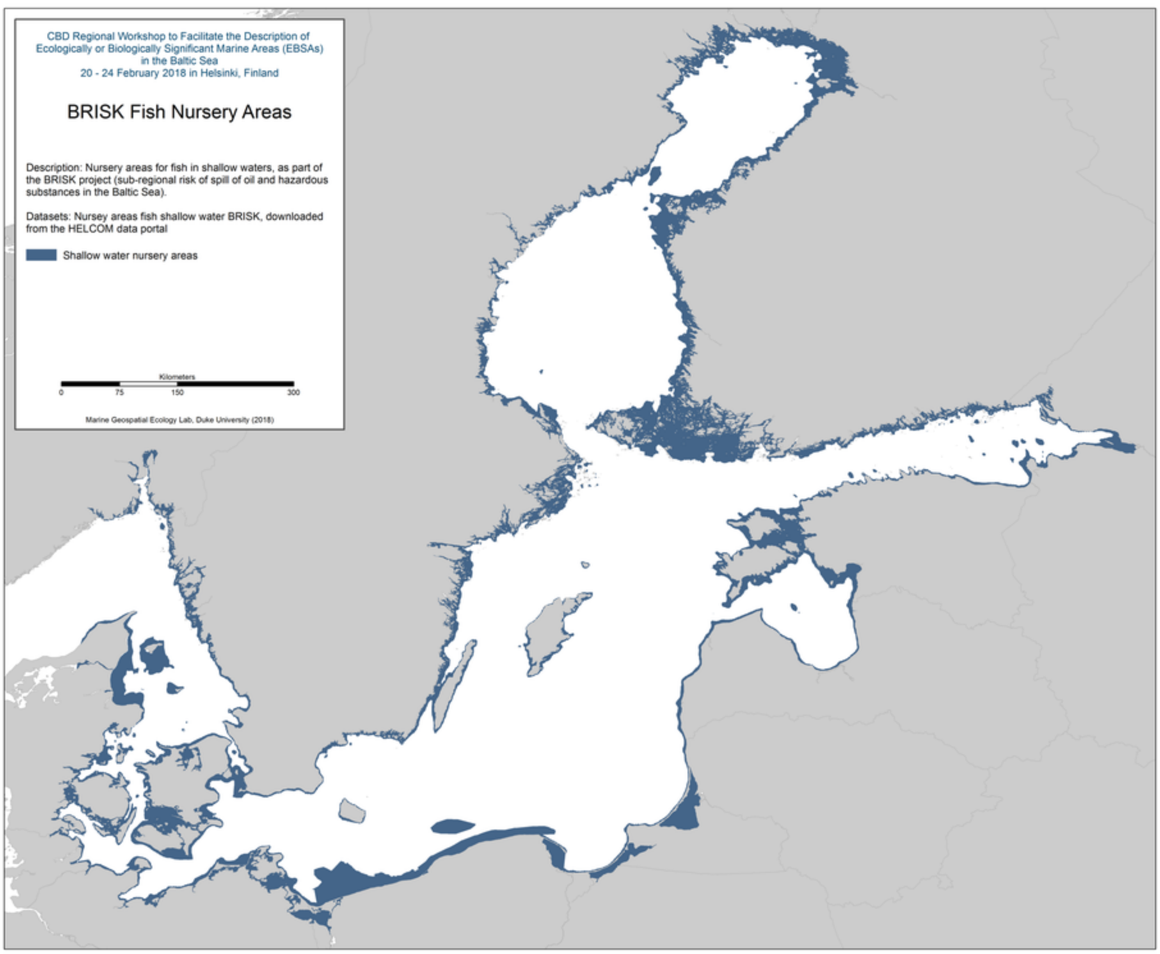


Figure 2.7-1 Nursery area for fish in shallow water (BRISK)

2.8 HELCOM Benthic Species Distribution

“HELCOM identified five presence/absence distribution datasets of Baltic benthic species for use in the workshop. The data are generalized into 5km x 5km grids.

- **“Mytilus** (blue mussel) distribution. Mainly pointwise occurrences of Mytilus spp. were submitted, originally gathered in national mapping and monitoring campaigns, or for scientific research. Point data from Poland was digitized based on Polish Marine Atlas. From Lithuania, a polygon delineating reefs was used to present Mytilus occurrence. For Germany, point data was complemented with a model describing Mytilus biomass in the German marine area (Darr et al. 2014), where predicted biomasses > 1g dw/ m2 were included as presence. From Estonian waters, a predictive model was used (200m resolution), that was converted to presence/absence using minimized difference threshold (MDT) criteria”

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/d83121ae-332b-401b-bd0e-208e907a7a40

- **“Zostera marina** (eelgrass) distribution. Mainly pointwise occurrences of eelgrass were submitted, originally gathered in national mapping and monitoring campaigns, or for scientific research. Polygon data from Puck Bay (Poland) was digitized based on Polish Marine Atlas and Orlowo cliff area was added based on expert knowledge. From Estonian waters, a predictive model was used (200m resolution), that was converted to presence/absence using minimized difference threshold (MDT) criteria.”

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/611d9dae-eb1c-4b48-b638-ecbb75e6d782

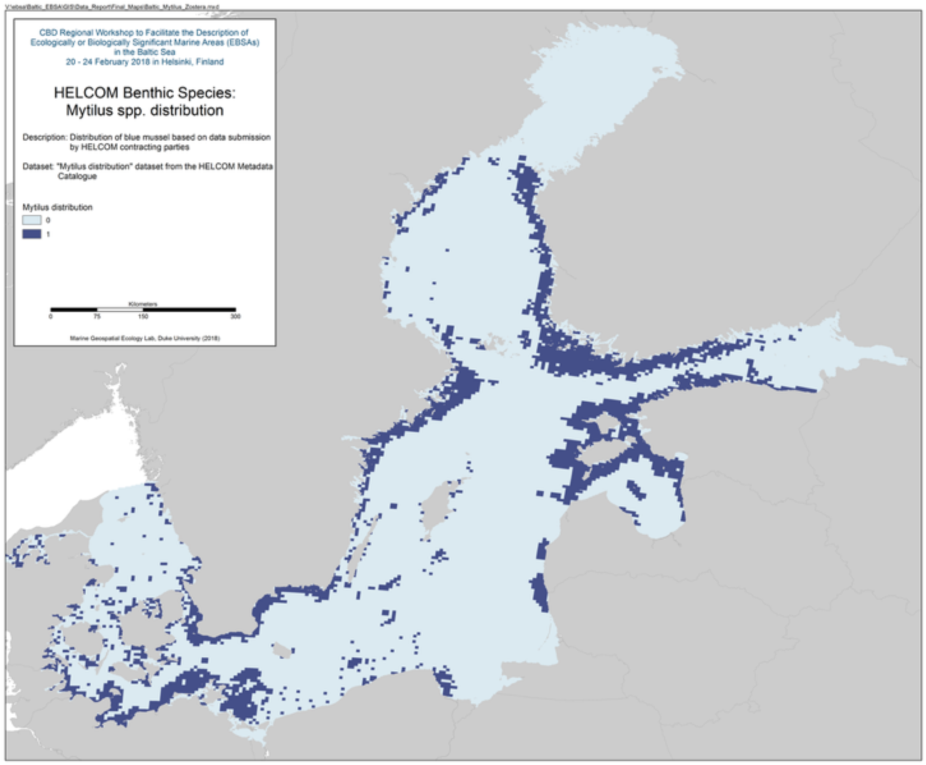


Figure 2.8-1 Mytilus spp. distribution

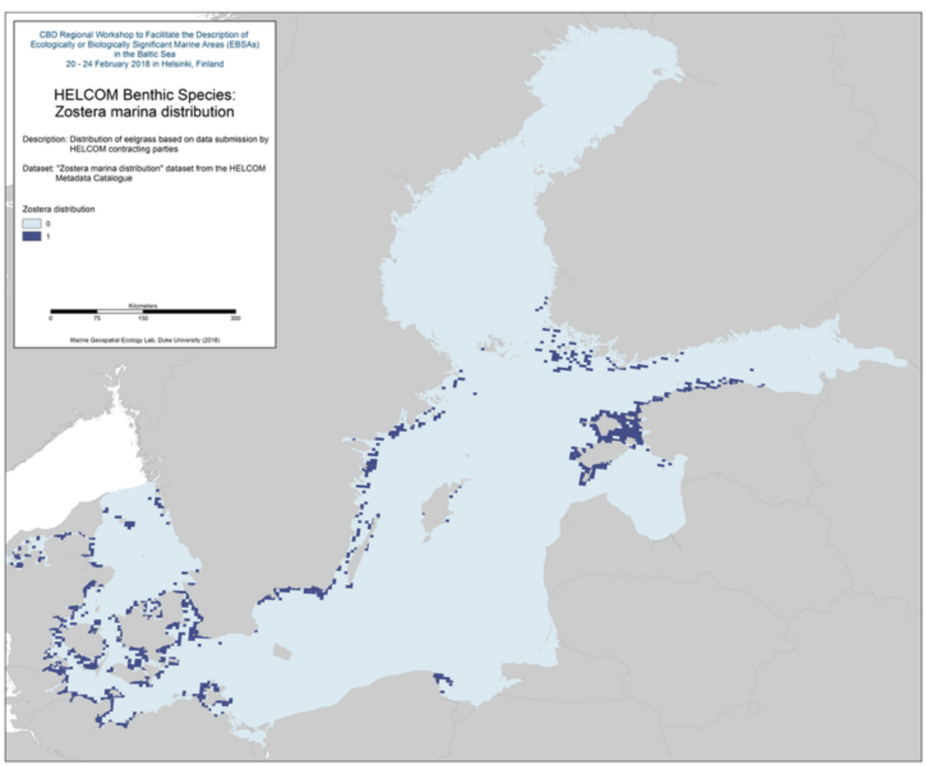


Figure 2.8-2 Zostera marina distribution

2.9 HELCOM Fish Areas

Six synthesized datasets from HELCOM provide abundance data and important areas for considering in the workshop.

"**Cod abundance**: Baltic International Trawl Survey (BITS) data (2011-2014) from ICES DATRAS database was used as a base to create a map of cod relative abundance (quarter 1 data, CPUE values per ICES subdivision). Cod > 30cm was included."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/bf20ca3b-6ce1-484f-be9a-f53ba023e6cc

Reference:
ICES 2014. Manual for the Baltic International Trawl Surveys (BITS). Series of ICES Survey Protocols SISP 7 - BITS. 71 pp.

"**Spawning area of cod**: The delineation of the spawning area is mainly based on Hüssy 2011. In addition, Gdansk deep (delineation based on Bagge et al. 1994) is included in the map, as it still sometimes contributes to reproduction of eastern Baltic cod stock ((Hinrichsen et al. 2016). Gotland basin has ceased to contribute to the reproduction of the Eastern Baltic cod due to oxygen deficiency and sedimentation related mortality (Hinrichsen et al. 2016)."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/e91d509d-bd3e-4bd8-a7c8-ac2d10bbfd1b

References:
Bagge, O., Thurow, F., Steffensen, E., Bay, J. 1994. The Baltic cod. Dana 10, 1-28.

Hinrichsen, H.H., Lehmann, A., Petereit, C., Nissling, A., Ustups, T., Bergström, U., Hüssy, K. 2016. Spawning areas of eastern Baltic cod revisited. Using hydrodynamic modelling to reveal spawning habitat suitability, egg survival probability, and connectivity patterns. Progress in Oceanography 143, 13-25.

Hüssy, K. 2011. Review of western Baltic cod (Gadus morhua) recruitment dynamics. ICES Journal of Marine Science 68(7), 1459-1471.

"**Herring relative abundance:** mainly based on Baltic International acoustic surveys (BIAS), years 2011-2015 (ICES WGBIFS reports 2012-2016), reported as millions of herring / ICES rectangle. Also, herring landings data were used to complement the data. The final layer was converted to 1 km x 1km grid cells."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/9cdc9e61-7ca2-47be-aebb-38a911acef49

References:
ICES 2012. Report of the Baltic International Fish Survey Working Group (WGBIFS), 26–30 March 2012, Helsinki, Finland. ICES CM 2012/SSGESST:02. 531 pp.

ICES 2013. Report of the Baltic International Fish Survey Working Group (WGBIFS), 21-25 March 2013, Tartu, Estonia. ICES CM 2013/SSGESST:08. 505 pp.

ICES 2014. Report of the Baltic International Fish Survey Working Group (WGBIFS), 24–28 March 2014, Gdynia, Poland. ICES CM 2014/SSGESST:13. 527 pp.

ICES 2015. First Interim Report of the Baltic International Fish Survey Working Group (WGBIFS), 23-27 March 2015, Öregrund, Sweden. ICES CM 2015/SSGIEOM:07. 724 pp

ICES 2016. Second Interim Report of the Baltic International Fish Survey Working Group (WGBIFS), 30 March-3 April 2016, Rostock, Germany. ICES CM 2016/SSGIEOM:07. 591 pp

"**Perch recruitment area:** The occurrence of suitable nursery habitats is crucial for maintaining fish populations (Sundblad et al. 2013). For perch, species distribution modelling studies (Snickars et al. 2010, Bergström et al. 2013, Sundblad et al. 2013) have shown the importance of suitable environmental conditions for reproduction. Due to lack of coherent data on perch spawning and nursery areas across the Baltic Sea countries, environmental variables were used in delineating potential recruitment areas for perch."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/3f8fc3c7-e5f2-4f67-a0ae-cbdfea01f2f7

References:
Bergström, U., Sundblad, G., Downie, A-L., Snickars, M., Boström, C., Lindegarth, M. 2013. Evaluating eutrophication management scenarios in the Baltic Sea using species distribution modelling. Journal of Applied Ecology 2013, 50, 680-690.

Snickars M., Sundblad G., Sandström A., Ljunggren L., Bergström U., Johansson G. & Mattila J. 2010. Habitat selectivity of substrate spawning fish - modelling requirements of the Eurasian perch, Perca fluviatilis. Marine Ecology Progress Series 398: 235-243.

Sundblad, G., Bergström, U., Sandström, A., and Eklöv, P. 2013. Nursery habitat availability limits adult stock sizes of predatory coastal fish. – ICES Journal of Marine Science.

"Pikeperch recruitment area: The occurrence of suitable nursery habitats is crucial for maintaining fish populations (Sundblad et al. 2013). Species distribution modelling studies have shown the importance of suitable environmental conditions for pikeperch recruitment. Due to lack of coherent data on pikeperch spawning and nursery areas across the Baltic Sea countries, environmental variables were used in delineating potential recruitment areas for pikeperch."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/7d6508ec-164e-4b65-b170-2074c2eec599

Reference:
Sundblad, G., Bergström, U., Sandström, A., and Eklöv, P. 2013. Nursery habitat availability limits adult stock sizes of predatory coastal fish. – ICES Journal of Marine Science.

"Sprat relative abundance: mainly based on Baltic International acoustic surveys (BIAS), years 2011-2015, (ICES WGBIFS reports 2012-2016), reported as millions of sprat per ICES rectangle. The BIAS surveys cover almost the whole area where sprat is commonly encountered."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/8f55de2c-b115-4d54-b686-3b7532bd6427

References:
ICES 2012. Report of the Baltic International Fish Survey Working Group (WGBIFS), 26–30 March 2012, Helsinki, Finland. ICES CM 2012/SSGESST:02. 531 pp.

ICES 2013. Report of the Baltic International Fish Survey Working Group (WGBIFS), 21-25 March 2013, Tartu, Estonia. ICES CM 2013/SSGESST:08. 505 pp.

ICES 2014. Report of the Baltic International Fish Survey Working Group (WGBIFS), 24–28 March 2014, Gdynia, Poland. ICES CM 2014/SSGESST:13. 527 pp.

ICES 2015. First Interim Report of the Baltic International Fish Survey Working Group (WGBIFS), 23-27 March 2015, Öregrund, Sweden. ICES CM 2015/SSGIEOM:07. 724 pp

ICES 2016. Second Interim Report of the Baltic International Fish Survey Working Group (WGBIFS), 30 March-3 April 2016, Rostock, Germany. ICES CM 2016/SSGIEOM:07. 591 pp

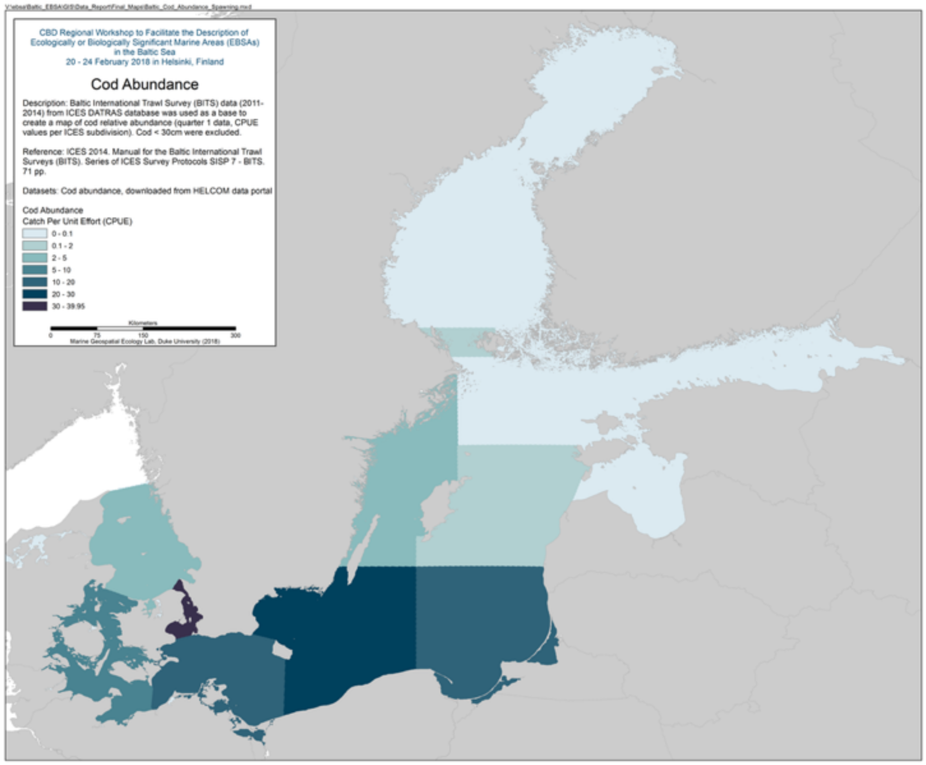


Figure 2.9-1 Cod abundance areas

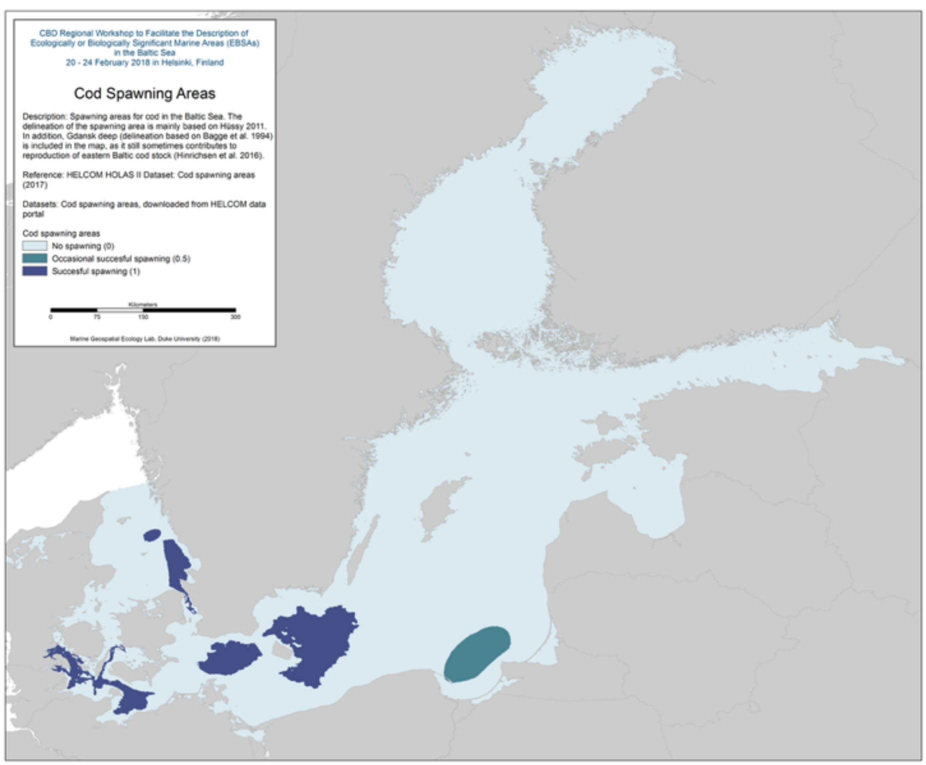


Figure 2.9-2 Cod spawning areas

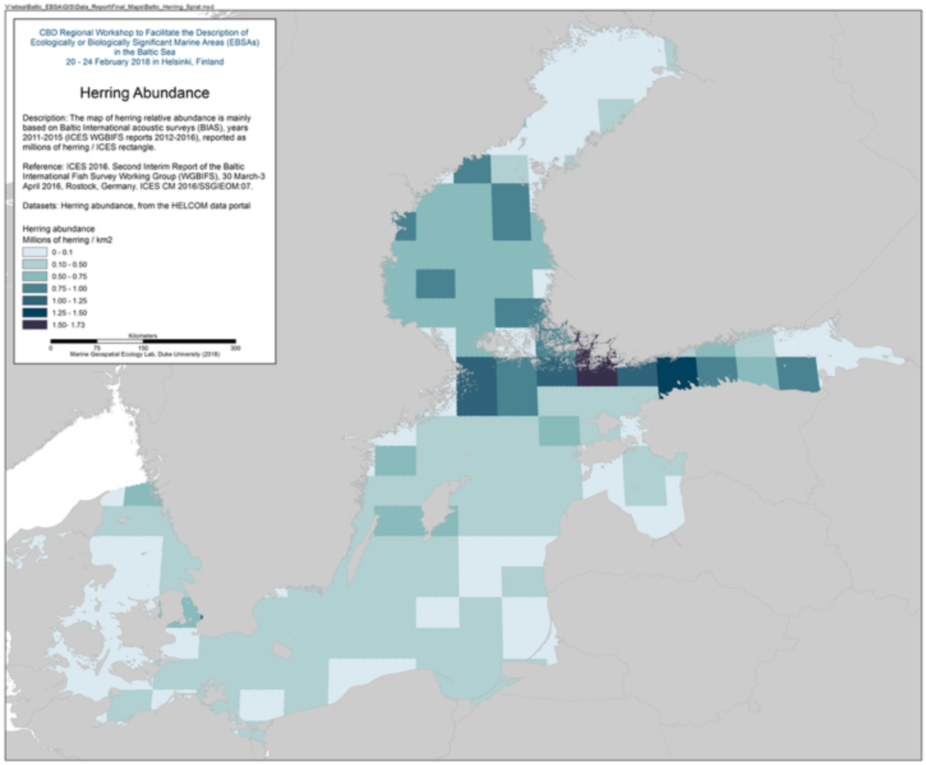


Figure 2.9-3 Herring relative abundance

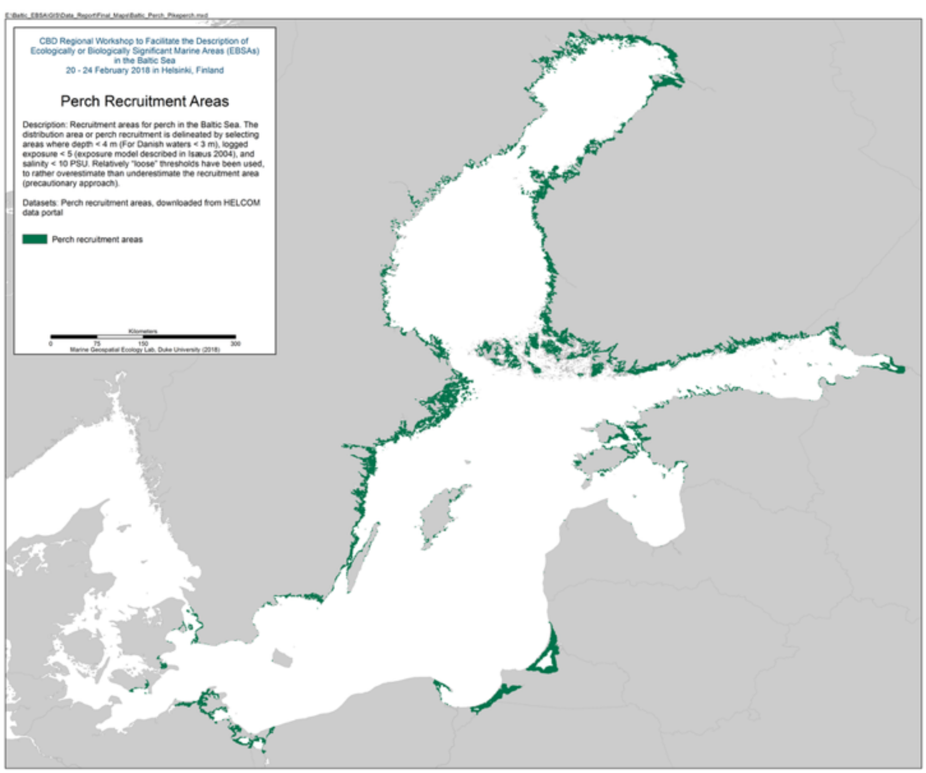


Figure 2.9-4 Perch recruitment areas

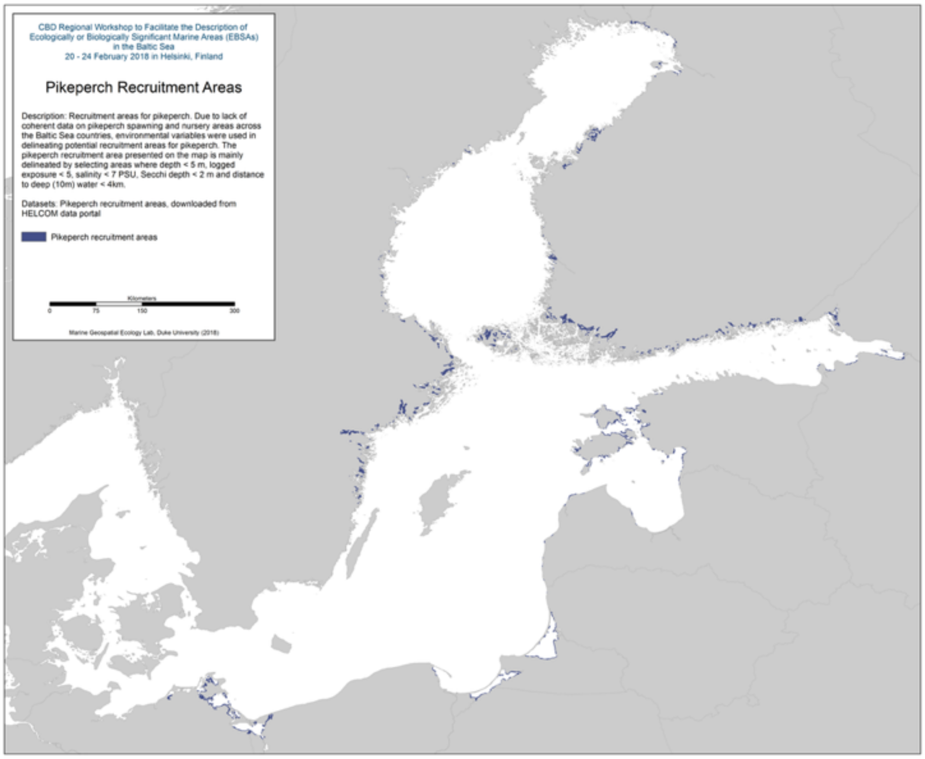


Figure 2.9-5 Pikeperch recruitment areas

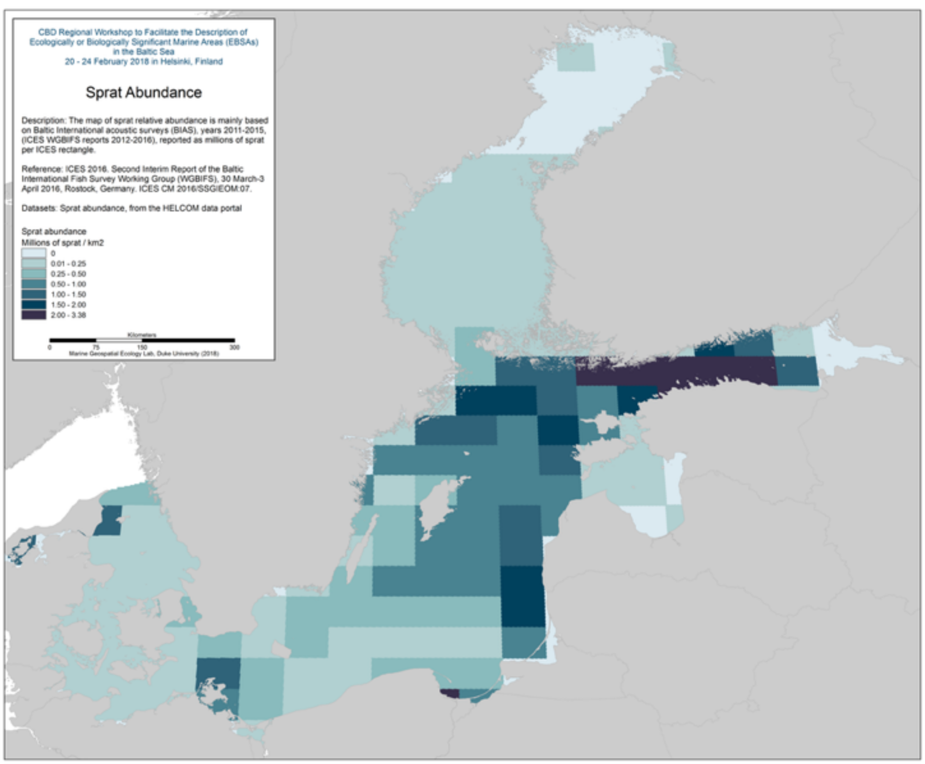


Figure 2.9-6 Sprat relative abundance

2.10 HELCOM Red-listed Species

"The HELCOM Red List of Baltic Sea species in danger of becoming extinct (2013) is the first threat assessment for Baltic Sea species that covers all marine mammals, fish, birds, macrophytes (aquatic plants), and benthic invertebrates, and follows the Red List criteria of the International Union for Conservation of Nature (IUCN).

Almost 2800 species or subspecific assessment units were considered in the Red List assessment and about 1750 were evaluated according to the IUCN Red List criteria. In all, 4% of those were regarded threatened (VU, EN, CR), which means that they are in danger of becoming extinct in the Baltic Sea."

Source: http://www.helcom.fi/baltic-sea-trends/biodiversity/red-list-of-species

Species were assessed in the following taxons, with biotopes also assessed:

- Benthic Invertebrates
- Birds
- Fish
- Marine Mammals
- Macrophytes

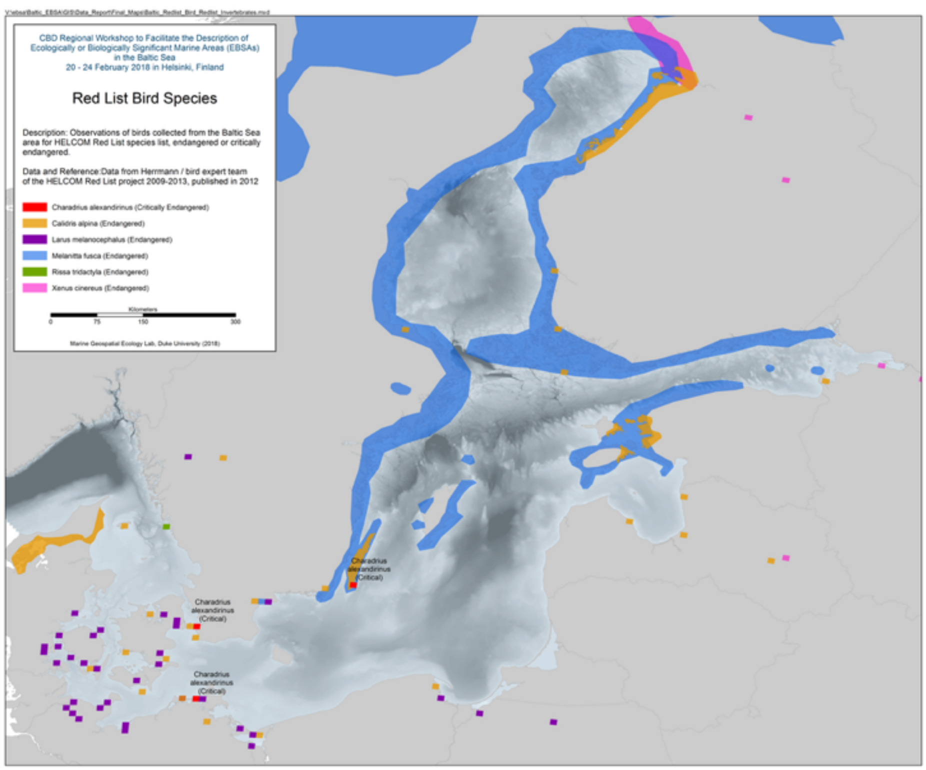


Figure 2.10-1 HELCOM Red-Listed Birds

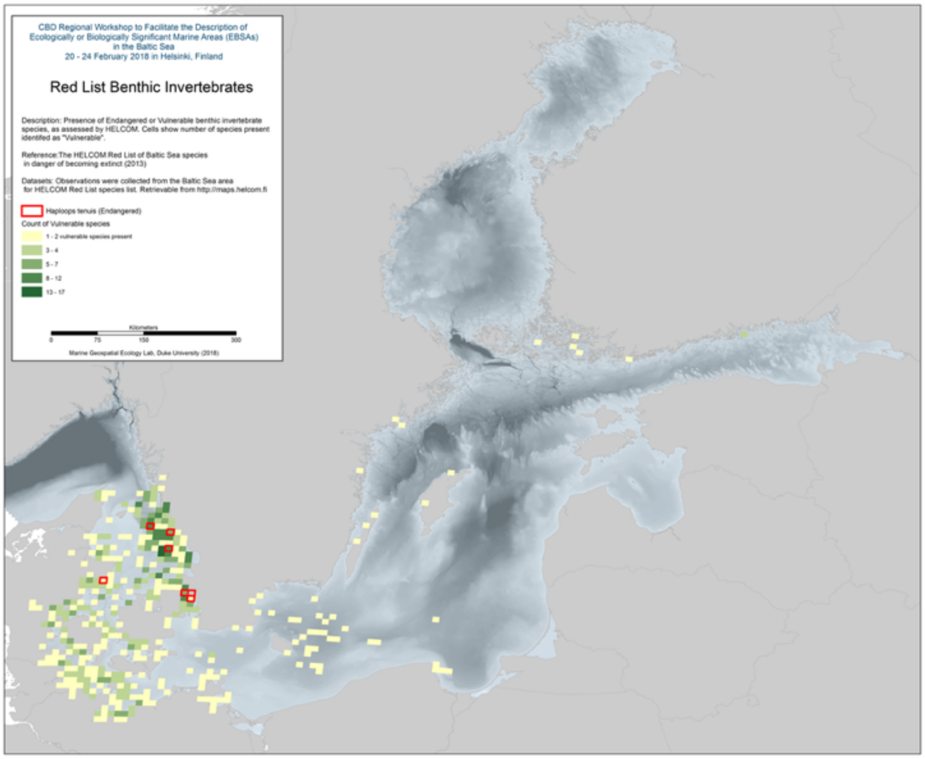


Figure 2.10-2 HELCOM Red-Listed Invertebrates

2.11 Harbour Porpoise - Probability of Detection

"This dataset was produced by the EU LIFE+ funded SAMBAH project and maps the probability of detection of harbour porpoises in the study area, which extends from the Åland Islands in the north to the Darss and Limhamn underwater ridges in the southwest. The study area excludes areas of depths greater than 80 m.

Probability of detection was modelled using General Additive Modelling and static covariates such as depth, topographic complexity, month, spatial coordinates and with time surveyed as a weight. Monthly predictions were done on a 1x1 km grid and averaged to result in seasonal distribution maps for May – Oct and Nov – Apr. This division of the year is a result of visual inspection of data and results, showing a clear separation of spatial clusters of harbour porpoises in the summer season May – Oct and a more dispersed pattern with no clear separation in Nov – Apr.

This dataset was produced by the EU LIFE+ funded SAMBAH project and submitted to HELCOM in September 2017. The dataset was converted to ETRS89LAEA and published to HELCOM Map and Data service."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/568d790f-6ed8-4787-92cc-8afc74ebee77

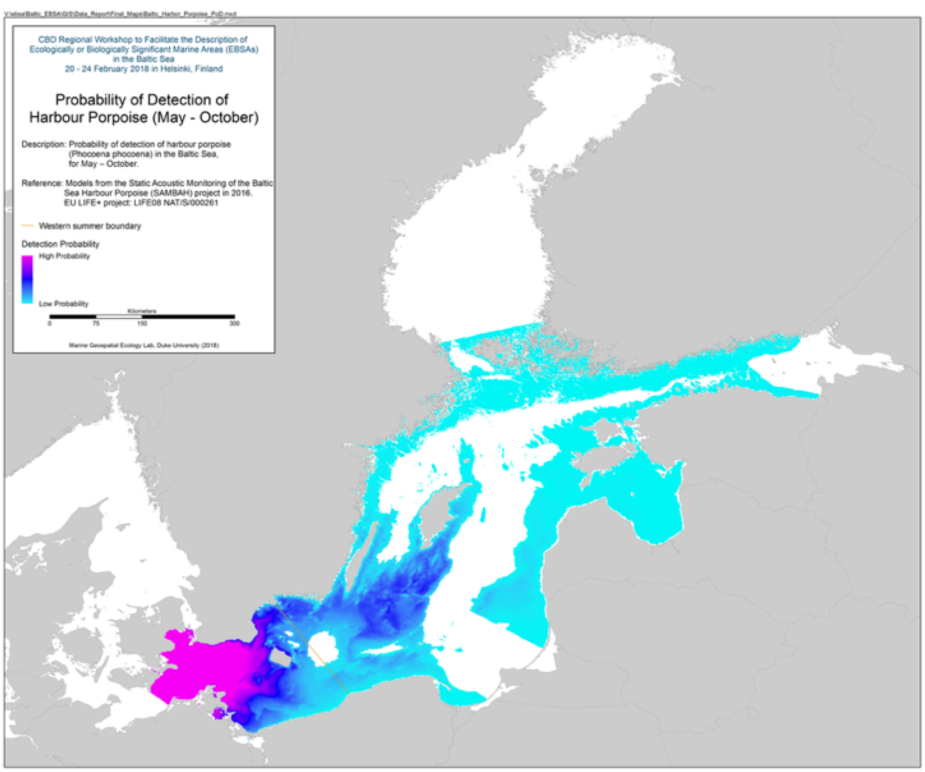


Figure 2.11-1 Probability of detection of Harbour porpoise, May – October

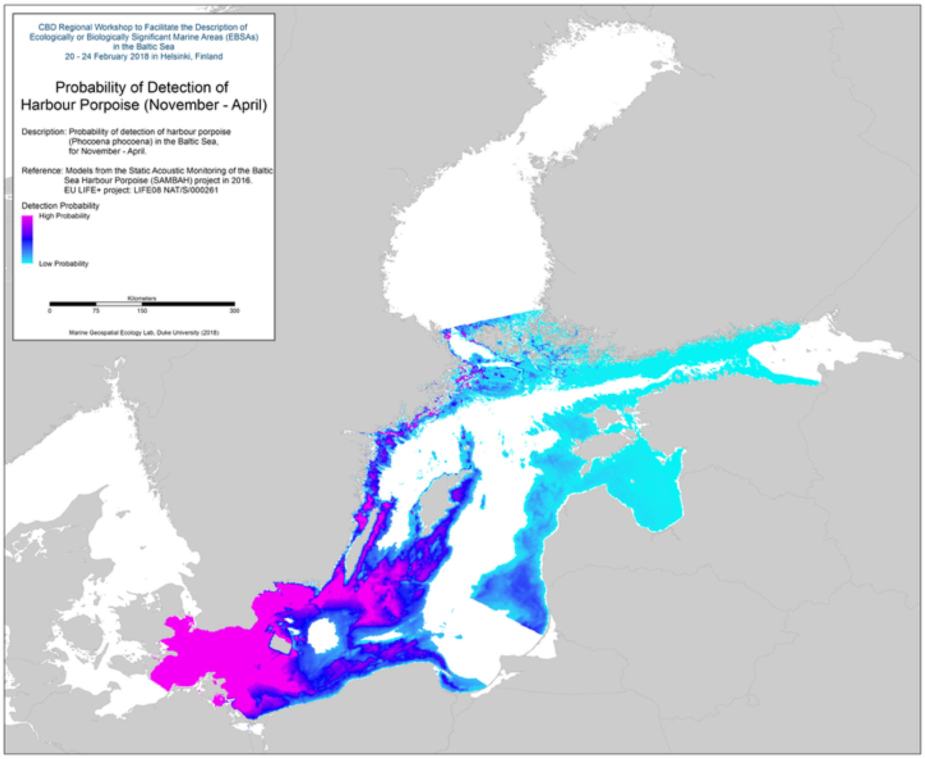


Figure 2.11-2 Probability of detection of Harbour porpoise, November – April

2.12 HELCOM Seal Database

"HELCOM Seal database stores information on abundance of grey seal, harbour seal and ringed seal as gathered by HELCOM SEAL Expert Group based on counted seals. The data collection activity has been supported by the BALSAM project (2013-2015, co- financed by the European Union DG Environment) and is carried on by the HELCOM SEAL EG. Figures represent counted numbers of seals during the standardized aerial surveys. The surveys are carried out during the species specific peak moulting period when the proportion of individuals hauling out at their moulting sites/habitats is the highest. Numbers can be considered as minimum population estimates since a part of the population is always in the water and not reachable in the surveys. Numbers can be viewed per sea area, but it must be noticed that outside of the moulting time seals can travel long distances and may be differently distributed to the Baltic Sea. The abundance data is produced by national seal monitoring executives within Contracting Parties.

The maps below describe, as examples, habitat use of grey seals, harbour seals and ringed seals as gathered by HELCOM SEAL Expert Group based on seals marked with telemetry devices in several projects. The data aggregation activity has been supported by the BALSAM project (2013-2015; co-financed by the European Union DG Environment). The maps are based on data with two locations per day (closest to midnight and midday) for up to several months per individual.

See below density grids (number of locations per 5 x 5 km grid cell) of seals by species based on satellite telemetry. Note that the maps do not show the distribution of the whole population and can be used only as an informative overview of areas used by the few tagged individuals."

Source:
http://www.helcom.fi/baltic-sea-trends/data-maps/biodiversity/seals

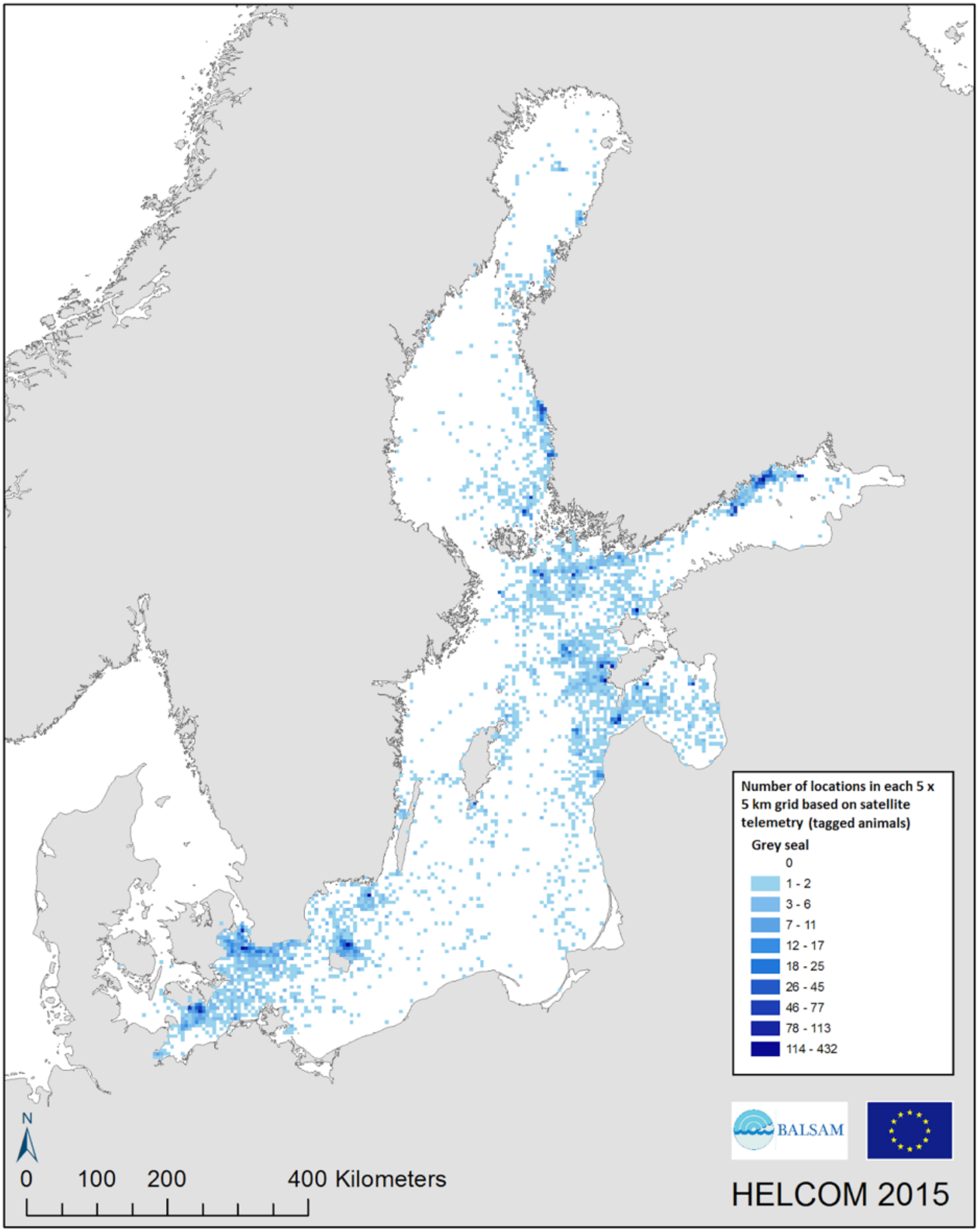


Figure 2.12-1 Grey seal: Number of locations per grid cell based on telemetry data

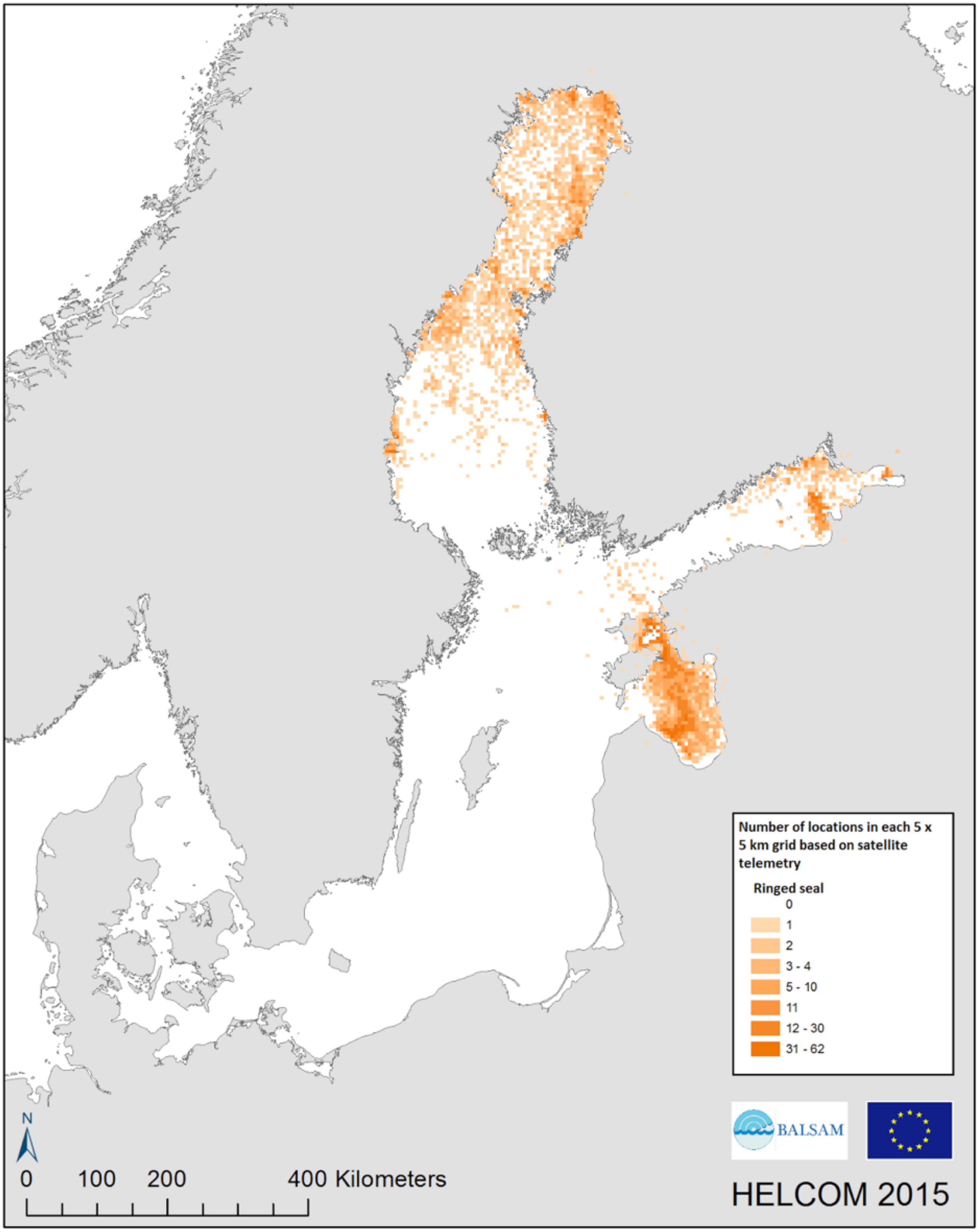


Figure 2.12-2 Ringed seal: Number of locations per grid cell based on telemetry data

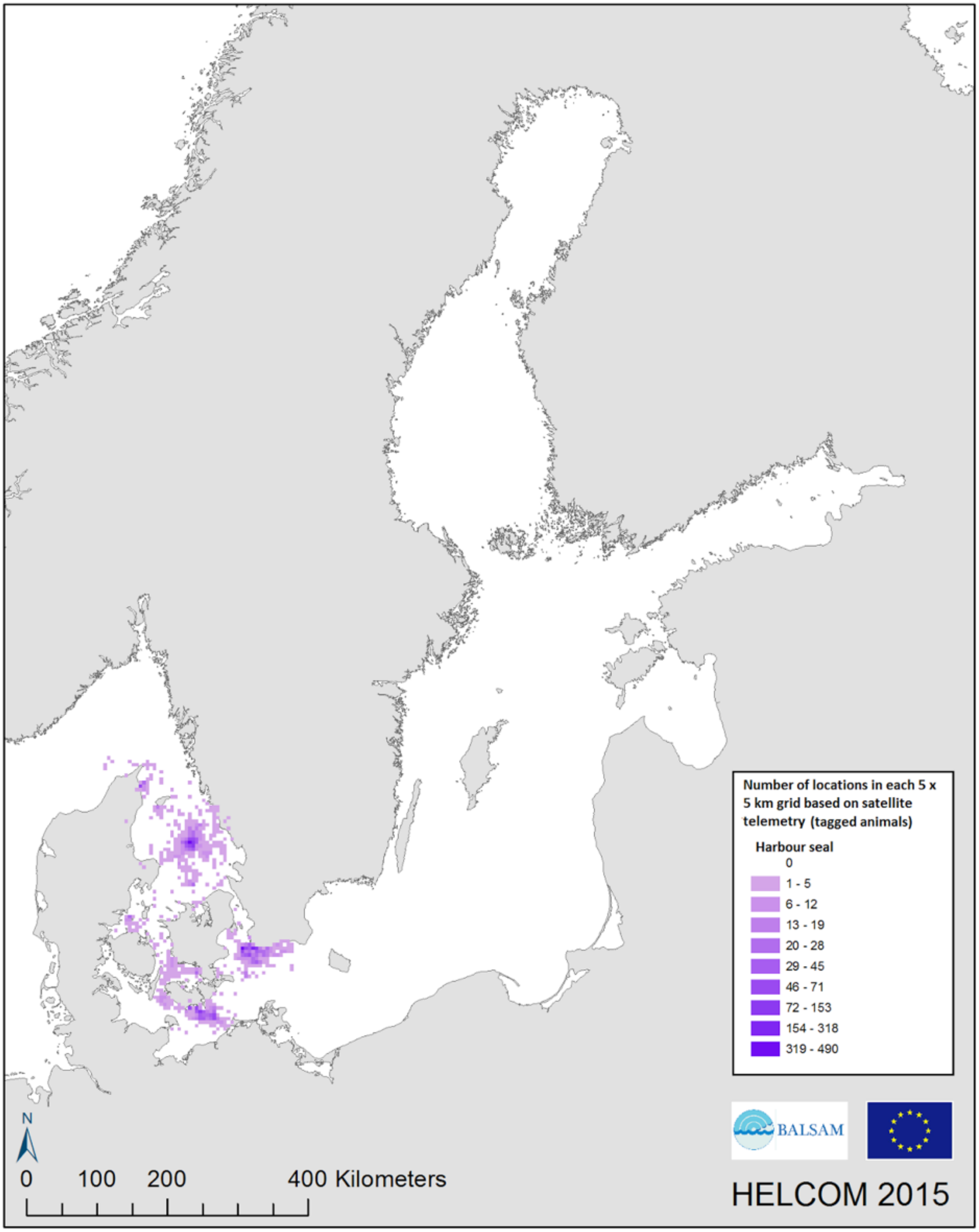


Figure 2.12-3 Harbor seal: Number of locations per grid cell based on telemetry data

2.13 Harbor Seal Distribution

"This map shows the distribution and abundance of harbour seals across the Baltic Sea.

The map was originally created for HELCOM Red list assessment of the Baltic Sea, using seal expert consultation. For the Baltic Sea Impact Index, the map was modified to represent four abundance classes, based on expert consultation."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/57a9e614-67bb-487c-99a3-d003320beb0c

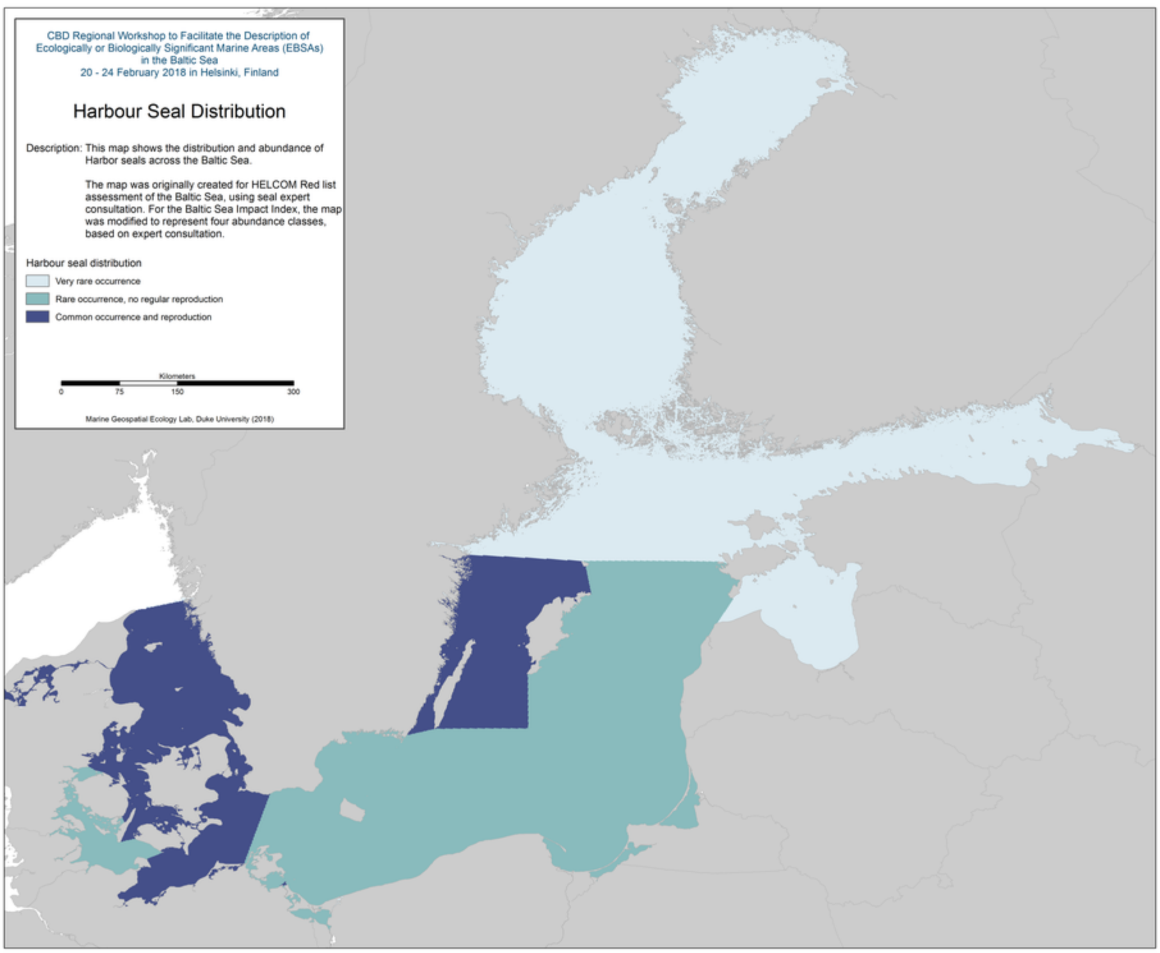


Figure 2.13-1 Harbour seal distribution

2.14 Grey Seal Distribution

"This map shows the distribution and abundance of grey seals across the Baltic Sea.

The map was originally created for HELCOM Red list assessment of the Baltic Sea, using seal expert consultation. For the Baltic Sea Impact Index, the map was modified to represent four abundance classes, based on expert consultation."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/82765d87-d10d-4361-befe-ea5214ba110a

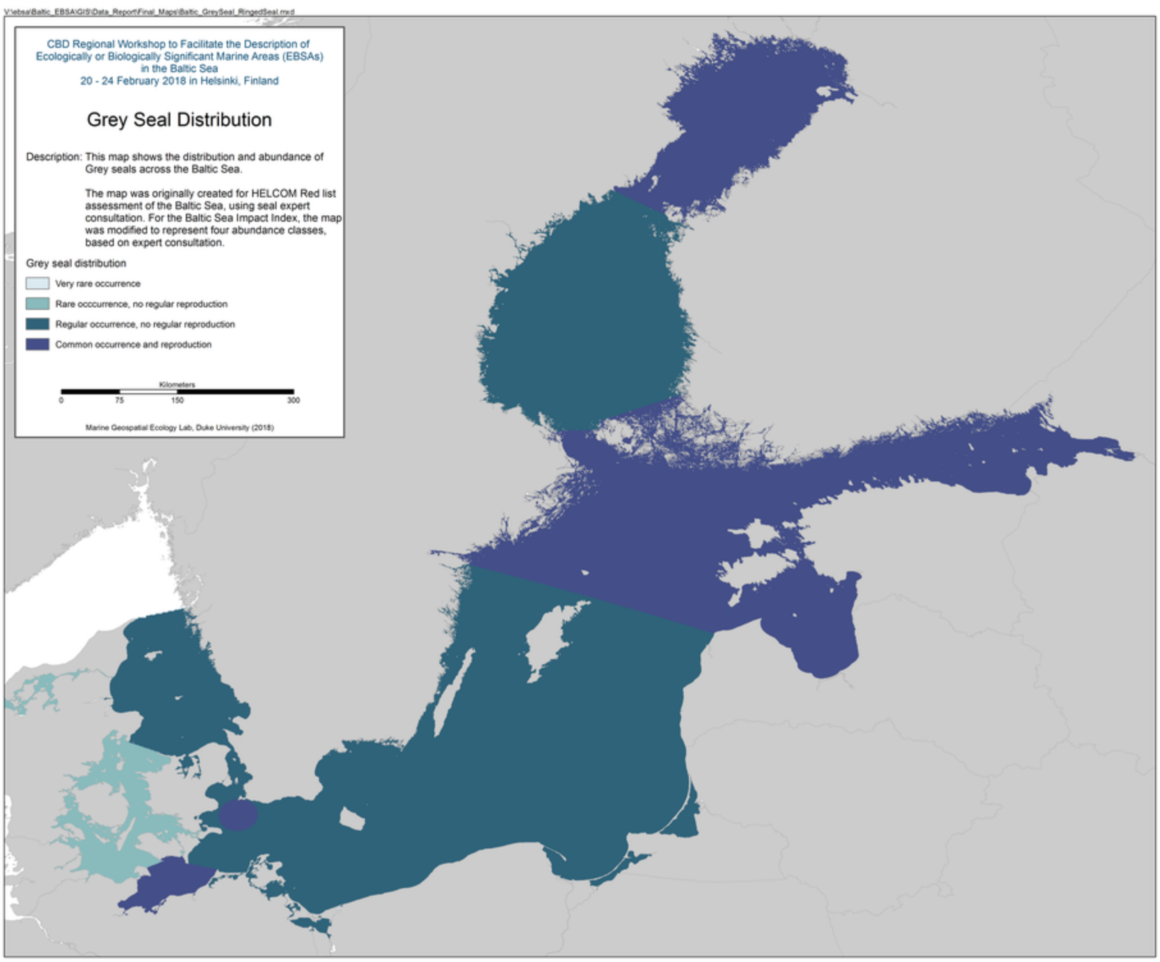


Figure 2.14-1 Grey seal distribution

2.15 Ringed Seal Distribution

"This map shows the distribution and abundance of ringed seals across the Baltic Sea.

The map was originally created for HELCOM Red list assessment of the Baltic Sea, using seal expert consultation. For the Baltic Sea Impact Index, the map was modified to represent four abundance classes, based on expert consultation."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/04f0c94d-bfa5-437b-9660-048bfa1a098a

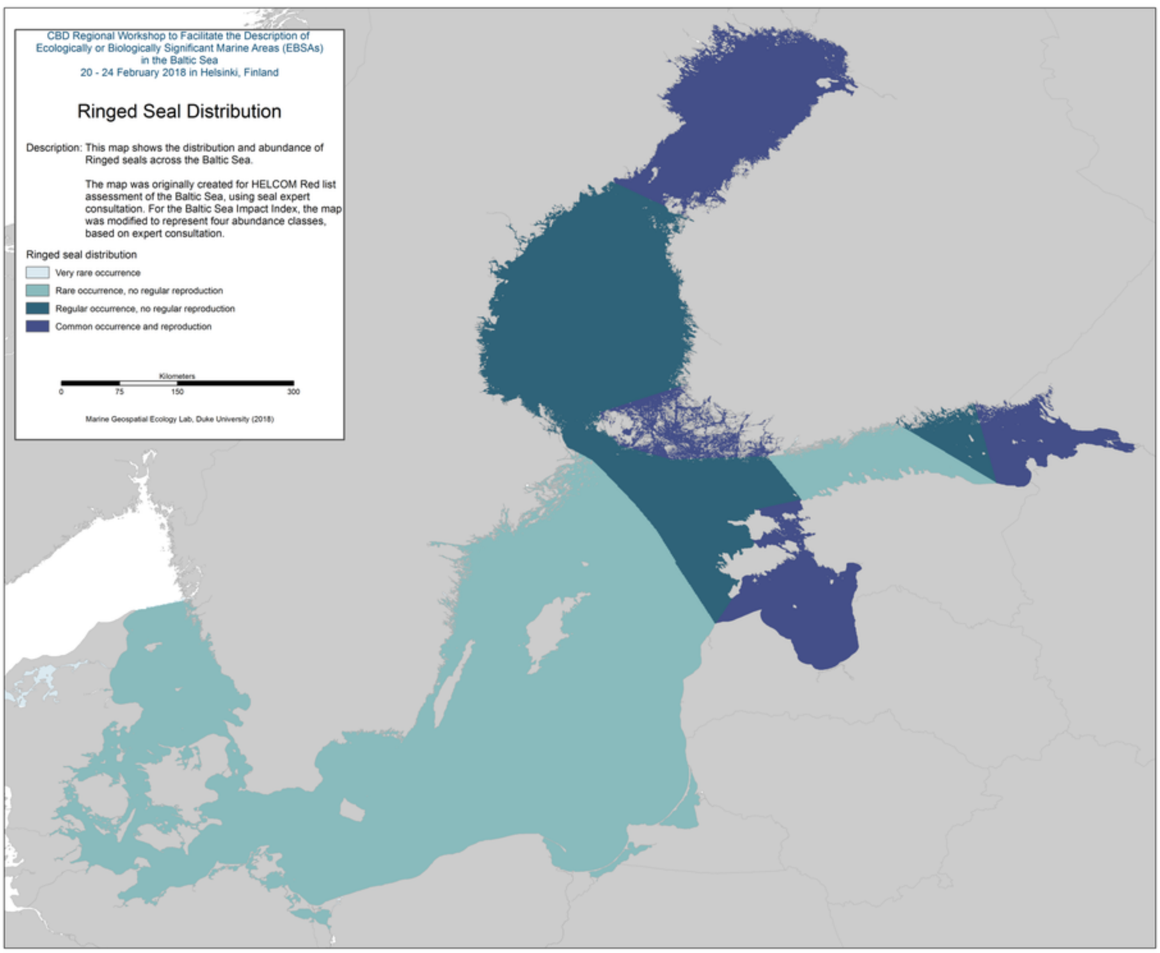


Figure 2.15-1 Ringed seal distribution

3 Physical Data

3.1 EMODnet Digital Terrain Model (DTM) Bathymetry and Slope

Abstract:
"The EMODnet-Bathymetry portal is being developed in the framework of the European Marine Observation and Data Network (EMODnet) as initiated by the European Commission. It provides services for discovery and requesting access to bathymetric data (survey data sets and composite DTMs) as managed by an increasing number of data providers from government and research. The portal also provides a service for viewing and downloading a harmonised Digital Terrain Model (DTM) for the European sea regions that is generated by the EMODnet Bathymetry partnership on the basis of the gathered data sources."

Source: http://www.emodnet-bathymetry.eu/

Reference:
EMODnet Bathymetry Consortium (2016). EMODnet Digital Bathymetry (DTM). EMODnet Bathymetry. http://doi.org/10.12770/c7b53704-999d-4721-b1a3-04ec60c87238

Slope derived from EMODnet Digital Terrain Model (DTM) bathymetry with ArcGIS 10.4.1.

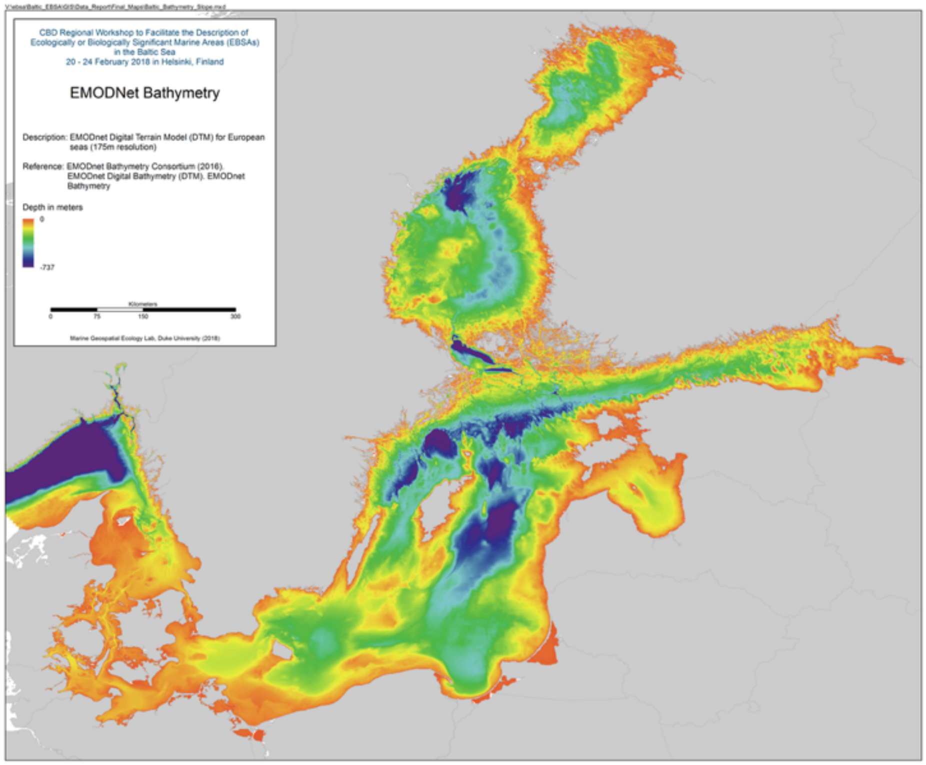


Figure 3.1-1 EMODnet Bathymetry

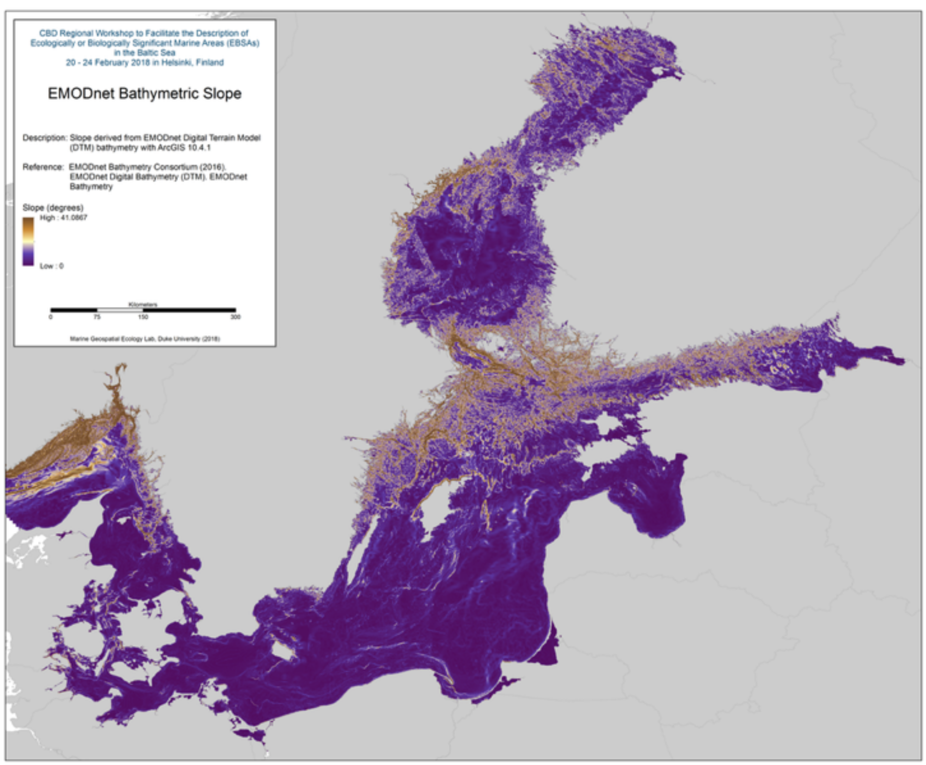


Figure 3.1-2 EMODnet Bathymetric Slope

3.2 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)."

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

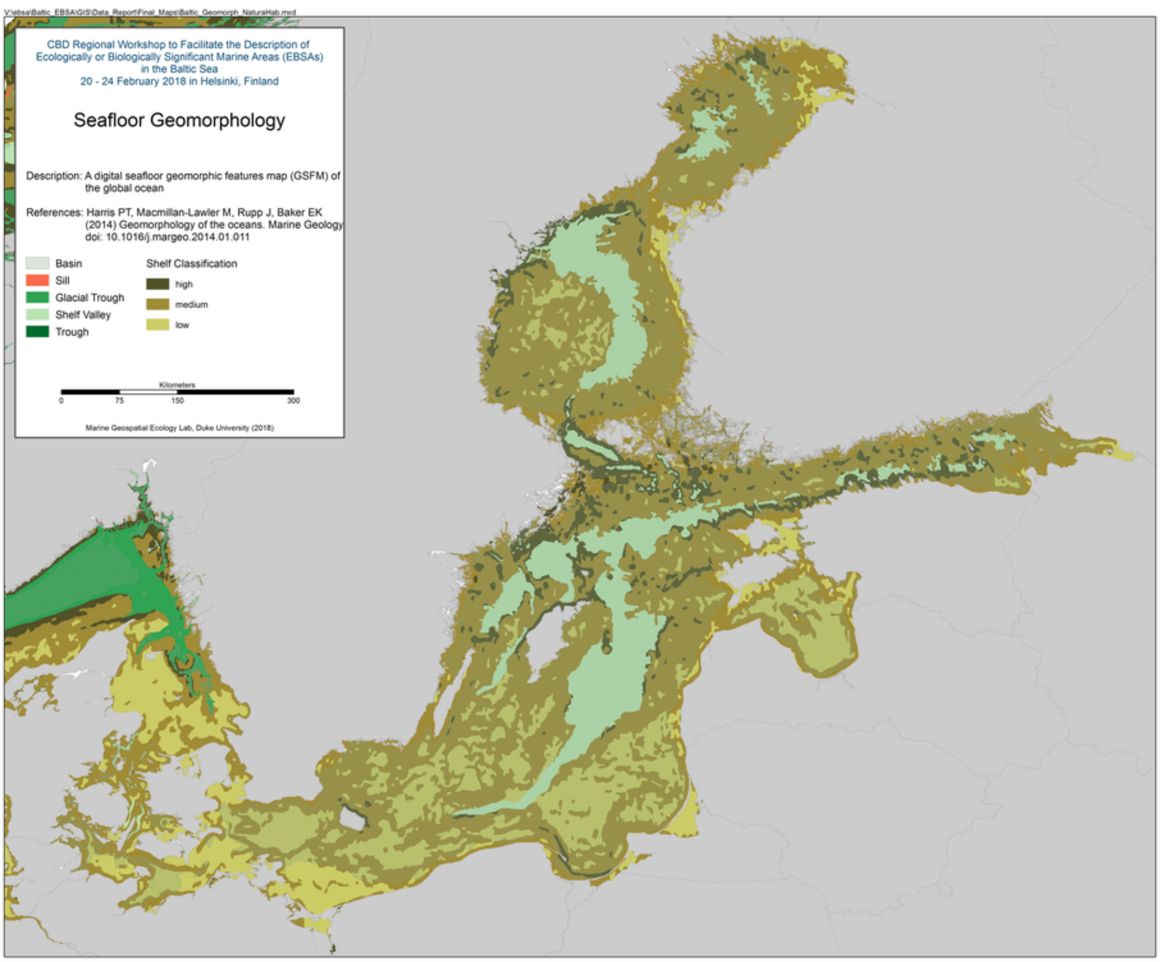


Figure 3.2-1 Seafloor Geomorphology

3.3 EMODnet Seabed Habitats

Overview:
"In the first phase of EMODnet Seabed Habitats (2009-2012) over two million square kilometres of European seabed were mapped using levels 3 and 4 of the EUNIS (European Nature Information System) classification system to produce the EMODnet broad-scale seabed habitat map for Europe (EUSeaMap). In phase 2 (2013-2016), the coverage of the maps has been extended to all European seas and the existing maps have been improved."

"Building on the highly successful INTERREG IIIB-funded MESH and BALANCE projects, phase 1 of EMODnet Seabed Habitats (2009-2012) improved and harmonised predictive benthic habitat layers across the Celtic Seas, Greater North Sea and Baltic Sea, as well as undertaking broad-scale mapping of the western Mediterranean for the first time. In phase 2 (2013-2016), the coverage of the maps has been extended to all European seas and the existing maps have been improved. The map is referred to as the EMODnet broad-scale seabed habitat map for Europe (AKA EUSeaMap)."

Source:
http://www.emodnet-seabedhabitats.eu/default.aspx?page=2011)

Reference:
EMODnet Phase 2 Final Report - Seabed Habitats (2016)

Mapped below is the output of the 2016 EUSeaMap broad-scale predictive model, produced by EMODnet Seabed Habitats.

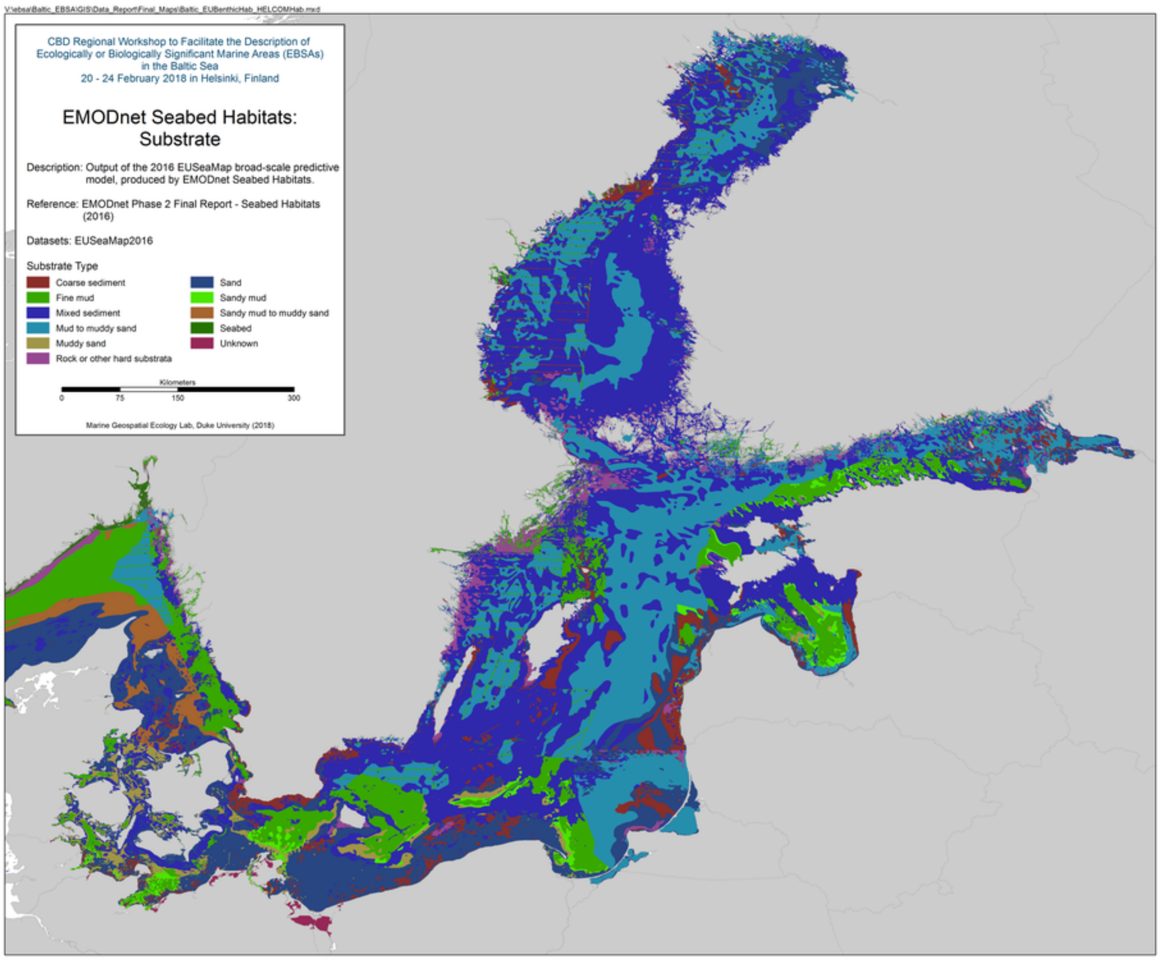


Figure 3.3-1 EMODnet Seabed Habitats - Substrate

3.4 HELCOM Broad-scale Habitats

"Broad-scale habitat maps for the Baltic Sea have been produced in the EUSeaMap project in 2016. For German and Estonian marine areas, national (more accurate) datasets were used. German data included both substrate and light information (division into infralittoral/circalittoral). Estonian data included only substrate and the division into light regimes was obtained from the EuSeaMap data. The original polygon maps have been converted to a 1 km x 1 km grid."

"These EUSeaMap habitats have been further classified to more general habitats, including:

- **Circalittoral hard substrate**: includes classes "Rock and other hard substrate" and "Coarse substrate" of the original data, in the circalittoral zone
- **Circalittoral mixed substrate**: includes classes "mixed sediment" of the original data, in the circalittoral zone

- **Circalittoral mud**: includes classes "Fine mud", "Sandy mud" and "Mud to sandy mud" of the original data, in the circalittoral zone
- **Circalittoral sand**: includes classes "Sand" and "Muddy sand" of the original data, in the circalittoral zone
- **Infralittoral hard substrate**: includes classes "Rock and other hard substrate" and "Coarse substrate" of the original data, in the infralittoral zone
- **Infralittoral mixed substrate**: includes classes "mixed sediment" of the original data, in the infralittoral zone
- **Infralittoral mud**: includes classes "Fine mud", "Mud to sandy mud" and "Sandy mud" of the original data, in the infralittoral zone
- **Infralittoral sand**: includes classes "Sand" and "Muddy sand" of the original data, in the infralittoral zone"

Individual datasets retrieved from HELCOM data portal:
http://maps.helcom.fi/website/mapservice/index.html

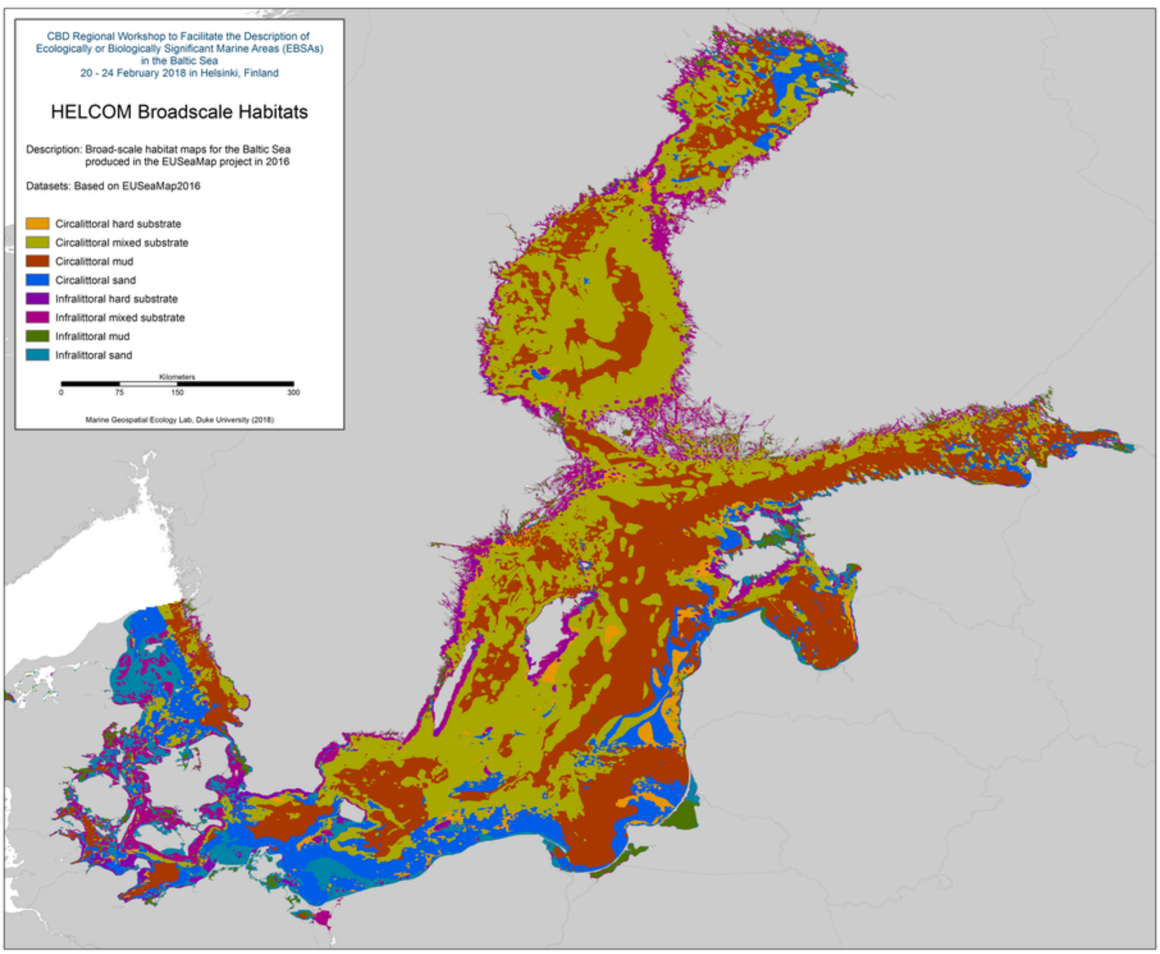


Figure 3.4-1 HELCOM broadscale habitats

3.5 HELCOM Natura Habitats

"HELCOM Natura 2000 habitat types, including:

- **Baltic Esker islands**: Esker islands (according to Habitats Directive Annex I) are glaciofluvial islands consisting mainly of relatively well sorted sand, gravel or less commonly of till. Also their underwater parts are included in the habitat. The distribution map is based on data submission by HELCOM contracting parties. Only Sweden and Finland reported occurrences of esker islands. Only underwater parts are included in the datasets. The data is based on modelling and GIS analysis. Data coverage, accuracy and the methods in obtaining the data vary between countries.
- **Boreal Baltic islets and small islands**: Boreal Baltic islets and small islands (according to Habitats Directive Annex I) are groups of skerries, islets or single small islands, mainly in the outer archipelago or offshore areas. They are important nesting sites for birds and resting sites for seals. The surrounding sublittoral vegetation is also included. The distribution map is based on data submission by HELCOM contracting parties. Only Sweden and Finland reported occurrences of boreal Baltic islets and small islands.
- **Coastal lagoons**: Lagoons are expanses of shallow coastal waters, wholly or partially separated from the sea by sandbanks or shingle, or by rocks. Salinity may vary from brackish water to hypersalinity depending on rainfall, evaporation and addition of fresh seawater from storms, temporary flooding, or tidal exchange. The distribution map is based on data submission by HELCOM contracting parties. Most of the submitted data is based on modelling and/or GIS analysis. Data coverage, accuracy and the methods in obtaining the data vary between countries.
- **Estuaries**: Estuaries (according to Habitats Directive Annex I) are coastal inlets that are strongly influenced by freshwater. The distribution map is based on data submission by HELCOM contracting parties. Most of the submitted data is based on modelling, GIS analysis and/or aerial photos. Data coverage, accuracy and the methods in obtaining the data vary between countries.
- **Large shallow inlets and bays**: Large shallow inlets bays (according to Habitats Directive Annex I) are large, shallow indentations of the coast, sheltered from wave action and where, in contrast to estuaries, the influence of freshwater is generally limited. The distribution map is based on data submission by HELCOM contracting parties. Most of the submitted data is based on GIS analysis and modelling, but also field inventories and ground-truthing has been carried out in some areas. Data coverage, accuracy and the methods in obtaining the data vary between countries.
- **Mudflats and sandflats**: Mudflats and sandflats not covered by seawater at low tide (according to Habitats Directive Annex I) are often devoid of vascular plants, usually coated by blue algae and diatoms. They are of particular importance as feeding grounds for wildfowl and waders. The distribution map is based on data submission by HELCOM contracting parties. Only Denmark, Germany and Estonia reported occurrences of mudflats and sandflats. Most of the submitted data is based on modelling and/or GIS analysis. Data coverage, accuracy and the methods in obtaining the data vary between countries.
- **Reefs**: Reefs (according to Habitats Directive Annex I) are hard compact substrata (either biogenic or geogenic) on solid and soft bottoms, which arise from the seafloor in the sublittoral and littoral zone. Distribution of mapped Natura 2000 habitat "Reefs" based on data submission by HELCOM contracting parties. Most of the submitted data is based on modelling and limited ground-truthing. Data coverage, accuracy and the methods in obtaining the data vary between countries.

- **Sandbanks**: Sandbanks (according to Habitats Directive Annex I) are areas elevated from their surroundings that consist mainly of sand, but where cobbles and boulders can occur. Distribution map is based on data submission by HELCOM contracting parties. Most of the submitted data is based on modelling, GIS analysis and only limited ground-truthing has been carried out. Data coverage, accuracy and the methods in obtaining the data vary between countries.
- **Submarine structures made by leaking gas**: Submarine structures made by leaking gases (according to Habitats Directive Annex I) are also known as “bubbling reefs”. These formations support a zonation of diverse benthic communities consisting of algae and/or invertebrate specialists of hard marine substrates different to that of the surrounding habitat. The distribution map is based on data submission by HELCOM contracting parties. Only Sweden and Denmark reported occurrences of submarine structures made by leaking gases.”

Retrieved from HELCOM data portal:
http://maps.helcom.fi/website/mapservice/index.html

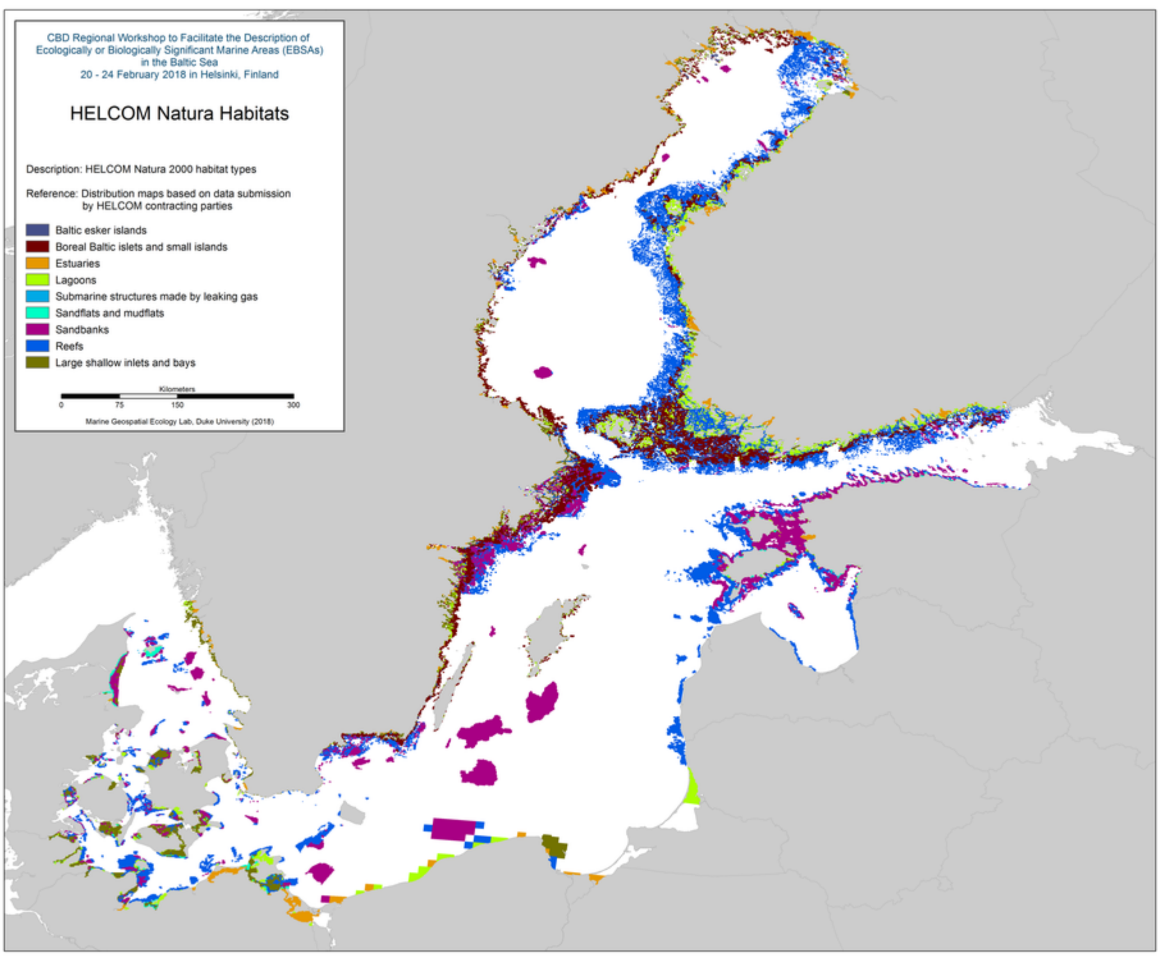


Figure 3.5-1 HELCOM Natura habitats

3.6 Sea 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, a cumulative climatology (2006 – 2016) was 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.

Two seasonal maps are shown below. All four seasons are available for use by workshop attendees.

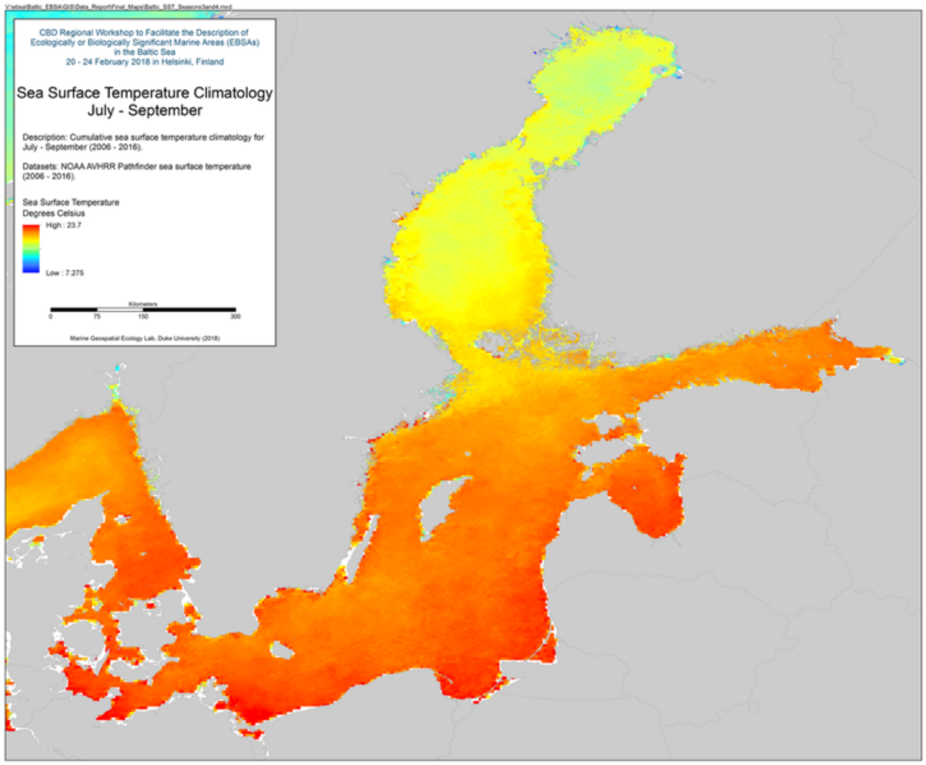


Figure 3.6-1 Sea Surface Temperature: July – September Cumulative Climatology

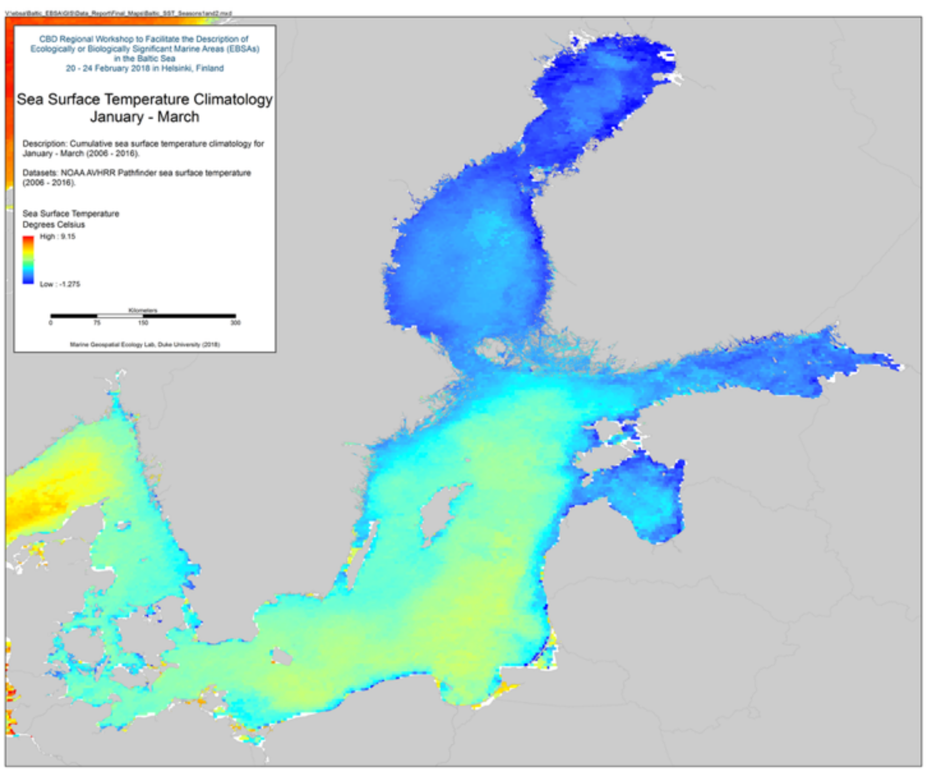


Figure 3.6-2 Sea Surface Temperature: January – March Cumulative Climatology

3.7 Sea Ice Coverage

Sea ice coverage fraction was extracted from the Baltic Sea Physics Reanalysis model data from SMHI. Two dates were extracted to highlight a recent severe winter (2011) and a recent mild winter (2008).

"Reanalysis products for the physical condition in the Baltic Sea are provided.
This reanalysis BALTICSEA_REANALYSIS_PHY_003_008 for the Baltic Sea was produced in 2014 at SMHI with the circulation model HIROMB (High-Resolution Operational Model for the Baltic). The data assimilation scheme used was a 3D Ensemble Variational data assimilation scheme. The product has been updated in 2015 to include the year 2014; and in 2016 to include year 2015. The product provides data on a 3 nautical miles grid (5.5 km) for the physical conditions in the Baltic Sea for the period 1989 – 2015. SMHI reanalysis run NS03_201511000000+000H00M"

Source:
http://sextant.ifremer.fr/en/geoportail/sextant#/metadata/9c2bc47e-504c-42d7-a48b-e0ff326c27ae

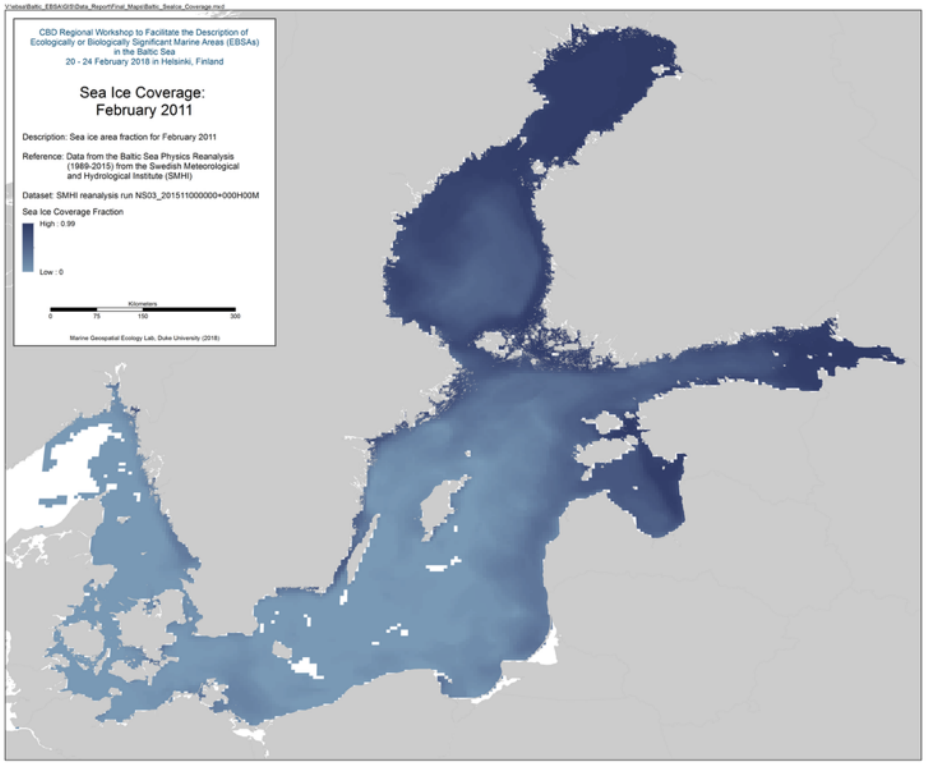


Figure 3.7-1 Sea Ice coverage, February 2011

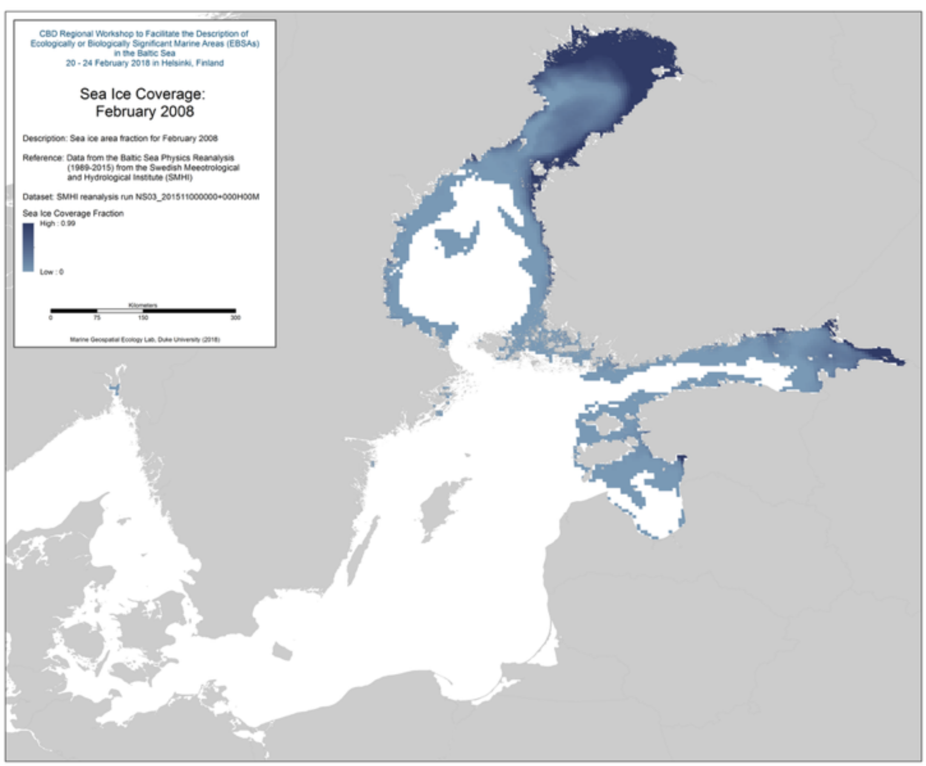


Figure 3.7-2 Sea Ice coverage, February 2008

3.8 Salinity Climatology

"Seadatanet temperature and salinity monthly climatologies 1900-2012 by DIVA software v4.6.10. Based on Seadatanet historical dataset v1.1. Data processing by the Swedish Meteorological and Hydrological Institute (SMHI).

DIVA settings: DIVA 4D analysis of Salinity (psu) from year 1900 to year 2012.
Seasonal background fields, months 12-02, 03-05, 06-08, 09-11. Weighting have been used with length of weighting 0.5° and time of weighting 2 days."

Surface and "deepest" data for August are shown as an example below. Data for all 12 months are available.

Source:
http://sextant.ifremer.fr/en/geoportail/sextant#/metadata/bf35a7c5-c843-4a23-8040-07ddcf3d8e71

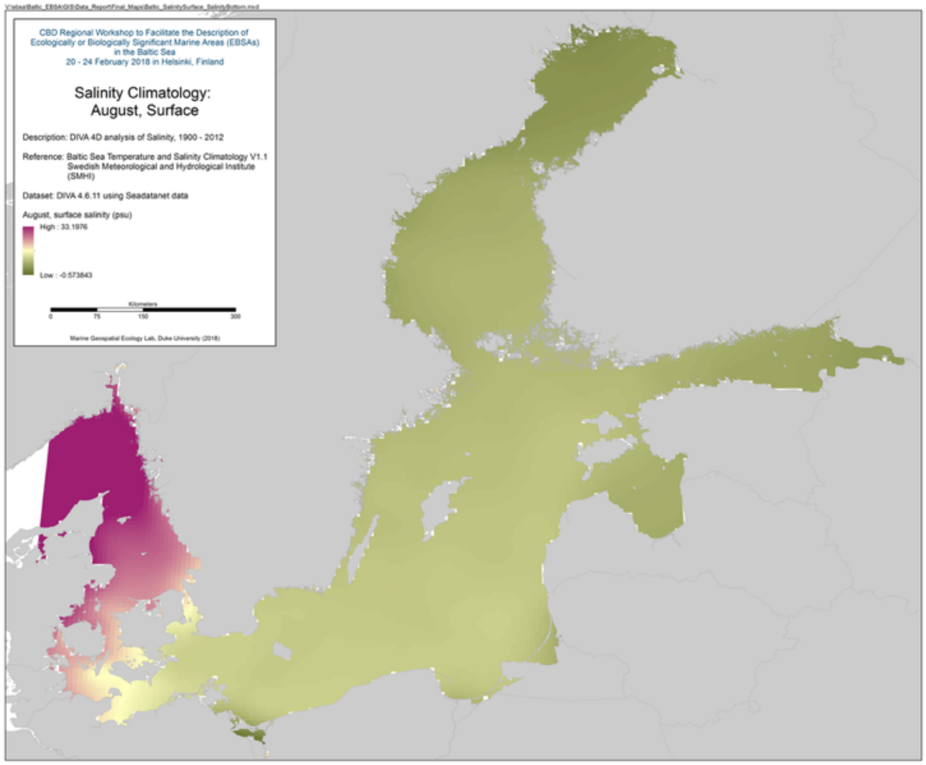


Figure 3.8-1 Salinity Climatology: August, Surface

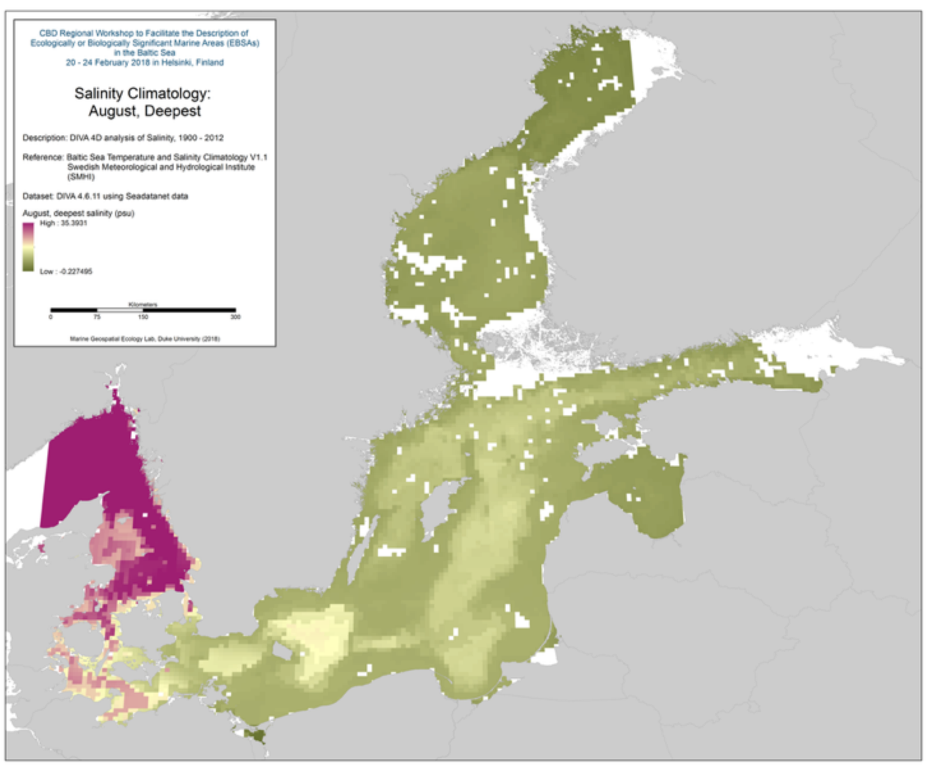


Figure 3.8-2 Salinity Climatology: August, Deepest

3.9 Chlorophyll A Climatology

Here, seasonal cumulative (2006-2016) 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 4km monthly data from the MODIS Terra platform. One 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.

Two seasonal maps are shown below. All four seasons are available for use by workshop attendees.

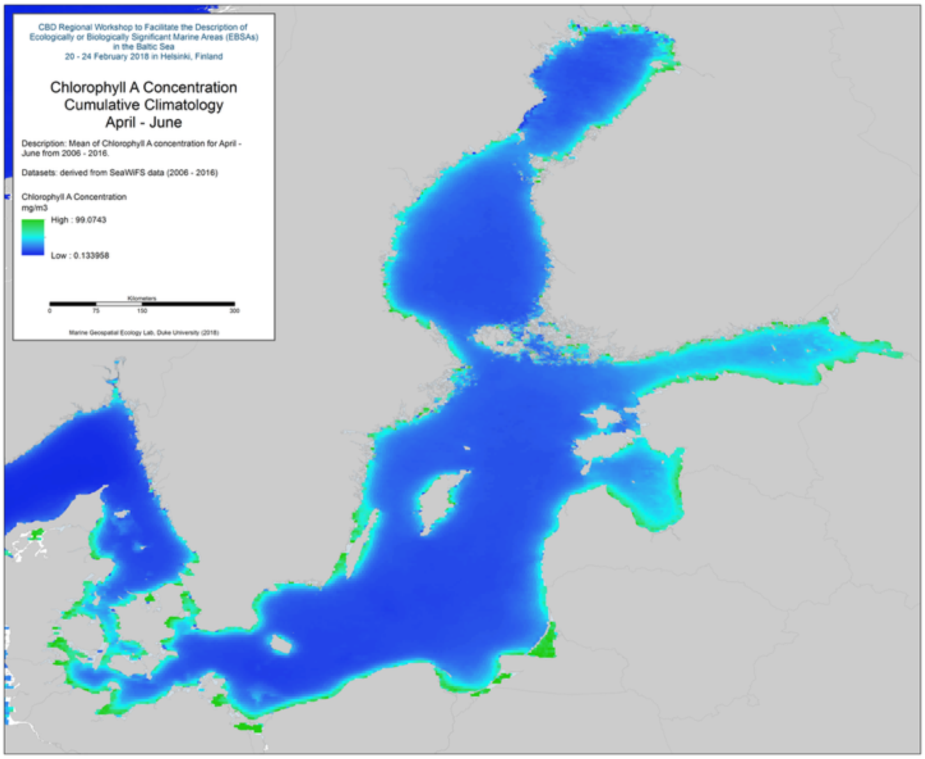


Figure 3.9-1 Chlorophyll A Concentration: April - June Cumulative Climatology

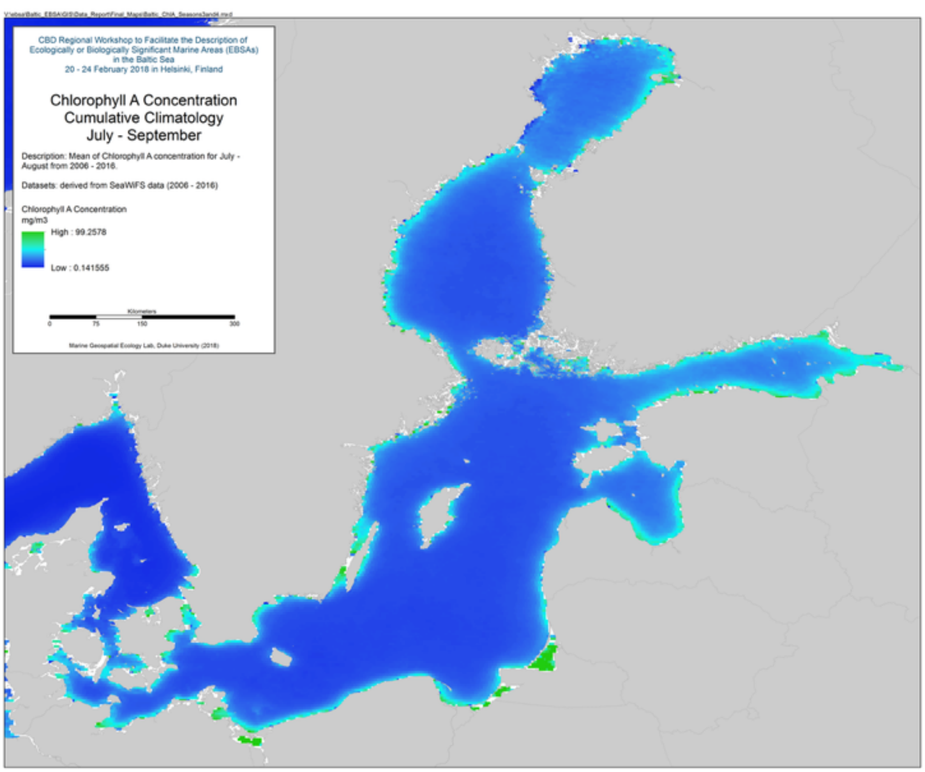


Figure 3.9-2 Chlorophyll A Concentration: July - September Cumulative Climatology

3.10 HELCOM Productive Surface Waters (Chl-A)

"Springtime Chl-A concentration is here used as a proxy for productive surface waters. In the Baltic Sea Impact Index (BSII), areas with high springtime phytoplankton production will be given higher importance, as they are considered important areas for the Baltic Sea food web. In the current map, mean of springtime maximum weekly values (weeks 12-22, years 2003-2011) Chl-a concentration of the surface waters has been used, derived from satellite data (MERIS). The data for eastern Baltic Sea is provided by the Finnish Environment Institute (~300m resolution). Outside this high resolution data, MERIS-data downloaded from JRC-database has been used (~4 km resolution, to calculate average of maximum monthly values for April or May for 2003-2011)."

HELCOM HOLAS II Dataset: Productive surface waters (2017)

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/972c58e2-b197-4929-aa10-85e703510d64

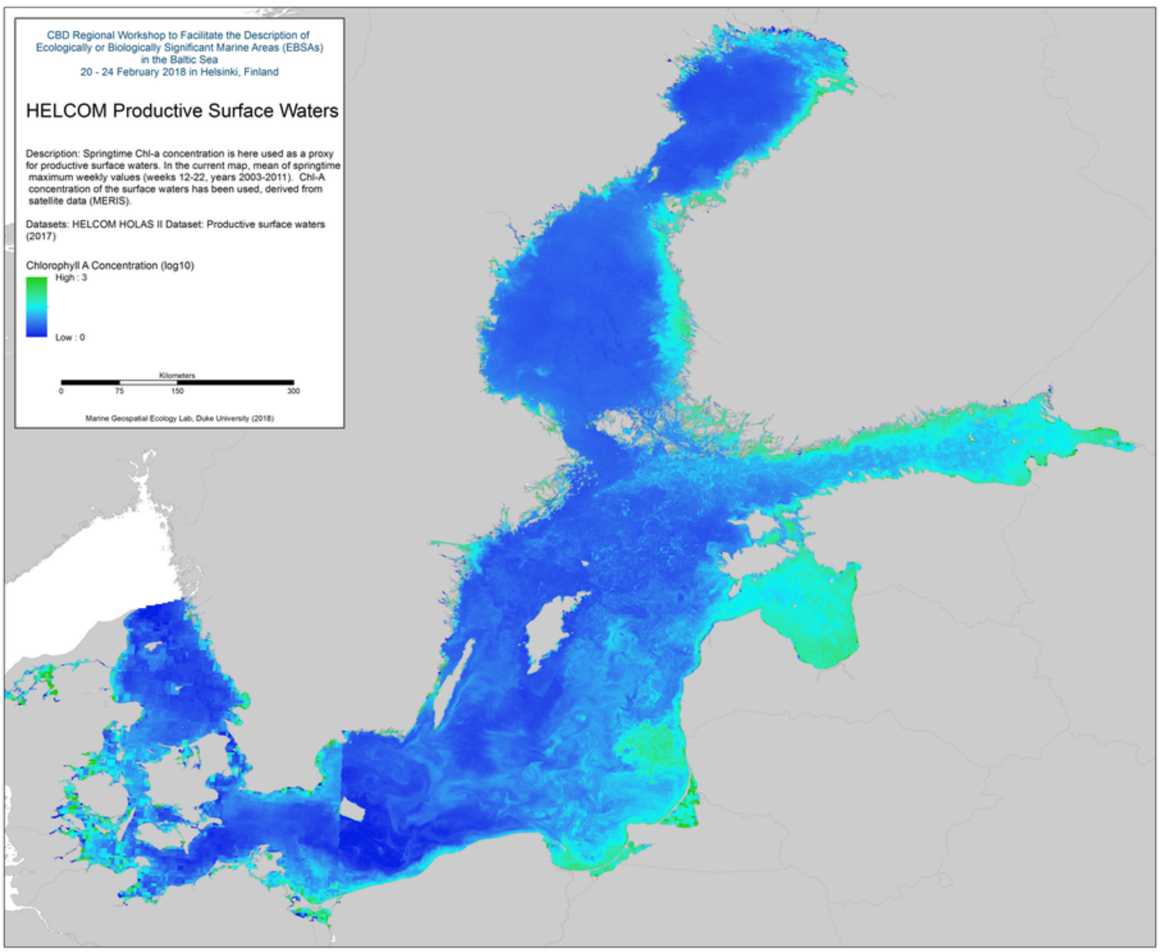


Figure 3.10-1 HELCOM Productive Surface Waters

3.11 HELCOM Deep Water Habitat (Bottom Oxygen Index)

"Bottom oxygen index describes the suitability of the bottom areas for the Baltic Sea biota, with regard to oxygen conditions of the near bottom waters. The areas are based on five seasonal monitoring cruises by IOW and a fixed set of standard stations from HELCOM's Baltic monitoring programme have been used to extrapolate the areas of oxygen deficiency (Feistel et al. 2016). The polygons were converted to raster layers () in a way, that for each time period (5 years, 5 time periods each year), areas with H_2S got a value 0, areas with <2ml/l oxygen (but no H_2S) got a value of 1, and areas with =2ml/l oxygen got the value 2. The value represents the value of that area for Baltic Sea bottom biota.

All layers were summed, (representing 5 years, 5 time periods each year). As a result, areas that always had H_2S got the value 0 (= no value for BS bottom biota) and areas that never had oxygen deficiency, got the value 50 (= areas of highest value for BS bottom biota)."

HELCOM HOLAS II Dataset: Bottom oxygen index (2017)

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/cac7da65-7984-453d-958b-843bee8334e6

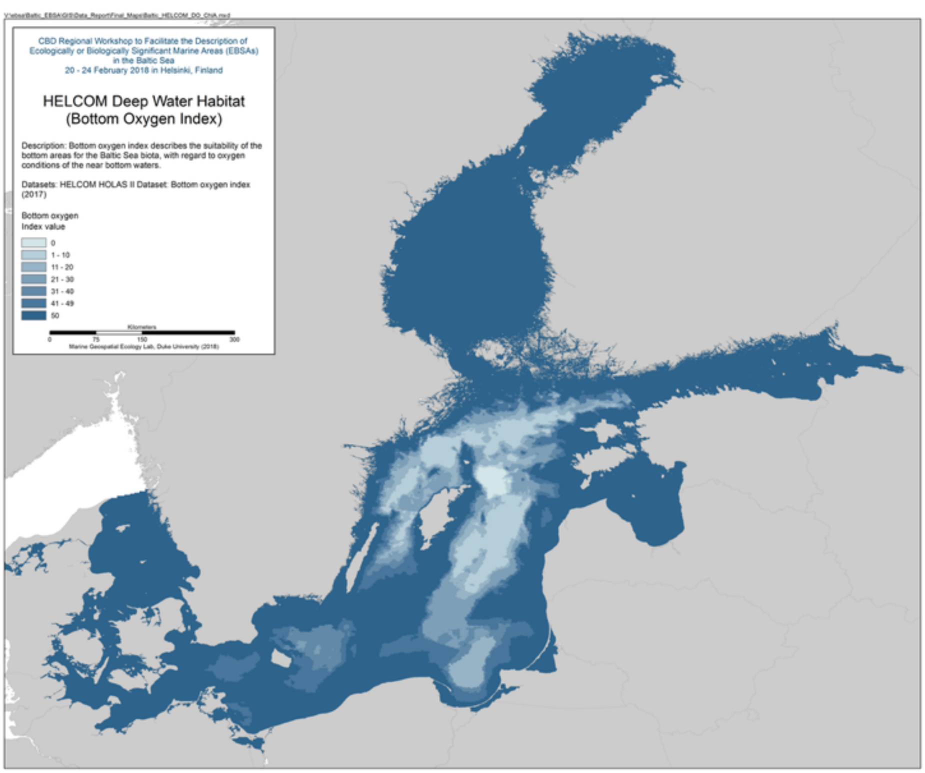


Figure 3.11-1 HELCOM Deep Water Habitat (Bottom Oxygen Index)

4 Important Areas

4.1 Marine Protected Areas

"Protected Planet is the most up to date and complete source of information on protected areas, updated monthly with submissions from governments, non-governmental organizations, landowners and communities. It is managed by the United Nations Environment Programme's World Conservation Monitoring Centre (**UNEP-WCMC**) with support from IUCN and its World Commission on Protected Areas (**WCPA**).

It is a publicly available online platform where users can discover terrestrial and marine protected areas, access related statistics and download data from the World Database on Protected Areas (**WDPA**)."

Source: http://www.wdpa.org/c/about

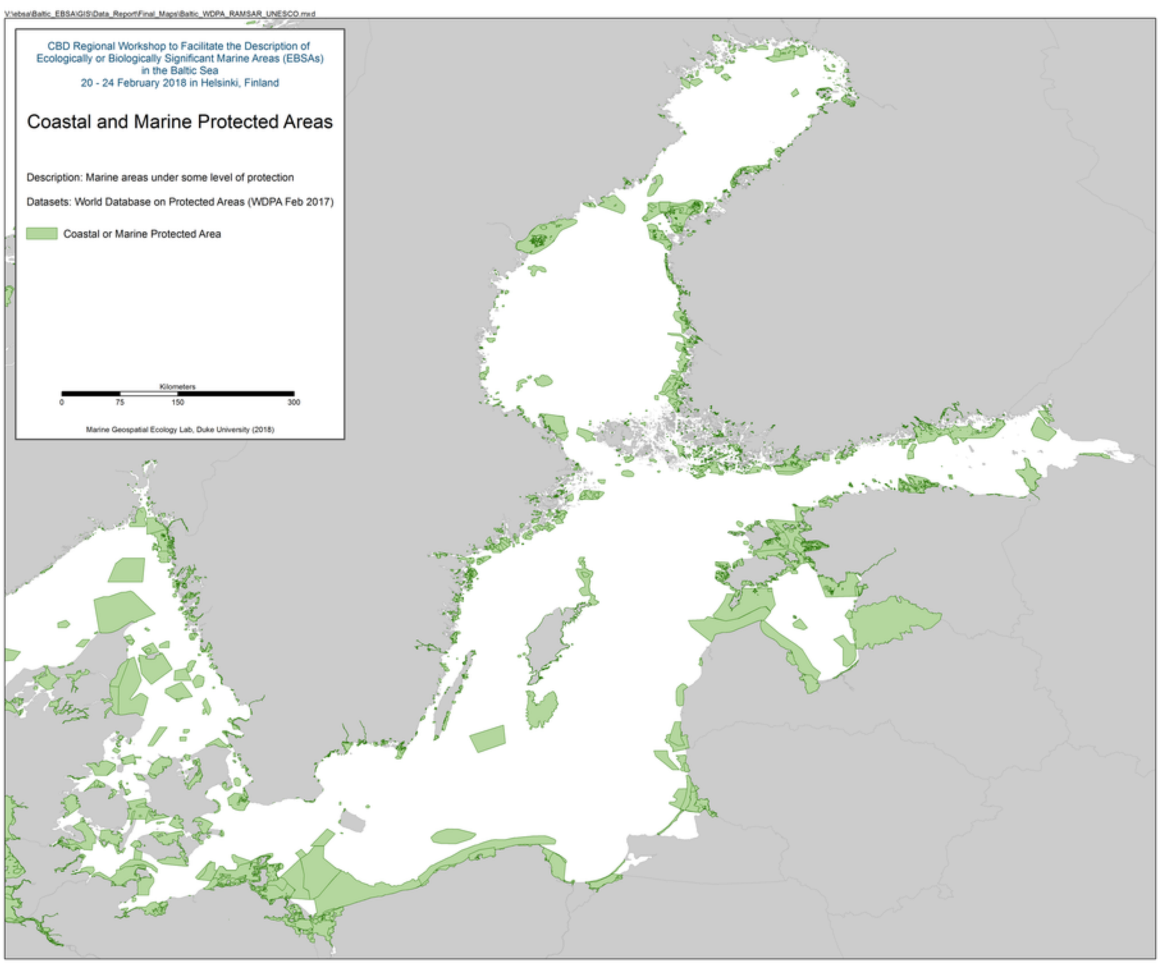


Figure 4.1-1 Marine Protected Areas (WDPA)

4.2 HELCOM Marine Protected Areas

"This dataset contains borders of the HELCOM MPAs (former Baltic Sea Protected Areas (BSPAs). The dataset has been compiled from data submitted by HELCOM Contracting Parties. It includes the borders of designated HELCOM MPAs stored in the HELCOM Marine Protected Areas database. The designation is based on the HELCOM Recommendation 15/5 (1994). The dataset displays all designated or managed MPAs as officially reported to HELCOM by the respective Contracting State until March 2017. The latest related HELCOM publication based on MPA related data is Ecological coherence assessment of the Marine Protected Area network in the Baltic. Balt. Sea Environ. Proc. No. 148 (HELCOM 2016)"

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/d27df8c0-de86-4d13-a06d-35a8f50b16fa

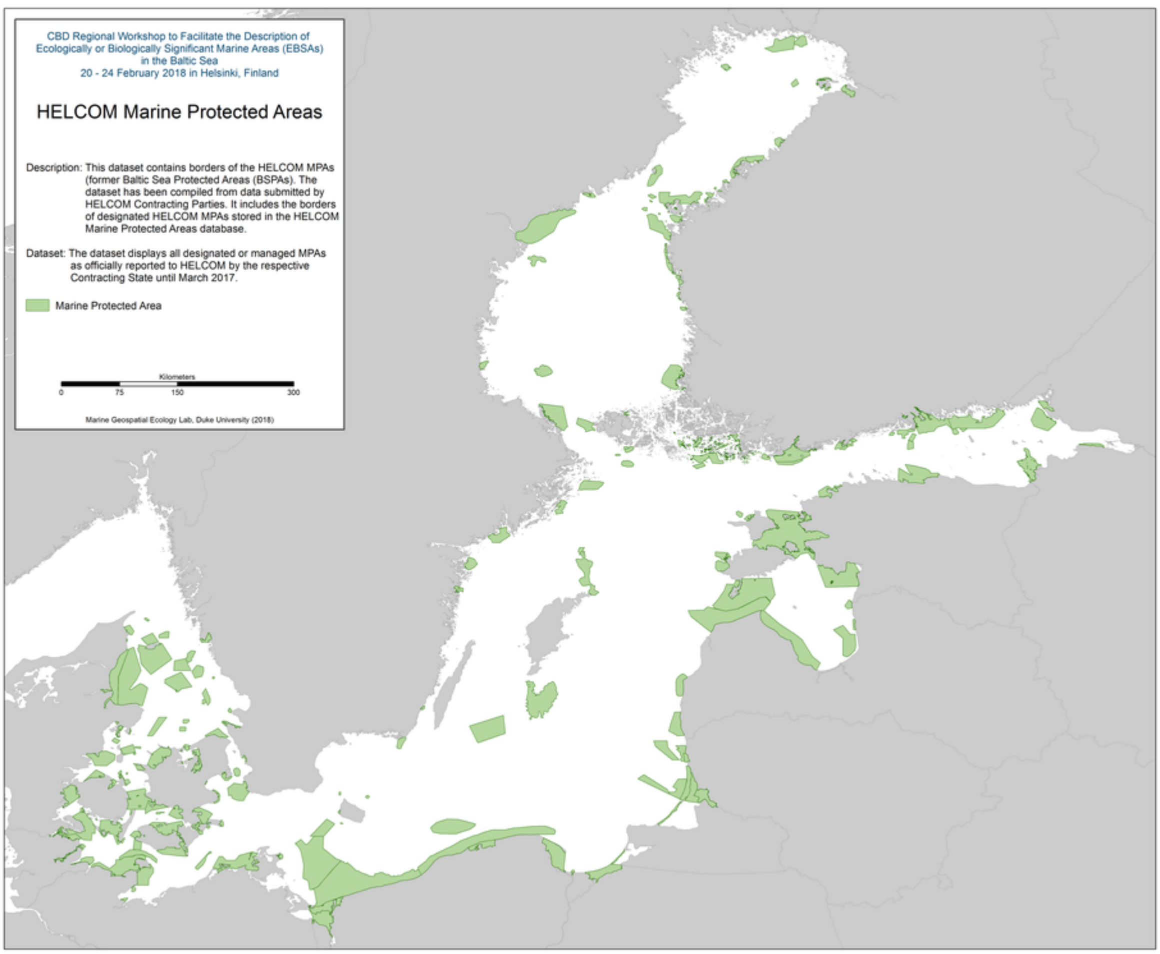


Figure 4.2-1 HELCOM Marine Protected Areas

4.3 Natura 2000 sites

"Natura 2000 is an ecological network composed of sites designated under the Birds Directive (Special Protection Areas, SPAs) and the Habitats Directive (Sites of Community Importance, SCIs, and Special Areas of Conservation, SACs).

The European database on Natura 2000 sites consists of a compilation of the data submitted by Member States to the European Commission. This European database is generally updated once per year, so as to take into account any updating of the content of the national databases by Member States. However, the release of a new EU-wide database does not necessarily entail that a particular national dataset has recently been updated."

Source: http://natura2000.eea.europa.eu/

Reference:

Sundseth, K. (2008). *NATURA 2000 protecting Europe's biodiversity*. European Commission, Environment Directorate General.

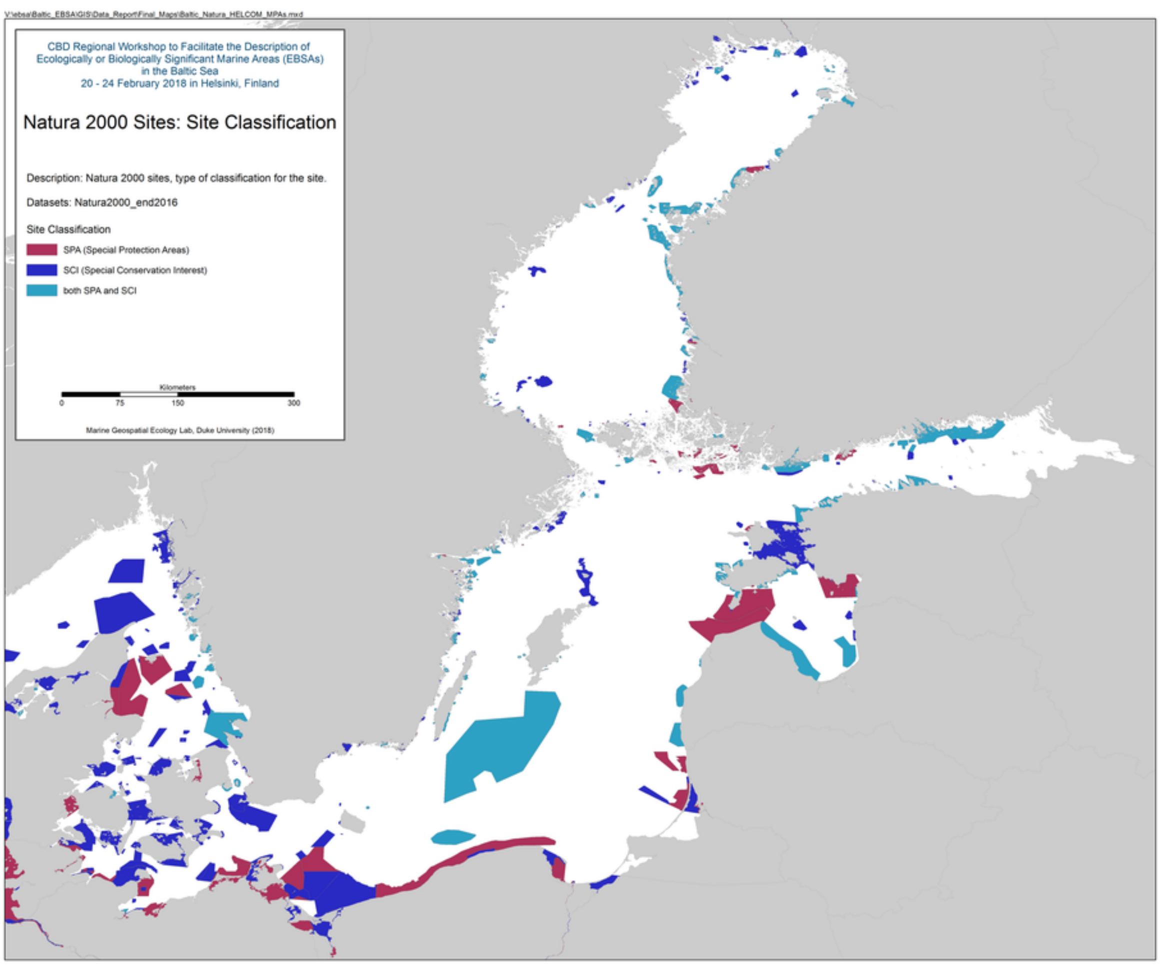


Figure 4.3-1 Natura 2000 Sites

4.4 Ramsar Wetlands of International Importance

"Under the Convention on Wetlands (Ramsar, 1971), each Contracting Party undertakes to designate at least one wetland site for inclusion in the List of Wetlands of International Importance (the "Ramsar List"). There are over 2,000 "Ramsar Sites" on the territories of over 160 Ramsar Contracting Parties across the world.

For more information on the Convention, please visit the Ramsar website http://www.ramsar.org.

All Site information is provided by the Contracting Parties to the Convention and is managed by the Ramsar Secretariat. Responsibility for the accuracy of the data lies with the Administrative Authority of the Party in which the Ramsar Site is located.

This dataset displays Ramsar site polygon areas downloaded from https://rsis.ramsar.org/ in 17.2.2016. The dataset was subset by selecting only the sites that are within Baltic Sea drainage area and projected to ETRS89LAEA by the HELCOM Secretariat."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/91bfbaea-c586-4178-8c2d-16fbba5aea8b

4.5 UNESCO sites

"Dataset contains the UNESCO Man and the Biosphere (MAB) Biosphere reserves in the Baltic Sea area (in 1998). Biosphere Reserves are areas of terrestrial and coastal ecosystems promoting solutions to reconcile the conservation of biodiversity with its sustainable use. They are internationally recognized, nominated by national governments and remain under sovereign jurisdiction of the states where they are located. Biosphere reserves serve in some ways as 'living laboratories' for testing out and demonstrating integrated management of land, water and biodiversity. The source of this data set was 'Baltic Pipeline System: Environmental Impact on the Baltic Sea' by Tacis services DG IA, European Commission. The dataset has later been amended with UNESCO World Heritage Sites. See attribute table for details."

Source:
http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/78e50e17-0049-4212-8288-922ba6f32e4f

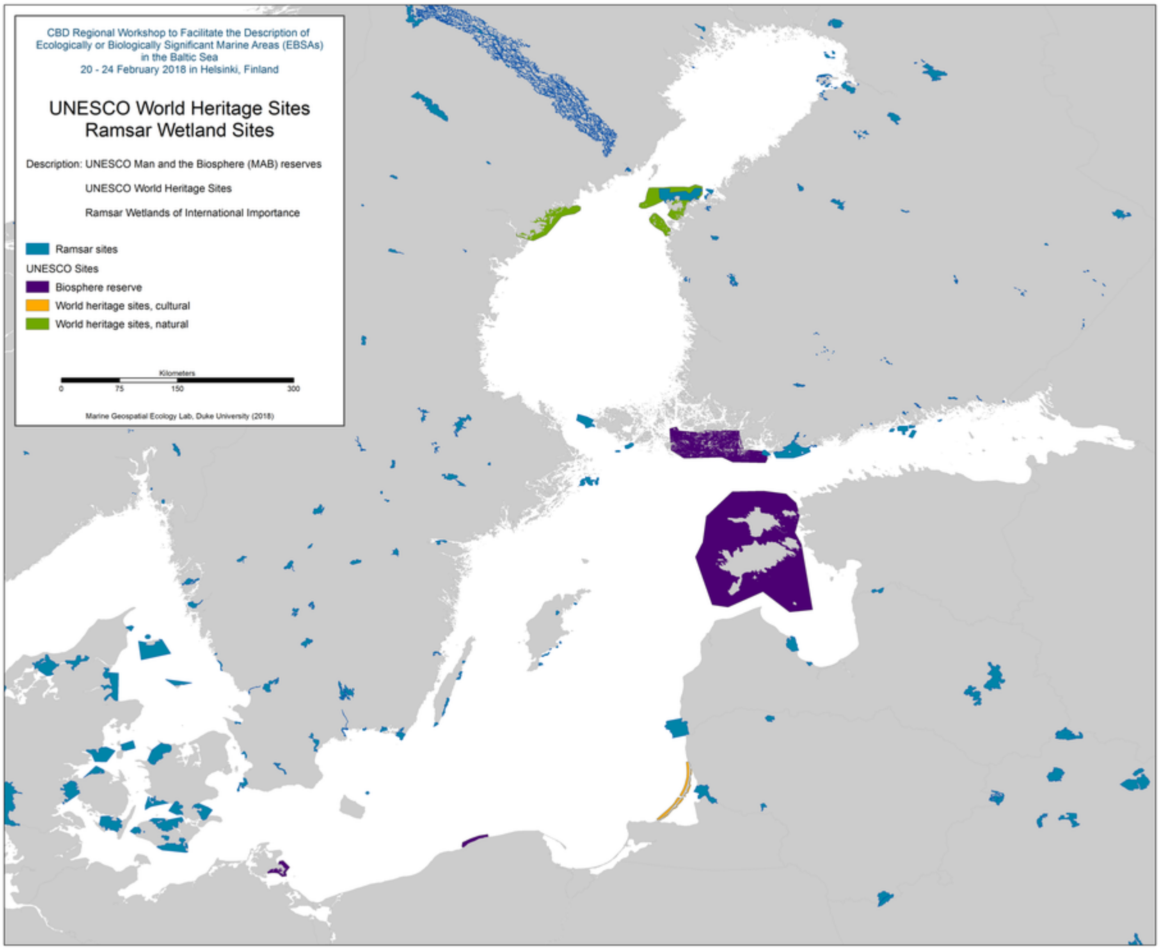


Figure 4.5-1 UNESCO sites and Ramsar sites

5 Additional Literature, Data Reports and Data Portals

There are many data reports from ongoing scientific research programs and planning processes were recommended for review by workshop attendees.   Additional literature, data reports and data portals from across the region were reviewed and summarized below.

5.1 ASCOBANS Conservation Plans for the Harbour Porpoise

ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas) has produced two reports on the Baltic Harbour Porpoise, *Conservation Plan for the Harbour Porpoise Population in the Western Baltic, the Belt Sea and the Kattegat* and *Recovery Plan for Baltic Harbour Porpoises (Jastarnia Plan)*. These reports detail a conservation framework for improving habitat for the species, which is critically endangered in the Baltic.

The Western Baltic Report identifies “Special Areas of Conservation” which could assist population recovery.

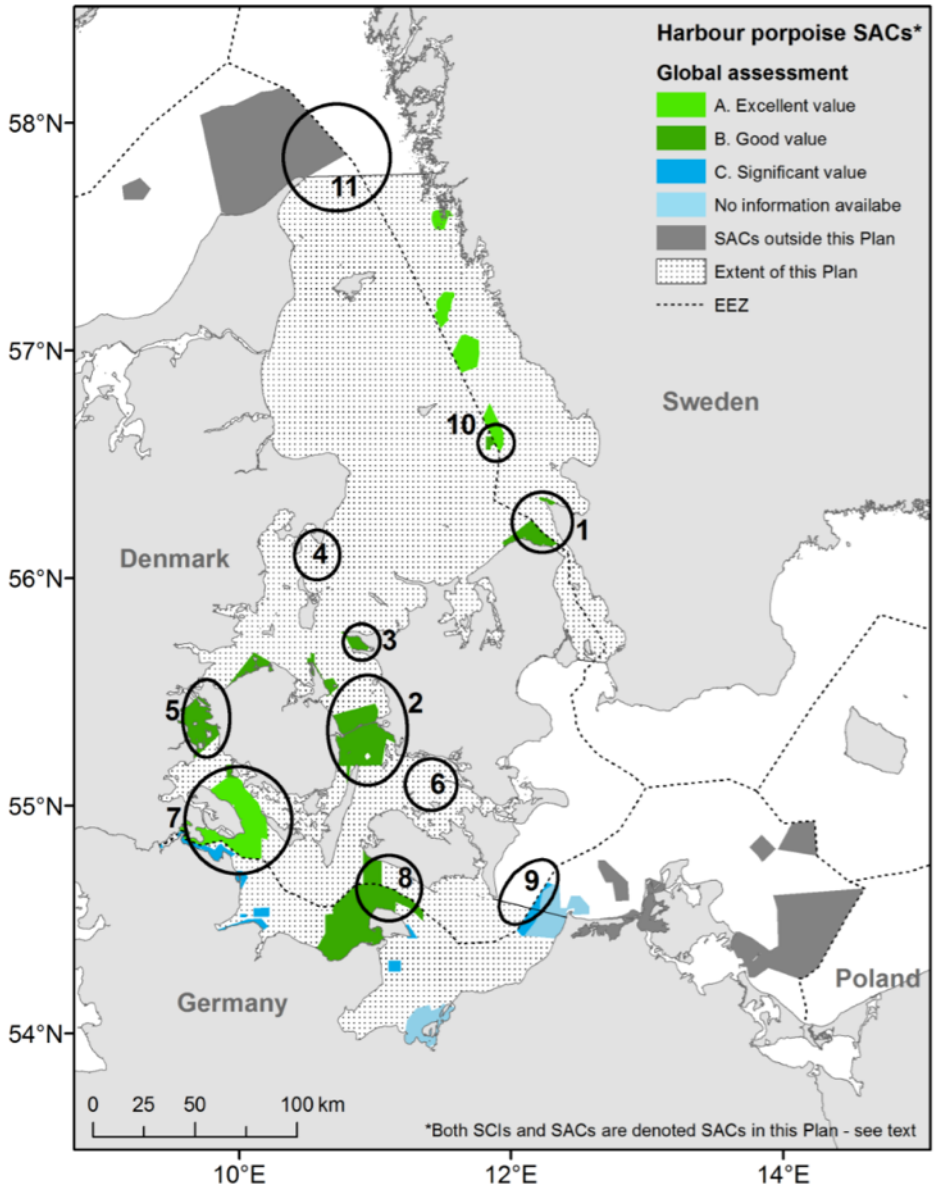


Figure 2 *Special Areas of Conservation (SACs) designated according to the EU Habitats Directive for harbour porpoises (i.e. where harbour porpoises are part of the selection criteria and listed as Population status A, B or C) by Denmark, Germany and Sweden within the Western Baltic, the Belt Sea and the Kattegat. Colours refer to the global assessment of each site to harbour porpoises (from ICES WGMME report 2011 and http://eunis.eea.europa.eu/sites.jsp). Black circles indicate areas of high porpoise density identified by satellite tracking, surveys and passive acoustic monitoring: Northern Sound (1), Great Belt (2), Kalundborg Fjord (3), northern Samsø Belt (4), Little Belt (5), Smålandsfarvandet (6), Flensborg Fjord (7), Fehmarn Belt (8), Kadet Trench (9), Store Middelgrund (10) and Tip of Jutland (11). The order of the numbers is arbitrary.*

Figure 5.1-1 Species Areas of Conservation (SACs) for harbour porpoise

The *Jastarnia Plan* considers EBSA criteria in its assessment, specifically: importance for life history stages, and importance for threatened, endangered or declining species and/or habitats. The report reviews density predictions from the SAMBAH project, which modeled the population. In assessing spatio-temporal areas for the species, the report concludes:

> "Given the criteria and principles set out above, and due to the lack of information on Baltic habitat preferences derived from other sources than modelling of detection rate and density, and the almost year-round engagement in reproductive activity by adult harbour porpoise females (mating, pregnancy, calving and/or nursing), critical habitats for Baltic harbour porpoises can currently only be identified based on areas of high probability of detection or density. With further information on habitat use or responses to anthropogenic pressures, potentially varying among different life stages or sexes, the identification of critical habitats and the management needs of those habitats may be developed further.
>
> In the Baltic Sea, high-density areas for harbour porpoises have been identified based on predictions of probability of detection per month. Two levels of high-density areas were defined: larger areas encompassing 30 per cent or more of the population, and smaller sub-areas encompassing 7.8 per cent of the population. In the Skagerrak and Kattegat Seas, areas encompassing 30 per cent of the population have been used to identify high-density areas of harbour porpoises (Sveegaard et al., 2011)."

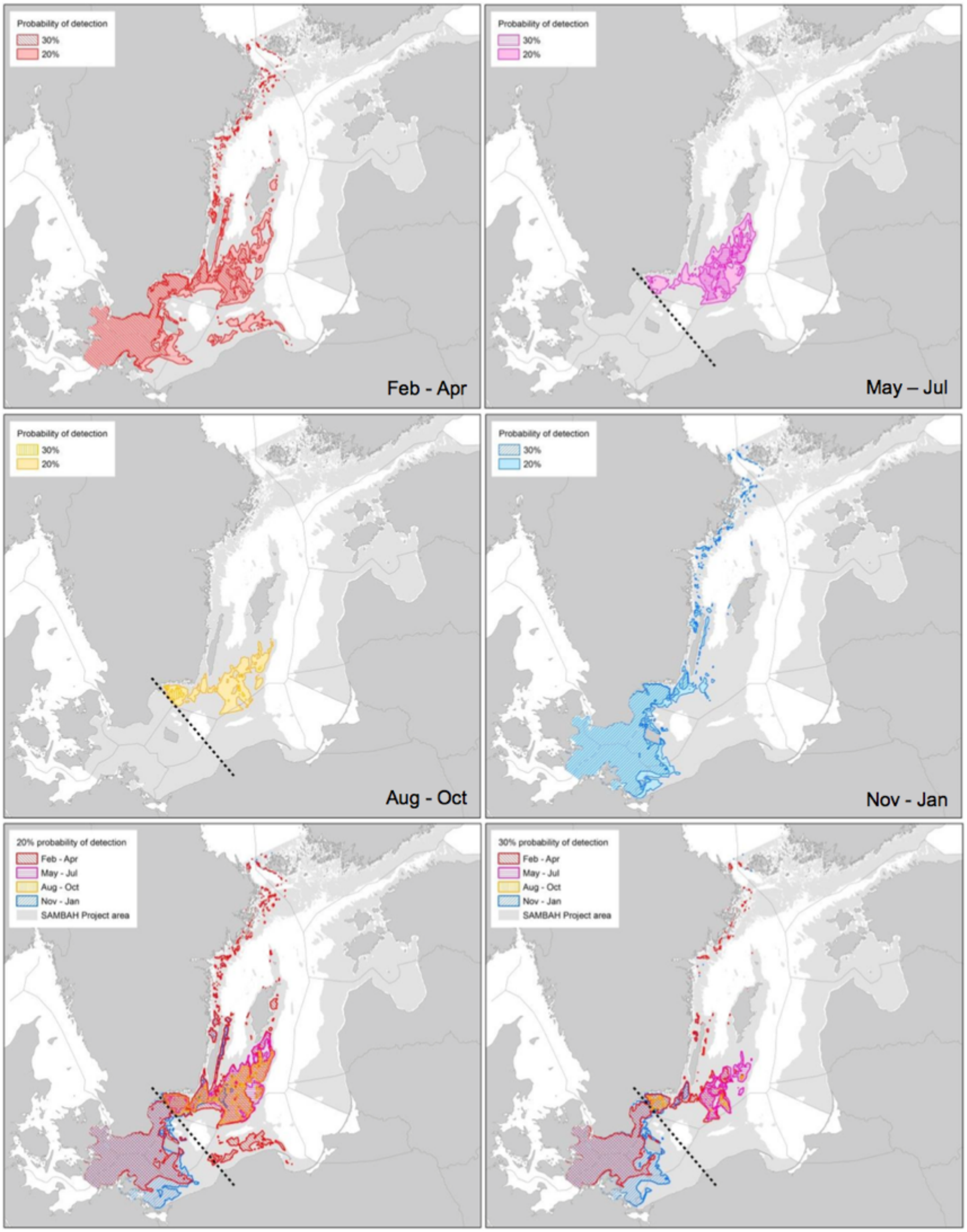


Figure 7. High-density areas for harbour porpoises in the SAMBAH area (shaded) based on predictions of probability of detection. The four upper panels show the high-density areas of two different levels per quarter, and the two lower panels show the full-year pictures for each of the two density levels. During May – October, the isoline of 20% probability of detection encompasses approximately 30% of the Baltic harbour porpoise population, while the isoline of 30% probability of detection encompasses approximately 7.8% of the Baltic harbour porpoise population. During November – April, the same isolines for probability of detection are shown without correlating them to the proportions of the population. Southwest of the SAMBAH population border, the high-density areas are inhabited by animals from both the Baltic and the Belt Sea populations during November – April.

Figure 5.1-2 High density areas for harbour porpoise in the SAMBAH area

5.2 HELCOM Ecological coherence assessment of the Marine Protected Area network in the Baltic Sea

The analysis undertaken in this report ultimately concludes that ecological coherence has not yet been achieved by the HELCOM and Natura 2000 MPAs, with the criteria of connectivity the barrier to coherence. Some landscapes and habitats however, have achieved protection targets.

From the report:

"Since the designation of the first HELCOM MPAs in 1994, there has been a substantial increase in the areal coverage of MPAs: in 2004, the protected marine area of the Baltic Sea was 3.9%, in 2010 it was 10.3%, and today, in 2016, it is 11.8%. Thus, the target of conserving at least 10% of coastal and marine areas, set by the UN Convention on Biological Diversity, was reached already in 2010 in the Baltic Sea…

...The assessment of ecological coherence carried out for this report considered four aspects; representativity, replication, adequacy and connectivity. Two of these aspects were evaluated to be at an acceptable level for supporting a coherent MPA network: the areal representation of different types of geographical features and broad scale habitats, and the replication of a set of indicative species and biotope complexes, as well the broad scale habitats. However, evaluations of adequacy, which considers the quality of the network, and connectivity, which measures how well the network supports the migration and dispersal of species, indicate that the network is not yet ecologically coherent. Improving connectivity requires joint efforts from all HELCOM countries when planning and nominating new sites to the HELCOM MPA network, as connectivity cannot be improved on the level of single sites….

...However, the protection of certain landscapes, such as photic sand 5-18 psu, improves remarkably when the Natura 2000 network and the HELCOM MPAs are evaluated together, and nine landscapes reach the stricter 60% protection target. The HELCOM MPA network covers 53% of this landscape, while the combined network covers 99% of the landscape. This is mainly explained by the fragmented distribution and coastal location of the Natura 2000 network, as the photic sand 5-18 psu is a typical coastal landscape…"

Reference:

HELCOM 2016. Ecological coherence assessment of the Marine Protected Area network in the Baltic, Balt. Sea Environ. Proc. No. 148

5.3 HELCOM Red List of Baltic Sea species in danger of becoming extinct

This report assesses species endemic to the Baltic with IUCN Red List criteria to evaluate regionally endangered species. The species found to be critically endangered:

Anguilla anguilla – European Eel
Lamna nasus – Porbeagle
Squalus acanthias – Spurdog/Spiny dogfish
Thymallus thymallus – Grayling
Charadrius alexandrinus (breeding) – Kentish Plover
Gavia arctica (wintering) – Black-throated diver
Gavia stellata (wintering) – Red-throated diver
Phocoena phocoena (Baltic Sea population) – Harbor porpoise

The table excerpted below shows the other endangered and vulnerable species.

From the report:

"This HELCOM Red List assessment of threatened species follows the International Union for Conservation of Nature (IUCN) Red List categories and criteria (IUCN 2001) ...The general aim of the IUCN system is to provide an explicit and objective framework for the classification of the broadest range of species according to their extinction risk…

Provided that the regional population to be assessed is isolated from conspecific populations outside the region, the IUCN Red List Criteria (IUCN 2001) can be used without modification within any geographically defined area. The extinction risk for such an isolated population is identical to that of an endemic taxon."

Reference:
HELCOM, 2013. HELCOM Red List of Baltic Sea species in danger of becoming extinct. Balt. Sea Environ. Proc. No. 140.

6 Conclusions and proposals of the HELCOM Red List project

Three Baltic Sea species - the American Atlantic sturgeon (*Acipenser oxyrinchus*), the common skate (*Dipturus batis*) and the gull-billed tern (*Gelochelidon nilotica*) - are regionally extinct from the Baltic Sea. Altogether, 69 species or other assessment units are threatened and

Table 6.1. List of Regionally Extinct (RE) and threatened (CR; Critically Endangered, EN; Endangered, VU; Vulnerable) species in the Baltic Sea and their threat status.

	Scientific name	English name
RE	*Acipenser oxyrinchus*	American Atlantic sturgeon
RE	*Dipturus batis*	Common skate
RE	*Gelochelidon nilotica* (breeding)	Gull-billed tern
CR	*Anguilla anguilla*	European eel
CR	*Lamna nasus*	Porbeagle
CR	*Squalus acanthias*	Spurdog / Spiny dogfish
CR	*Thymallus thymallus*	Grayling
CR	*Charadrius alexandrinus* (breeding)	Kentish plover
CR	*Gavia arctica* (wintering)	Black-throated diver
CR	*Gavia stellata* (wintering)	Red-throated diver
CR	*Phocoena phocoena* (Baltic Sea population)	Harbour porpoise
EN	*Hippuris tetraphylla*	Fourleaf Mare's Tail
EN	*Lamprothamnium papulosum*	Foxtail stonewort
EN	*Persicaria foliosa*	
EN	*Haploops tenuis*	
EN	*Anarhichas lupus*	Atlantic wolf-fish
EN	*Coregonus maraena*	Whitefish
EN	*Molva molva*	Ling
EN	*Anser fabalis fabalis* (wintering)	Taiga bean goose
EN	*Calidris alpina schinzii* (breeding)	Southern dunlin
EN	*Clangula hyemalis* (wintering)	Long-tailed duck
EN	*Larus melanocephalus* (breeding)	Mediterranean gull
EN	*Melanitta fusca* (wintering EN, breeding VU)	Velvet scoter
EN	*Melanitta nigra* (wintering)	Common scoter
EN	*Podiceps grisegena* (wintering)	Red-necked grebe
EN	*Polysticta stelleri* (wintering)	Steller's eider
EN	*Rissa tridactyla* (breeding EN, wintering VU)	Black-legged kittiwake
EN	*Somateria mollissima* (wintering EN, breeding VU)	Common eider
EN	*Xenus cinereus* (breeding)	Terek sandpiper
VU	*Alisma wahlenbergii*	
VU	*Chara braunii*	Braun`s stonewort
VU	*Nitella hyalina*	Many-branched stonewort
VU	*Zostera noltii*	Dwarf eelgrass
VU	*Abra prismatica*	
VU	*Atelecyclus rotundatus*	Circular crab/Old mans face crab
VU	*Clelandella miliaris*	
VU	*Cliona celata*	Yellow boring sponge
VU	*Deshayesorchestia deshayesii*	
VU	*Epitonium clathrus*	Common wentletrap/ European wentletrap
VU	*Haploops tubicola*	
VU	*Hippasteria phrygiana*	Rigid cushion star
VU	*Hippolyte varians*	Chamaeleon prawn
VU	*Lunatia pallida*	Pale moonsnail
VU	*Macoma calcarea*	Chalky macoma
VU	*Modiolus modiolus*	Northern horsemussel
VU	*Nucula nucleus*	Common nut clam
VU	*Parvicardium hauniense*	Copenhagen cockle
VU	*Pelonaia corrugata*	
VU	*Scrobicularia plana*	Peppery furrow shell
VU	*Solaster endeca*	Purple sun star
VU	*Stomphia coccinea*	Spotted swimming anemone
VU	*Gadus morhua**	Atlantic cod
VU	*Galeorhinus galeus*	Tope shark
VU	*Merlangius merlangus*	Whiting
VU	*Petromyzon marinus*	Sea lamprey
VU	*Raja clavata*	Thornback ray
VU	*Salmo salar*	Salmon
VU	*Salmo trutta*	Trout
VU	*Arenaria interpres* (breeding)	Ruddy turnstone
VU	*Aythya marila* (breeding)	Greater scaup
VU	*Cepphus grylle arcticus* (wintering)	Black guillemot
VU	*Hydroprogne caspia* (breeding)	Caspian tern
VU	*Larus fuscus fuscus* (breeding)	Lesser black-backed gull
VU	*Mergus serrator* (wintering)	Red-breasted merganser
VU	*Philomachus pugnax* (breeding)	Ruff
VU	*Podiceps auritus* (breeding VU, wintering NT)	Slavonian grebe
VU	*Phoca vitulina* (Kalmarsund population)	Harbour seal
VU	*Phocoena phocoena* (Western Baltic subpopulation)	Harbour porpoise
VU	*Phoca hispida botnica*	Baltic ringed seal

* There are differences in the concepts and methodologies applied by the IUCN and ICES in assessing harvested fish species.

Some of the differences concern the delineation of assessment units (whether e.g. a species, population or stock is addressed), approaches to defining tolerated risk levels and precaution, time perspectives, as well as the use of data sources and modelling. These can lead to different conclusions about the assessed organisms.

The approach of ICES is using a minimum biomass limit for a stock (called Blim), which is more precautionary than the IUCN criteria. For the cod stocks in the Baltic, ICES in 2013 has identified both the eastern (HELCOM listing VU) and western (HELCOM listing NT) Baltic Sea cod stocks to be above these biomass limits. In addition, ICES projections for these two stocks show a further increase by 2015. For the Kattegat cod stock (here CR) ICES advises that no directed fishery takes place and by-catch and discards should be minimized and the stock has been below biomass limit since year 2000.

Further explanation about the differences in the IUCN and ICES approaches, as well as ICES advice indicating some critical issues regarding the application of the IUCN criteria to Baltic cod has been included in the Species Information Sheet for cod available at www.helcom.fi.

44

Figure 5.3-1 List of red-listed species in the Baltic

In addition, HELCOM has aggregated spatial data for species meeting Red List criteria in the Baltic. Depending on the taxa, the data is presented in different forms.

- Benthic **invertebrates**: a grid where each cell indicates the presence of a species before the year 2000, after the year 2000 or present in both eras. Each cell is assessed against ~60 species, though *Haploops tenuis* is the only endangered species.
- **Birds**: depending on the species, data is a similar grid-cell presence format, or in a habitat polygon.
- **Fish**: presence of a given species in Baltic subbasins.
- **Mammals**: depending on the species, habitat polygons or presence in subbasins.
- **Macrophytes**: a grid of species presence, similar to the invertebrate data.

Source:
http://helcom.fi/Lists/Publications/BSEP140.pdf

5.4 HELCOM State of the Baltic Sea - Holistic Assessment

"This report contains the first version of the 'State of the Baltic Sea' report, presenting the assessment of status, pressures and impacts on the Baltic Sea marine environment as well social and economic analyses of the use of marine waters and costs of degradation. The report has been prepared by HELCOM during 2015–2017, and covers the period 2011–2015.

The report provides biodiversity status of Baltic sub-basins assessed by many factors; identifying pelagic and benthic habitats, coastal and anadromous fish, mammals and red listed species, natural vs disturbed areas.

The assessment of fish from a biodiversity perspective indicates good status in about half of the assessed coastal areas. In the open sea, good status is not achieved in any assessment area. Two out of five assessed pelagic fish stocks (herring in the central Baltic Sea and Bothnian Sea) have good status, and one of three assessed demersal stocks (plaice in the Kattegat, Sound and Belt Sea). Demersal fish are only assessed in the Kattegat and the western Baltic Sea, and an assessment for the eastern parts of the Baltic Sea is currently lacking (Figure ES4). Core indicators for the migratory species salmon and sea trout show that good status is not achieved in most areas where they are assessed.

Among the marine mammals, grey seals and harbour seals show increasing population sizes, but the assessment for grey seal indicates that the nutritional and reproductive status is not good. Of the three management units of harbour seals in HELCOM area, only the Kattegat population shows good status. The population of ringed seal in the Gulf of Finland is of concern. The population is sensitive to climate change, and it is decreasing and currently represented by around 100 animals. A particular concern is also the Baltic Proper population of harbour porpoise, with a population size recently estimated at around 500 animals. The Kattegat-Belt-Sea-Western Baltic subpopulation is also assessed as threatened by HELCOM, but the sub-population is estimated at around 40 500 animals and the sub-population is stable.

Water birds are assessed by their abundance during the breeding and the wintering season. Both indicators failed the threshold values, particularly due to a decline in benthic feeding birds during both seasons, as well as a decline in surface feeders and waders during the breeding season, and in grazing feeders during the wintering season. Pelagic feeding birds as a group shows good status."

Website:
http://stateofthebalticsea.helcom.fi/

Report Source:
http://www.helcom.fi/Lists/Publications/State%20of%20the%20Baltic%20Sea%20-%20First%20version%202017.pdf

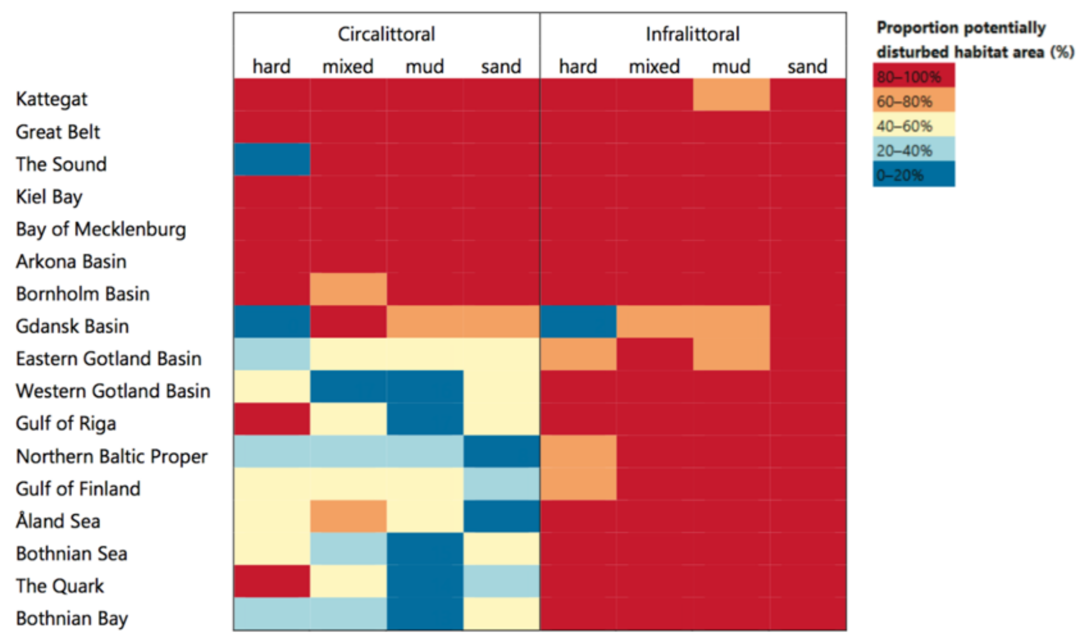


Figure 4.7.5. Estimate of the proportion (%, given in ranges) of the different broad benthic habitat types potentially disturbed due to human activities per sub-basin. The estimate is based on the total number of human activities linked to potentially causing this pressure, and does not reflect the actual level of impact.

Figure 5.4-1 Proportion of benthic habitat types potentially disturbed due to human activities

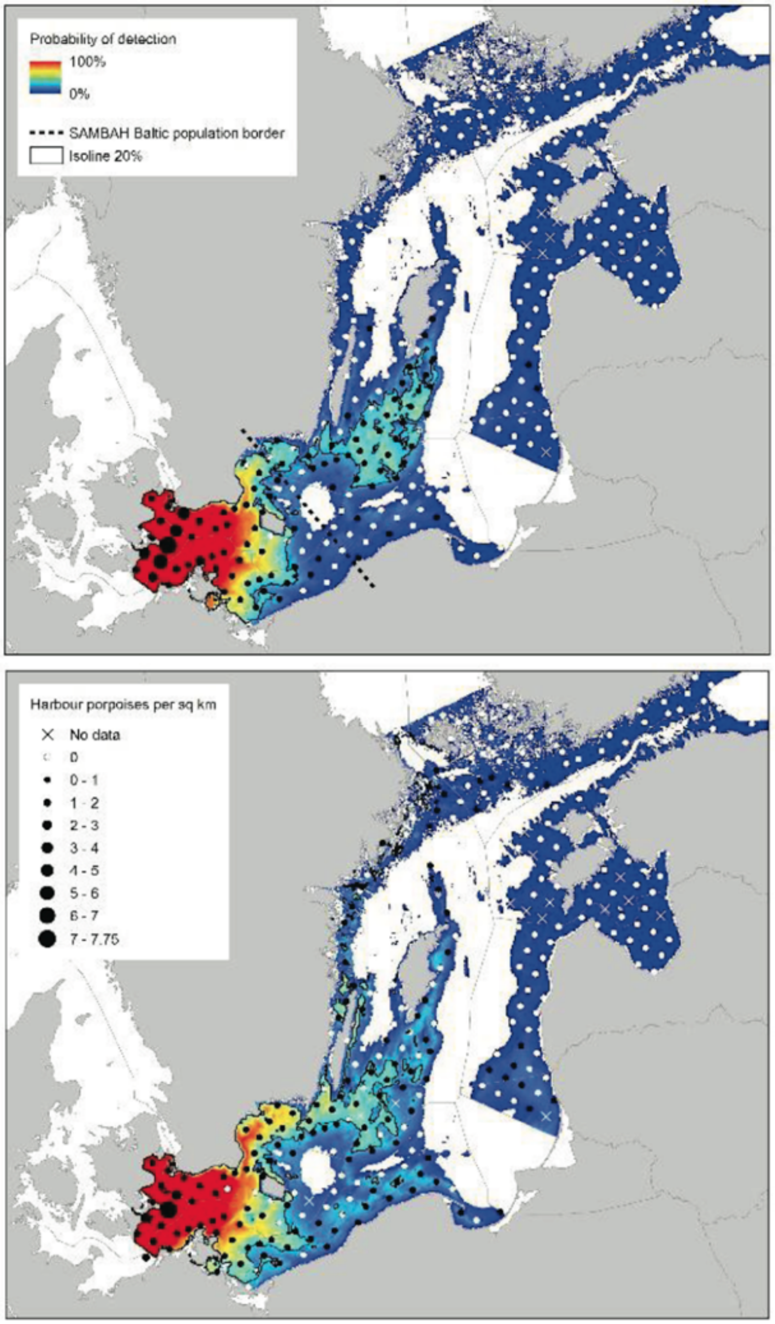


Figure 5.4.8. Predicted probability of detection of harbour porpoises per month between May and October (upper graph) and between November and April (lower graph). The black line indicates areas with 20 % probability of detection of harbour porpoise (Denoted 'Isohaline 20 %' in the legend). This area is approximately comparable to the area encompassing 30 % of the population, and the limit is often used to define high-density areas. The hatched line in the upper figure indicates the spatial separation between the Belt Sea and Baltic harbour porpoise populations during May to October according to SAMBAH (2016). White colour denotes areas that were not surveyed in SAMBAH (2016).

Figure 5.4-2 Predicted probability of detection of harbour porpoises

5.5 Oceana - Conservation proposals for ecologically important areas in the Baltic Sea

From the report: "The Baltic Sea has a relatively low biodiversity and therefore the maintenance of species diversity is important to its health and survival, and to the overall quality of the environment. It is also critical to the long term functioning of the whole ecosystem. Certain species are of particular importance because they make up forming structures that serve as habitats for many other species. Such key species in the Baltic Sea include: brown algae bladder wrack (Fucus vesiculosus), red algae black carrageen (Furcellaria lumbricalis), eelgrass (Zostera marina), and blue mussels (Mytilus trossulus and in Kattegat M. edulis)."

The report identifies nine critical areas in the Baltic and Kattegat.

- Djupa rännan trench
- Kattegat trench
- Groves Flak
- Ven Island
- Klinkts bank
- Hanko peninsula
- Åland Islands
- Bothnian Bay deep
- Ulkokrunni

The areas are mapped, and the spatial extent supported with species lists, habitat descriptions, and methods of data gathering. These areas are distinct from the proposed MPAs described in the next Oceana report.

Source:
http://oceana.org/sites/default/files/reports/OCEANA_Baltic_report_2011_ENG.pdf

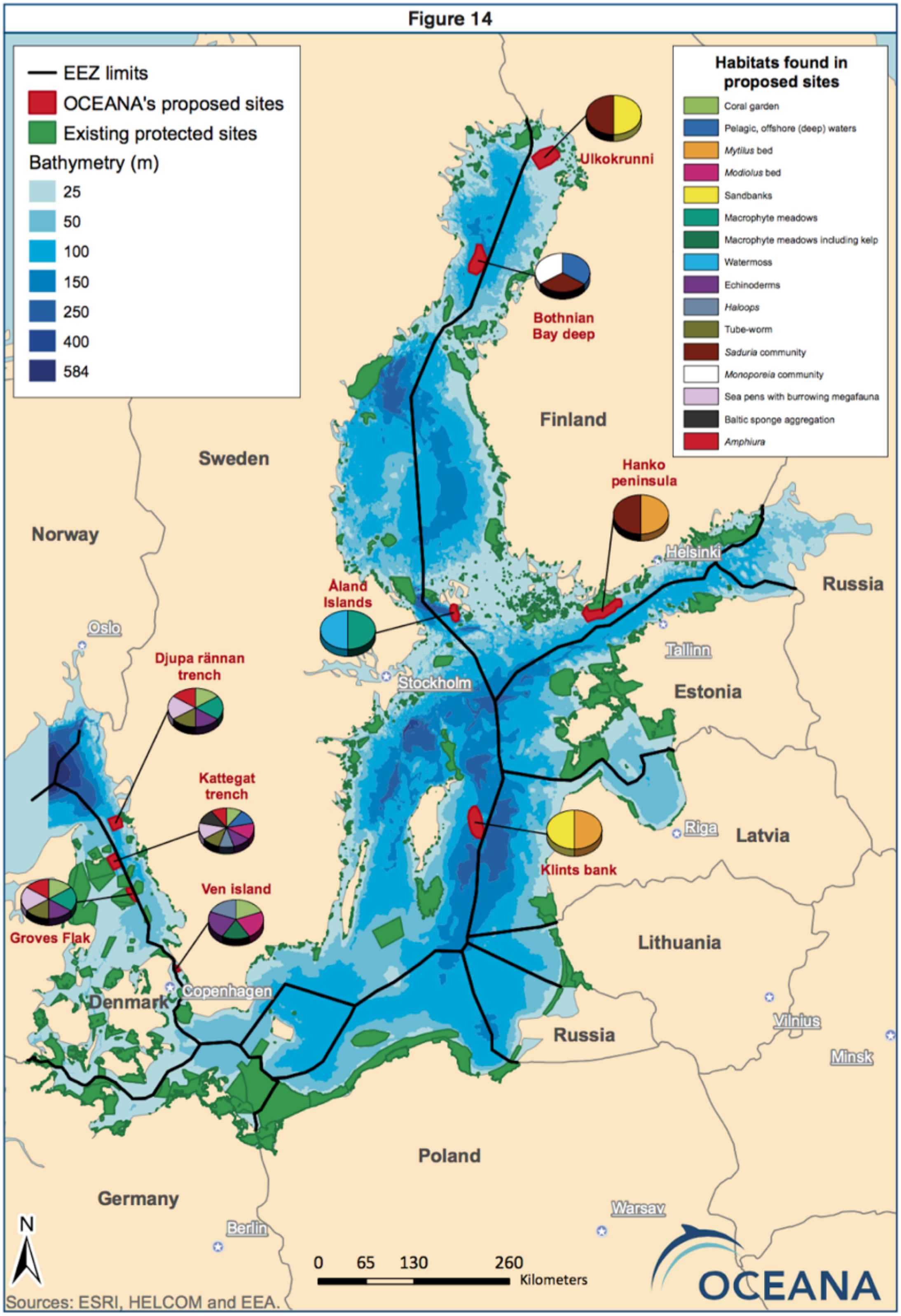


Figure 5.5-1 Map of Natura 2000 sites and Oceana's proposed conservation sites

5.6 Oceana - Proposals for Marine Protected Areas

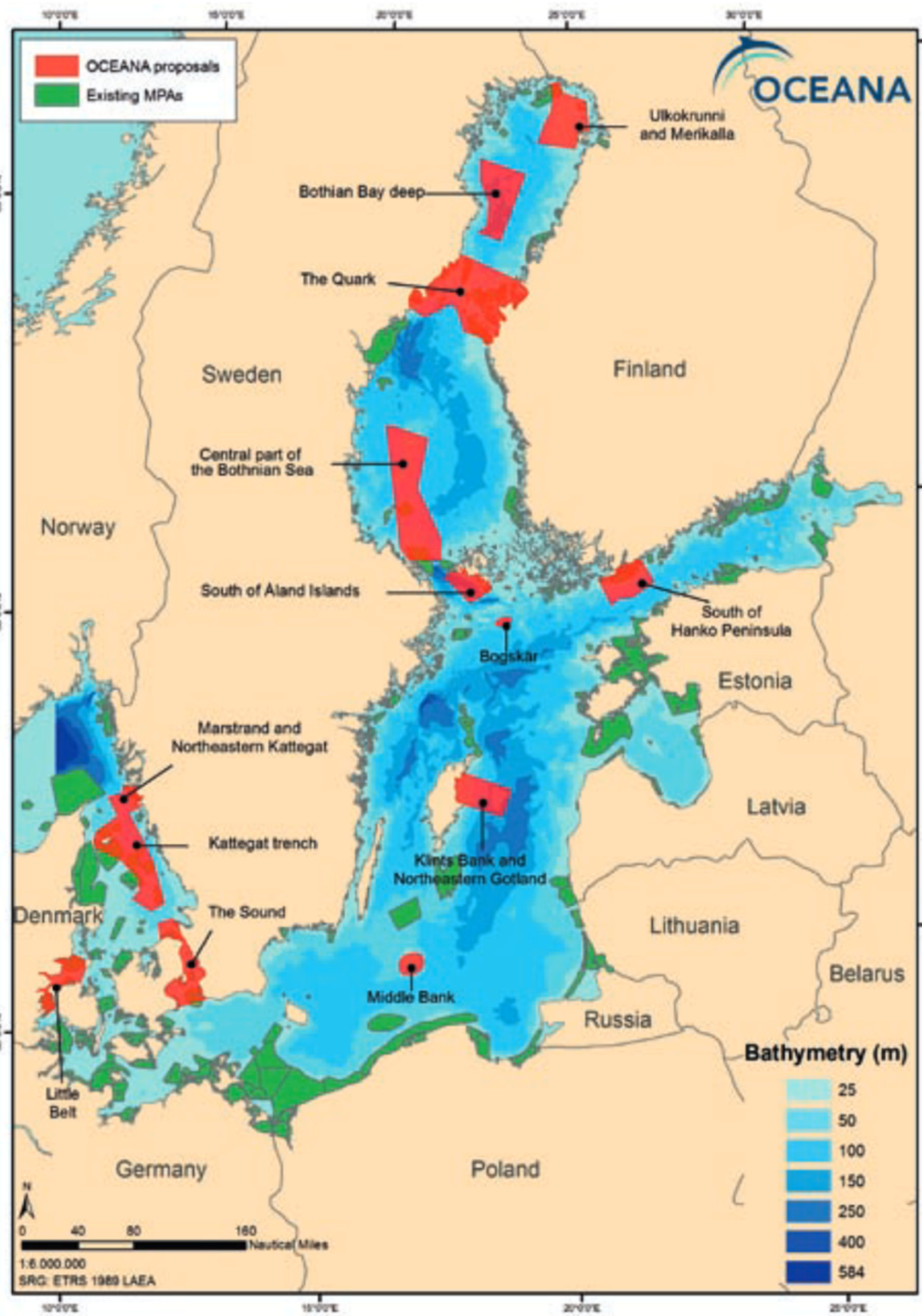
"Based on three expeditions in the Baltic Sea and the Kattegat, both in shallow and deep waters, Oceana has put together 13 comprehensive conservation proposals for ecologically important areas. The information collected consists altogether of over 200 ROV (Remotely Operated Vehicle) recordings, 70 scuba dives with video and photo material and over 80 sediment samples (with Van Veen grab). Over the course of the expeditions, Oceana documented benthic biodiversity and its status both inside designated marine protected areas and in areas not currently protected, some of which were identified as important marine habitats and ecosystems that deserve protection."

The proposal website provides reports on each area, including descriptions of the ecology, species lists and supporting references. The full list of proposed areas is:

- Marstrandskärgården, Kattegat, Sweden
- Kattegat trench, Denmark and Sweden
- Northern part of the Sound, Sweden and Denmark
- Little Belt, Denmark
- Klints Bank, Baltic Proper, Sweden
- Bogskär, Åland Islands, Finland
- South of Åland Islands, Finland
- South of Hanko Peninsula, Gulf of Finland, Finland
- Bothnian Bay Deep, Sweden
- Ulkokrunni and Merikalla, Bothnian Bay, Finland
- Middle Bank, Poland and Sweden
- Central part of the Bothnian Sea, Sweden

These areas are distinct from the proposed conservation areas also described by Oceana.

Individual reports:
http://baltic.oceana.org/en/bl/media-reports/reports/oceana039s-proposals-for-marine-protected-areas



Existing Natura 2000 areas and Oceana's proposals for new and/or enlarged Marine Protected Areas.

Figure 5.6-1 Natura 2000 sites and Oceana's proposed new/enlarged MPAs

5.7 SAMBAH Project Final Report on Harbour Porpoise

"SAMBAH targeted the Baltic Sea population of harbour porpoise (Phocoena phocoena). This population is small and has been drastically reduced during the last decades. The species is listed in Annexes II and IV of the EC Habitats Directive as well as in the national red lists of several Member States. When SAMBAH started, the conservation status of the species in combination with a complex of threats necessitated improved methodologies for collecting data on population size and distribution, and fluctuations over time. The overall objective of the project has been to launch a best practice methodology for this purpose and to provide data for a reliable assessment of distribution and preferred habitats of the species. This would make possible an appropriate designation of SCIs for the species within the Natura 2000 network as well as the implementation of other relevant mitigation measures.

SAMBAH objective 1 has been to estimate densities, produce distribution maps and estimate abundances of harbour porpoises in the project area. Density and Abundance estimates have been produced by season for the whole study area and within country. Distribution maps showing probability of detection have been produced per month while maps showing the spatial variation in density have been produced per season.

SAMBAH objective 2 has been to identify hotspots, habitat preferences, and areas with higher risk of conflicts with anthropogenic activities for the Baltic Sea harbour porpoise. In Swedish waters, these results have been used to identify appropriate areas for protection, and within these areas to suggest appropriate management of anthropogenic activities with known or potential negative impact.

SAMBAH objective 3 has been to increase the knowledge about the Baltic Sea harbour porpoise among policymakers, managers, stakeholders, users of the marine environment and the general public, in the EU Member States bordering the Baltic Sea.

SAMBAH objective 4 has been to implement best practice methods for cost efficient, large-scale surveillance of harbour porpoises in a low-density area. The implementation of coherent methods throughout the distribution range of the Baltic Sea harbour porpoise aimed at facilitating future monitoring actions in order to follow up the effects of conservations measurements taken on a local regional, national or transnational scale."

Source:
http://www.sambah.org/SAMBAH-Final-Report-FINAL-for-website-April-2017.pdf

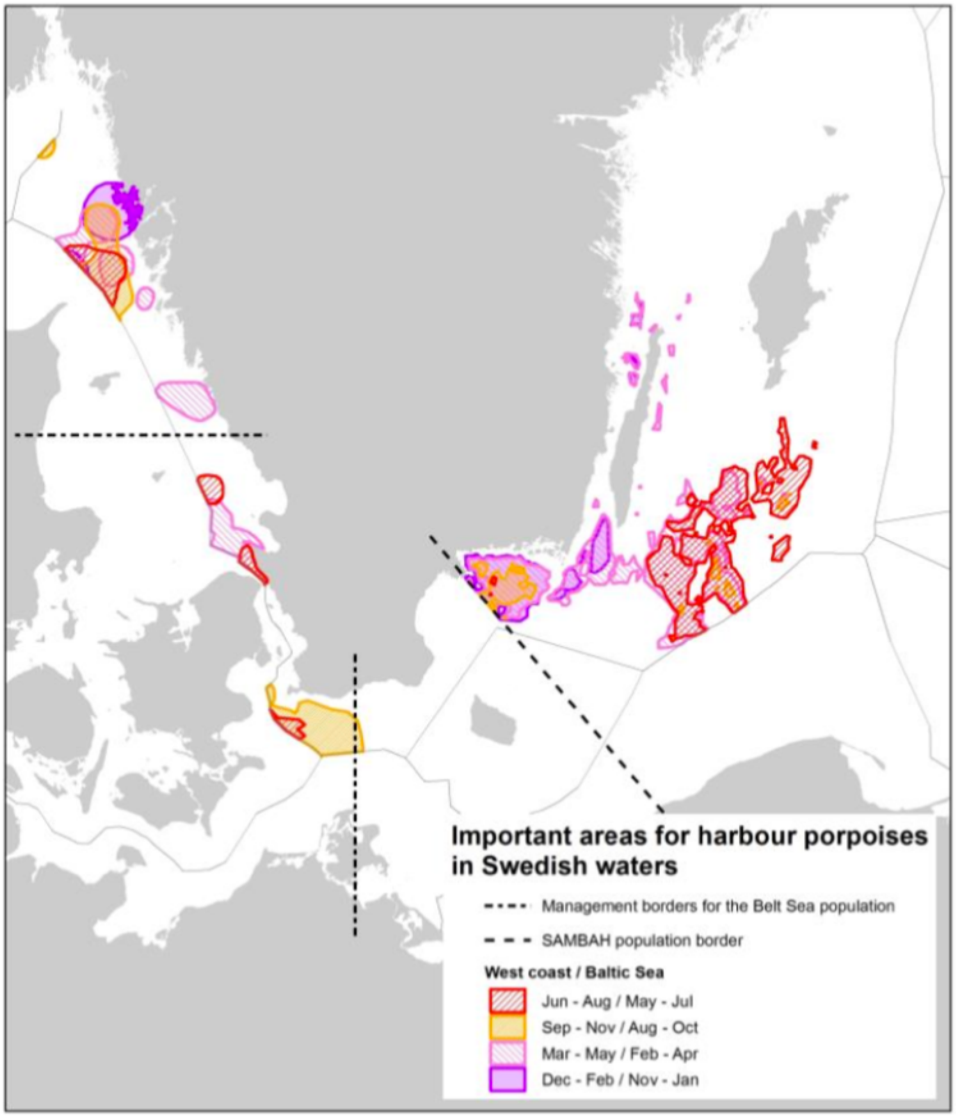


Figure 10. Important areas for harbour porpoises in Swedish waters.

Figure 5.7-1 Important areas for harbour porpoise in Swedish waters (SAMBAH)

5.8 Spatial prediction of demersal fish diversity in the Baltic Sea: comparison of machine learning and regression-based techniques

Abstract:
"Marine spatial planning (MSP) is considered a valuable tool in the ecosystem-based management of marine areas. Predictive modelling may be applied in the MSP framework to obtain spatially explicit information about biodiversity patterns. The growing number of statistical approaches used for this purpose implies the urgent need for comparisons between different predictive techniques. In this study, we evaluated the performance of selected machine learning and regression-based methods that were applied for modelling fish community indices. We hypothesized that habitat features can influence fish assemblage and investigated the effect of environmental gradients on demersal fish diversity (species richness and Shannon–Weaver Index). We used fish data from the Baltic International Trawl Surveys (2001–2014) and maps of six potential predictors: bottom salinity, depth, seabed slope, growth season bottom temperature, seabed sediments and annual mean bottom current velocity. We compared the performance of six alternative modelling approaches: generalized linear models, generalized additive models, multivariate adaptive regression splines, support vector machines, boosted regression trees and random forests. We applied repeated 10-fold cross-validation, using accuracy as the measure of model quality. Finally, we selected random forest as the best performing algorithm and implemented it for the spatial prediction of fish diversity from the Baltic Proper to the Kattegat. To obtain information on the data reliability and confidence of the developed models, which are essential for MSP, we estimated the uncertainty of predictions with standard deviation of predictions obtained from all the trees in the ensemble random forest method. We showed how state-of-the-art predictive techniques, based on easily available data and simple Geographic Information System tools, can be used to obtain reliable spatial information about fish diversity. Our comparative work highlighted the potential of machine learning method to reduce prediction error in modelling of demersal fish diversity in the framework of MSP."

Reference:
Smoliński, Szymon, and Krzysztof Radtke. 2017. "Spatial Prediction of Demersal Fish Diversity in the Baltic Sea: Comparison of Machine Learning and Regression-Based Techniques." *ICES Journal of Marine Science* 74 (1):102–11. https://doi.org/10.1093/icesjms/fsw136.

Figure 4.

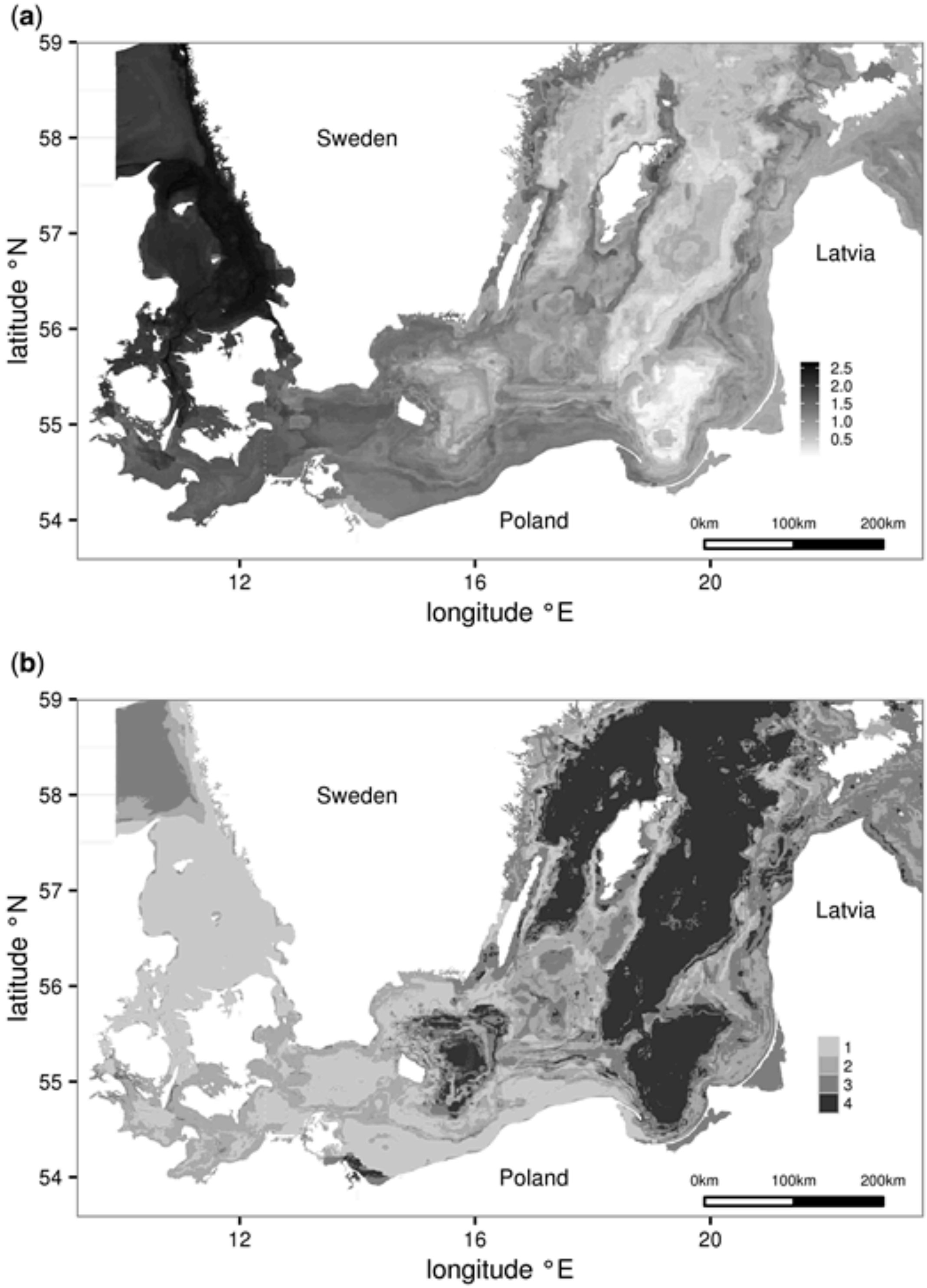


Figure 5.8-1 Predicted Shannon Weaver index of demersal fish community (a) and prediction uncertainty (b), (Figure 4 in original reference)

5.9 Spawning areas of eastern Baltic cod revisited: Using hydrodynamic modelling to reveal spawning habitat suitability, egg survival probability, and connectivity patterns

Abstract
"In the highly variable environment of the Baltic Sea two genetically distinct cod stocks exist, one west of the island of Bornholm, which is referred to as the western stock, and one to the east of Bornholm, the eastern stock. A hydrodynamic model combined with a Lagrangian particle tracking technique was utilised to provide spatially and temporally resolved long-term information on environmentally-related (i) spawning habitat size, (ii) egg/yolk-sac larval survival, (iii) separation of causes of mortality, and (iv) connectivity between spawning areas of eastern Baltic cod. Simulations were performed to quantify processes generating heterogeneity in spatial distribution of cod eggs and yolk sac larvae up to the first-feeding stage. The spatial extent of cod eggs represented as virtual drifters is primarily determined by oxygen and salinity conditions at spawning, which define the habitat requirement to which cod's physiology is suited for egg development. The highest habitat suitability occurred in the Bornholm Basin, followed by the Gdansk Deep, while relatively low habitat suitability was obtained for the Arkona and the Gotland Basin. During drift egg and yolk sac larval survival is to a large extent affected by sedimentation. Eggs initially released in the western spawning grounds (Arkona and Bornholm Basin) were more affected by sedimentation than those released in the eastern spawning grounds (Gdansk Deep and Gotland Basin). Highest relative survival of eastern Baltic cod eggs occurred in the Bornholm Basin, with a pronounced decrease towards the Gdansk Deep and the Gotland Basin. Relatively low survival rates in the Gdansk Deep and in the Gotland Basin were attributable to oxygen-dependent mortality. Low oxygen content had almost no impact on survival in the Arkona Basin. For all spawning areas temperature dependent mortality was only evident after severe winters. Egg buoyancy in relation to topographic features like bottom sills and strong bottom slopes could appear as a barrier for the transport of Baltic cod eggs and yolk sac larvae and could potentially limit the connectivity of Baltic cod early life stages between the different basins in the western and eastern Baltic Sea. The possibility of an eastward directed transport up to the first-feeding larval stage exists only for eggs and yolk sac larvae at high buoyancy levels, suggesting that dispersal of early life stages between these spawning areas is limited."

Reference:
Hinrichsen, H. -H., A. Lehmann, C. Petereit, A. Nissling, D. Ustups, U. Bergström, and K. Hüssy. 2016. "Spawning Areas of Eastern Baltic Cod Revisited: Using Hydrodynamic Modelling to Reveal Spawning Habitat Suitability, Egg Survival Probability, and Connectivity Patterns." *Progress in Oceanography* 143 (April):13–25. https://doi.org/10.1016/j.pocean.2016.02.004.

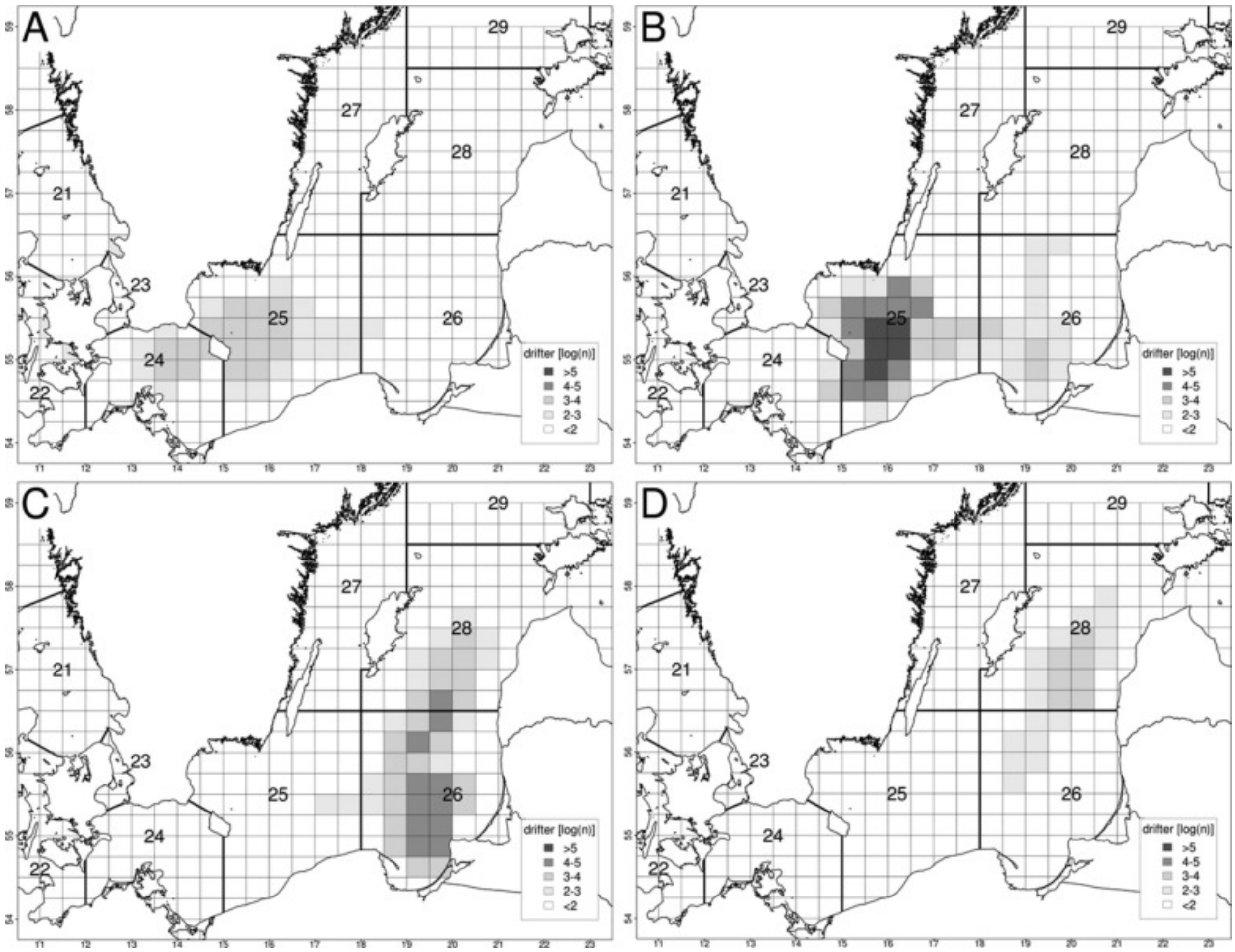


Figure 5.9-1 Final horizontal distributions of virtual drifters (1971–2010) representing surviving eastern Baltic cod first-feeding yolk-sac larvae (log10-transformed) successfully spawned in different spawning groundsin the central Baltic Sea (a) Arkona Basin, (b) Bornholm Basin, (c) in Gdansk Deep, and (d) in Gotland Basin (Fig 9 in original reference)

5.10 Spatio-temporal dynamics of cod nursery areas in the Baltic Sea

Abstract

"In this study the drift of eastern Baltic cod larvae and juveniles spawned within the historical eastern Baltic cod spawning grounds was investigated by detailed drift model simulations for the years 1971–2010, to examine the spatio-temporal dynamics of environmental suitability in the nursery areas of juvenile cod settlement. The results of the long-term model scenario runs, where juvenile cod were treated as simulated passively drifting particles, enabled us to find strong indications for long-term variations of settlement and potentially the reproduction success of the historically important eastern Baltic cod nursery grounds. Only low proportions of juveniles hatched in the Arkona Basin

and in the Gotland Basin were able to settle in their respective spawning ground. Ocean currents were either unfavorable for the juveniles to reach suitable habitats or transported the juveniles to nursery grounds of neighboring subdivisions. Juveniles which hatched in the Bornholm Basin were most widely dispersed and showed the highest settlement probability, while the second highest settlement probability and horizontal dispersal was observed for juveniles originating from the Gdansk Deep. In a long-term perspective, wind-driven transport of larvae/juveniles positively affected the settlement success predominately in the Bornholm Basin and in the Bay of Gdansk. The Bornholm Basin has the potential to contribute on average 54% and the Bay of Gdansk 11% to the production of juveniles in the Baltic Sea. Furthermore, transport of juveniles surviving to the age of settlement with origin in the Bornholm Basin contributed on average 13 and 11% to the total settlement in the Arkona Basin and in the Gdansk Deep, respectively. The time-series of the simulated occupied juvenile cod habitat in the Bornholm Basin and in the Gdansk Deep showed a similar declining trend as the Fulton's *K* condition factor of demersal 1-group cod, which may confirm the importance of oxygen-dependent habitat availability and its effect on density dependence as a process relevant for recruitment success."

Reference:

Hinrichsen, H. -H., B. von Dewitz, A. Lehmann, U. Bergström, and K. Hüssy. 2017. "Spatio-Temporal Dynamics of Cod Nursery Areas in the Baltic Sea." *Progress in Oceanography* 155 (June):28–40. https://doi.org/10.1016/j.pocean.2017.05.007.

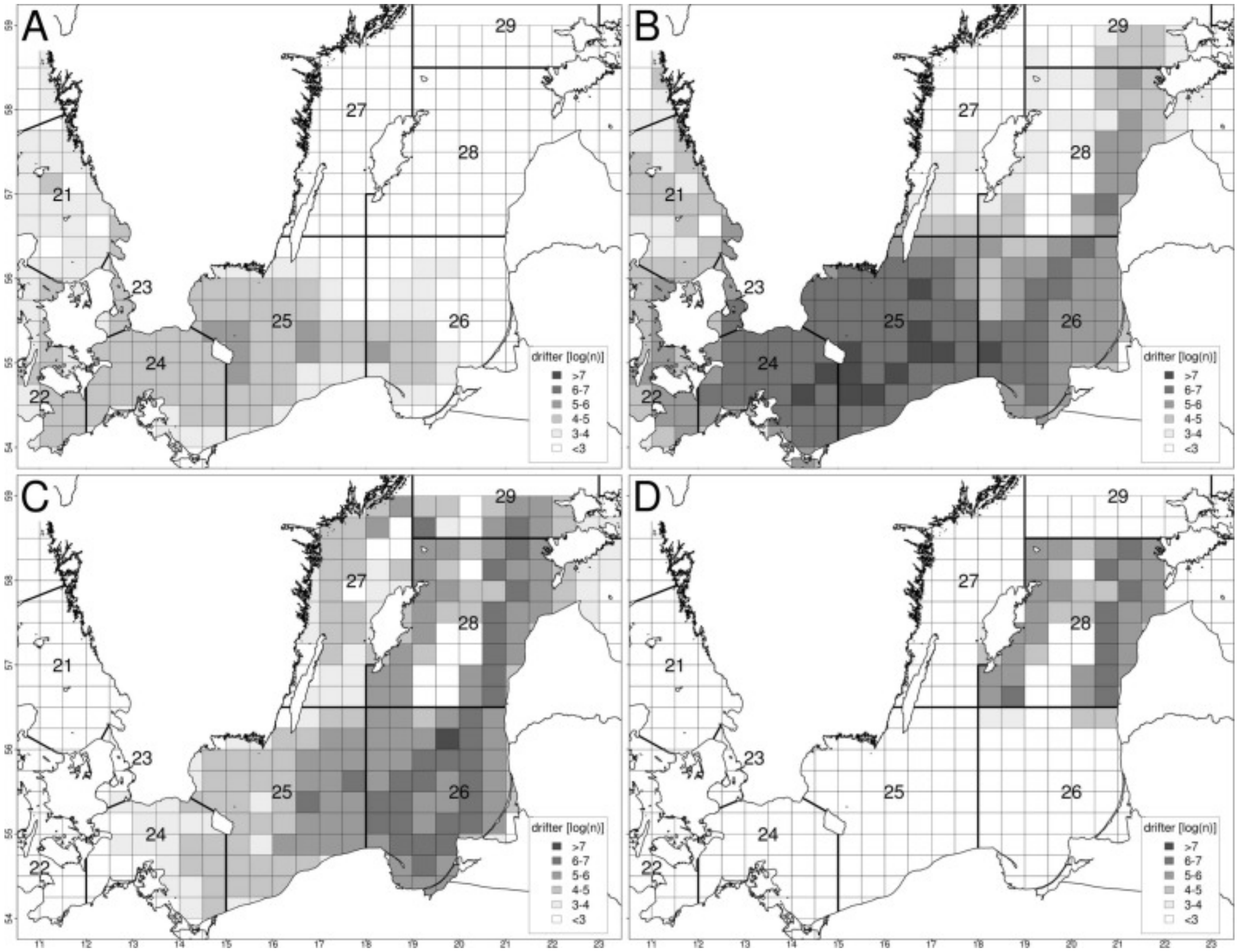


Figure 5.10-1 Horizontal distribution of virtual drifters (1971–2010) representing successfully settled Baltic cod juveniles (log10-transformed) hatched in different ICES subdivisions in the central and eastern Baltic Sea a) Arkona Basin, b) Bornholm Basin, c) in Gdansk Deep, and d) Gotland Basin. (Figure 8 in original reference)

5.11 Review of western Baltic cod (*Gadus morhua*) recruitment dynamics

Abstract

"Important processes in the recruitment dynamics of western Baltic cod (*Gadus morhua*) are identified. Spawning areas are in the deep, saline waters below 20–40 m, depending on area topography. Spatial distribution remains relatively stable over time. Peak spawning shows an area-specific pattern, with progressively later spawning towards the east. Genetic stock structure and tagging indicate some degree of natal homing for spawning. The highly variable hydrodynamic conditions and the fact that cod eggs float in the water column cause their entrainment by currents, and their destination is determined by the prevailing winds and currents. Drift is almost exclusively to the east, but the magnitude and its impact on the structure of the affected stocks (Kattegat, western Baltic, and eastern Baltic) remains unresolved. Salinity limits the east–west exchange of eggs as a consequence of the

stocks' differential requirement for neutral buoyancy. Superimposed on this, oxygen content and temperature have a significant effect on fertilization, egg/larva development, and survival. Within the Baltic Sea ecosystem, mixing of stocks may be anticipated and is particularly pronounced in the Arkona Basin because of its use for spawning by both western and eastern stocks, the advection of early life stages from the west and immigration/emigration from the east."

Reference:

Hüssy, K. 2011. Review of western Baltic cod (*Gadus morhua*) recruitment dynamics. – ICES Journal of Marine Science, 68: 1459–1471.

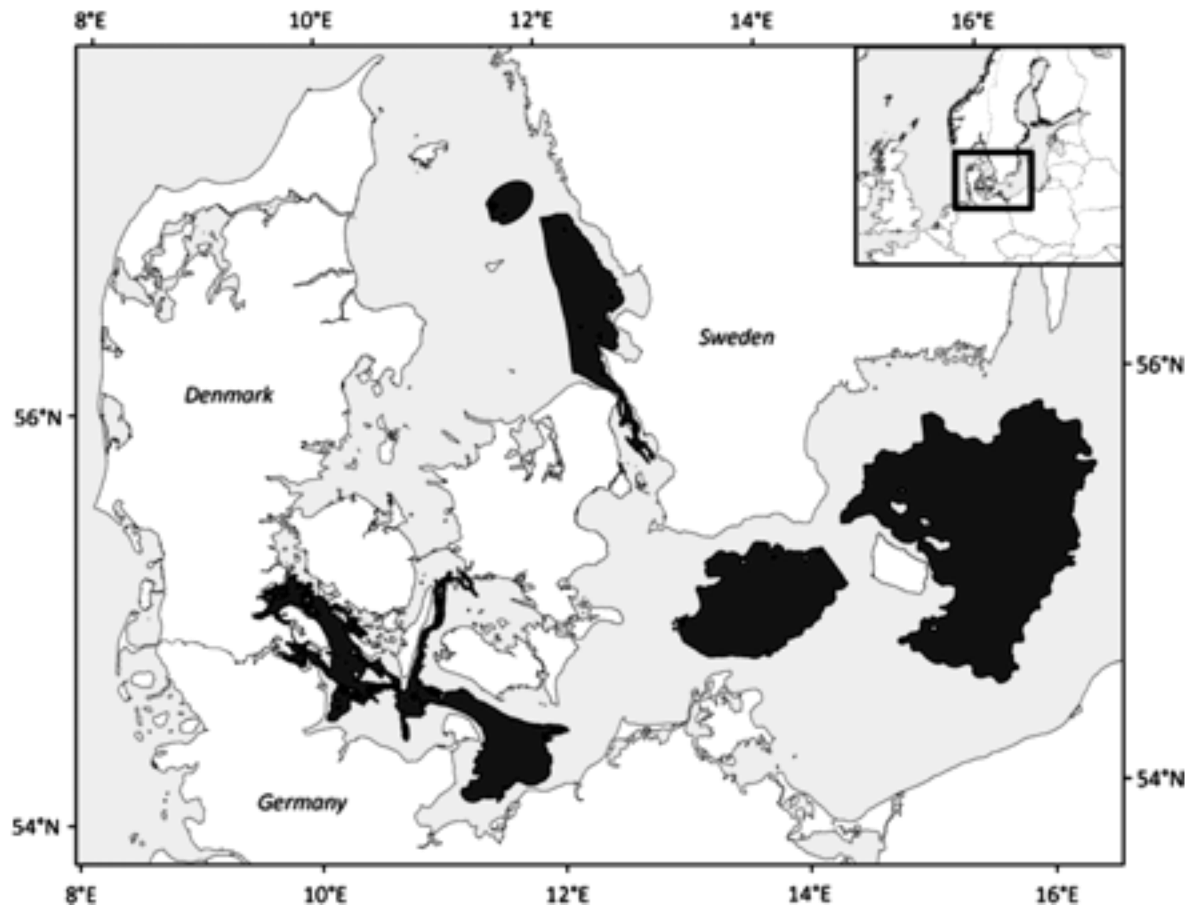


Figure 5.11-1 Spawning areas (black) in the Baltic Sea from the Kattegat to the Bornholm Basin derived from a combination of ichthyoplankton surveys and surveys of spawning adults (Figure 4 in original reference)

5.12 Undersökning av utsjöbankar Inventering, modellering och naturvärdesbedömning

"In order to raise awareness of the Swedish offshore marine environment the Swedish Environmental Protection Agency was given the task to continue the mapping of offshore banks, with the addition to also include inventories of seabirds and fish. The first mapping of the offshore banks (U1) was conducted in 2003-2005 (EPA Report 5576, 2006), while the continued mapping (U2) was conducted from December 2007 to 2010, and reported here. Within the framework of the two surveys 42 offshore banks have been surveyed with a total area of 5452 km2, or about 3 % of Sweden's maritime areas.

The work within U2 included fish, seabirds, bottom flora, and bottom fauna (invertebrates), respectively.

This report presents, at first hand, the results of the field surveys conducted within U2. For some of the reported sites data from earlier surveys, conducted in other projects, were made available. The results are also presented as maps of predicted species distributions, constructed through spatial modeling. The mission was designed to incorporate the development of an assessment system for the biological and ecological conservation values of offshore banks on the basis of national and international recommendations. An important ambition has been to base the assessment on empirical field data rather than on subjective opinions.

The conservation value of the banks was assessed in relation to other offshore banks, not comparing them to the rest of the marine environment. It is important to remember that all offshore banks have general values that are not, or only partly, included in the assessment. Since the banks are located off the coast, they are less affected by human activities, which means that in many cases they function as refuges for species dispelled from coastal areas by human influence. Offshore banks can thus serve as important source sites for recolonization if conditions in the coastal areas improve. Furthermore, offshore banks are rare features compared to coastal areas and surrounding soft bottoms and therefore have a high value for the criterion of uniqueness.

The assessment of biological and ecological value covered the all so far investigated offshore banks, i.e. all banks within both U1 and U2, and was carried through separately for fish, seabirds, and benthic flora and fauna. To some extent, the assessment also included marine mammals, for which data were taken directly from expert evaluations of seals and porpoises."

Reference:

Naturvårdsverket (2010). Undersökning av Utsjöbankar - Inventering, modellering och naturvärdesbedömning. Rapport 6385. ISBN 978-91-620- 6385-6, ISSN 0282-7298

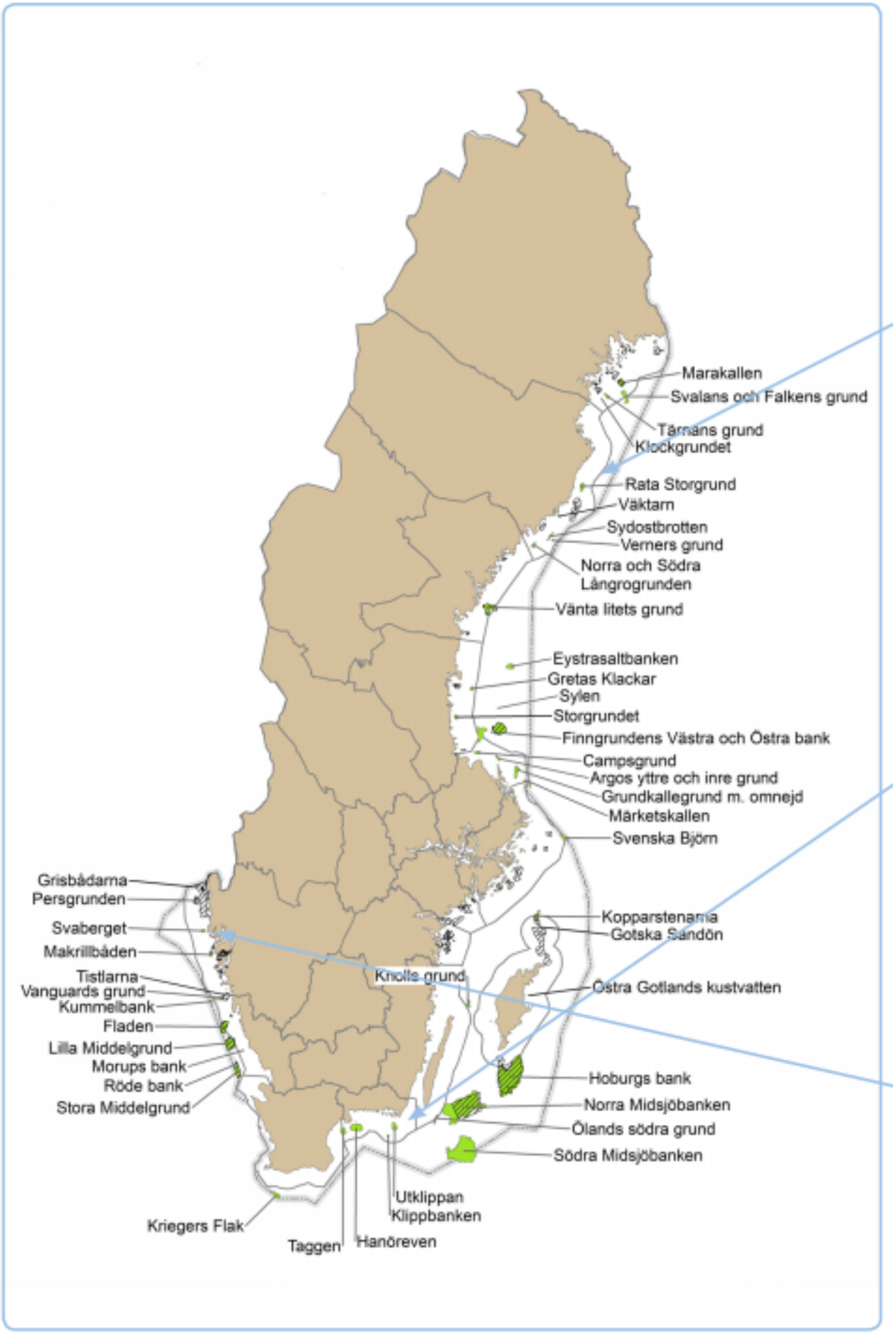


Figure 5.12-1 Swedish offshore banks

5.13 Baltic Sea scale inventory of benthic faunal communities

Abstract:
"This study provides an inventory of the recent benthic macrofaunal communities in the entire Baltic Sea. The analyses of soft-bottom benthic invertebrate community data based on over 7000 locations in the Baltic Sea suggested the existence of 10 major communities based on species abundances and 17 communities based on species biomasses, respectively. The low-saline northern Baltic, characterized by silty sediments, is dominated by Monoporeia affinis, Marenzelleria spp., and Macoma balthica. Hydrobiidae, Pygospio elegans, and Cerastoderma glaucum dominate the community in sandy habitats off the Estonian west coast and in the southeastern and southern Baltic Sea. Deep parts of the Gulf of Finland and central Baltic Sea often experience hypoxia, and when oxygen levels in these regions recover, Bylgides sarsi was the first species to colonize. The southwestern Baltic Sea, with high salinity, has higher macrofaunal diversity compared with the northern parts. To spatially interpolate the distribution of the major communities, we used the Random Forest method. Substrate data, bathymetric maps, and modelled hydrographical fields were used as predictors. Model predictions were in good agreement with observations, quantified by Cohen's k of 0.90 for the abundance and 0.89 in the wet weight-based model. Misclassifications were mainly associated with uncommon classes in regions with high spatial variability. Our analysis provides a detailed baseline map of the distribution of benthic communities in the Baltic Sea to be used both in science and management. "

Reference:
Gogina, Mayya, Henrik Nygård, Mats Blomqvist, Darius Daunys, Alf B. Josefson, Jonne Kotta, Alexey Maximov, et al. 2016. "The Baltic Sea Scale Inventory of Benthic Faunal Communities." *ICES Journal of Marine Science* 73 (4):1196–1213. https://doi.org/10.1093/icesjms/fsv265.

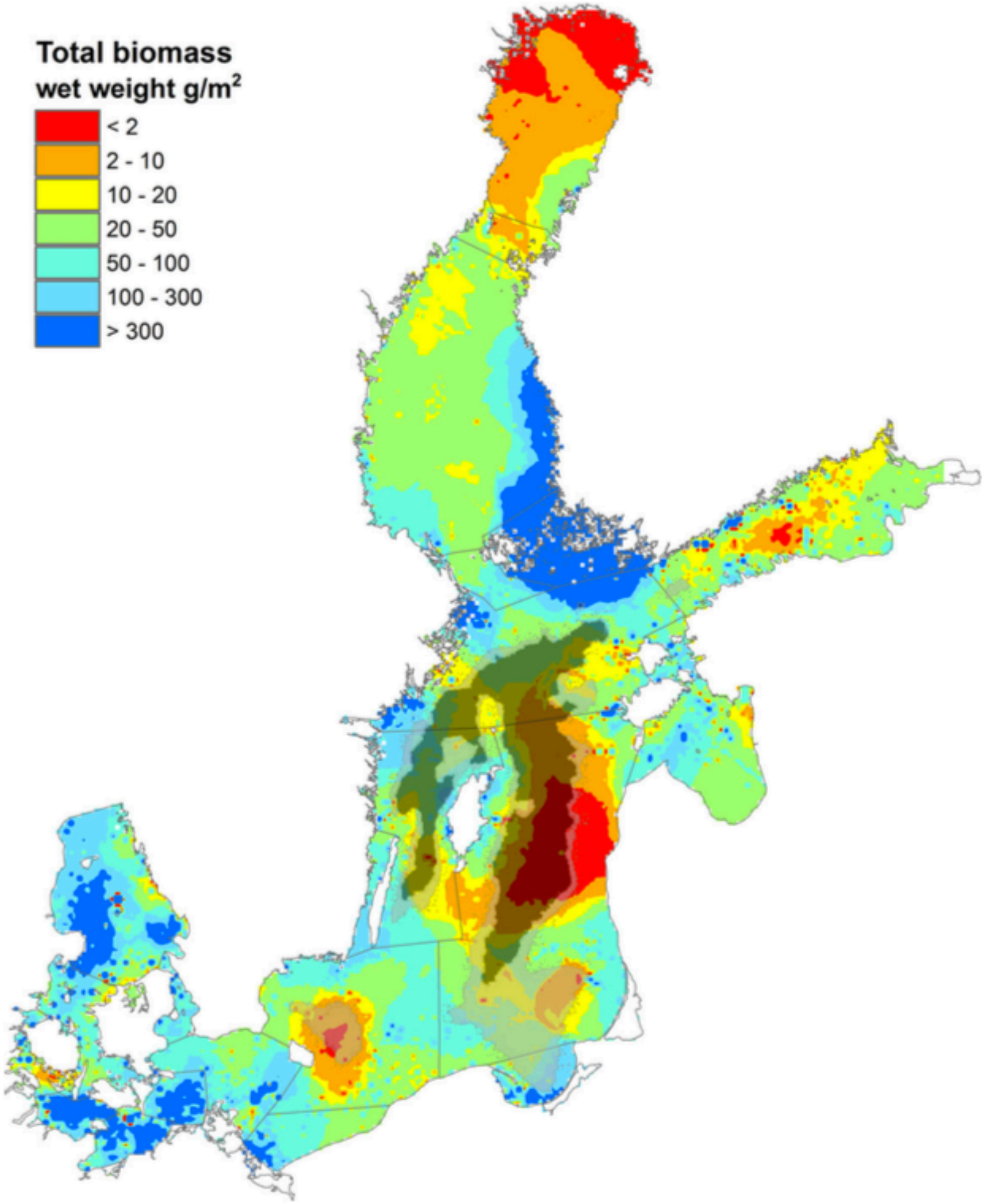


Figure 8. Distribution of interpolated total wet weight biomass, derived using ordinary kriging interpolation of available biomass data averaged per 5 × 5 km grid cell. Transparent light grey and dark grey areas mask out the deep water hypoxic and anoxic oxygen conditions. Note that at the areas where biomass data are lacking interpolation artefacts are evident, for instance, values at the shallow parts of the Eastern Gotland Basin at the west coast off Latvia are presumably too low. This figure is available in black and white in print and in colour at *ICES Journal of Marine Science* online.

Figure 5.13-1 Distribution of interpolated total wet biomass (figure 8 from original reference)

5.14 Hypoxic and anoxic regions in the Baltic Sea, 1969 - 2015

Abstract:
“The Baltic Sea is a complex ecosystem characterized by a strongly fluctuating, fragile balance between high freshwater runoff and saline water inflows, a stable stratification and a topography composed of connected basins. The sensitivity of the system “Baltic Sea” amplifies climatological fluctuations on the decadal scale. Such changes may be irrelevant in the open ocean but constitute significant indicators in the Baltic Sea. Salt and nutrients in the Baltic Sea remain present there for 20 and more years before being flushed to the Atlantic along with the freshwater export. This long residence time attenuates short-time fluctuations in environmental conditions, but highlights systematic, even small long-term anomalies.

The maps in this publication allow a visual evaluation of inflow events, of the progress of oxygen-consuming processes and of the development of hydrogen sulphide distribution over longer periods of time. The currently used method is a database- and software-based, transparent and reproducible way to represent the distribution of hypoxic and anoxic water in the near-bottom layer of the Baltic Sea. The datasets of IOWTOPO1 and RANGS2 form the framework for all created maps. The oceanographic database IOWDB3 serves as the standard primary data source and contains harmonized, quality-controlled oxygen and hydrogen sulphide data from the regular seasonal monitoring cruises that have visited the western and central Baltic Sea since 1969. The final graphic is created in XML4-based format SVG5 and is editable in any text editor. Furthermore SVG is a vector graphic that is editable with any software application capable of processing vector graphics.”

Reference:
Susanne Feistel, Rainer Feistel, Dietwart Nehring, Wolfgang Matthäus, Günther Nausch, Michael Naumann: Hypoxic and anoxic regions in the Baltic Sea, 1969 - 2015. Meereswiss. Ber., Warnemünde, 100 (2016), doi:10.12754/msr-2016-0100

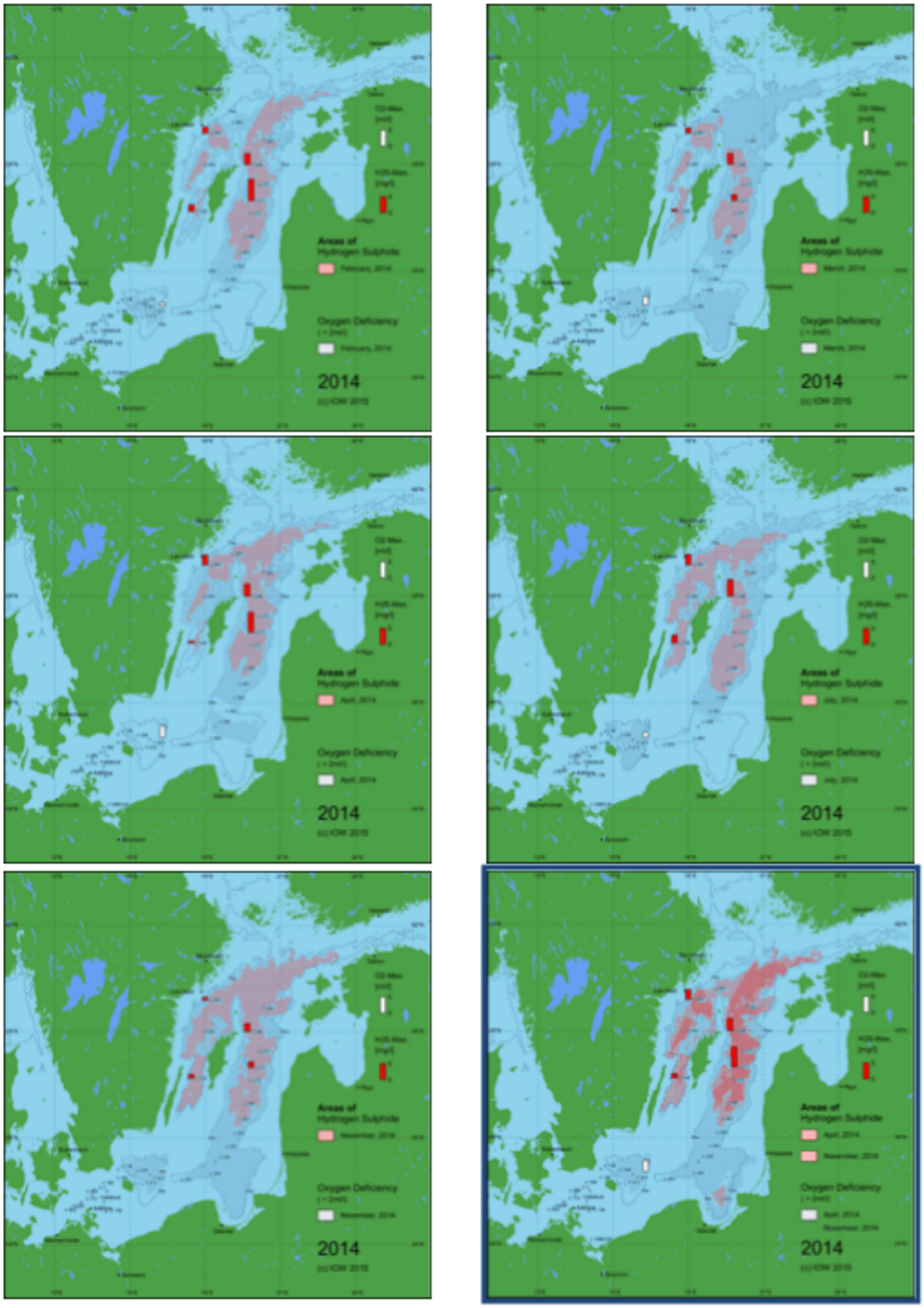


Figure 5.14-1 Distribution maps for 2014 (figure 60 in original reference)

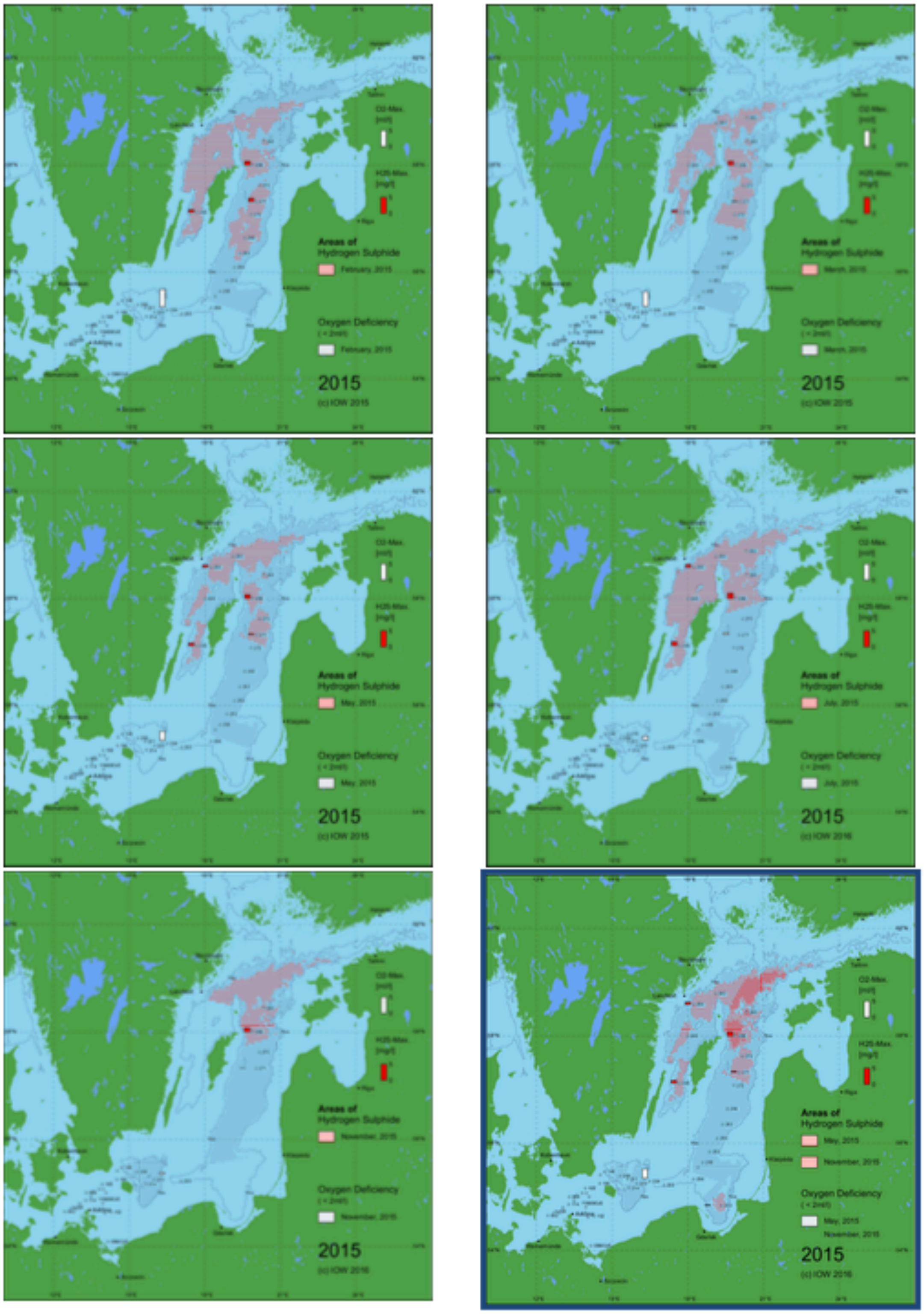


Figure 5.14-2 Distribution maps for 2014 (figure 61 in original reference)

5.15 Oxygen Survey in the Baltic Sea 2016 - Extent of Anoxia and Hypoxia, 1960-2016

Summary
"A climatological atlas of the oxygen situation in the deep water of the Baltic Sea was first published in 2011 in SMHI Report Oceanography No 42. Since 2011, annual updates have been made as additional data have been reported to ICES. In this report the results for 2015 have been updated and the preliminary results for 2016 are presented. Oxygen data from 2016 have been collected during the annual Baltic International Acoustic Survey (BIAS) and from national monitoring programmes with contributions from Sweden, Finland, Poland and Estonia.

For the autumn period each profile in the dataset was examined for the occurrence of hypoxia (oxygen deficiency) and anoxia (total absence of oxygen). The depths of onset of hypoxia and anoxia were then interpolated between sampling stations producing two surfaces representing the depth at which hypoxic respectively anoxic conditions are found. The volume and area of hypoxia and anoxia have been calculated and the results have then been transformed to maps and diagrams to visualize the annual autumn oxygen situation during the analysed period."

Reference:
Hansson, M. & Lars Andersson (2016) "Oxygen Survey in the Baltic Sea 2016 - Extent of Anoxia and Hypoxia, 1960-2016". REPORT OCEANOGRAPHY No. 58, Swedish Meteorological and Hydrological Institute, Göteborg, Sweden

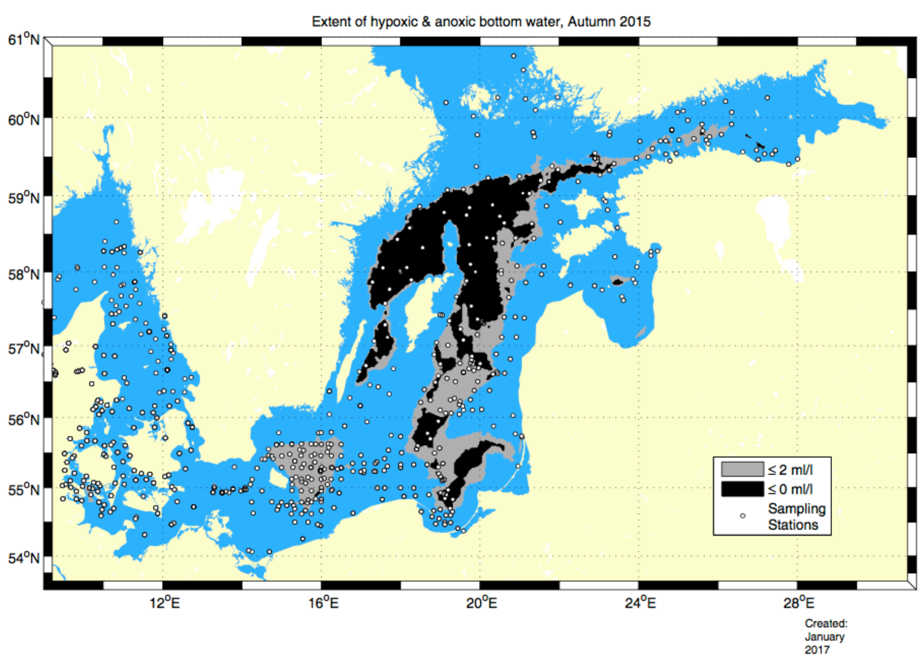


Figure 5.15-1 Extent of hypoxic and anoxic bottom water, Autumn 2015

5.16 Maps and Data Submitted by Sweden

A range of maps and data reports were provided by Sweden for use at the Baltic workshop. An example map and GIS table of contents from these submissions appear below and the full datasets will be available for use by workshop attendees in Helsinki.

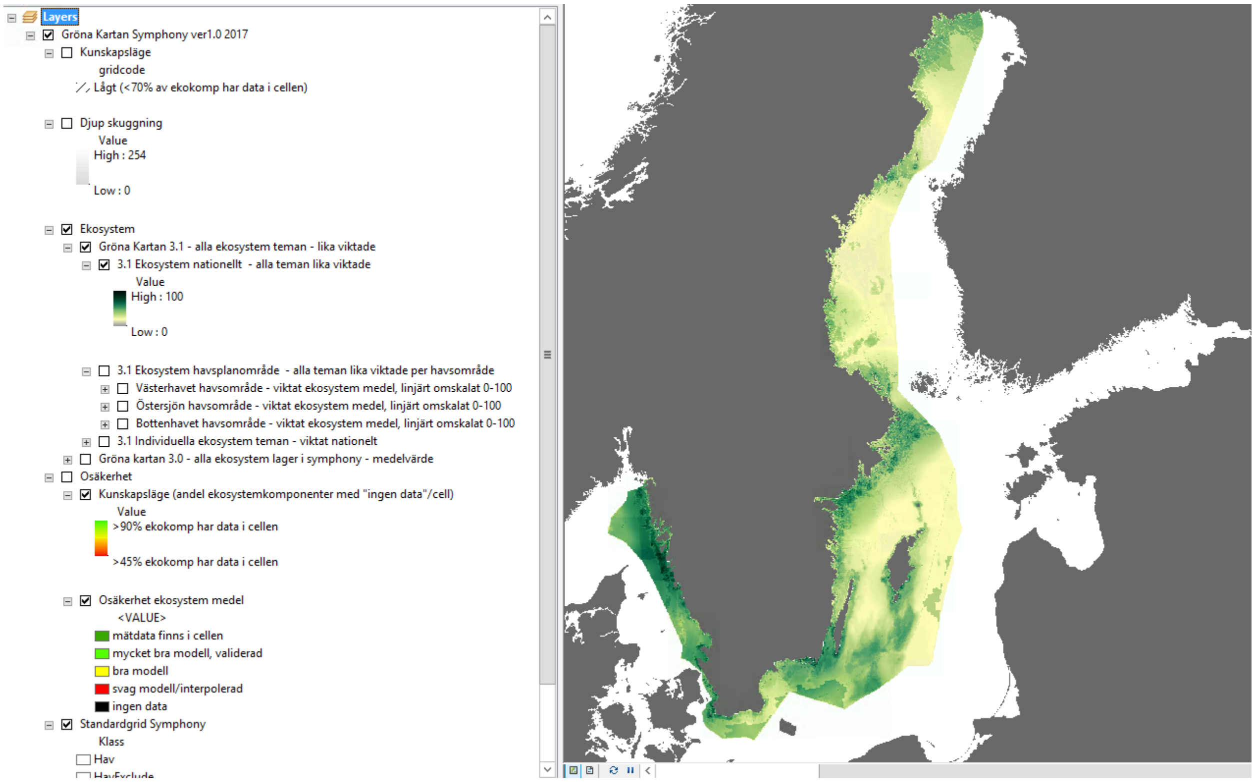


Figure 5.16-1 Example Datasets contributed by Sweden

	Figur	Latinskt namn	Individer/m2	Filnamn
Havsborstmaskar	32	*Bylgides sarsi*	> 0	AqB_MARMONI_K_Bylgides_sarsi_PA
	33	*Hediste diversicolor*	> 0	AqB_MARMONI_K_Hediste_diversicolor_PA
	34	*Hediste diversicolor*	≥ 100	AqB_MARMONI_K_Hediste_diversicolor_PA100
	35	*Marenzelleria* spp.	> 0	AqB_MARMONI_K_Marenzelleria_spp_PA
	36	*Marenzelleria* spp.	≥ 100	AqB_MARMONI_K_Marenzelleria_spp_PA100
	37	*Marenzelleria* spp.	≥ 300	AqB_MARMONI_K_Marenzelleria_spp_PA300
	38	*Oligochaeta*	> 0	AqB_MARMONI_K_Oligochaeta_PA
	39	*Spionidae*	> 0	AqB_MARMONI_K_Spionidae_PA
	40	*Spionidae*	≥ 500	AqB_MARMONI_K_Spionidae_PA500
Leddjur	41	*Asellus aquaticus*	> 0	AqB_MARMONI_K_Asellus_aquaticus_PA
	42	*Bathyporeia pilosa*	> 0	AqB_MARMONI_K_Bathyporeia_pilosa_PA
	43	*Bathyporeia pilosa*	≥ 100	AqB_MARMONI_K_Bathyporeia_pilosa_PA100
	44	*Chironomidae*	> 0	AqB_MARMONI_K_Chironomidae_PA
	45	*Chironomidae*	≥ 100	AqB_MARMONI_K_Chironomidae_PA100
	46	*Corophium volutator*	≥ 100	AqB_MARMONI_K_Corophium_volutator_PA100
	47	*Diastylis rathkei*	≥ 100	AqB_MARMONI_K_Diastylis_rathkei_PA100
	48	*Monoporeia affinis*	> 0	AqB_MARMONI_K_Monoporeia_affinis_PA
	49	*Monoporeia affinis*	≥ 100	AqB_MARMONI_K_Monoporeia_affinis_PA100
	50	*Monoporeia affinis/Pontoporeia femorata*	> 0	AqB_MARMONI_K_Monoporeia_Pontoporeia_PA
	51	*Monoporeia affinis/Pontoporeia femorata*	≥ 100	AqB_MARMONI_K_Monoporeia_Pontoporeia_PA100
	52	*Monoporeia affinis/Pontoporeia femorata*	≥ 300	AqB_MARMONI_K_Monoporeia_Pontoporeia_PA300
	53	*Pontoporeia femorata*	> 0	AqB_MARMONI_K_Pontoporeia_femorata_PA
	54	*Saduria entomon*	> 0	AqB_MARMONI_K_Saduria_entomon_PA
Blötdjur	55	*Cerastoderma* spp.	> 0	AqB_MARMONI_K_Cerastoderma_spp_PA
	56	*Cerastoderma* spp.	≥ 100	AqB_MARMONI_K_Cerastoderma_spp_PA100
	57	*Hydrobiidae*	> 0	AqB_MARMONI_K_Hydrobiidae_PA
	58	*Macoma balthica*	> 0	AqB_MARMONI_K_Macoma_balthica_PA
	59	*Macoma balthica*	≥ 100	AqB_MARMONI_K_Macoma_balthica_PA100
	60	*Macoma balthica*	≥ 500	AqB_MARMONI_K_Macoma_balthica_PA500
Övriga	61	*Halicryptus spinulosus*	> 0	AqB_MARMONI_K_Halicryptus_spinulosus_PA

*Fria att sprida ur sekretessynpunkt enligt tillstånd från sjöfartsverket (beteckning 14-01373)

Vegetation, samt blåmussla

Fria att sprida ur sekretessynpunkt enligt tillstånd från sjöfartsverket (beteckning 14-01373)

	Figur	Svenskt namn	Latinskt namn	Täcknings-grad %	Filnamn
Brunalger	1	Sågtång	*Fucus serratus*	> 0	AqB_MARMONI_K_Fucus_serratus_PA
	2	Blåstång	*Fucus vesiculosus*	> 0	AqB_MARMONI_K_Fucus_vesiculosus_PA
	3	Blåstång	*Fucus vesiculosus*	≥ 10	AqB_MARMONI_K_Fucus_vesiculosus_PA10
	4	Blåstång	*Fucus vesiculosus*	≥ 25	AqB_MARMONI_K_Fucus_vesiculosus_PA25
	5	Blåstång	*Fucus vesiculosus*	≥ 50	AqB_MARMONI_K_Fucus_vesiculosus_PA50
	6	Sudare	*Chorda filum*	> 0	AqB_MARMONI_K_Chorda_filum_PA
	7	Trådslick/ molnslick	*Ectocarpus siliculosus/ Pylaiella littoralis*	> 0	AqB_MARMONI_K_Ectocarpus_Pylaiella_PA
Rödalger	8	Kräkel	*Furcellaria lumbricalis*	> 0	AqB_MARMONI_K_Furcellaria_lumbricalis_PA
	9	Kräkel	*Furcellaria lumbricalis*	≥ 10	AqB_MARMONI_K_Furcellaria_lumbricalis_PA10
	10	Kräkel	*Furcellaria lumbricalis*	≥ 25	AqB_MARMONI_K_Furcellaria_lumbricalis_PA25
	11	Rödblad	*Coccotylus truncatus/ Phyllophora pseudoceranoides*	> 0	AqB_MARMONI_K_Coccotylus_Phyllophora_PA
	12	Filamentösa rödalger		> 0	AqB_MARMONI_K_Filamentous_red_alga_PA
	13	Perenna rödalger		> 0	AqB_MARMONI_K_Perennial_red_algae_PA
	14	Perenna makroalger		> 0	AqB_MARMONI_K_Perennial_macroalgae_PA
Kärlväxter	15	Axslinga	*Myriophyllum spicatum*	> 0	AqB_MARMONI_K_Myriophyllum_spicatum_PA
	16	Axslinga	*Myriophyllum spicatum*	≥ 10	AqB_MARMONI_K_Myriophyllum_spicatum_PA10
	17	Borstnate	*Stuckenia pectinata*	> 0	AqB_MARMONI_K_Stuckenia_pectinata_PA
	18	Borstnate	*Stuckenia pectinata*	≥ 10	AqB_MARMONI_K_Stuckenia_pectinata_PA10
	19	Borstnate	*Stuckenia pectinata*	≥ 25	AqB_MARMONI_K_Stuckenia_pectinata_PA25
	20	Natingar	*Ruppia* spp.	> 0	AqB_MARMONI_K_Ruppia_spp_PA
	21	Hornsärv	*Ceratophyllum demersum*	> 0	AqB_MARMONI_K_Ceratophyllum_demersum_PA
	22	Hårsärv	*Zannichellia palustris*	> 0	AqB_MARMONI_K_Zannichellia_palustris_PA
	23	Ålgräs	*Zostera marina*	> 0	AqB_MARMONI_K_Zostera_marina_PA
	24	Ålgräs	*Zostera marina*	≥ 10	AqB_MARMONI_K_Zostera_marina_PA10
	25	Ålgräs	*Zostera marina*	≥ 25	AqB_MARMONI_K_Zostera_marina_PA25
	26	Höga undervattenskärlväxter		> 0	AqB_MARMONI_K_High_submerged_vascular_plants_PA
	27	Höga undervattenskärlväxter		≥ 10	AqB_MARMONI_K_High_submerged_vascular_plants_PA10
	28	Höga undervattenskärlväxter		≥ 25	AqB_MARMONI_K_High_submerged_vascular_plants_PA25
Blåmussla	29	Blåmussla	*Mytilus edulis*	> 0	AqB_MARMONI_K_Mytilus_edulis_PA
	30	Blåmussla	*Mytilus edulis*	≥ 10	AqB_MARMONI_K_Mytilus_edulis_PA10
	31	Blåmussla	*Mytilus edulis*	≥ 25	AqB_MARMONI_K_Mytilus_edulis_PA25

*Fria att sprida ur sekretessynpunkt enligt tillstånd från sjöfartsverket (beteckning 14-01373)

Figure 5.16-2 List of datasets provide by Sweden

5.17 Maps and Data Submitted by Finland

A range of maps and data reports were provided by Finland for use at the Baltic workshop. Several example maps from these submissions appear below and the full datasets will be available for use by workshop attendees in Helsinki.

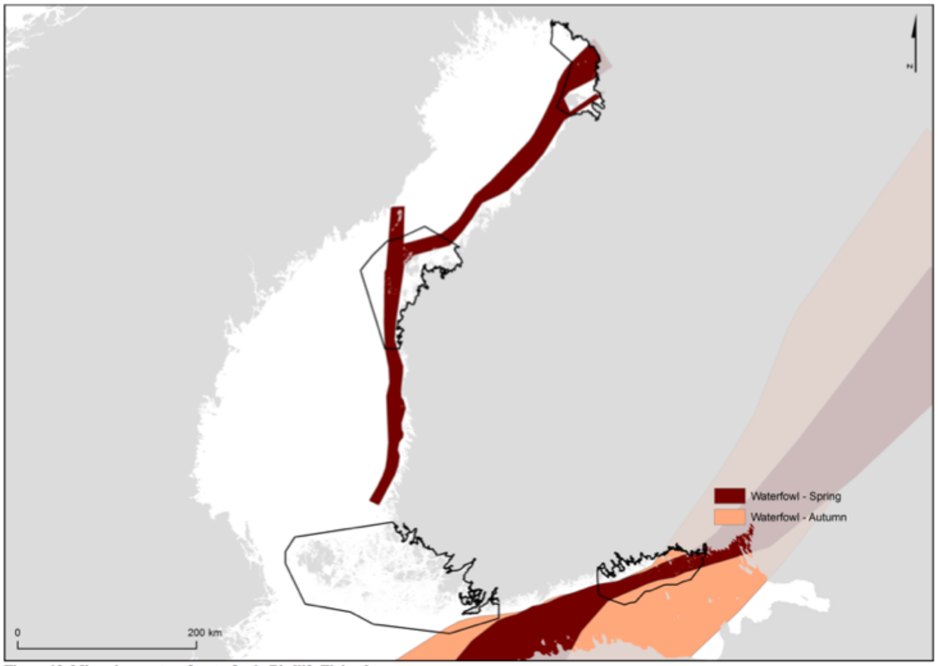


Figure 10. Migration routes of waterfowl. Birdlife Finland.

Figure 5.17-1 Migration routes of waterfowl (figure 10 in Finland data submission)

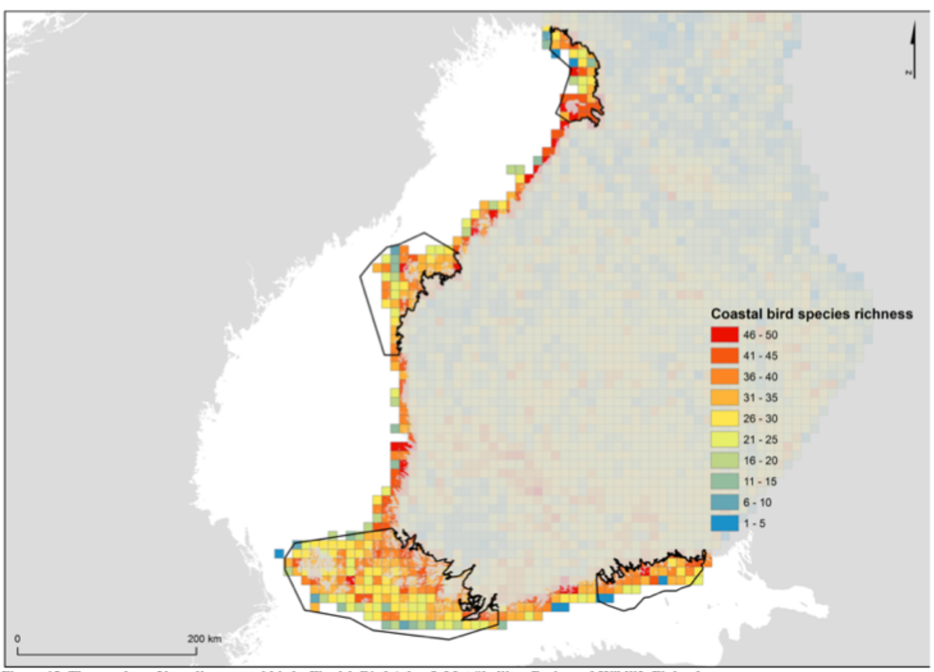


Figure 13. The number of breeding coastal birds. Finnish Bird Atlas & Metsähallitus Parks and Wildlife Finland.

Figure 5.17-2 Number of breeding coastal birds (figure 13 in Finland data submission)

FIN EBSA proposals - metadata for additional spatial datasets		
Category	Parameter	Clarification
Biodiversity	Genus number: macroalgae	
Biodiversity	Species richness: algae	
Biodiversity	Species richness: charophytes	
Biodiversity	Species richness: vascular plants	
Biodiversity	Species richness: flora (vascular plants, charophytes, bryophyta, macroalgae)	
Biodiversity	Species richness model: benthic taxa	
Bird	Nesting bird species richness	10km grid
Bird	Many migration routes	Polygons
Bird	IBA	Polygons
Bird	Common eider (Somateria mollissima)	Point observations
Environmental variables	Surface salinity	
Environmental variables	Mean ice cover duration (days)	Raster as text file
Environmental variables	Secchi depth	MERIS 2003-2011
Environmental variables	Water quality (pintavesien laatuluokitus)	
Fish	Fish reproduction areas	5 species, models
Fish	Fish observation points	12 taxons, point data
Fish	Juvenile fish areas	4 species distribution models
Geology	Patchiness	Seabed patchiness
Geology	Rock type	
Geology	Seabed structures	
Geology	Seabed substrate	
Habitats	Coastal lagoons (1150)	
Habitats	Large shallow inlets and bays (1160)	
Habitats	Boreal Baltic narrow inlets (1650)	
Habitats	Reefs (1170)	
Habitats	Reef areas	
Habitats	Sandbanks (1110)	
Human pressures	Baltic Sea Pressure Index	Model
Human pressures	Aquaculture	Polygon
Human pressures	Dredging	Polygon
Human pressures	Sand and gravel extraction	Polygon
Human pressures	Constructions on shoreline	Line
Key species	Fucus spp	Species distribution model
Key species	Mytilus trossulus	Species distribution model
Key species	Dreissena polymorpha	Species distribution model
Key species	Zostera marina	Species distribution model
Key species	Charophytes	Species distribution model
Key species	Vascular plants	Species distribution model
Key species	Filamentous algae	Species distribution model
Key species	Furcellaria lumbricalis	Species distribution model
Key species	Furcellaria lumbricalis	Species distribution model
Key species	Bryophyta	Species distribution model
Key species	Fucus spp	Observation points
Key species	Mytilus edulis & Dreissena polymorpha	Observation points
Key species	Zostera marina	Observation points
Key species	Charophytes	Observation points
Key species	Vascular plants	Observation points
Key species	Filamentous algae	Observation points
Key species	Furcellaria lumbricalis	Observation points
Key species	Bryophyta	Observation points
Key species	HUB	Model
Key species	HUB	Point data
Mammals	Harbour porpoise	Acoustic observations
Rare species	VELMU endangered species	5km grid
Rare species	Number of species	Raster, 10 km resolution

Figure 5.17-3 List of available datasets provided by Finland

5.18 Maps and Data Submitted by Germany

A range of maps and data reports were provided by Germany for use at the Baltic workshop. Several example maps from these submissions appear below and the full datasets will be available for use by workshop attendees in Helsinki.

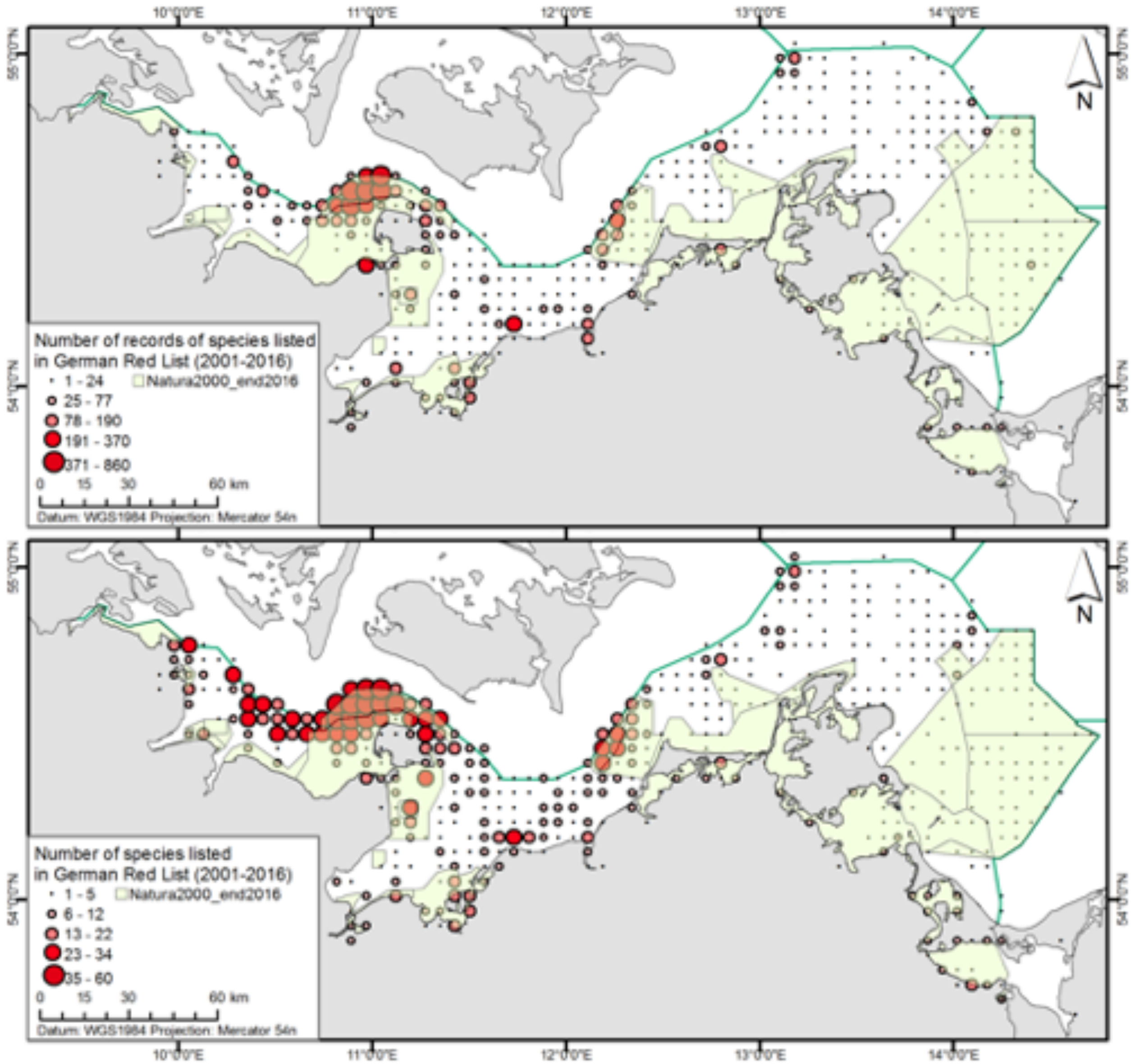


Figure 5.18-1 Observation count for German red-listed species (top) and species richness of red-listed species (bottom)

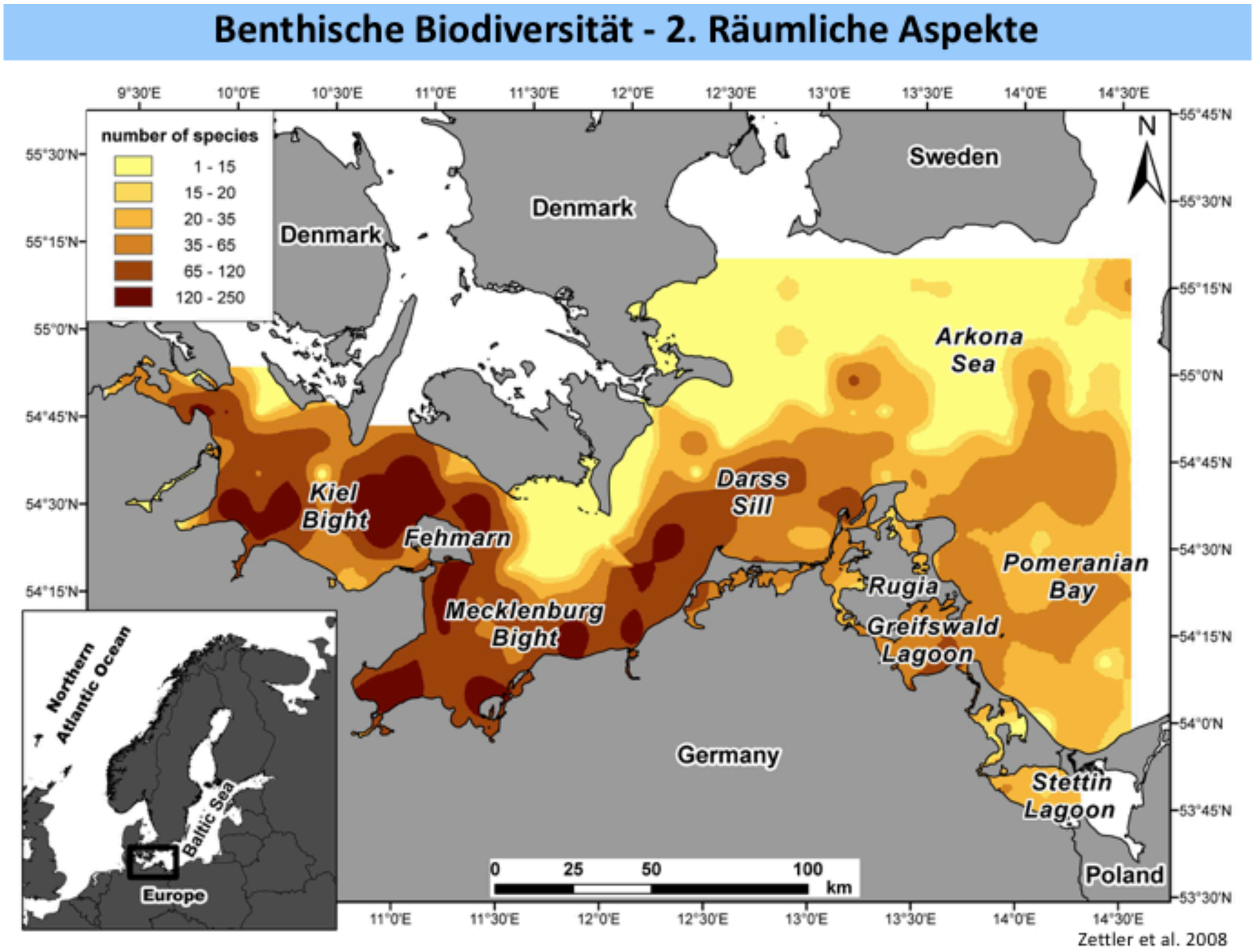


Figure 5.18-2 Benthic species richness

5.19 Maps and Data Submitted by Poland

A range of maps and data reports were provided by Poland for use at the Baltic workshop. Several example maps from these submissions appear below and the full datasets will be available for use by workshop attendees in Helsinki.

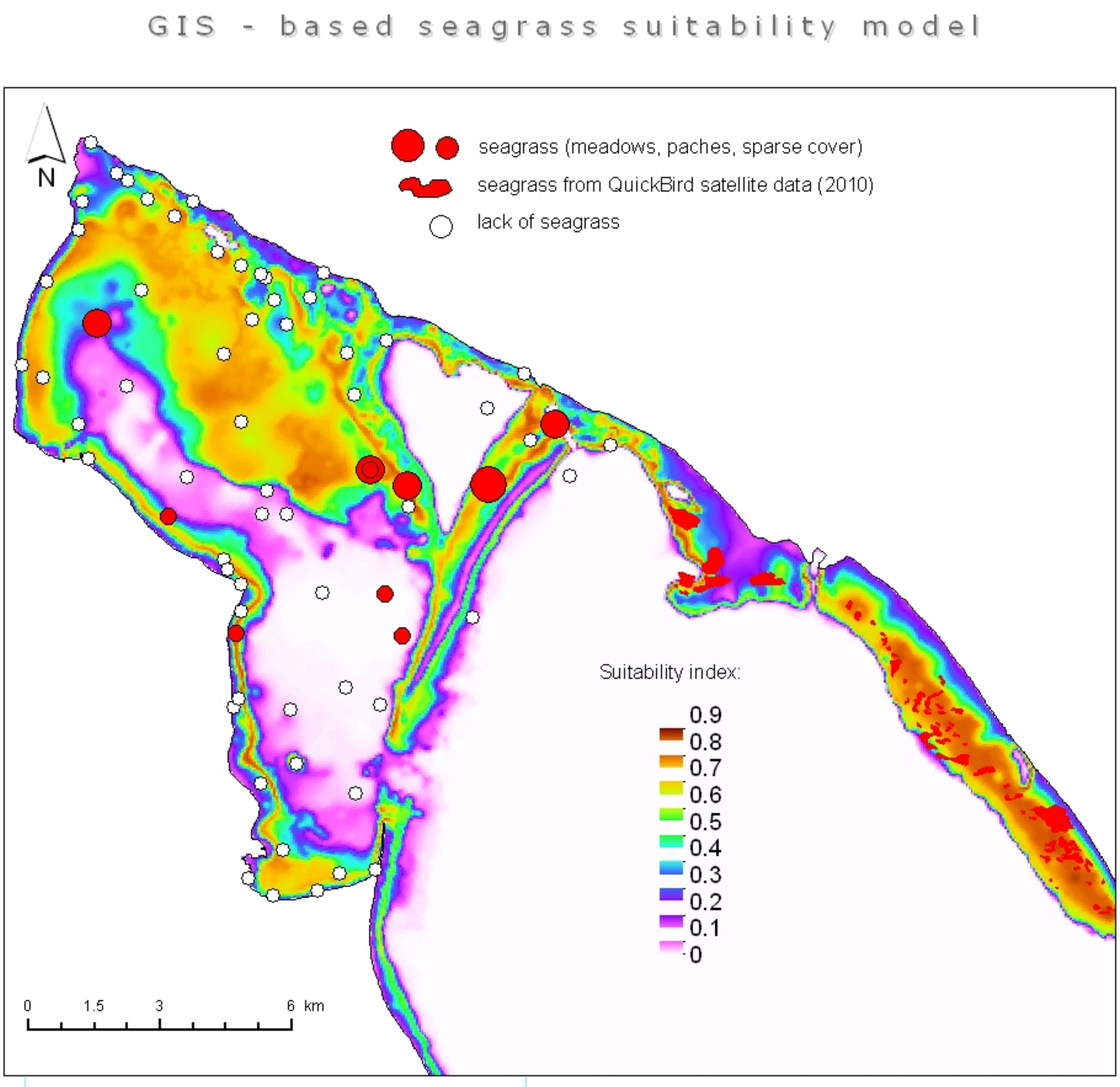


Figure 5.19-1 Seagrass suitability model

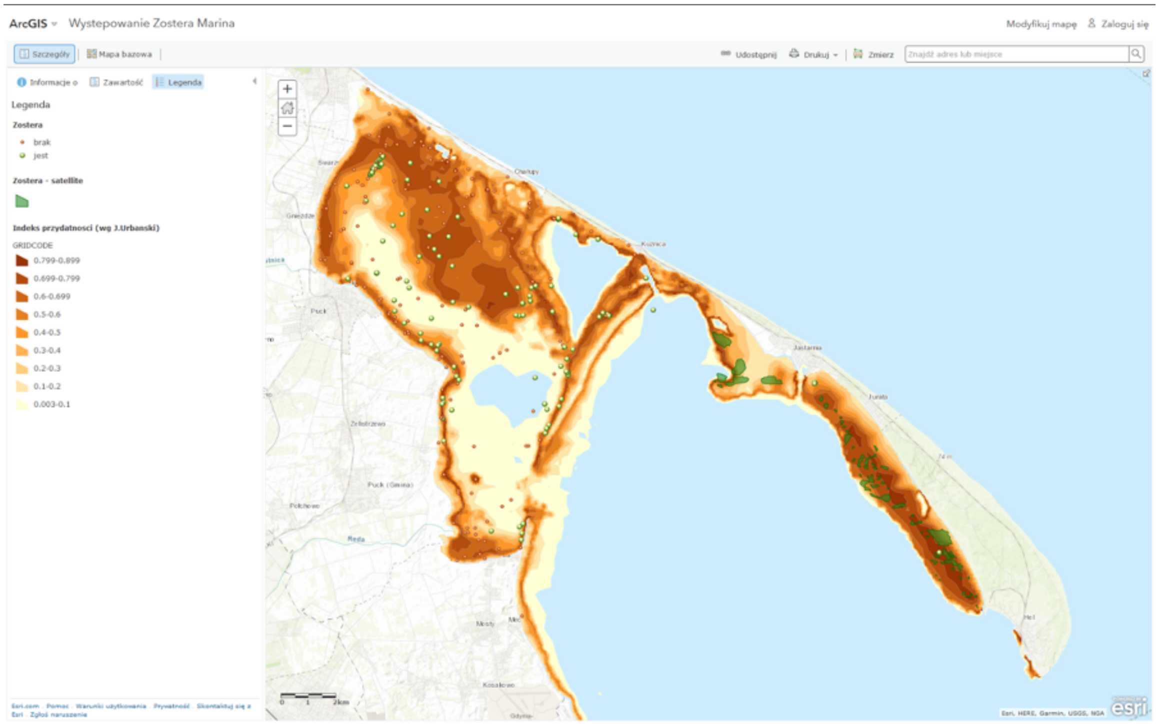


Figure 5.19-2 Predicted Zostera marina habitat

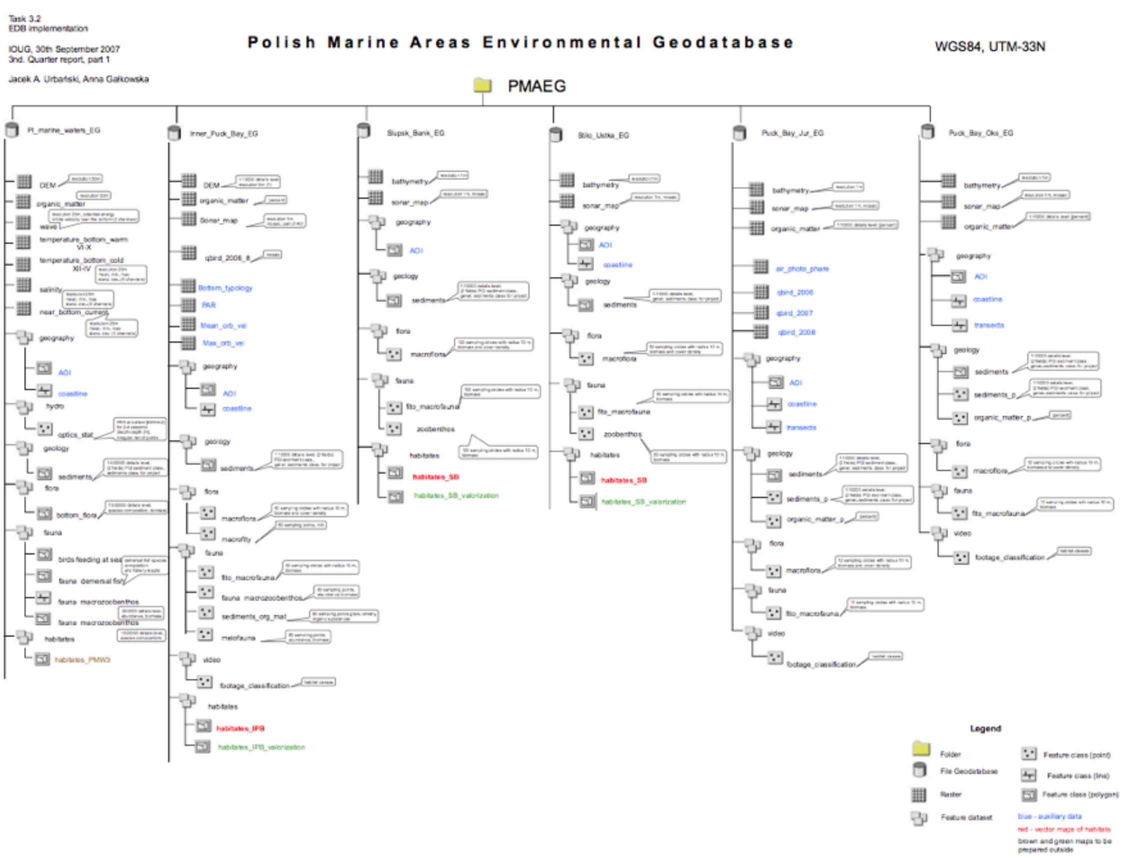


Figure 5.19-3 Data schema for the "Polish Marine Environmental Geodatabase"

6 Acknowledgments

This work was undertaken as commissioned and sponsored by the Ministry of the Environment of Finland, in consultation with the Secretariat of the Convention on Biological Diversity.

The authors gratefully acknowledge the contributions of data and advice from:

Ville Karvinen, Joni Kaitaranta (HELCOM)

Penina Blankett (Ministry of Environment, Finland)

Juho Lappalainen (Finnish Environment Institute)

Pia Norling (Swedish Agency for Marine and Water Management)

Ida Carlén (Coalition Clean Baltic)

Nicola Breier (Ministry for the Environment, Germany)

Andrzej Ginalski (General Directorate for Environmental Protection, Poland)

Miles Macmillan-Lawler (GRID-Arendal)

Maria Dias (BirdLife International)

Ward Appletans, Pieter Provoost (Ocean Biogeographic Information System, UNESCO)

Nic Bax, Piers Dunstan, Mike Fuller (CSIRO Australia)