Baltic Sea Environment Proceedings No. 138

Red List of Baltic Sea underwater biotopes, habitats and biotope complexes

CO CR EN VU NT DD LC

Helsinki Commission

Baltic Marine Environment Protection Commission

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Executive Summary

The HELCOM Underwater Biotope and habitat classification (HELCOM HUB) defines a total of 328 benthic and pelagic habitats. Of these HELCOM HUB biotopes, a threat assessment was made for 209 biotopes of which 59 were red-listed. Of the assessed biotopes, 73% were classified LC and are therefore currently not seen to be at risk of collapse. Only one biotope was categorized in the most severe threat category CR, the biotope delineated by aphotic muddy bottoms dominated by the ocean quahog (*Arctica islandica*) mussel. The Red List assessment results indicate that many of the threatened biotopes occur in the deep areas of the Baltic Sea. The reason for most of these biotopes becoming threatened is eutrophication, indirectly causing oxygen depletion in the deep areas. Many of the deep biotopes occurring on soft sediments have declined due to destructive fishing methods such as bottom trawling. Furthermore, many of the red-listed biotopes occur in the southwestern Baltic Sea due to the salinity restricted distribution of the species that are characteristic of the biotope.

The ten biotope complexes recognized in HELCOM HUB, also listed in the EU Habitats Directive Annex 1, were all red-listed. Estuaries (code 1130) were assessed CR due to severe changes to the natural functions of nearly all estuaries around the Baltic Sea. All biotope complexes were assessed based on quality degradation in recent decades, except the complex Submarine structures made by leaking gas (code 1180) which was red-listed based on rarity.

The *HELCOM Red List of Baltic Sea underwater biotopes, habitats and biotope complexes* is the result of four years of work with contributions from over 30 experts from all coastal countries of the Baltic Sea. This report describes the results of the Red List assessment, the assessment methodology and suggests conservation measures for threatened biotopes.

A Red List is the outcome of a threat assessment using quantitative Red List criteria to identify the risk of collapse for biotopes, or the extinction of species. Red Lists of species are well established globally and assessment criteria for Red Lists of ecosystems or biotopes are under development by the International Union for Conservation of Nature (IUCN). This HELCOM assessment of threatened Baltic Sea biotopes largely relies on the proposed IUCN criteria and assessment principles. However, some modifications have been made due to the lack of data on the distribution and quality of the biotopes, impeding the use of some of the proposed IUCN criteria.

HELCOM made a first Red List assessment of marine and coastal biotopes and biotope complexes in 1998. The aim of the Red List project was to update the assessments and to improve the classification. A direct comparison of the results between the current assessment and the one made in 1998 has proven difficult due to the revision of the classification system and changes in threat assessment methodology. However, some of the assessed biotopes, and also some of the complexes, can be identified in both assessments. The biotopes generally seemed to have become more threatened, partly due to methodological bias from the biotopes being split into more detailed communities.

This report demonstrates the application of harmonized assessment criteria adapted for the use in the Baltic Sea. It provides an assessment of the risk of collapse of Baltic Sea biotopes, habitats and biotope complexes with medium or low confidence. Red List assessments should optimally be carried out based on extensive long-term data. As regards the Baltic Sea biotopes, this kind of information is not available. The current Red List assessment relies heavily on expert judgement and inference, which is reflected in the confidence rating - none of the assessments received a 'high' rating. The severe gap in information on trends in both the quantity and quality of the biotopes needs to be rectified, and it is suggested that the Red List of biotopes be updated by the year 2019. Many on-going mapping projects will make more data on the distribution on biotopes and habitats available within a few years and will help to ensure that steps will be taken to increase the confidence of the assessments in the future.

1 Introduction

1.1 The Baltic Sea

The Baltic Sea is an inland, non-tidal sea with varied biota in the different basins. The brackish water with salinities varying from high salinity marine conditions in the south to low salinity freshwater conditions in the north creates unique habitats in the different sub-basins of the sea. The coasts of the Baltic Sea differ considerably. The southern coasts are characterized by long sandy beaches, whereas rocky and moraine shores are a common feature in the northern regions. These features along the coasts continue underwater.

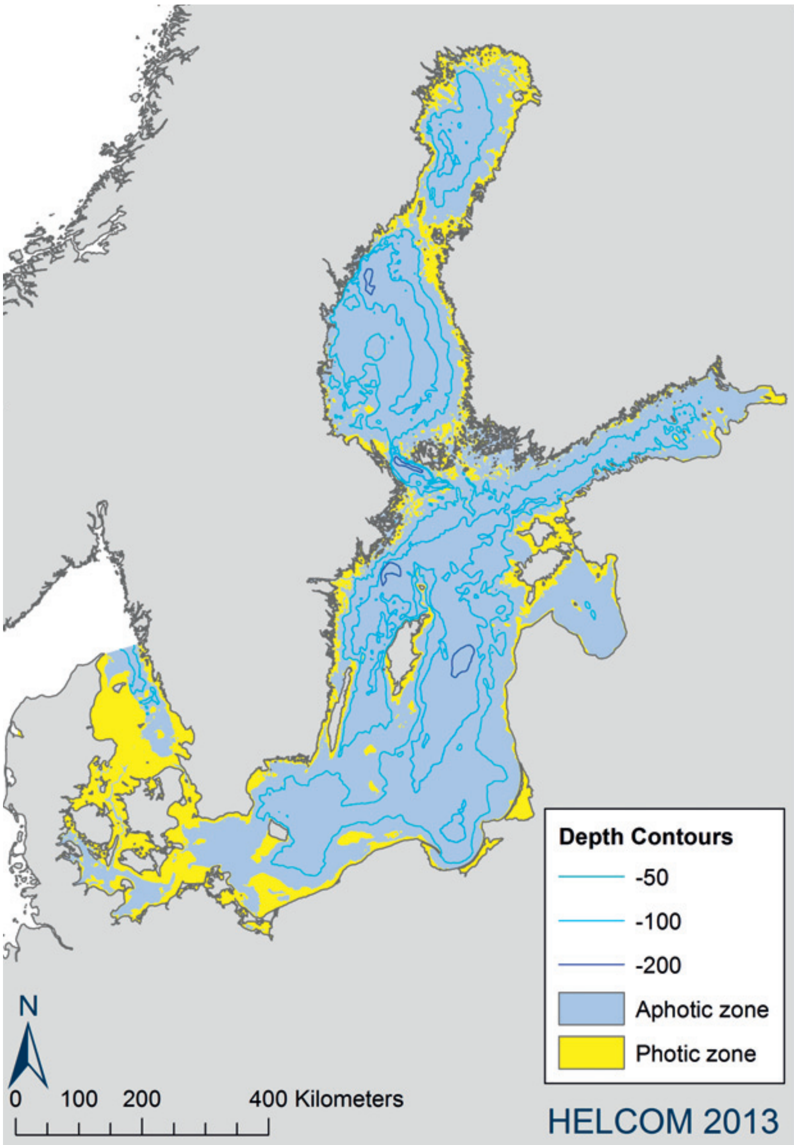


Figure 1. The photic and aphotic zones in the Baltic Sea with a 100x100 km grid (data from EUSeaMap).

The Baltic Sea is regularly covered by ice in the winter period. Even though it is shallow, with an average depth of 52 meters (HELCOM 2009a), the water at the bottom remains cold during the summer. In general, the water is more turbid than oceanic water. This implies that the photic layer available to photosynthesising plants, algae and bacteria is narrower in the Baltic Sea than in the oceans and in many areas light does not reach the bottom. But due to the shallow average depth of the sea bottom, the photic zone covers a significant area of the sea, especially in the archipelagos (Figure 1).

Species diversity is rather low in the Baltic Sea compared to many other marine environments, as the brackish water environment is physiologically demanding to most organisms. The species that have adapted to the Baltic Sea conditions often appear in great abundance. While communities in the Baltic typically consist of only a few species, the number of individuals per area unit can be high. This structure makes the communities sensitive to any changes in the environment such as physic-chemical conditions (HELCOM 2009b). As many of the species live on the edge of their tolerance of variation in their living environment, any changes can cause the abundance of the species to alter radically. Accordingly, the structure of the communities and the biodiversity in a region of the Baltic Sea has the potential to change significantly due to even a small change in the environmental conditions.

The Baltic Sea is naturally a highly dynamic system, and distinguishing human-induced changes from natural variation is challenging. Both the biotic and the abiotic conditions are constantly changing. The Baltic Sea first emerged from under the inland ice sheet after the last ice age some 8 000 years ago. Since then, the sea has, in turn, been a freshwater and marine environment. Land upheaval is still on-going and continuously creates new shallow water habitats, especially along the northern coasts (HELCOM 1998, HELCOM 2009b for more details). Due to all these changes, the disappearance and transformation of biotopes from the sea on a long-term time scale can be seen as a rather natural process. However, human activities have greatly speeded up the process of collapse of biotopes in the Baltic Sea.

1.2 The HELCOM Red List project

Identifying biotopes, habitats and biotope complexes at risk of collapse by quantitative criteria is the aim of the HELCOM Red List project. Preventing the extinction of species or the collapse of biotopes can sometimes be achieved by specific conservation measures. This *HELCOM Red List of Baltic Sea underwater biotopes, habitats and biotope complexes* and the HELCOM *Red List of Baltic Sea Species in danger of becoming extinct* complement and support each other, and ought to be simultaneously considered by managers and policy-makers.

In comparison with Red List assessments of species, a Red List assessment of biotopes has some inherent advantages. Species assessments tend to exhibit a taxonomical bias (e.g. Rodríguez et al. 2011), meaning that some of the more cryptic species may never be considered. A Red List assessment of biotopes has the potential to identify areas where the risk of extinction is great for many species (Rodríguez et al. 2011). A Red List of biotopes can therefore provide a good assessment of the trends in biodiversity in a region. However, the threat status of birds, for instance, cannot be assessed via a Red List of underwater biotopes. Protecting a biotope can be an efficient measure for protection of a threatened species, as species depend on the persistence of the habitat for their survival (Rodríguez et al. 2011).

As stated in Article 15 of the Helsinki Convention on nature conservation and biodiversity, the HELCOM Contracting Parties are to take all appropriate measures, with respect to the Baltic Sea Area and its coastal ecosystems influenced by the sea, to conserve natural habitats and biological diversity, and to protect ecological processes. In the HELCOM Baltic Sea Action Plan (adopted in 2007), these targets are further specified by the goal to achieve a favourable status of marine biodiversity as well as the ecological objective "thriving and balanced communities of plants and animals" and "viable populations of species" by the year 2021.

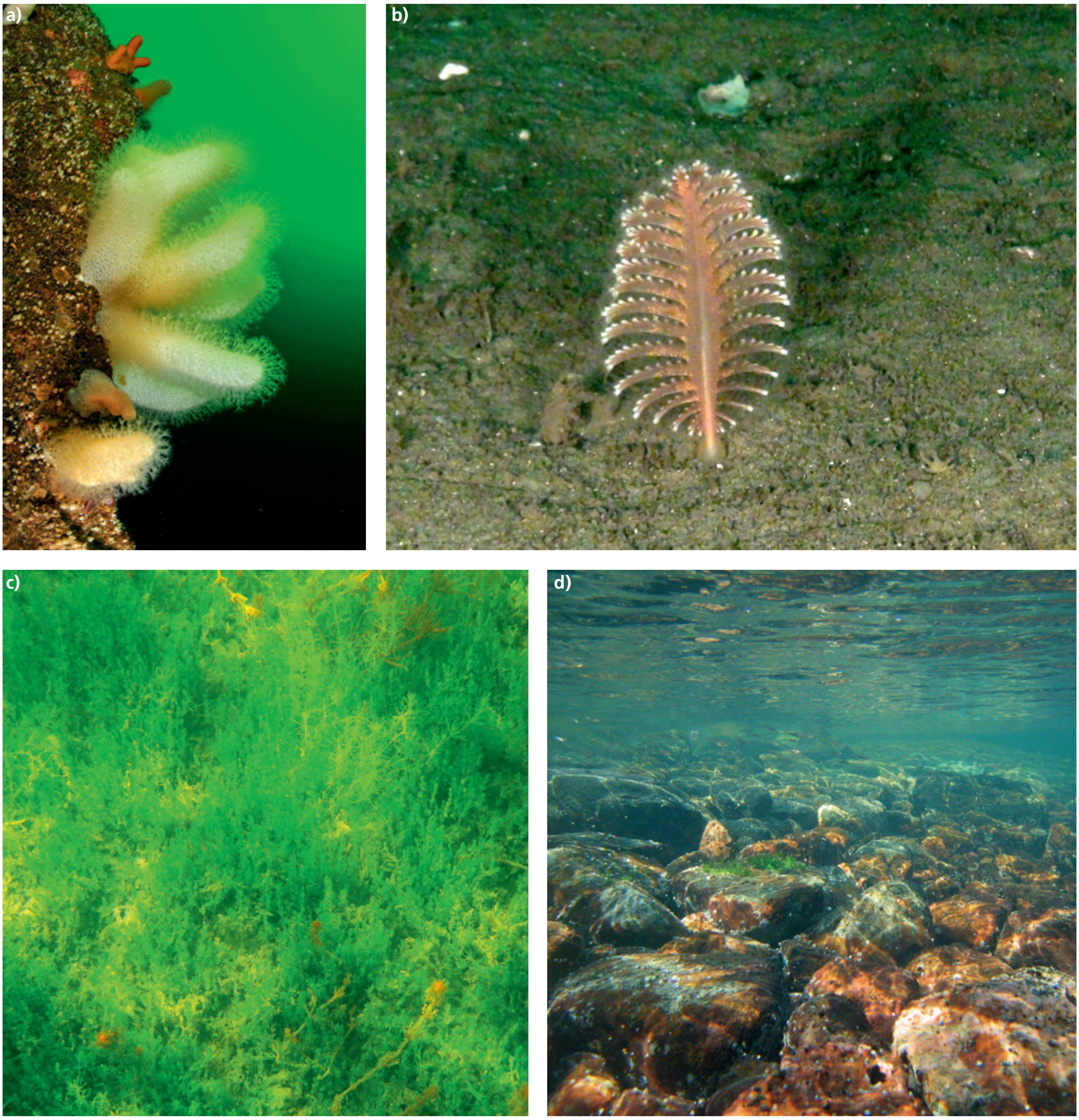
The original aim of the HELCOM Red List of biotopes/habitats project was to update the HELCOM Red List of biotopes and biotope complexes created in 1998 (HELCOM 1998). The previous Red List identified threatened and/or declining biotopes; indicating the areas where the biotope was threatened; and also included a limited classification system of Baltic Sea marine and coastal biotopes. The threat assessments were made based on expert judgement and qualitative, descriptive criteria. The list of threatened biotopes was extended when additional biotopes and habitats included in the OSPAR list of threatened or declining species were included in the HELCOM list (HELCOM 2007). The threat assessment methodology in the current assessment retains some criteria from the assessment carried out in 1998. At the very beginning of the HELCOM Red List of Baltic Sea underwater biotopes and habitats project, it became apparent that biotope definitions varied significantly among the coastal countries and no classification system covered the whole Baltic Sea. Assessing the biotopes and creating a Red List first required the HELCOM Red List Biotope Expert Group to develop the HELCOM Underwater Biotope and habitat classification (HELCOM HUB) (HELCOM 2013c) that identifies biotopes, habitats and biotope complexes. Due to the changes in the assessment criteria as well as in the methods of defining biotopes, the results in the current assessment and the assessment carried out in 1998 cannot be directly compared.

1.3 Biotopes, habitats and biotope complexes in the Baltic Sea

Biotopes in the Baltic Sea can cover either large, homogenous areas, small patches or be a part of a small-scale mosaic. The size and structure of the biotopes depends on variations in the seafloor substrate types, bathymetry and other environmental gradients. Baltic Sea biotopes exhibit a great diversity in function and structure. Some biotopes are dominated by large perennial vegetation that creates a three-dimensionally complex biotope, such as the bladderwrack (*Fucus vesiculosus*) on rocky bottoms or the common eelgrass (*Zostera marina*) on sandy bottoms. Biotopes in the aphotic zone are typically dominated by semi-sessile macrofauna that either attach to the hard surface or burrow into soft substrates, for example blue mussels (*Mytilus* spp.) or the ocean quahog (*Arctica islandica*), respectively.

A biotope is defined as the combination of a habitat and an associated community of organisms exhibiting a distinct community function (Connor et al. 2004, Olenin & Ducrotoy 2006). A habitat is defined as the abiotic environment which contributes to the nature of the seabed (Connor et al. 2004). Biotope complexes form a functional unit on a landscape scale. Several different biotopes and habitats can occur in a biotope complex, which is often defined by biotopes and habitats being arranged in a specific pattern.

The biotopes and habitats that are considered in the threat assessment are delineated and defined through the HELCOM Underwater Biotope and habitat classification system (HELCOM HUB)



Biotopes, habitats and biotope complexes in the Baltic Sea vary in size and shape. In the southern Baltic Sea biotopes dominated by softcoral (a) occurs on hard substrates and seapens (b) on soft sediment. In the northern biotopes dominated by Charales (c) are typical in shallow soft sediment areas and hard substrates can be covered by microscopic algae (d). Photos: (a) OCEANA/Carlos Miguell, (b) OCEANA, (c) Kajsa Rosqvist, (d) Metsähallitus NHS.

(HELCOM 2013c). HELCOM HUB biotopes are written in italics in this report, whereas biotopes from previous HELCOM Red Lists or other biotope lists are not. In HELCOM HUB, biotopes are defined based on the coverage of substrate, epibenthic biota, infauna or the lack of macrofauna as well as the coverage and biomass of specified taxonomical groups. The spatial scale of the biotopes is not strictly defined. It is only stated that the biotopes are commonly measured on a minimum spatial scale of square meters and that the biotope forming community must be distinct compared to other communities by, for example, exhibiting a specific function. During the growing season in the Baltic Sea, the coverage of annual algae varies significantly. The hierarchical HELCOM HUB recognizes this and classifies biotopes primarily by the perennial, attached biota and only then by annual biota. Furthermore, it is highlighted that sampling should take place when the community is fully developed and that the dominance should be related to the fully developed community.

The biotopes that are assessed are mainly defined on HELCOM HUB Level 5 and Level 6. The lowest possible biotope was assessed, implying that the Level 5 biotopes that have further been specified in Level 6 biotopes were not assessed. Some benthic biotopes which occur on rare substrate types have not been defined down to Level 5 - these are assessed on Level 3 and likewise pelagic habitats are assessed on Level 4. In total, 170 biotopes were assessed on Level 6 and 39 on a higher level (Annex 2). Some of the biotopes defined in HELCOM HUB are integral parts of biotope complexes. HELCOM HUB recognizes ten biotope complexes that are defined through the Habitats Directive Annex 1 (HELCOM 2013c). The threat status of the biotope complexes was assessed by the same criteria as the biotopes.

2 Red List Assessment of biotopes

Compared to many other regional sea areas, the level of knowledge on the ecological processes of the Baltic Sea is relatively extensive. Only a few Red List assessments of biotopes in a regional marine context have been carried out globally. Utilizing HELCOM Underwater Biotope and habitat classification and quantitative threshold values in the criteria creates a Red List of threatened biotopes that incorporates both sampling data and expert judgement.

2.1 General assessment principles

Threat assessments should be made using methods that are commonly accepted and applied. The Red List assessment of species relies on criteria developed by IUCN (HELCOM 2013d, IUCN 2001). Currently, IUCN is developing Red List criteria for assessing ecosystems (Rodríguez et al. 2011, Keith et al. 2013). The ecosystems which the IUCN criteria assess are defined by the same functional elements by which biotopes are defined in the HELCOM Red List project (Rodríguez et al. 2011). The criteria used in this assessment are based on the criteria under development by IUCN; however, some modifications have been made by the HELCOM Red List Biotope Expert Group.

The Red List criteria used in this assessment define threshold values for the different threat categories. Biotopes should always be assessed against as many criteria as possible permitted by the available data, for example both a quantity and a quality criterion. To be red-listed, the biotope only needs to reach one threshold value for one of the Red List categories. Based on the precautionary principle, the criterion indicating the highest threat category defines the overall threat category of the biotope. If the highest threat category is reached in more than one criterion, then all the applicable criteria should be indicated together with the threat category for that biotope (e.g. Vulnerable VU: A1, B2a(ii) see Figure 3 and Table 2). The best available data on the trend in quantity and quality is applied, which also includes expert judgment and inference.

Some of the used data was up to 150 years old (HELCOM 1998) in the HELCOM 1998 Red List assessment. Keith et al. (2013) suggest using the year 1750 as the limit of historical data - the Baltic Sea has undergone significant natural change during the past 250 years. The Red List criteria (Table 2) do not differentiate between natural or anthropogenically induced changes. The usefulness of the Red List results in management will lessen if the assessment incorporates large amounts of natural historical changes. Moreover, since the amount of reliable data going back 250 years is very limited, the threat assessments based on historical data are limited to the past 150 years whenever data are available (Table 2).

In HELCOM HUB biotopes, habitats and biotope complexes are delineated based on split rules for coverage and biomass or biovolume (HELCOM 2013c). Biotopes are arranged hierarchically in six levels based on the split rules. When making a threat assessment, cumulative threats and pressures should be considered. This implies that threats or pressures acting on for example, a substrate on HELCOM HUB Level 3 should be taken into consideration when making a threat assessment for a biotope dominated by a certain taxon on that particular substrate on Level 6.

Biotopes and habitats that have been created in the Baltic Sea due to human activities have been defined in HELCOM HUB as the aim of the classification was to cover the entire Baltic Sea underwater area (HELCOM 2013c). Assessing the threat to these biotopes and habitats by applying the Red List criteria was, however, deemed inappropriate. Anthropogenically created hard (e.g. bridge pylons) or soft substrates (e.g. dumped dredged material) defined on HELCOM HUB Level 3 were not assessed (category Not Evaluated, NE). Similarly, some biotopes characterized by recently established alien species were not threat assessed (NE). However, some biotopes characterized by alien species that have been present for over 150 years within the HELCOM Area were assessed. The approach of assessing alien species differently based on the time period they have been present in the region has been adopted in some national management strategies. The temporal cut-off point has often been determined by the availability of reliable data (e.g. Ministry of Agriculture and Forestry in Finland 2012). Large areas of Baltic Sea sea-bottom communities and food chains are dominated by invasive species, especially in the southern parts of the Baltic Sea and some of the coastal lagoons in the region (HELCOM 2009b).

2.2 The Red List Categories

Biotopes are categorized based on the probability of the biotope 'collapsing' in the Baltic Sea; this probability is quantified by the decline in quantity and/or quality of the biotope as adapted from Keith et al. (2013). The more severe the decline has been or the higher it is predicted to become, the more threatened the biotope is perceived to be and the higher the assigned threat category. Only one threat category can be assigned per biotope. Careful balancing is needed: the precautionary principle is to be applied, but at the same time the credibility and the usefulness of the Red List must be maintained by not assigning a high threat category for all biotopes where the trend is uncertain.

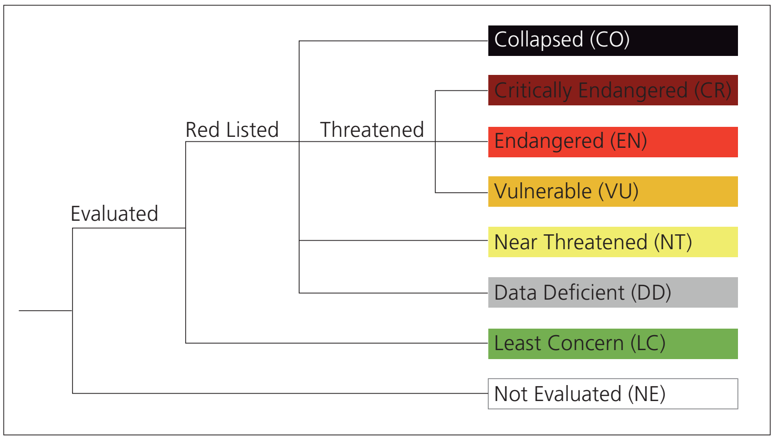


Figure 2. The Red List threat categories.

Biotopes assigned to the threat categories Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), or Data Deficient (DD) are red-listed; of these, the CR, EN or VU categories list biotopes that are considered to be threatened (Figure 2). Biotopes that have been assessed and are not red-listed are assigned to the category Least Concern (LC). Biotopes that were not assessed at all are categorized Not Evaluated (NE).

Biotopes that have completely disappeared from the Baltic Sea are categorized Collapsed (CO) (Figure 2, Table 1), an analogue category to the category Extinct (EX) applied in species assessments (IUCN 2001). A collapse can be identified through chronic changes in the nutrient cycling, disturbance regimes, a loss of connectivity between the biotopes or other ecological processes (Keith et al. 2013). Features defining a collapse are "…*a transformation of identity, loss of defining features, and replacement by a novel ecosystem. It occurs when all occurrences lose defining biotic or abiotic features, and characteristic native biota are no longer sustained*" (Keith et al. 2013).

The collapse of a biotope can be very difficult to detect. Exhaustive surveys having been undertaken in the previously known and other possible locations where the biotope could be identified at an appropriate time in the season, and the biotopes occurrence having been clearly documented in previous studies, are prerequisites of categorizing a biotope CO. In other words, if a biotope has been categorized CO, this implies that the biotope has been adequately searched for - it has previously been present in the survey area, but during the assessment it can no longer be proven to exist. It should be noted that changes between biotopes are in many cases based on common agreements of classification principles. Thus, the event that is regarded as the collapse of the biotope may not be dramatic but simply a shift beyond the cut-off values that define the biotope (e.g. decrease in abundance of a characterizing species).

A collapsed biotope may or may not have the capacity to recover given long enough time, or by the means of restoration. The area previously occupied by the biotope will be claimed by a novel biotope. While the novel biotope may retain some of the collapsed biotopes characteristics, the dominance, structure and function will have changed in a way that defines the area as the novel biotope (Keith et al. 2013).

The category Data Deficient (DD) is commonly used in Red List evaluations (IUCN 2001). The category is also taken into consideration in this Red List assessment of Baltic Sea underwater biotopes and habitats; however, the use of this category was very restrictive. Biotopes placed in this category may be severely threatened and may need strong conservation measures to ensure their prevalence in the area. In the HELCOM Red List of Baltic Sea species, the DD category was mainly assigned to species that potentially could have

Table 1. **Description of the threat categories.**

Category		Description
Collapsed	CO	The biotope is no longer known to occur in the Baltic Sea; the biotope does not retain its defining features; and characteristic biota performing key functions is no longer retained.
Critically Endangered	CR	The best available evidence indicates that the biotope meets any of the Red List criteria for Critically Endangered and it is therefore considered to be facing a very severe risk of collapse throughout its distribution.
Endangered	EN	The best available evidence indicates that the biotope meets any of the Red List criteria for Endangered and it is therefore considered to be facing a severe risk of collapse throughout its distribution.
Vulnerable	VU	The best available evidence indicates that the biotope meets any of the Red List criteria for Vulnerable and it is therefore considered to be facing a moderately severe risk of collapse throughout its distribution.
Near Threatened	NT	The best available evidence indicates that the biotope meets any of the Red List criteria for Near Threatened and it is therefore considered to be facing a moderate risk of collapse throughout its distribution.
Data Deficient	DD	A habitat or biotope is Data Deficient when there is inadequate information to make a direct, or indirect, assessment according to the Red List criteria. Listing a biotope in this category indicates that more information is required and that future research might categorize the biotope in one of the categories indicating that the biotope is threatened.
Least Concern	LC	The habitat or biotope is Least Concern when it unambiguously meets none of the criteria threshold values for red-listed categories and it is therefore currently not seen to face a risk of collapse throughout its distribution.
Not Evaluated	NE	A habitat or biotope that has not yet been evaluated against the criteria. This criteria has been applied e.g. for Level 5 biotopes for which lower Level 6 biotopes have been evaluated.

been placed in any category between LC and CR - the uncertainty of where they belong was due to a lack of data. The assessor should always use all available data, which also includes inference and expert judgements; moreover, a biotope or species should only be placed in the DD category when the uncertainty of the risk of collapse or extinction, respectively, is very high. As the data available for Baltic Sea biotopes are very limited, the use of the DD category must be restrictive since it would be neither informative nor productive to categorize all biotopes as DD.

2.3 The Red List Criteria

Applying comparable and quantitative criteria to all the biotopes will identify the biotopes most at risk of collapse. The trends in biotope quantity, quality and rarity are assessed by applying the criteria that contain threshold values, placing the biotope in a threat category. The criteria are designed to identify symptoms of a potential collapse; however, the cause of the severe decline is not identified by the criteria. Consequently, the criteria are applicable to any trend in quantity or quality of the biotope that occurs due to any threat or threatening process. A habitat or biotope may be classified as threatened even if a threatening process cannot be identified.

The Red List criteria applied in the assessment are based on the methodology applied in previous HELCOM Red List assessments (HELCOM 1998, HELCOM 2007) and on threat assessment criteria that have been developed by the IUCN through global consultation (Rodríguez et al. 2011, Keith et al. 2013). The criteria developed by the IUCN are quantitative and often require significant amounts of data for a complete assessment. Simultaneously applying the previous HELCOM assessment criteria, which are more qualitative in nature, supports making a threat assessment when data on the Baltic Sea biotopes are scarce. Even if data on the temporal trend of the biotopes quantity or quality are not available, an assessment can be made based on inference and projection supported by expert judgement.

Biotopes were assessed by three criteria in the HELCOM Red List project (Table 2):

Criterion A. Declining distribution, describes a decline in the quantity of the biotope.

Criterion B. Restricted distribution, identifies biotopes that occur in very restricted areas or cover very small areas and are thus in danger of collapse also due to random threat effects.

Criterion C. Qualitative degradation, describes a decline in the quality of the biotope.

The thresholds values for the category NT were generated by determining a value that indicates a decline that is 10% less severe than for the threshold value for VU, as suggested in Keith et al (2013) (Table 2). Listing a biotope in a threat category only requires the biotope to meet the threshold values for one of the criteria. However, a habitat or biotope should be assessed against as many criteria as available data permit, and the listing should be annotated by all the criteria that are applicable for the highest category of threat (for example, Critically Endangered: A1, B2a(ii)).

Criterion B measures the risk of collapse due to rarity by different measures of spatial extent and have been directly adapted from Keith et al. (2013) (Table 2). Many concepts applied to the threat assessment of species can be applied to the assessment of biotopes, habitats or ecosystems (Keith et al. 2013), and the extent of occurrence (EOO) and area of occupancy (AOO) (Table 3) are defined by a similar method as in the Red List of species (IUCN 2001). The EOO area is calculated by encompassing all known and assumed occurrences of a biotope by drawing the smallest possible convex polygon around the locations (Table 3). The measure describes the ability to spread the risk of collapse within an area on several different

Table 2. **The Red List criteria applied in the HELCOM Red List assessment of biotopes; threshold values are adapted from criteria described in Keith et al. (2013) and HELCOM (1998). Read table from left to right and top to bottom.**

Criterion	Quantitative sub-criteria and threshold values of the threat categories to be assessed simultaneously with the qualitative descriptions	
A Declining distribution (quantity) **as indicated by either:**	1 An observed, estimated or inferred reduction in a measure of spatial extent appropriate to the biotope, habitat or biotope complex of ≥80% → CR ≥50% → EN ≥30% → VU ≥25% → NT over the past 50 years; **OR**	**In immediate danger of complete destruction:** biotope, habitat or biotope complex of which only (small) fractions of their reference (former) spatial expanse or appearance, respectively, is present in the survey area, and their complete destruction → CR **Endangered:** biotope, habitat or biotope complex which show a heavy decline of their spatial expanse or appearance in almost the entire assessed area, respectively, or are already completely destroyed in several regions. → EN
	2 A projected or inferred future reduction in a measure of spatial extent appropriate to the biotope, habitat or biotope complex of ≥80% → CR ≥50% → EN ≥30% → VU ≥25% → NT over: a the next 50 years; or b any 50-year period including the present and future; **OR**	**Vulnerable:** biotope, habitat or biotope complex which show a decline of their spatial expanse or appearance in large parts of the assessed area, respectively, or are locally completely destroyed. → VU
	3 An observed, estimated or inferred or long-term reduction in a measure of spatial extent appropriate to the biotope, habitat or biotope complex of ≥90% → CR ≥70% → EN ≥50% → VU ≥45% → NT over the past 150 years.	**Pre-warning-list:** biotope, habitat or biotope complex which show a tendency for decline in the survey area, but are not threatened according to the categories CR–VU. → NT Presumably not threatened at present. → LC

B Restricted distribution as indicated by either:	**1** The extent of a minimum convex polygon or similar boundary enclosing all occurrences (Extent of occurrence EOO) estimated to be ≤2 000 km² → CR ≤20 000 km² → EN ≤50 000 km² → VU ≤55 000 km² → NT	**AND** least one of the following: **a** An observed or inferred continuing decline in **(i)** a measure of spatial extent appropriate to the biotope, habitat or biotope complex; **or** **(ii)** a measure of environmental quality appropriate to the characteristic biota of the biotope, habitat or biotope complex; **or** **(iii)** a measure of disruption to biotic interactions appropriate to the characteristic biota of the biotope, habitat or biotope complex; **b** Observed or inferred threatening processes that are likely to cause continuing declines in either geographic distribution, environmental quality or biotic interactions within the next 20 years; **c** The biotope, habitat or biotope complex exists at **(i)** only a single location if EOO ≤2 000 km² **(ii)** 5 or fewer locations if EOO ≤20 000 km² **(iii)** 10 or fewer locations if EOO ≤50 000 km²; **OR**
	2 The number of 10×10 km grid cells occupied (Area of occupancy AOO) estimated to be ≤2 → CR ≤20 → EN ≤50 → VU ≤55 → NT	**AND** least one of the following: **a** An observed or inferred continuing decline in **(i)** a measure of spatial extent appropriate to the biotope, habitat or biotope complex; **or** **(ii)** a measure of environmental quality appropriate to the characteristic biota of the biotope, habitat or biotope complex; **or** **(iii)** a measure of disruption to biotic interactions appropriate to the characteristic biota of the biotope, habitat or biotope complex; **b** Observed or inferred threatening processes that are likely to cause continuing declines in either geographic distribution, environmental quality or biotic interactions within the next 20 years; **c** The biotope, habitat or biotope complex exists at **(i)** only a single location if AOO ≤2 grid cells (10×10 km) **(ii)** 5 or fewer locations if AOO ≤20 grid cells (10×10 km) **(iii)** 10 or fewer locations if AOO ≤50 grid cells (10×10 km); **OR**
	3 A very small number of locations (generally fewer than 5) **AND** prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and thus capable of collapse or becoming CR within a very short time period → VU	

C Quality degradation as indicated by either:	1 An observed, estimated or inferred change of a specified severity in an environmental variable appropriate to the characteristic biota of the biotope, habitat or biotope complex over a certain proportion of the biotope over the past 50 years; Very severe decline on >80% of the original distribution → CR Very severe decline on >50% of the original distribution → EN Severe decline on >80% of the original distribution → EN Very severe decline on >30% of the original distribution → VU Severe decline on >50% of the original distribution → VU Moderately severe decline on >80% of the original distribution → VU Very severe decline on >25% of the original distribution → NT Severe decline on >45% of the original distribution → NT Moderately severe decline on >70% of the original distribution → NT **OR**	**In immediate danger of complete destruction:** biotope, habitat or biotope complex where quality has declined so much that occurrences with typical natural variants are in immediate danger of collapse in almost the entire survey area. → CR **Endangered:** biotope, habitat or biotope complex where quality has declined so much that either a heavy decline of occurrences with typical natural variants is observed throughout almost the entire area, or occurrences with typical variants have already collapsed in several regions. → EN **Vulnerable:** biotope, habitat or biotope complex where quality has declined so much that either a decline of occurrences with typical natural variants is observed in large parts of the area, or occurrences with typical variants have already collapsed locally. → VU Presumably not threatened at present. → LC
	3 An observed, estimated or inferred change of a specified severity in an environmental variable appropriate to the characteristic biota of the biotope, habitat or biotope complex over a certain proportion of the biotope over the past 150 years; Very severe decline on >90% of the original distribution → CR Very severe decline on >70% of the original distribution, → EN severe decline on >90% of the original distribution → EN Very severe decline on >50% of the original distribution → VU Severe decline on >70% of the original distribution → VU Moderately severe decline on >90% of the original distribution → VU Very severe decline on >45% of the original distribution → NT Severe decline on over 65% of the original distribution → NT Moderately severe decline on >80% of the original distribution → NT	

patches (IUCN 2001, Keith et al. 2013). The area of occupancy (AOO) is a measure of the number of 10x10 km^2 grid cells occupied by the biotope (Table 3). This measure estimates how well the risk of collapse can be spread between biotope patches (IUCN 2001, Keith et al. 2013).

The first signals of a loss of biotopes often manifests as a degradation of quality. Keith et al. (2013) suggest that quality be assessed by two separate quality criteria 'C. Degradation of abiotic environment' and 'D. Altered biotic processes and interactions', and at the core of the suggested criteria a ratio between the observed change and the amount of change that would cause a collapse the 'relative severity' is applied. Applying both the criteria was deemed unrealistic within the frame of this assessment. Thus, in this assessment the quality descriptor (criterion C, Table 2) encompasses both environmental descriptors such as oxygen level, water clarity, the level of siltation or ice cover, and functional characteristics of the community such as species diversity, species composition or dominance in the community, state of the key species or different measures of functional or trophic diversity. Instead of identifying the 'relative severity', the trend in quality is described in a more qualitative manner as 'Very severe', 'Severe' or 'Moderately severe' (Table 4). In principle, a subcriterion for inferring the trend in quality over the coming 50 years could have been defined as subcriterion C2 (Table 2). However, the criterion was not included in this assessment as useful information to carry out the assessment was unavailable.

Table 3. Definition of EOO and AOO used in criterion B

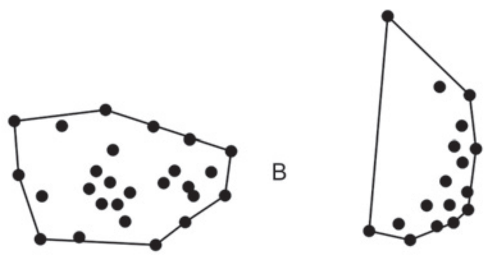
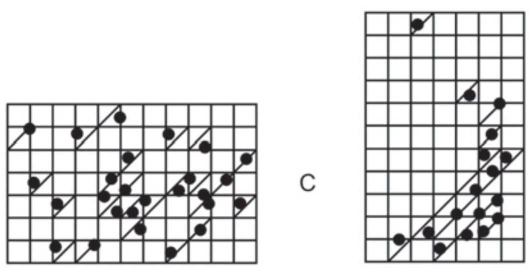
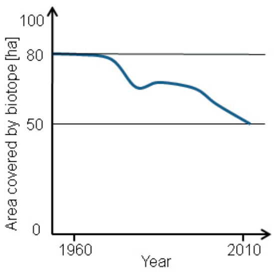
	**The spatial distribution of a known, inferred or projected site of present occurrence.**
	**One possible boundary to the extent of occurrence, which is the measured area within this boundary.** **Extent of occurrence - EOO** The extent of occurrence (EOO) is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a biotope/habitat. This measure may exclude discontinuities or disjunctions within the overall distributions of biotopes/habitats (e.g., large areas of obviously unsuitable habitat, for marine biotopes this includes terrestrial areas). EOO can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence).
	**One measure of area of occupancy which can be achieved by the sum of the occupied grid squares** **Area of occupancy - AOO** The area of occupancy (AOO) for a biotope/habitat as the number of 10x10 km^2 grid cells within its 'extent of occurrence' which is occupied by a biotope/habitat. The measure reflects the fact that a biotope/habitat will not usually occur throughout the area of its extent of occurrence.

Table 4. **The trend in quality is described by three categories of severity; 'key roles in the community' refers to trophic or structural dominants, unique functional groups, ecosystem engineers, etc.**

Very severe	Severe	Moderately severe
• **most** of the characteristic species of the biotope are lost, or	• **many** of the characteristic species of the biotope are lost, or	• **some** of the characteristic species of the biotope are lost, or
• the biota that perform key roles in the community **are greatly reduced** in abundance and **lose** the ability to recruit, or	• **some parts of** the biota that perform key roles in the community **are greatly reduced** in abundance and **are losing** the ability to recruit, or	• **some parts of** the biota that perform key roles in the community **are reduced** in abundance and **are losing** the ability to recruit, or
• the biotope experience **chronic severe changes** in nutrient cycling, disturbance regimes, connectivity or other biotic or abiotic processes that sustain the characteristic biota	• the biotope **experience long-standing severe changes** in nutrient cycling, disturbance regimes, connectivity or other biotic or abiotic processes that sustain the characteristic biota	• the biotope experience **at least temporary, but still considerable** changes in nutrient cycling, disturbance regimes, connectivity or other biotic or abiotic processes that sustain the characteristic biota

Box 1. **A theoretical example of a biotope where data from the past 50 years are available to assess the threat status by all three criteria. This biotope would be categorized EN: C1, since the highest threat category is indicated by this criterion. If no data had existed for the criterion C, then the biotope would be categorized VU: A1, B2b**

Criterion A



50 year time period
Decline in quantity is approximately 38%
Simultaneously the qualitative description of the biotope state applies;
Biotope types which show a decline of their spatial expanse or appearance in large parts of the assessed area, respectively, or are locally completely destroyed

→ VU: A1

Criterion B

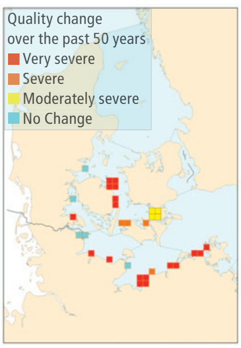
In a 10x10 km grid cell for the HELCOM area, the biotope occurs in 31 cells

AND

Observed or inferred threatening processes that are likely to cause continuing declines in either geographic distribution, environmental quality or biotic interactions within the next 20 years have been identified

→ VU: B2b

Criterion C



A very severe quality decline has taken place in 58% of the original distribution during the past 50 years

Simultaneously the qualitative description of the biotope state applies;
Biotopes where quality has declined so much that either a heavy decline of occurrences with typical natural variants is observed throughout almost the entire area, or occurrences with typical variants have already become extinct in several regions.

→ EN: C1

→ Biotope threat assessment result
EN: C1

2.4 Confidence categories

Evaluations of the biotopes or habitats against the Red List criteria are often carried out with considerable uncertainty (cf. species assessments, IUCN 2001, IUCN 2011). Uncertainty can arise from a scarcity of data, natural variation, vagueness in the terms and definitions used, and measurement errors. This makes it necessary to specify how uncertainty is handled using the assessment process. Indicating the confidence of the results can influence how the results are implemented in management schemes.

In this assessment, uncertainty has been indicated by assigning each red-listed biotope a 'confidence of threat assessment' category. A system of three categories was created, where the categories describe the uncertainty generated by a lack data and the level of agreement on the threat category by the assessing experts (Table 5).

If the confidence category Low (L) has been assigned to the assessment, this generally indicates that only expert judgement was used to make the assessment. The category Moderate (M) can generally be seen to describe assessments that were mainly done based on expert judgement but were supported by some available data on the biotope. High (H) confidence in the threat assessment indicates that it was made mainly by directly applying the quantitative criteria to data from sampling in the field or originating from a large-scale long-term mapping project, for example.

2.5 Data availability, inference and projection

For most of the biotopes in this assessment, the threat assessment does not rely on actual long-term monitoring data. Currently, biotopes and habitats are rarely, if at all, included in monitoring activities in the Baltic Sea. The Red List criteria assess the threat of collapse by analysing the trend in quantity and quality of the biotope during the past or the coming 50 years, or if historical changes are considered during the past 150 years. However, comparable data have only been gathered for any longer period of time for some species such as the bladderwrack (*Fucus vesiculosus*) and the common eelgrass (*Zostera marina*). The assessors use the best available information in combination with inference and projection to test a biotope/habitat against the criteria, following the same principle of inference and projection as in the species assessments (IUCN 2011, Keith et al. 2013).

As most of the data is scattered and incomplete, expert evaluation and judgement was needed

Table 5. The confidence of the threat assessment is expressed using three different levels of confidence; typically, more than one of the conditions are met to classify the confidence in a category.

Confidence of threat assessment	Description of the confidence of threat assessment category
High (H)	• The biotope distribution and extent is well studied and data describing important functional (quality) aspects of the biotope are available • Historical data describing the trend for quantity and quality of the biotope are available (at least for several decades), supporting extrapolations of future trends • Experts agree on the threat category
Moderate (M)	• Some data are available on the distribution and extent of the biotope, it is assumed that at least the most significant occurrences of the biotope are known and/or • Some data describing important functional (quality) aspects of the biotope are available • Some historical data describing the trend for quantity and quality of the biotope are available • Experts largely agree on the threat category
Low (L)	• Very little/no data are available on the distribution and extent of the biotope • Very little/no data describing important functional (quality) aspects of the biotope are available • Very little/no historical data describing the trend for quantity and quality of the biotope are available • Experts generally disagree on the threat category

to apply the criteria and determine the threat category when analysing the datasets. The relative role of expert judgement and field data is documented in the assessment justifications of each red-listed biotope. Relevant national data on the biotopes that were available to the experts were used in making the threat assessments. The development of HELCOM HUB was carried out in parallel with the threat assessment of the biotopes. To create HELCOM HUB, tens of thousands of data points from sampling of organism communities data were compiled and analysed (HELCOM 2013c). This information supported the threat assessments of biotopes. However, the compiled data for HELCOM HUB did not cover all biotopes and only contained little information on the historical distribution of biotopes.

Much of the environmental data that cover the whole Baltic Sea, and has previously been compiled and analysed by HELCOM, is very basic. Modelled potential biotope distributions based on substrates and the availability of light on the bottom were used to support the assessments. Especially in the coastal zone where the biotope distribution forms small-scale, patchy mosaics, the compiled data do not mirror the environmental gradients at a spatial scale relevant to the biotopes. Modelled distribution maps of substrates and other analyses were used with caution in the threat assessments, and only as support material.

Trends in water transparency (Secchi depth) in different sub-basins going back to the 1970s were used as support material for the threat assessment (Figure 3). For photic biotopes, water transparency is one of the main factors affecting the quantity and quality of the biotopes. Light availability at different depths impacts the growth of macrophytes and in the absence of light there is no growth. The CORESET benthic pressure index maps were also used to support the threat assessment of biotopes (Korpinen et al. 2013).

Maps depicting the area of large-scale oxygen depletion in the central areas of the Baltic Sea were also used as support material for the threat assessment.

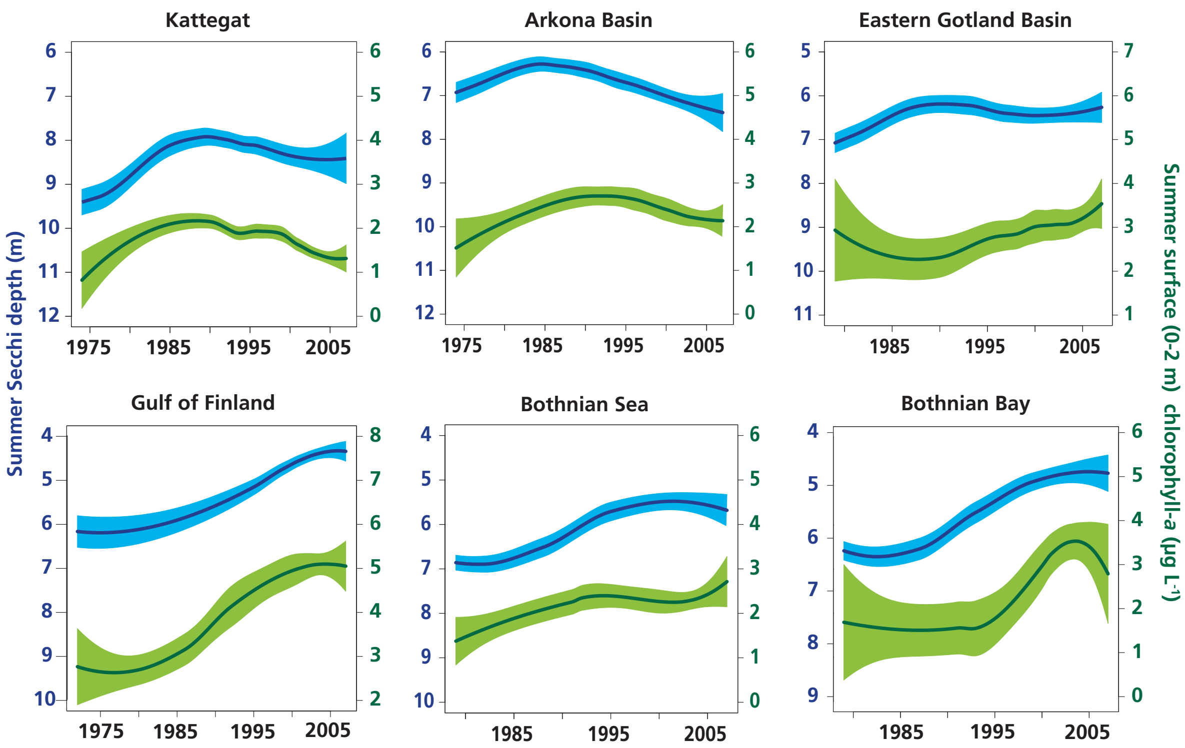


Figure 3. **The trend in water transparency measured as Secchi depth is a useful proxy for estimating the quantity and quality of biotopes that only occur in the photic zone (reprint from HELCOM 2009a).**

The benthic substrate maps of the HELCOM BALANCE project were considered to be very informative on the Baltic Sea scale but too basic for the actual threat assessments. The same was true for the HELCOM HEAT project eutrophication indicator maps that were compiled based on best available data – they had too few data points to actually reflect the regional variation in the status of biotopes, especially in the coastal zone.

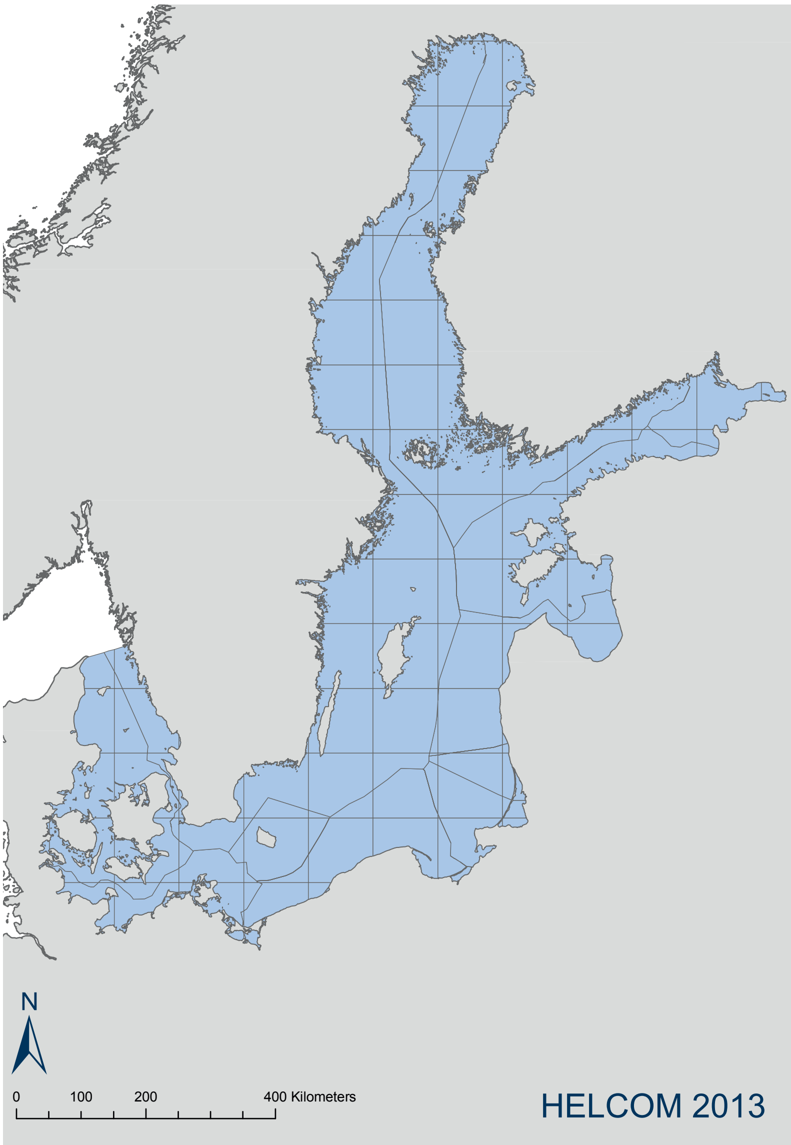


Figure 4. The entire HELCOM area was considered in the Red List assessment using a 100x100 km grid that was also sectioned based on the Exclusive Economic Zones (EEZ) of the coastal countries

2.6 Area under consideration

The entire marine HELCOM area was considered when creating this assessment. The assessments were made based on known point occurrences of the biotopes, but the occurrences were indicated using 100x100 km grid cells (Figure 4).

In the southwestern part of the HELCOM area, covered by the Kattegat and Belt Sea, some truly marine species can be encountered and the biotopes are more pronouncedly marine than in the northern region. The biotopes that exist in the Kattegat and Belt Sea area were assessed by simultaneously considering the prevalence of the biotope in the Atlantic. If the biotope is prevalent in the Atlantic but threatened only in the Kattegat, then a lower threat category was designated. National concern for a biotope was stated for the red-listed biotopes if a biotope was seen to be more threatened on a national scale than on the Baltic Sea wide scale.

Sub-basin specific assessments could have been created using the HELCOM sub-basin division; however, due to a general lack of resources and data from all the sub-basins this approach was not used. Also, as many biotopes occur in the entire Baltic Sea and may appear different due to their adaptation to the different environmental conditions, it is somewhat challenging to assess the same biotope separately for the different sub-basins.

2.7 Scope of the Red List assessment

This Red List considers all the 328 biotopes and habitats and the ten biotope complexes defined in HELCOM HUB (HELCOM 2013c). HELCOM HUB covers both benthic and pelagic habitats and in addition recognizes ten biotope complexes (HELCOM 2013c). HELCOM HUB was designed to include also rare biotopes and cover the entire Baltic Sea marine area. Thus, the Red List assessment can be seen to cover the whole marine HELCOM area.

Biotopes were assessed together if the split rules in HELCOM HUB had created several biotopes that were seen to be variations of the same biotope in nature. The functionality of the different classes was to be taken into account when aggregating classes in the threat assessment. However, information on functionality is still lacking on the Baltic Sea scale for several biotopes.

2.8 Assessment process

The Red List threat assessment of the Baltic Sea biotopes was carried out by the HELCOM Red List Biotope Expert Group with participation from all coastal countries and the EU. The work was carried out during a total of ten workshops during the years 2010–2013, and intersessionally. The group was chaired by Michael Haldin (Finland) and supported with funding from HELCOM, the Nordic Council of Ministers, Denmark, Germany and Sweden.

Assessment criteria were defined at the beginning of the project as described in previous chapters. The principles for conducting the threat assessments were also developed. The development of HELCOM HUB was a prerequisite to the Red List threat assessment process.

The threat assessment process was three-phased:

1) A questionnaire was sent out to collect data on trends in quality and quantity of the biotopes.
2) The HELCOM Red List Biotope Expert Group made initial threat assessments based on the responses to the questionnaire, other data and their own expertise.
3) The initial threat assessments were validated by circulating a second questionnaire.

The first and the second questionnaires were sent out through the HELCOM network to a wide range of experts at universities and other expert institutions in the region. The first questionnaire was designed to provide basic data on changes of the biotopes. The respondents were asked to estimate the trend in quantity and quality of the HELCOM HUB biotopes during the past and future 50 years, and the past 150 years. Quantitative decline (loss of area) was to be given as percentage declines (e.g. -50%) for the different assessment time periods. Quality decline was to be estimated as the percentage of the biotope extent that has suffered decline in quality described as three classes (moderately severe, severe and very severe). The total area covered by the biotope was asked for in square kilometres. In addition respondents were given the option to submit distributional data for rare biotopes by indicating the location with coordinates. The respondents were given the option to assess the trend of the biotope in specific 100x100 km grid cells or for the whole area of expertise indicated in the same grid. They were also asked to describe the confidence in their estimate as a percentage value, as well as what type of data supports the assessment. The content of the questionnaires is given in Annex 3.

In total, 12 separate replies from five countries were received for the first questionnaire. The information content of the replies varied. The respondents indicated that data on trends in quantity and quality of biotopes are currently not available. Estimating the abundance and location of biotopes in the area the respondents were familiar with was often not possible due to a lack of data on biotopes. Most biotopes received at least some assessment by the respondents; in many cases, however, the answer was simply presence/absence information without comments on trends in quantity or quality. Only a few biotopes were given decline estimates by more than one respondent. These biotopes were characterized by *Fucus* spp., *Zostera marina*, Mytilidae and corticated red algae.

The expert group made initial threat assessments based on the replies to the questionnaire as well as extra information provided by national experts on the trends in quantity and quality of the biotopes. The scarcity of replies to the questionnaire and the large geographical gaps in the information even for well-known biotopes resulted in the initial threat assessments being made based largely on other background data and the expert groups judgement. Based on all the available data on biotope trends and various pressures, the assessment criteria were applied to the biotopes.

A second questionnaire with initial assessment results was circulated to validate the initial threat assessments. In the second questionnaire, the initial threat assessment categories and assessment criteria were presented. The respondents were asked to provide presence/absence information for the initially red-listed biotopes in the area they are familiar with and to consider the initial threat category and the criteria used in the threat assessment for all the assessed biotopes. The respondents were asked to indicate whether they agree or disagree with the assessment. In the case of disagreement, they were asked to make a threat assessment using the assessment criteria and indicating the new threat category, and to describe the supporting data that were used as well as the confidence in the new threat assessment. The content of the questionnaire is given in Annex 3.

The second questionnaire did not yield any official replies. The HELCOM Red List Biotope Expert Group revised a few threat assessments for biotopes in shell gravel after new information was provided. Some adjustments were also made to the confidence in threat assessment for these biotopes.

3 The HELCOM Red List of Underwater Biotopes, Habitats and Biotope complexes

3.1 General Red List results

The HELCOM Underwater Biotope and habitat classification (HELCOM HUB) defines a total of 328 benthic and pelagic habitats (Annex 2). Of these HELCOM HUB biotopes, a threat assessment was made for 209 biotopes (Figure 5). Of the assessed biotopes, approximately a quarter were red-listed, while 73% were classified LC and are therefore currently not seen to be at a risk of collapse (Figure 5). Of these LC classified biotopes, 120 were Level 6 biotopes; 22 were Level 5; 4 were Level 3; and 4 of the pelagic biotopes were categorized as LC on Level 4 (Annex 2).

Of the assessed HELCOM HUB biotopes, 59 (28%) were red-listed (Table 6). One was categorized CR; 11 were categorized EN, 5 were categorized VU; and 42 were categorized NT (Figure 5). Among the benthic aphotic biotopes, the proportion of red-listed biotopes was the highest compared to the photic or the pelagic zone (Table 6).

Benthic aphotic biotopes characterized by macrofauna have the highest proportion of specific biotopes at risk of collapse (Table 6, Figure 6). Only one of the biotopes was assigned the threat category CR: A2b (Annex 1). This biotope occurs in deep muddy areas and is dominated by the ocean quahog (*Arctica islandica*), a species that requires oxygenated, saline water for successful reproduction and growth during the first decade of its lifespan. The water mass under the halocline that contains oxygen was assessed EN: A3 (Annex 1). All these red-listings are likely effects of the large scale hypoxia in the deep parts of the Baltic Sea, coupled to the lack of strong salt water inflows and eutrophication during the past decades (HELCOM 2009a).

Two thirds of the red-listed HELCOM HUB biotopes were characterized by macrofauna and 29% by macrophytes (Figure 6). One of the red-listed biotopes was characterized by peat, one by

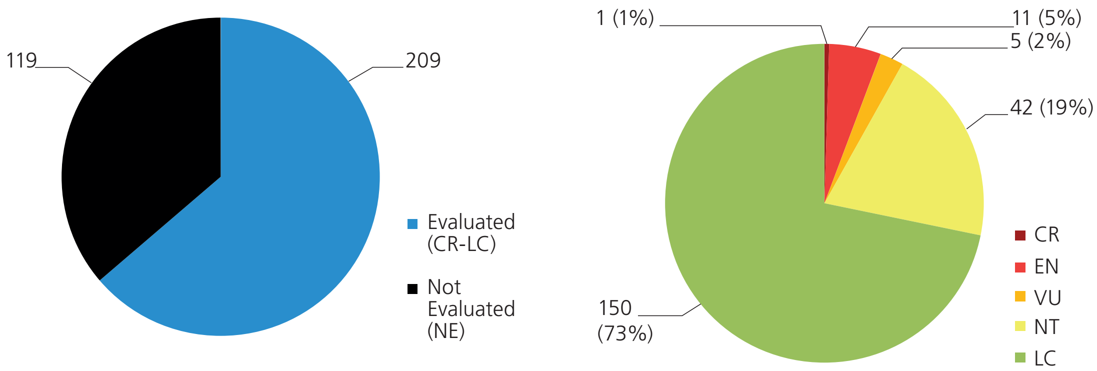


Figure 5. **The proportion of HELCOM HUB biotopes that were assessed (CR–LC) (left) and the proportions of biotopes in the different categories in the assessed group (right).**

Table 6. **Proportion of benthic photic, benthic aphotic and pelagic biotopes and habitats that were assessed and red-listed.**

	Numbers of assessed HELCOM HUB biotopes	Red-listed HELCOM HUB biotopes
Benthic photic HELCOM HUB biotopes	141	29 (21%)
Benthic aphotic HELCOM HUB biotopes	62	28 (45%)
Pelagic HELCOM HUB biotopes	6	2 (33%)
Total	**209**	**59 (28%)**

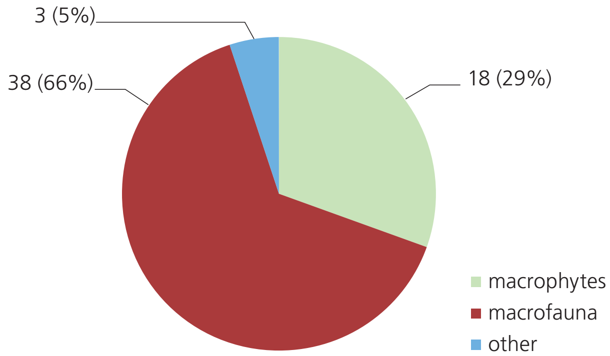


Figure 6. **Proportion of biotopes dominated by macrophytes, macrofauna or other groups that were red-listed.**

sea ice and one by water below the halocline that contains oxygen (Figure 6).

A regional decline will not cause a biotope to become red-listed unless the regional decline is strong enough to affect the quantity or quality of the biotope on the scale of the entire sea to such an extent that the NT threshold value is reached. Because the biotope dominated by *Fucus* spp. on rock, boulder and mixed substrate has declined in many regions, it was not assigned a threat category in the threat assessment. This biotope occurs in several large areas along the Swedish coast, constituting the majority of the distribution area - little or no net loss in quantity has been detected in recent years. Declines in other areas were not significant enough to red-list the biotope on the scale of the whole Baltic Sea.

All biotope complexes were red-listed in the HELCOM Red List assessment (Figure 7, Annex 1), even though some of the underwater biotopes that characterize the biotope complex were not red-listed. EU Member States monitor and report the state of the biotope complexes since all ten biotope complexes recognized in HELCOM HUB are listed in the Habitats Directive Annex 1 and have already been identified as requiring particular conservation measures. All biotope complexes, except one, were threat assessed based on a decline in quality. Since the biotope complexes are monitored, some data exist on the trends in quantity and quality. The spatially rare biotope complex '*Submarine structures made by leaking gas*' (1180) was assessed by the criterion B.

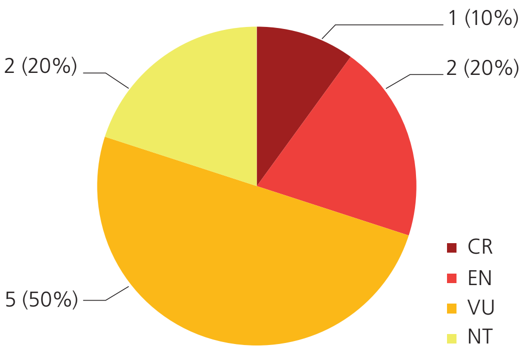


Figure 7. Proportion of the biotope complexes in the Red List categories.

The assessment justification and general descriptions of the biotopes, habitats and biotope complexes that were red-listed (CR–NT) are given in the Biotope Information Sheets (BIS). In total, 42 BIS were prepared for the red-listed biotopes, habitats and biotope complexes. As some of the 59 red-listed HELCOM HUB biotopes were seen to form one biotope in nature, only one BIS was prepared for them (Annex 1).

Results of the HELCOM Red List assessment made on the scale of the whole Baltic Sea can differ significantly compared to national or regional Red Lists or other threat assessments. For instance the biotope complex '*Reefs*' (1170) is considered to be more threatened in the southern parts of the Baltic sea compared to the northern parts where they occur commonly. In the Baltic Sea wide assessment, a regionally threatened complex will not raise the overall threat status unless the decline constitutes a large percentage of the total area covered by the complex. The same principle applies to the assessment of biotopes and habitats. For instance, while the biotope dominated by *Zostera marina* is considered Vulnerable (VU) in Finland's national Red List (Raunio et al. 2008), it was assessed as Near Threatened (NT) on the Baltic Sea scale. The Baltic Sea biotopes are affected by several environmental gradients in the case of the biotope dominated by *Zostera marina*, for example, the low salinities along the Finnish coast may have made the biotope more sensitive to other pressures. The HELCOM Red List of Biotopes should not be viewed as a replacement of national or regional Red Lists, but as an overarching assessment of the threat of biotopes collapsing on the scale of the whole Baltic Sea and accordingly providing a framework for the interpretation of regional assessments.

3.2 Application of the Red List sub-criteria

The application of the threat assessment criteria A, B and C to the biotopes was often problematic due to a lack of data. Optimally, long-term data on the characteristics of the biotope would be assessed directly against all three Red List criteria. Since data was unavailable or available for only one criterion, the threat assessments were mostly carried out based on inference and expert judgement.

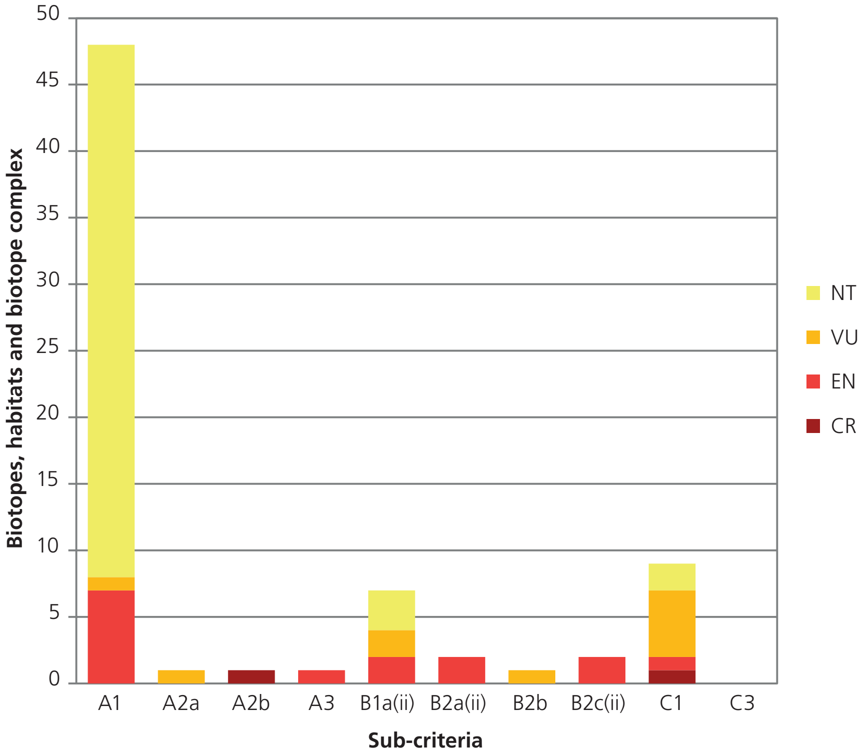


Figure 8. **Sub-criteria applied to the biotopes, habitats and biotope complexes in the assessment.**

However, the quantitative numeric threshold-values of the criteria were applied to the estimated trends. For instance, if the expert judgement was that the area covered by the biotope in the Baltic Sea has decreased by more than a third since 1970, then the biotope was categorized VU by criteria A1, simultaneously taking into account the qualitative criteria for the category "biotope types which show a decline of their spatial expanse or appearance in large parts of the assessed area, respectively, or are locally completely destroyed".

The absolute majority of the biotopes were assessed based on a decline in quantity, the criterion A (Figure 8). Sub-criterion A1, which describes the decline during the past 50 years, was the most commonly applied sub-criterion. The biotope *Baltic seasonal sea ice* (AC) was red-listed due to a predicted decline in quantity over the future 50 years described in criterion A2a and the aphotic muddy biotope dominated by *Arctica islandica* was assessed based on A2b as the biotope is predicted to disappear in the near future (Figure 8).

Nine of the HELCOM HUB biotopes were red-listed based on the criterion B and some of them were categorized by more than one sub-criterion (Annex 1, Figure 8). The most common sub-criterion B1a(ii) describes a rare biotope that has a restricted extent of occurrence (EOO) and a predicted continuing decline in an environmental parameter that affects the characteristic biota.

All biotope complexes, except for one, were assessed based on quality degradation during the past 50 years (sub-criterion C1, Figure 9). Biotope complexes are thought to be rather persistent and are not easily red-listed based on a decline to the extent described in the criterion A. The biotope complex '*Submarine structures made by leaking gases*' (1180) was threat assessed based on rarity (sub-criterion B2c(ii), Figure 8).

Some biotopes were given quality decline (criterion C) estimates in the first questionnaire, however for these biotopes the decline in quantity (criterion A) warranted an even higher threat category. The general level of data on decline in quality of biotopes has severe gaps, even for biotopes that are considered well studied, such as the bladderwrack (*Fucus* spp.) on hard substrates. The qualitative decline could therefore not be assessed strictly by quantitative criteria as sug-

Kelp has not declined to an extent that would warrant red-listing of the species on the Baltic Sea scale, however the biotope 'Baltic photic shell gravel dominated by kelp' (AA.E1C4) was categorized NT: B1a(ii) based on the rarity of the biotope. Phtoto: OCEANA/ Carlos Minguell

gested in Keith et al. (2013). The biotope dominated by *Fucus* spp. on rock, boulder and mixed substrate is functionally diverse, and it would thus be highly relevant to make a threat assessment based on the trend on functional characteristics. The degradation of a biotope is often manifested as a decline in function before a trend in quantity can be seen (Keith et al. 2013).

The assessed biotopes represent the lowest possible unit in HELCOM HUB. In practice, Level 6 biotopes were most commonly assessed and some Level 2–Level 5 biotopes were also assessed when the biotope had not been delineated to lower levels (Annex 2). HELCOM HUB Level 5 biotopes are thought to cover nearly the whole Baltic Sea and since Level 5 biotopes were not assessed if Level 6 biotopes were assessed, the current threat assessment might not cover the entire Baltic Sea underwater area (HELCOM 2013c).

Even though cumulative threats are to be taken into account when making a threat assessment of HELCOM HUB biotopes, a threat category assigned to a biotope on one Level cannot be directly transferred to biotopes on another Level. For instance, threat categories cannot be created for Level 5 biotopes by defining the 'mean' category of the lower Level 6 biotopes. The Red List criteria should be directly applied to the Level 5 biotope (Table 7); however, threats affecting the Level 5 biotope should be taken into account when assessing the lower Level 6 biotope. It is likely that on Level 5, the proportion of threatened biotopes would be lower since on that level, biotopes cover on average larger areas; on the other hand, potential declines in Level 6 biotopes are compensated by an increase of other Level 6 biotopes within the same Level 5 biotope. In other words, targeting the assessment only on Level 5 would mean losing information, especially on the status of rare biotopes.

It is possible that an assessment by quality criterion C would assign the Level 5 biotope a higher

Table 7. Hypothetical example of a Level 5 biotope that is assessed LC by the A1 criteria, based on the assumption that the Level 6 biotope assessed by the A1 criteria constitutes a small decline in the total quantity of the Level 5 biotope on the scale of the whole Baltic Sea.

Red List Category	Red List Criteria	Assessed Level 6 biotopes		Red List Category	Red List Criteria	Hypothetical assessment of the higher Level 5 biotope
LC	A1	AA.H1Q1 - Baltic photic muddy sediment dominated by stable aggregations of unattached *Fucus* spp. (typical form)				
EN	A1	AA.H1Q2 - Baltic photic muddy sediment dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)				
LC	A1	AA.H1Q3 - Baltic photic muddy sediment dominated by stable aggregations of unattached *Furcellaria lumbricalis*	→	LC	A1	AA.H1Q Baltic photic muddy sediment characterized by stable aggregations of unattached perennial vegetation
LC	A1	AA.H1Q4 - Baltic photic muddy sediment dominated by stable aggregations of unattached rigid hornwort (*Ceratophyllum demersum*)				
LC	A1	AA.H1Q5 - Baltic photic muddy sediment dominated by stable unattached aggregations of lake ball (*Aegagropila linnaei*)				

Example

The species ocean quahog (*Arctica islandica*) is listed LC on the Baltic Sea scale.

The data do not indicate a decline in the total population that would have exceeded 15 or 25% during the assessment period (three times the generation length) and it does not have a severely restricted range of occurrence.

The biotope 'Baltic aphotic muddy sediment dominated by ocean quahog (*Arctica islandica*)' is listed CR on the Baltic Sea scale.

This biotope used to occur in the deep southwestern parts of the Baltic Sea, but as the periodic hypoxia has become more frequent on these bottoms during the last decades (Figure 4) and is predicted to even increase in future, the biotope has been considered to be facing a very severe risk of collapse throughout is distribution.

Wikimedia / Hans Hillewaert

Figure 9. **Red List criteria are different for biotopes and species.**

threat category compared to an assessment based on the quantity criteria. In the qualitative description in criterion C, the disappearance of a 'typical variant' raises the threat category, a Level 6 biotope can be interpreted as 'a typical variant' of Level 5 (Table 2). However, such assessments have not been carried out in the current assessment, where threat categories have been assigned only for the lowest possible level in each branch of the classification tree.

The Red List assessment criteria differ somewhat for species and biotopes. For instance, the timescales to be assessed differ: biotopes are assessed on trends occurring over 50 or 150 years whereas species are assessed over 10 years or alternatively three times the generation length, whichever is the longer. The reason for some species being red-listed is the reduction or deterioration of the quality of their habitat (cf. HELCOM On-line Species Information Sheets). Red-listed species may be threatened due to a scarcity of the available biotope they rely on even though that particular biotope is not red-listed (Figure 9). One reason can be that the species is also restricted by salinity, for example, so that some of the available biotope occurrences elsewhere in Baltic Sea are not available to that species. A biotope defined by the domination of a certain species can also be red-listed without that particular species being red-listed in a Red List of species. This can occur, for example, if a threatened biotope is be defined by a certain substrate and the dominant species; however, the species might occur also on other substrates and might be a common species.

3.3 Confidence of the threat assessment

The availability of long-term monitoring data was poor - the assessments are mainly based on environmental data, some distribution data on the biotopes and expert judgements. None of the biotopes, habitats or biotope complexes on the Red List were assigned the confidence of threat assessment category High (H) (Annex 1, Figure 9). The assessment of the photic hard substrate biotope dominated by *Fucus* spp. might have qualified for the High (H) confidence category had the biotope been red-listed as the extent of the biotope has been monitored in many areas for several decades.

Confidence of the threat assessment was Low (L) for 39 and Moderate (M) for 18 of the red-listed biotopes (Annex 1, Figure 10). The characteristics of the currently red-listed biotopes have not been extensively monitored, and it is this lack of long-term data that causes the reliability of the assessment results to be categorized as low or moderate.

Biotope complexes were also assigned a confidence value. The confidence value Moderate (M) was assigned to seven of the ten biotope complexes. The biotope complexes '*Sandbanks which are slightly covered by sea water all the time*' (1110) '*Mudflats and sandflats not covered by seawater at low tide*' (1140) and '*Reefs*' (1170) were assigned the category Low (L) (Annex 1). The lower confidence mainly reflects the differences in the interpretation of the definition of the biotope complexes by the countries.

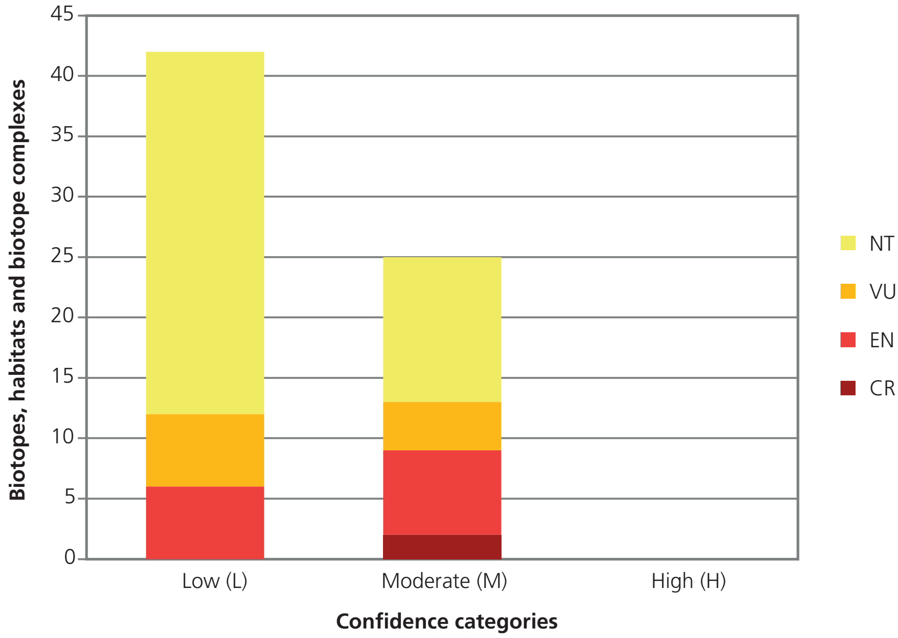


Figure 10. The confidence of the threat assessment of the red-listed biotopes by threat category.

3.4 Biotope Information Sheet (BIS)

A total of 38 Biotope Information Sheets (BIS) were created for the 59 red-listed HELCOM HUB biotopes as some were seen to describe the same biotope in nature (Annex 1). The BIS give further details of the ecology and distribution of the red-listed biotopes and also describe the threat factors that have caused a decline in the quantity or quality of the biotope. Some of the red-listed biotopes have been red-listed previously. To enable a comparison, the BIS also contain a reference to previous HELCOM Red Lists (HELCOM 1998, HELCOM 2007). They also contain an assessment justification, detailing why the biotope was assigned to a certain threat category. All the biotope complexes recognized in HELCOM HUB are included in the habitats directive (HELCOM 2013c). The information sheets created for the biotope complexes are based on how the biotope complexes have been defined in the EU Habitats Directive Article 17 and Annex 1.

In future Red List projects, it could prove useful to also create BIS for biotopes in decline, even though the decline has not been severe enough to make the biotope red-listed. Also, biotopes that have declined severely regionally but not on the scale of the whole Baltic Sea, or biotopes that have been red-listed in previous assessments could be described in more detail through Biotope Information Sheets.

All Biotope Information Sheets are published online and are available through the HELCOM website.

3.5 Past and current reasons for biotopes, habitats and biotope complexes becoming threatened and future threats

The Red List criteria only assess how much a biotope has declined in quantity or quality, but does not specify the reason for the decline. Biotopes that exhibited a decline exceeding the threshold values of the Red List categories were analysed further to also identify the factors causing the decline.

In the HELCOM Red List of Baltic Sea species in danger of becoming extinct, 24 different types of threats were identified (HELCOM 2013d). The same threats were used to assess the cause of decline for biotopes, excluding a few threat-types that apply only to species (Table 8). Some of the listed threats have not been identified as a specific threat for the currently red-listed biotopes, but they are considered to be potentially relevant in future updates of

Table 8. **The underlying cause of the decline of a biotope is identified by assigning threat codes to red-listed biotopes.**

Alien species: competition, predation, hybridization, diseases, ecosystem changes by introduced species	
Climate change: all detrimental effects of climate change	
Construction: all marine construction activities, e.g. wind power farms, gas pipelines, bridges, dredging, ports, coastal defence barriers, also coastal terrestrial construction, if relevant (vacation homes or roads), also noise from construction or operation	
Contaminant pollution: all pollution to waters by hazardous substances, except for oil spills which have their own code (coastal industry, riverine load of heavy metals, discharges of radioactive substances, atmospheric deposition of metals and dioxins, polluting ship accidents excluding oil spills)	
Ditching: ditching and draining of mires and coastal meadows	
Epidemics: large-scale epidemics or diseases	
Eutrophication: detrimental effects of nutrient enrichment that can be defined in more detail, e.g. anoxia and hypoxia, excessive growth of algae, reduction in water transparency, or siltation	
Fishing: both commercial and recreational fishing, surface and mid-water fishery, bottom-trawling, coastal stationary fishery, gillnets	
Litter: plastic waste, ghost nets etc.	
Mining and quarrying: extraction of bottom substrates	
Oil spills: oil spills from ship accidents, also from oil terminals, refineries, oil rigs	
Other threat factors: specific, known threat factors that are not covered by the other threat codes	
Overgrowth of open areas: e.g. coastal meadows or shallow water areas that become overgrown due to lack of management (related to eutrophication and interfloral competition, incl. expansion of reeds)	
Random threat factors: used only for biotopes or habitats that are so rare that even random catastrophic events can destroy the occurrence (applied to biotopes assessed by B-criteria)	
Tourism: detrimental effects of tourism, e.g. trampling of beaches, scuba diving	
Unknown: threats are not known	
Water traffic: physical impact due to traffic, e.g. erosion caused by anchoring, boat wakes and other vessel effects	

Dredging of shallow coastal areas and other construction activities has been identified as one of the most severe past and future threats to underwater biotopes. Photo: Metsähallitus NHS/Jan Ekebom

Eutrophication is identified as the threat that has affected nearly all red-listed biotopes, habitats and biotope complexes. Photo: Maritime Office Gdynia.

the Red List. The threats are further specified for the red-listed biotopes in the Biotope Information Sheets (BIS) using the threat codes of the Habitats Directive Article 17.

Of the 14 main classes of threat factors in Table 8, eutrophication has had an adverse effect on the highest number of the red-listed HELCOM HUB biotopes in the past and this threat is predicted to continue to affect the biotopes (Figure 11). Eutrophication in this context refers to the anthropogenic eutrophication stemming from the exess of nutrient inputs from various scources. Biotopes characterized by algae or plants are adversely affected by lower water clarity, whereas biotopes characterized by epibenthic filtering animals may be adversely affected by higher siltation levels. Certain organisms such as some annual filamentous algae and macrophytes as well as certain fish and bird species tend to benefit from eutrophication. Oxygen depletion is another eutrophication driven mechanism that can cause biotopes to become red-listed, although it simultaneously may increase the extent of some biotopes characterized by anoxia. The effects by which eutrophication threatenes the biotopes have not been specified for the red-listed biotopes.

The threat caused by fishing (Figure 11) refers mostly to physical damages to benthic biotopes

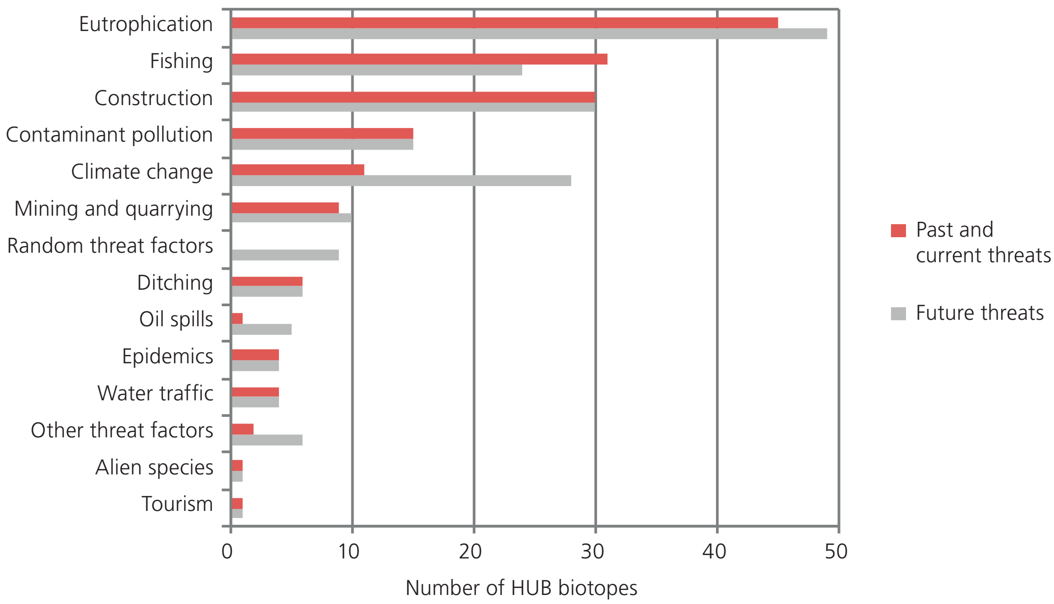


Figure 11. Threats affecting the 59 red-listed HELCOM HUB biotopes.

from bottom trawling, which is mainly practised in the southern parts of the Baltic Sea. Various marine construction activities have also affected a large number of the red-listed biotopes in an adverse way (Figure 11). Among the varying construction acitivities, the pressure from sand extraction and various other marine constructions further specified according to the Habitat Directive, in particular, have had and are predicted to continue to adversely affect the red-listed biotopes.

In the future, climate change is predicted to be a significant threat factor to the biotopes (Figure 11). The predicted decline in sea ice due to climate change is a factor for red-listing the habitat '*Baltic Sea seasonal ice*' (AC) as VU by the sub-criterion A2. This threat factor was also identified as a possible future threat in other biotopes characterized by species that prefer cold and saline water, such as the mussels *Astarte* spp. and the ocean quahog (*Arctica islandica*). Climate change is also predicted to affect the biotopes through ocean acidification, which may affect calcified organisms as the decreasing pH of sea water harms shell formation. This is inferred to cause a decline in the quality and quantity of the biotopes characterized by a shell gravel substrate among others.

'Random threat factors' are a distinct future threat identified for the very rare biotopes that have been assessed using criterion B (Figure 11). They describe any random event that can affect the local environment and cause changes to the biotopes. If the area affected by a random event is larger than the whole distribution of a biotope, the random event can potentially cause the collapse of the biotope in the entire Baltic Sea. Such random events in the Baltic Sea might include unforeseen changes in environmental conditions due to construction work or a local point source of pollution by hazardous substances. The very rare biotopes include e.g. *Baltic photic and aphotic maërl beds* (AA.D, AB.D), *Baltic aphotic hard clay dominated by Astarte spp.* (AB.B1E4), *Baltic photic peat bottom* (AA.G), *Baltic photic or aphotic shell gravel dominated by vase tunicate (Ciona intestinalis)* (AA.E1F1 & AB.E1F1). These biotopes are mostly found in the southwestern part of the Baltic Sea and for many, fishing in the form of bottom trawling has also been identified as a significant threat factor. 'Eutrophication'

Estuaries have been severely affected by construction activities in the Baltic Sea region, historically harbours were often established in these areas. Photo: Maritime Office Gdynia.

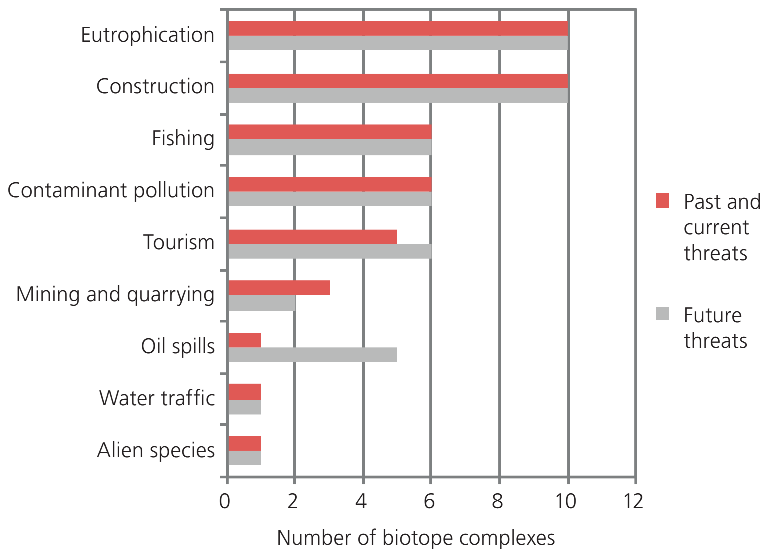


Figure 12. **Threats affecting the ten biotope complexes.**

is also believed to have had a negative impact on the rare biotopes in the past and is believed to continue in the future.

The ten biotope complexes were all red-listed - eutrophication is thought to have affected most of the complexes in an adverse way (Figure 12). Construction has affected the 'Estuaries' (1130) to an extent where only very few estuaries retain the natural function causing the complex to be listed as CR: C1. The rare biotope complex '*Submarine structures made by leaking gas*' (1180) is believed to be threatened in the future by tourism activities such as scuba diving (Figure 12).

3.6 Comparison of the results with the previous evaluations of threatened biotopes in the Baltic Sea

Fifteen years have passed since the last comprehensive Red List threat assessment of Baltic Sea underwater biotopes (HELCOM 1998). The report gave some cause for concern as 15% of the biotopes were classified as 'heavily endangered' and 68% as 'endangered', implying that only one in five underwater or terrestrial coastal biotopes was not under threat. Some additions were made to the Red List assessment in 2007 (HELCOM 2007).

Comparing the up- or down-listing of the threat categories directly between this assessment and the one made in 1998 is not possible since the criteria, categories and the biotope classification have changed. Most of the changed threat categories are probably a result of the changed methodology rather than a dramatic change in the biotopes status in nature. The new classification system for Baltic Sea Biotopes, HELCOM HUB, has produced a finer grained separation of the biotopes based on ecological data. In 1998, the qualitative criteria of the German Red list of Biotopes were used as a basis for the threat assessment and a selection of biotopes were assessed.

Eutrophication was identified as the most significant threat to Baltic Sea biotopes fifteen years ago (HELCOM 1998) and the same major threat still remains (Figure 11). Construction is also a remaining significant threat factor. Dredging and dumping of dredged materials also remain a threat.

Of the underwater biotopes, only the biotopes 'sublittoral level sandy bottoms dominated by macrophyte vegetation' and 'offshore (deep) waters below the halocline' were assigned the higher threat category '2' in the 1998 assessment (HELCOM 1998). None of the assessed HELCOM HUB biotopes corresponds directly to the biotope assessed in 1998, in the current threat assessment this biotope has been assessed at a more detailed scale defined by various biotope forming vegetation communities. For instance, the biotopes '*Baltic photic sand dominated by Charales* (AA.J1B4), *Baltic photic sand dominated by common eelgrass'* (AA.J1B7) and '*Baltic photic sand dominated by spiny naiad'* (AA.J1B5) were assigned the threat category NT, and the biotope '*Baltic photic sand dominated by stable aggregations of Fucus spp. (dwarf form)*' (AA.J1Q2) was categorized EN. Other biotopes delineated based on the sandy substrate and macrophyte vegetation were assessed as LC.

In 1998, all the pelagic biotopes were assigned the threat category '3', which most closely corresponds to the category VU in the current assessment. It should be noted that HELCOM HUB delineates pelagic biotopes based on the horizontal stratification; in the 1998 assessment, however, the pelagic habitat was delineated based on whether they were off shore or coastal. In the current Red List assessment, only the pelagic habitat under the halocline that remains oxic (AE.O5) was red-listed and categorized as EN due to a decline in quantity.

Table 9. **Summary of the results of the current assessment and the HELCOM Red List assessment made in 1998. The results are not directly comparable due to the difference in threat categories and assessment methodology.**

Threat category HELCOM 2013	Number of biotopes assessed by category	Closest corresponding threat category HELCOM 1998	Number of biotopes assessed by category
CO	0 (0%)	0	0 (0%)
CR	1 (0%)	1	0 (0%)
EN	11 (3%)	2	2 (3%)
VU	5 (2%)	3	58 (87%)
NT	42 (13%)	P	4 (6%)
LC	150 (46%)	*	0 (0%)
DD	0 (0%)	?	2 (3%)
		-	0 (0%)
NE	119 (36%)	x	0 (0%)

Not enough of the quality trend was known to assess the criteria C for the pelagic habitats.

Shell gravel biotopes were the only benthic biotopes assigned '?' in 1998. In the current assessment based on the HELCOM HUB delineation of the biotopes, shell gravel biotopes have been assessed. Shell gravel biotopes, formed by *Mytilus* spp. shells, which also occur in the northern parts of the Baltic Sea, were assessed as LC whereas shell gravel areas formed by molluscs that require high salinity waters were assessed NT for biotopes where the shell has been ground to fine sand (AA.E3Y, AB.E3Y), and VU if the shell gravel is characterized by the tunicate *Ciona intestinalis* (AA.E1F1, AB.E1F1). The level of knowledge as regards the shell gravel biotopes is still low however, especially for the biotopes occurring in the southwestern regions of the Baltic Sea.

The highest up-listing of a biotope could be seen to have occurred for the biotope '*Baltic aphotic muddy sediment dominated by ocean quahog (Arctica islandica)*' (AB.H3L3). In the 1998 assessment, the closest resembling biotope, which covers a much larger variety of biotopes, 'Muddy bottoms of the aphotic zone' (2.7.1.) was only categorized '3'.

A total of 14 biotope complexes were assessed in the HELCOM 1998 Red List, of which some were coastal and semi-terrestrial. All of the biotope complexes were seen to be threatened and assigned category '3'; the complex 'Lagoons including Bodden, barrier lagoons and Flads' was assigned the higher threat category '2'.

Estuaries were assessed both in 1998 (code J) and 2013 (code 1130). When applying the Red List criteria (Table 2) to estuaries, those exhibiting natural water dynamics and naturally functioning biotopes were seen to have become nearly non-existent (Annex 1). In the 1998 assessment, the complex was only seen to be in danger of becoming 'decisively changed' characterized by a decline in typical biotope types of the complex in several regions. Category '1' was defined by the complex being in 'in immediate danger of becoming decisively changed' characterized by the 'quality being negatively affected nearly in the whole area so that all biotope types with their typical or natural variants being only left in one or very few subregions'. This definition describes the situation of the estuaries that caused them to be categorized as CR: C1 in the current assessment. The result cannot be interpreted as decisively indicating a dramatic deterioration in quantity; rather, it can be argued that the interpretation of the natural state and quality is stricter in the current assessment of the estuaries compared to the 1998 assessment.

In the current Red List assessment, the biotope complex '*Submarine structures made by leaking gas*' (1180) was assessed EN as one complex, while in 1998 the bubbling structures were categorized 'P' and assessed as a group of different biotopes: 'Bubbling reefs in the aphotic zone' (2.10.1.), 'Sublittoral bubbling reefs with little or no macrophyte vegetation of the photic zone' (2.10.2.1.) and 'Sublittoral bubbling reefs dominated by macrophyte vegetation of the photic zone' (2.10.2.2.). Category P was not a threat category, and it is also stated that 'biotopes potentially threatened are those which have been always rare or which exist only in a small area but which might easily quality for even the category '0' if their small area of distribution is affected by adverse impacts'. In the current assessment, the complex was assessed as EN based on criterion B2c(ii) indicating that it is very rare and that random threat factors may therefore cause it to collapse.

3.7 Other national and regional Red Lists of marine habitats or ecosystems

3.7.1 Globally

Globally, the majority of Red Lists or lists of threatened habitats/ecosystems/communities have focused on terrestrial biotopes with some coastal areas also being considered (e.g. Paal 1998, Westhof et al. 1993). A few assessments have focused on terrestrial biotopes and included underwater marine areas when specific biotopes in the marine areas have been known to be under threat or decline (e.g. Raunio et al. 2008, Riecken et al. 2006).

The methodology for assessing biotopes, ecosystems or ecological communities has been developed both regionally (e.g. Faber-Langendoen et al. 2007, Nicholson et al. 2009) and on a more global scale by IUCN with the aim of developing unified criteria (Rodríguez et al. 2011, Keith et al. 2013). In accordance with the resolution in 2012, IUCN strives to seamlessly integrate methods and Red Lists of both species and ecosystems so that databases containing information from either type of list, for example, can be searched simultaneously. The generic criteria should be applicable to both terrestrial and marine systems.

3.7.2 OSPAR

OSPAR has adopted a list of threatened or declining habitats that have been identified based on the Texel-Faial Criteria (OSPAR 2003). When the Texel-Faial Criteria are applied, the sufficiency of data and extent of reasonable expert judgement has to be evaluated and all the defined six criteria should be applied as far as possible (OSPAR 2003). The selection criteria for habitats include: global importance, regional importance, rarity, sensitivity, ecological significance and status of decline. Decline is defined as a significant decline in extent or quality that can be historic, recent or current, and should only be regarded when it goes beyond the natural variability and resilience of the habitat (OSPAR 2003). This Red List applies the precautionary principle by listing biotopes that are assumed to have declined, compared to the OSPAR approach that requires data to indicate a decline before a habitat can be listed. The confidence in the decline and threat status of the habitats listed by OSPAR is more stringently validated compared to the HELCOM Red List.

Many of the habitats listed as declined and/or threatening by OSPAR (OSPAR 2008a) do not occur in the HELCOM area and are thus not included on the HELCOM Red List. The OSPAR list identifies the habitat 'Sea-pen and burrowing megafauna communities' as being under threat and/or in decline in Region II that includes the Kattegat (OSPAR 2008a). The corresponding HELCOM HUB biotope '*Baltic aphotic muddy sediment dominated by sea pens*' (AB.H2T1) has been assessed as EN: A1 with moderate confidence in the threat assessment. The OSPAR assessment states that the current level of information on the decline in extent is uncertain due to the difficulty of sampling the habitat, whereas the threat posed by demersal fisheries is clearly significant (OSPAR 2008b). HELCOM red lists the 'Baltic photic and aphotic maërl beds' (AA.D, AB.D) EN: A1 for the Kattegat region where the habitat is known to occur; the confidence of the assessment for the photic habitat is moderate (M) whereas it is low (L) for the aphotic habitat as it is not clear whether maërl beds occur in this zone. 'Maerl beds' are included in the OSPAR list of declining and/or threatened habitats, however the habitat is not listed in OSPAR Region II and in the case report it is stated that maërl does not occur in the Baltic Sea (OSPAR 2008b). OSPAR lists 'Zostera beds' as threatened and declining based on the past mass die-back caused by the wasting disease and later indications of decline in extent especially in Region II (OSPAR 2008b). '*Baltic photic muddy sediment, coarse sediment, sand or mixed substrate dominated by common eelgrass (Zostera marina)*' (AA.H1B7, AA.I1B7, AA.J1B7, AA.M1B7) is red-listed (NT: A1) by HELCOM.

3.7.3 Other Red Lists and threat assessments

In the German Red List of habitats, the underwater habitats of the Baltic Sea coast have been defined and assessed much in the same way in the HELCOM assessment (Riecken et al. 2006, HELCOM 1998). The threat assessments are made based on (1) loss of area and (2) loss of quality, and whenever both criteria are applied, the one which gives a higher threat category is chosen to define the final threat category. Rarity is regarded as a category in the German Red List, while in the current HELCOM assessment rarity is a criterion. The habitats can be threatened due to factors and processes that can directly and rather quickly destroy an occurrence of a biotope (e.g. dredging), but also by processes that cause slower and more gradual changes (e.g. gradual eutrophication causes changes in relative species abundances within a biotope). The criteria are qualitative, and therefore somewhat prone to subjectivity. In total, 13 Baltic Sea offshore biotopes were assessed in addition to Baltic Sea coastal areas such as Boddens and fjords (Riecken et al. 2006).

The German approach was further developed in Austria and Finland in order to improve the repeatability and transparency of the method (Essl et al. 2002, Kontula & Raunio 2009). In Austria, quantitative thresholds were added to the criterion that concerns change in quantity and changes that have occurred during the past 50 years. The Finnish method builds on the Austrian method and adds sub-criteria that define the rules of how to adjust the assessment results on the basis of near future trends, early decline or deterioration (prior to the 1950s) and commonness/rarity of the biotope. The Finnish assessment method produces Red List Categories similar to the IUCN criteria system that is applied for species. The most fundamental drawback of the Finnish method is the remaining subjectivity, especially in the assessment of the qualitative change of a biotope.

In Australia, threat assessments on ecological communities have been carried out under federal law (Anonymous 2009). The Australian assessment criteria for ecological communities have integrated a variable time span but they lack quantitative thresholds. A Scientific Committee assesses whether the community meets the criteria for listing threatened ecological communities (New South Wales Government 2009). Of the assessed communities in Australia, only one, the 'Giant Kelp Marine Forests of South Eastern Australia' which is listed as 'Endangered', clearly describes an underwater marine community.

In America, NatureServe has developed methods for the threat assessment of species and ecosystems (Master et al. 2012). The methods are applied by the natural heritage programmes and conservation data centres that are members of the organization throughout North America, and the network collects data to assess the risk of extinction on both the national and regional levels as well as globally (Master et al. 2012). The methods are mainly applied to threat assessments of terrestrial ecosystems, even though freshwater and marine ecosystems are also included (Master et al. 2012).

4 Conservation of threatened biotopes in the Baltic Sea

4.1 Conservation globally

Developing global methods for Red List assessments of ecosystems or biotopes and creating comparable Red Lists will support monitoring and reporting on the state of biodiversity (Keith et al. 2013) as required in the Aichi targets adopted by the 10th meeting of the UN Convention on Biological Diversity (CBD) in 2010 (UNEP 2010). All HELCOM countries have ratified the CBD (UNEP 1992). The countries are committed to reaching the three main goals of the Convention: conservation of biodiversity, the sustainable use of components of biodiversity and the fair and equitable sharing of the benefits from the use of genetic resources. The Natura 2000 network is the major EU instrument for fulfilling global commitments of the CBD. It was created based on the Habitats Directive (HD) (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) and the Birds Directive (BD) (Council Directive 79/409/EEC on the conservation of wild birds). The network of HELCOM Baltic Sea Protected Areas (BSPAs) is based on HELCOM Recommendation 15/5 System of coastal and marine Baltic Sea Protected Areas (BSPA) from 1994; many BSPAs encompass the marine areas of Natura 2000 sites.

4.2 Conservation in the EU

The threat assessed biotope complexes in the current Red List are directly protected by European Union nature protection legislation as they are included in Annex 1 of the Habitats Directive, a binding international legal instrument on conservation of species and habitats for the EU Member States. The biotope complexes and how to assess the state of the complexes is also included in the documents of the Marine Strategy Framework Directive (MSFD) (EC Decision 2010/477/EU). The MSFD, HD and BD compel EU Member States to protect and maintain habitats that are not threatened; furthermore, the Member States are compelled, where possible, to restore and enable the recovery of habitats that have declined and become threatened. This implies that the restoration of habitats that are near collapse should be carried out.

The Habitats Directive assessment applies a one-out-all-out approach. This means that a habitat that is judged to be in an unfavourable condition by one criterion is assessed to be in a bad state, even if it is judged to be in a good state by all other criteria. The same approach is applied in Red List assessment criteria. In the Habitats Directive, favourable conservation status (FCS) in the case of natural habitats (ref Article 1(e)) is achieved when:

- its natural range and the areas it covers within that range are stable or increasing;
- the specific structure and functions necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future; and
- the conservation status of its typical species is favourable as defined in Article 1(i).

MSFD Descriptor 1 on biological diversity assesses the functional traits of the biotope complexes and compares the results to a predefined Good Environmental Status (GES). The MSFD is not limited to biotope complexes. The state of predominant habitat types of the water column and the seabed are also to be assessed by three specified criteria by the same Descriptor 1 (Table 10). For the Baltic Sea, the 'predominant habitat types' could be identified through HELCOM HUB. Descriptor 1 qualitative GES is achieved when:

- biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions'.

The HELCOM Red List quantity and quality criteria can identify a biotope that would be classified as being in good or bad state according to, MSFD Descriptor 1, for example. The HELCOM Red List threat assessment should not, however, be directly translated to the HD or MSFD state assessments. A biotope where the quality is degrading is not necessarily in a better state than a biotope where the quantity is degrading. Furthermore, a biotope can become red-listed even though the decline is due to natural processes, whereas a state below GES is due to anthropogenic pressures. The MSFD directs that an ecosystem-based management approach should be applied to human activities in marine strategies, keeping the anthropogenic pressures at a level that does not impede the achievement of GES by 2020. No formal timetable exists for achieving FCS for the HD and BD.

Table 10. **Comparison of criteria for the assessment of biotopes and habitats in the HELCOM Red List, Habitats Directive (HD) and the Marine Strategy Framework Directive (MSFD).**

HELCOM Red List	HD	MSFD
Declining distribution (criterion A) Restricted distribution (criterion B)	Range	Habitat distribution – distributional range – distributional pattern
	Area covered within range	Habitat extent – habitat area – habitat volume, where relevant
Quality degradation (criterion C) – very severe, severe or moderately severe decline in environmental variables or characteristic biota of the biotope	Specific structures and functions including typical species Future prospects	Habitat condition – condition of the typical species and communities – relative abundance and/or biomass, as appropriate – physical, hydrological and chemical conditions

The European Commission considers a Pan European level Red List to be an efficient reporting frame for assessing the threat status of biotopes that have been identified in national and regional Red List projects (Rodwell et al. 2013). The Pan European Red List assessment activity is currently under preparation at the DG Environment. The assessment will be carried out utilizing the EUNIS system that covers all habitat types in Europe. HELCOM HUB was developed to be EUNIS compatible (HELCOM 2013c), and the HELCOM Red List of Baltic Sea biotopes and habitats can therefore be integrated in the forthcoming Red List assessments of marine areas on the European scale.

The majority of the Baltic Sea biotopes delineated in HELCOM HUB are currently insufficiently protected from the various threats that have caused a declining trend in their quantity or quality. In the future when more information on biotope distribution (i.e. maps) becomes available, it will be highly relevant to carry out analyses on the extent of protection through the MPAs for the respective biotopes. Protection may be completely lacking for some of the biotopes whereas others may occur in areas encompassed in the current network of MPAs. Even in this case, it will need to be scrutinized if the protection regime of those MPAs addresses the respective biotopes.

5 Conclusions and proposals of the HELCOM Red List of Habitats/Biotopes project

5.1 Updating the Red List of underwater biotopes, habitats and biotope complexes

The HELCOM Red List of underwater biotopes, habitats and biotope complexes is to be updated regularly in parallel with the updating of the HELCOM Red List of Baltic Sea species in danger of becoming extinct. Updating threat assessments of species and biotopes, the macrospecies checklist and the species and biotope information sheets (SIS and BIS) have been made a part of HELCOM's regular assessment cycle described in the revised Monitoring and Assessment Strategy (HELCOM 2013a). Several projects that generate information on the quantity and quality in the Baltic Sea area are currently on-going and should provide the needed data for future updates.

An update of the Red Lists is planned by the end of 2019. The target of the EU MSFD is to reach good environmental status (GES) in the Baltic Sea by 2020, and by 2021 the actions detailed in the Baltic Sea Action Plan (BSAP) should be implemented. Delivering an updated Red List of Biotopes and Red List of Species for the Baltic Sea in time for this process is important. In the long run, the Red List assessment could be repeated every twelve years.

In future updates of the Red List of biotopes, the assessment approach should become even more data-based and include consideration of the changes in biotope quality (criterion C) whenever possible. The finalization of the HELCOM Underwater Biotope and habitat classification (HELCOM HUB) provides a framework for collecting data that are comparable in the whole Baltic Sea context.

The assessment criteria applied in the HELCOM assessment have been developed for a Baltic Sea-wide Red List assessment. Applying the criteria at local, regional or national levels can be useful. National or regional Red Lists of biotopes in the Baltic Sea could be created and existing Red Lists updated within the following years, supporting the planned update of the HELCOM Red Lists that provide a pan-Baltic perspective on the state of underwater biodiversity. When interpreting the results of national or regional Red Lists, it is important to recognize that due to scaling, the threat category may differ for the biotope on a regional scale compared to the HELCOM Baltic Sea-wide assessment. For instance, a biotope classified as Least Concern (LC) on the scale of the whole Baltic Sea may be Critically Endangered (CR) in a particular region.

In future updates of the Red List when more data supporting the biotopes defined in HELCOM HUB has become available, it may be relevant to apply the Collapsed (CO) category. The prerequisite of assigning category CO is extensive mapping. Some of the biotopes defined through HELCOM HUB have only been recorded a few times and thus little is known about the underwater biotopes in the CO category. It is also possible that previously extant but currently non-existent biotopes in the Baltic Sea were not included in HELCOM HUB since they have not been documented in enough detail. A CO threat assessment can only be as relevant as the underlying biotope classification. Biotopes defined through HELCOM HUB could be categorized CO if a change of coverage by the characteristic biotic element took place. For example, if a biotope is defined by a coverage cut-off value of >10% by a characteristic species, and the coverage changed from 15% to 5% and if the biotope characterized by the 15% dominance is no longer found in the Baltic Sea, then the CO category would be applied. Categorizing a HELCOM HUB biotope as CO will become more relevant and better informed as the HELCOM HUB classification system is used in practice, reaffirming the ecological relevance of the cut-off values or indicating values that need to be adjusted.

Since HELCOM HUB was designed to cover every section of the seafloor, biotopes that can be seen to depict a 'bad' environmental state have been included. These biotopes are dominated by, for example, invasive species or anaerobic organisms as in the biotope *Baltic aphotic muddy sediment characterized by anaerobic organisms* (AB.H4U2). Efficient management practices to reduce eutrophication could lead to a significant decrease in area covered by the biotope characterized by anaerobic organisms causing it to become red-listed. A shrinking anoxic area or a reduction in area covered by invasive species is generally considered to be a favourable development, even though it could lead to biotopes becoming red-listed. In order to make the Red List more useful as management tools, one option in future updates is to incorporate the category Not Applicable (NA) and assign biotopes considered to depict an unfavourable environmental state to this category. In the Red List of Baltic Sea species, the category Not Applicable (NA) is applied to taxa not eligible for assessment, such as alien species and vagrants, in accordance with the definition of the category by IUCN (2001) (HELCOM 2013d). Biotopes assigned to the category NA would not become red-listed.

In the current assessment, the biotopes dominated by long-established alien species have been assessed, whereas newer arrivals have not been evaluated. In future updates, the approach to alien species should be better specified. The abundance of alien species in a naturally occurring biotope could be interpreted as a degradation of that biotope's quality; if this interpretation is assumed, it implies that biotopes formed by alien species would not be assessed at all. Another possible method of improving the assessment principles for biotopes characterized by a community dominated by alien species would be to omit the biomass of these species from the split rules in HELCOM HUB where other naturally occurring macroscopic organisms are present. As HELCOM HUB biotopes are defined by relative dominance of coverage and/or biomass or biovolume, a great increase in an alien species in an area may potentially cause a natural biotope to disappear completely due to a change in the biotope classification.

One of the more recent alien species to have affected the biotopes in the Baltic Sea are the *Marenzelleria* spp. polychaete worms that have exhibited a tremendous increase in abundance during the last decades (Norkko et al. 2011). The biotope '*Baltic aphotic muddy sediment dominated by Marenzelleria spp*' (AB.H3M3) has become established in some areas where no macrofauna community previously existed due to a low level of oxygen. However, the *Marenzelleria* spp. dominated biotope has also spread into areas previously classified as '*Baltic aphotic muddy sediment dominated by Monoporeia affinis and/or Pontoporeia femorata*' (AB.H3N1) possibly contributing to the quantity of this biotope decreasing to such an extent that it has become red-listed. Even though the *Marenzelleria* spp. biotope was not directly assessed, it was indirectly considered through the assessment of the *Monoporeia affinis* and/or the *Pontoporeia femorata* dominated biotope. *Marenzelleria* spp. has also spread into areas along the

The invasive polychaete species *Marenzelleria* spp. has occupied benthic areas previously void of macrozoobenthic fauna, but the polychaete is also believed to compete for resources with native macrozoobenthos. Photo: Lena Avellan.

southeast coast classified as '*Baltic aphotic muddy sediment dominated by Chironomidae*' (AB.H3P1). There the appearance of the alien species has not had a visible negative effect on the biomass of the native Chironomidae to date. Theoretically, the absolute biomass of the Chironomidae could remain unchanged; however, if the biomass of the *Marenzelleria* spp. grew to >50% of the total biomass, then the biotope classification in the area would change. These examples highlight the need to further clarify how biotopes assumed to depict an unfavourable environmental status are to be considered in a Red List assessment.

5.2 Coverage and comparability of biotope data

During the Red List assessment process, the severe lack of long-term data on characteristics of all the different biotopes in the Baltic Sea became apparent. Currently, the national monitoring programmes only cover characteristics of a small number of the biotopes and a fraction of the biodiversity. The availability long-term data was poor, especially for rare biotopes. The Contracting Parties should enhance their data collection activities and make the monitoring of species and biotopes part of their regular activities. These data collection and monitoring activities should be coordinated regionally within HELCOM to ensure geographically even distribution of activities and timing of activities that allows data to be compared. Data are especially needed in areas not covered by monitoring linked

More information on the distribution of biotopes is needed and can be gathered through mapping projects and monitoring activities. Photo: Metsähallitus NHS/Sabina Långström.

to the EU Water Framework Directive and the current COMBINE monitoring programme.

The harmonization of monitoring methods is also needed in order to ensure comparability of the data. Identifying a biotope correctly may require several different types of samples from an area. As monitoring practices differ nationally, it is possible that the same biotope is identified differently based on the different sampling methods and the monitoring of different characteristics (e.g. coverage vs. biovolume of macrophytes). Therefore, a method that applies both quantitative grab samples and visual sampling techniques should be developed for when new benthic areas are mapped. Defining biotopes based on the split rules in HELCOM HUB in the whole Baltic Sea area will improve the comparability of the collected data.

5.3 Conservation measures

The assessments of habitats and biotopes using Red List criteria represents a first step towards setting priorities for conservation measures by assessing the threat of collapse. Other factors that may be considered when prioritizing conservation measures include costs, available resources, logistics, the probability of success of the conservation measures, legal frameworks and other biological characteristics (Mace & Lande 1991, Rodríguez et al. 2011). Some habitats and biotopes assessed by the Red List criteria will already be subject to some level of conservation action, for example through the EU Habitats Directive.

It is important to emphasize that a habitat or biotope may require conservation action even if it is not red-listed. Effectively conserved threatened biotopes may, as their status improves over time, cease to qualify for red-listing.

Red-listed biotopes, habitats and biotope complexes in the Baltic Sea require both specific and large-scale conservation measures in order to down-list and avoid collapse. Generally, more than one anthropogenic pressure or other factor threatens the persistence of the biotope. Existing conservation programmes, environmental policies and management plans currently address a majority of the threats and must be implemented. Full implementation of the Baltic Sea Action Plan (BSAP)

Table 11. Some red-listed species occurring in red-listed biotopes or biotope complexes; the table provides some examples and is not exhaustive.

Code Name of red-listed biotope or biotope complex	Red List category and criteria	Characteristic species or taxonomic group of the red-listed biotope or biotope complex		Species Red List category and criteria
1110 Sandbanks slightly covered by sea water all the time	VU: C1	Wintering birds	*Melanitta nigra* *Gavia stellata* *Gavia arctica*	EN: A2b CR: A2b CR: A2b
		Fish and lamperey species	*Pomatoschistus* spp.	
1130 Estuaries	CR: C1	Macrophytes	*Zostera noltii*	VU: B2ab(iii,iv)
		Breeding birds	*Charadrius alexandrinus*	CR: D
		Macrophytes	Charales	
			Potamogeton spp.	
1150 Coastal lagoons	EN: C1	Macrophytes	*Lamprothamnium papulosum*	EN: B2ab(ii,iii,iv,v)
		Benthic invertebrates	*Abra* ssp.	
1170 Reefs	VU: C1	Benthic invertebrates	*Modiolus modiolus*	VU: A2c
1620 Boreal Baltic islands and small islets	NT: C1	Mammals	*Phoca hispida botnica*	VU: A3c
		Breeding birds	*Larus fuscus fuscus*	VU: A2abce
			Arenaria interpres	VU: A2abce + 3ce + 4abce
		Wintering- /Breeding birds	*Cepphus grylle grylle*	NT: A2b
1650 Boreal Baltic narrow inlets	VU: C1	Macrophytes	*Nitellopsis obtusa*	NT: B2a
AA.H1B4, AA.I1B4, AA.J1B4, AA.M1B4 Baltic photic muddy or coarse sediment, sand or mixed substrate dominated by Charales	NT: A1	Macrophytes	*Chara horrida*	NT: B2b(ii,iii,iv,v)
			Chara braunii	VU: B2ab(iii)
			Lamprothamnium papulosum	EN: B2ab(ii,iii,iv,v)
			Charales *(Nitella hyalina)*	VU: B2ab(iii)
			Nitellopsis obtusa	NT: B2a
AA.J3L10, AB.J3L10 Baltic photic and aphotic sand dominated by multiple infaunal bivalve species: *Macoma calcarea*, *Mya truncata*, *Astarte* spp. *Spisula* spp.	NT: A1	Benthic invertebrates	*Macoma calcarea* *Mya truncata*	VU: A2c NT: A2c
AB.H1I2 Baltic aphotic muddy sediment dominated by *Haploops* spp.	EN: A1	Benthic invertebrates	*Haploops tenuis*	EN: B1ab(i,iii) +2ab(ii,iii)
			Haploops tubicola	VU: B1ab(i,iii) +2ab(ii,iii)
AC Baltic Sea seasonal sea ice	VU: A1+2a	Mammals	*Phoca hispida bothnica*	VU: A3c
AB.A1G2, AB.M1G2 Baltic aphotic rock and boulders or mixed hard and soft substrates dominated by sea anemones (Actiniarida)	NT: A1	Benthic invertebrates	*Stomphia coccinea*	VU: B1ab(iii)
AA.D, AB.D Baltic photic and aphotic maërl beds (unattached particles of coralline red algae)	EN: B1+2a(ii)	Benthic invertebrates	*Corystes cassivelaunus*	NT: D2
			Thia scutellata	DD

would, for example, greatly reduce the risk of collapse for the red-listed biotopes through actions that reduce eutrophication.

The management time scale for biotopes is decades and thus conservation measures aimed at preserving biotopes should be implemented in the long term. Any change towards a better quality and quantity happens slowly - it should further be noted that a collapsed biotope may never become re-established (Keith et al. 2013). Currently, red-listed biotopes may become down-listed as a result of increasing knowledge on the trends in distribution and quality expected to be gained through several on-going projects where biotopes are being mapped.

Taking the slow recovery processes into consideration, it is more likely that the status of the red-listed Baltic Sea species will improve compared to the state of red-listed biotopes and biotope complexes by 2021 - a target year in the BSAP. Conserving the habitats and biotopes that serve as a living environment for red-listed species is one of the most important measures in order to retain the special biodiversity of the Baltic Sea (Table 11, HELCOM 2013d, HELCOM 2009b). Baltic Sea biodiversity has intrinsic value and is also valuable as the basis for valuable ecosystem services (HELCOM 2009b).

5.3.1 Reduce eutrophication

The Red List assessment underlines the importance of the ongoing work to decrease the level of eutrophication in the Baltic Sea. Eutrophication has been identified as having an adverse effect on nearly all the red-listed biotopes and biotope complexes. Eutrophication stimulates primary production, which increases turbidity and indirectly causes oxygen depletion in deep areas of the sea as well as at shallower depths in archipelagos. Many measures to reduce eutrophication are already in place and it is important to implement these measures as soon as possible.

Action: Reduce eutrophication

According to the recent PLC-5 (HELCOM 2011) and the TARGREV reports (HELCOM 2012), nutrient loads to the Baltic Sea have been declining since the 1980s and 1990s. However, the decline is not yet much reflected in the status of the Baltic Sea marine environment as seen through, for example, chlorophyll a concentrations and Secchi depth which depicts water clarity.

HELCOM addresses eutrophication through the BSAP nutrient load reduction scheme. Provisional nutrient load reduction targets have been assigned to each Baltic Sea country. The scheme is under review and is to be finalized by the HELCOM 2013 Ministerial Meeting.

Nitrogen and phosphorus loads are addressed in various HELCOM recommendations, such as Recommendation 28E/5 Municipal wastewater treatment, which sets more ambitious targets for phosphate removal than the EU Wastewater treatment directive. HELCOM Recommendation 28E/6 addresses the on-site wastewater treatment of single family homes, small businesses and settlements up to 300 person equivalents (P.E.), while the revised Annex III of the Helsinki Convention 'Criteria and measures Concerning the Prevention of Pollution from Land-Based Sources' focuses on reducing discharges from agricultural land, for example.

Contracting Parties that are also EU Member States further reduce eutrophication by implementing various directives such as the Water Framework Directive and its River Basin Management Plans; the Marine Strategy Framework Directive; the Nitrate Directive; and the Urban Wastewater Treatment Directive.

Agriculture is currently the major source of nutrients. For those Contracting Parties that are also EU Member States, the Common Agricultural Policy demands much of agriculture practices; it will be decisive for the Baltic Sea and the threatened species how the agricultural sector incorporates water protection needs into its activities. The Common Agricultural Policy is currently under review.

5.3.2 Improve knowledge on Baltic Sea biodiversity

Currently, the distribution of biotopes is rather poorly known and thus more information on the distribution and mosaic structure of the biotopes is needed to efficiently implement conservation measures. It has become apparent during the HELCOM RED LIST project that there is a lack of data on most biotopes and regular monitoring activities only concern a small fraction of Baltic Sea biodiversity.

Action: Improve monitoring and data collection on Baltic Sea biotopes

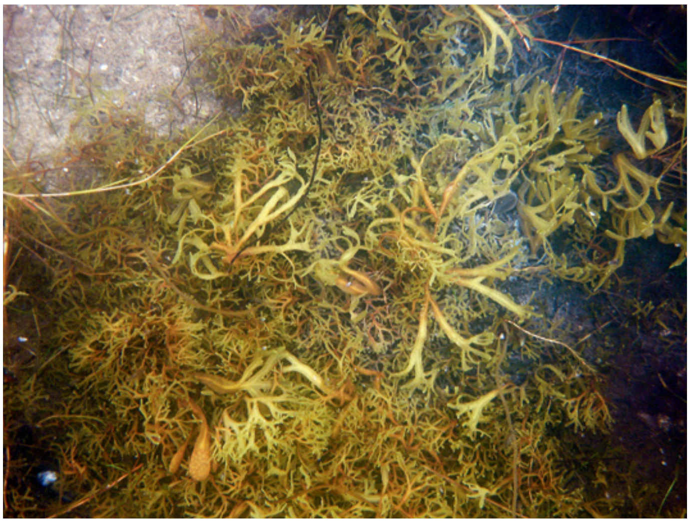
The Contracting Parties should enhance their data collection activities and make some level of monitoring of all biotopes and habitats in the Baltic Sea area as a part of regular monitoring activities. Data collection and monitoring should be coordinated regionally within HELCOM according to the revised HELCOM Monitoring and Assessment Strategy to ensure, for example, geographically relevant distribution and the coordinated timing of activities to allow and ensure the comparability of data. Data collection needs to be more harmonized; for example, substrate definitions vary between national sampling programmes.

Specific improved data and information needs:
- higher resolution mapping projects indicating the distribution of biotopes more accurately;
- information on the temporal variation of biotope distribution; and
- information on the persistence and function of mosaic structures of biotopes in order to better define underwater biotope complexes.

Training new generations of scientists capable of identifying Baltic Sea species is needed. Currently, the lack of expertise may result in a lack of data and false results on the state macrophyte dominated biotopes, for example. HELCOM could initiate activities to support this.

Action: Set up a project as the first step to manage biodiversity data within HELCOM

HELCOM should ensure that the biodiversity data and information on species and biotopes collected during the HELCOM RED LIST project and used for assessments will be made publicly available on the Internet. HELCOM should also develop a biodiversity data portal where regional biodiversity data can be managed and made publicly available to support nature conservation and maritime spatial planning.



The biotope dominated by the unattached dwarf form of Fucus spp. is red-listed, however the taxonomical status of the growth form is currently under scientific debate. Photo: Marilim GmbH/ Karin Fürhaupter.

This should include making available the species assessment justifications; the distributional data on species (at a 10x10 km grid scale for macrophytes and benthic invertebrates); biotope descriptions; photographs on species and biotopes; check-list data; and HELCOM HUB. Linking the HELCOM biodiversity data portal to relevant external data portals, such as national portals for the retrieval of original data, should be an ultimate long-term aim of HELCOM.

This work should be designed so as to serve nature conservation needs as well as those stemming from maritime spatial planning. The work, especially its spatial data component and database, could be developed in such a way that it could be extended to spatial data on human pressures and activities.

HELCOM should set up a project with a Project Manager in the Secretariat, supported by the HELCOM Data Administrator and the HELCOM RED LIST projects species and biotopes teams, to develop an efficient regional biodiversity data management system and database, which are connected to the HELCOM Map and Data system, and via this, ensure public availability.

Action: Regularly update the HELCOM Red List assessments

Regularly updating the Red List assessments of species and biotopes - and the macrospecies checklist and HELCOM HUB if needed - will be made part of HELCOM's regular assessment cycle described in the revised Monitoring and Assessment Strategy.

The first update should be done with the aim of further improving data availability on species and biotopes and, through this, the quality of the red list assessments. In the long run, the assessment could be repeated every twelve years. The Contracting Parties should consider producing and updating their national Red Lists of marine species prior to the HELCOM assessments in order to make data available for the HELCOM assessments.

Bearing in mind that the future work on threatened species and biotopes will require experts, HELCOM Contracting Parties should aim to ensure that the RED LIST projects expert network will be able to continue its work and will be kept active and available.

5.3.3 Strengthening the Marine Protected Areas network

The recovery of a degraded biotope is a slow process while the complete collapse of a biotope can be a rapidly progressing event, especially for rare biotopes. Several biotopes that have been categorized as Endangered or Vulnerable have been assessed according to the criterion B due to a restricted distribution and rarity. These biotopes only occur in a few locations and are often quite small. The most efficient conservation measure for these biotopes is to strengthen the network of Marine Protected Areas (MPA) and their management plans in the Baltic Sea. Strengthening the protective measures in the MPAs should be supported by an efficient management of threats that affect the entire Baltic Sea region, such as eutrophication, ocean acidification and pollution, which affect the biotopes even if they reside in an MPA.

Whenever the network of MPAs is revised or enlarged by designating new areas, the occurrence of different underwater biotopes should be considered. Red-listed biotopes should be protected through the network; however, biotopes that are characterized by important biotope forming species such as *Fucus* spp. and *Mytilus* spp. should also be included in order to protect more cryptic species that rely on these biotopes (HELCOM 2009b). Biotopes that are important for a wide variety of other organisms may currently be widely spread in the Baltic Sea and may not have exhibited a decline that would cause them to become red-listed.

Action: To achieve and maintain an ecologically coherent network of well-managed marine protected areas in the Baltic Sea and provide protection to the red-listed biotopes, habitats and biotope complexes

The assessment of ecological coherence of the network of protected areas revealed that while the network covered 12.3% of the marine areas of the Baltic Sea, it was still not ecologically coherent (HELCOM 2010b). Further efforts are required to identify which of the declining biotopes are currently outside the network of protected areas.

The Baltic Sea network of marine protected areas should be strengthened to ensure the protection of red-listed biotopes. According to the MARXAN analysis carried out in 2010, the MPA network should be expanded to at least twice the size of the then existing network to provide protection to the full range of biodiversity. Areas in the northernmost Baltic, in particular, were pointed out as in need of further protection. The management of the areas should be improved to provide shelter from anthropogenic pressures and to avoid 'paper parks'. According to the 2010 report, activities commonly mentioned as threats to the threatened species, such as fisheries, tourism and recreation, were not at all or only seldom prohibited in the protected areas. Cooperation between the countries and sharing of experiences could be useful when further developing the management of these areas.

Action: Update HELCOM Recommendation 15/5 on Protected Areas

The process of strengthening the network should include the revision of HELCOM Recommendation 15/5 on Baltic Sea Protected Areas to ensure that the needs of the red-listed species and biotopes are sufficiently covered in the network of marine protected areas.

5.3.4 Reducing the pressure of bottom-trawling

Fishing, especially bottom trawling, is a significant threat identified for several biotopes. Bottom-trawling heavily and directly impacts the substrate as well as macrophytes and macrofauna living in or on the bottom. This fishing activity also causes increased turbidity and siltation, which can have an indirect, adverse impact on the biotopes. According to the HELCOM Initial Holistic Assessment (HELCOM 2010a), bottom trawling is especially prevalent in the southern Baltic Sea, the Danish Straits, the Belts and the Kattegat.

HELCOM BSAP contains numerous measures that address fisheries with the Fisheries and Environment Forum being established to oversee their implementation. Fisheries are not in the mandate of the environmental sector and thus cooperation is needed with the competent authorities to reduce this pressure. For those HELCOM Contracting States that are also EU Member States, the fisheries sector is governed by the EU Common Fisheries Policy (CFP), for which the EU has exclusive Community competence.

Action: To address the competent authorities with the view to ensure the reduction of negative direct and indirect effects of bottom trawling

The distribution, intensity and quality of the effects from bottom trawling are still not well understood. A detailed overview of bottom trawling activities, apart from that based on fish landings, is lacking since the VMS data have not been made openly available, even though the enforcement of the DCF calls for Member States to share their VMS data. Member States should currently be producing a VMS data-based overview of bottom trawling activities and should be openly shared by all end users, including the environmental sector. This information should be compared with the information on the distribution of those threatened biotopes and habitats that are under a pressure from trawling. Finally, measures should be taken to bring bottom trawling to a level that is no longer a threat to biotopes and habitats at risk of extinction.

The HELCOM Moscow 2010 Ministerial Declaration addresses unsustainable fishing practices: 'AGREE to further assess the environmentally negative impacts of fishing activities, including unsustainable fishing practices, with the aim as a first step to consider the exclusion of the use of certain techniques in marine protected areas to achieve their conservation objectives.' To this end, HELCOM has developed the BALTFIMPA project (HELCOM Managing Fisheries in Baltic Marine Protected Areas). The project has not achieved sustainable project funding to date, but should be secured in the future.

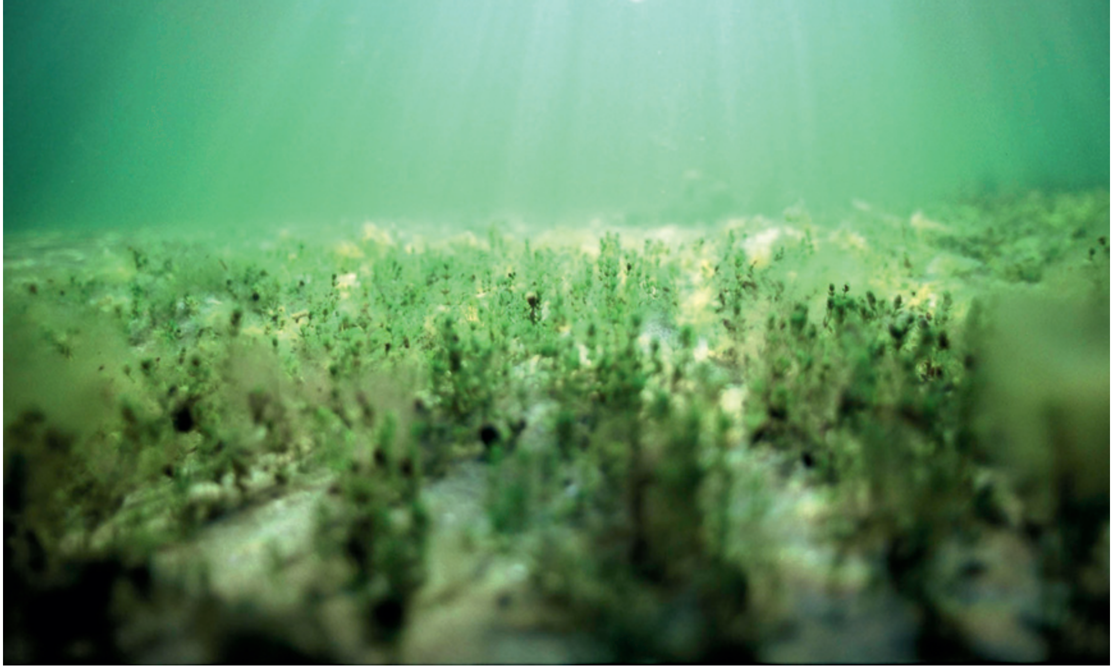
5.3.5 Managing construction activities

Construction activities are the second most often mentioned pressure affecting red-listed biotopes. They include all marine construction activities both coastal and off-shore as well as dredging and building coastal defence structures. Taking the distribution of biotopes into consideration in marine spatial planning is an important conservation measure in order to limit the adverse effect of various construction activities on biotopes.

Action: Maritime Spatial Planning processes should be used to regulate construction activities; prior to construction, baseline studies and risk assessments should be carried out in accordance with standards for the Environmental Impact Assessment; monitoring should also be carried out during the operation phase

Maritime Spatial Planning (MSP) should be used to direct construction activities to areas and intensities that allow the recovery of the red-listed biotopes. Data on the distribution and ecology on the red-listed biotopes should be available for planning processes and their conservation needs incorporated in the plans. Whenever relevant, restrictions to coastal construction activities and dredging should be implemented.

The HELCOM-VASAB Working Group on Maritime Spatial Planning (MSP) was established in 2010. It has developed common principles for MSP in a transboundary setting. According to these principles, Maritime Spatial Planning is a key tool for sustainable management by balancing between economic, environmental, social and other interests in spatial allocations; by managing specific uses and coherently integrating sectoral planning; and by



The soft bottom of shallow lagoons and flads are often covered by meadows of stoneworts (Charales). Photo: Metsähallitus NHS.

applying the ecosystem approach. When balancing interests and allocating uses in space and time, longterm and sustainable management should be prioritized.

Action: Halt the loss of coastal and off-shore habitats

This action is called for by the biodiversity experts and it is fully in line with the BSAP target 'to halt the degradation of threatened and/or declining marine biotopes/habitats in the Baltic Sea', and by 2021 'to ensure that threatened and/or declining marine biotopes/habitats in the Baltic Sea have largely recovered' and the UN CBD Aichi Target 5 'By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced'.

Since the understanding on the current status of habitats is not at a good level, it is proposed that as the first step, core indicators with underlying habitat monitoring will be developed that have targets for the rate of loss of habitats; second, reasons behind habitat loss should be identified; and third, measures should be taken to halt the loss.

5.3.6 Habitat and biotope restoration

The UN CBD Aichi target 15 addresses habitat restoration. HELCOM should consider the regional approach to the implementation of this target on habitats in the Baltic Sea setting in general, specifically from the perspective of the red-listed biotopes, habitats, biotope complexes and species. Habitat and biotope restoration also supports the implementation of the MSFD.

Action: Restore severely degraded habitats and biotopes

Habitat restoration is called for especially in flooded coastal meadows and coastal lagoons. In the BSAP, the Contacting Parties also committed themselves to developing research on the possibilities to reintroduce valuable phytobenthos species in regions of their historical occurrence, especially in degraded shallow waterbodies in the southern Baltic Sea. However, this is one of the few actions on which no activities have been reported in the countries.

Action: Promoting cattle grazing in coastal areas

Threatened macrophyte biotopes are under a pressure from overgrowth by other plant species such as reed. Overgrowth by reed and other plants is related both to eutrophication and the cessation of cattle grazing, especially in the north. With regard to threatened macrophyte biotopes, it seems relevant to promote cattle grazing in shallow, sheltered bays, lagoons and inlets, in particular.

5.3.7 Climate change adaptation and mitigation

HELCOM has addressed the global level by informing the Conferences of the Parties of the UN Framework Convention on Climate Change on the potential deleterious effects of climate change on the Baltic Sea ecosystem. Since combatting climate change is beyond the realm of HELCOM, its work focuses on the adaptation and mitigation of the impacts. Adaptation and mitigation is proposed to include reductions to other human-derived pressures.

Climate change is predicted to increase both precipitation and temperature in the Baltic Sea region (HELCOM 2013b). Over the past 140 years, the increase of the surface water temperature has been of the order a tenth of a degree per decade (HELCOM 2013b). A decrease in salinity coupled with increased temperatures poses a challenging environment for many of the Baltic Sea species that live close to their physiological tolerance limits.

Action: Strengthen the network of marine protected areas to provide shelter from climate change impacts

An ecologically coherent network of protected areas is essential to ensure a space for species and habitats where they are unaffected by other anthropogenic pressures. It may become necessary to assess the boundaries of marine protected areas (MPA) to accommodate possible changes in the distribution of species, biotopes and habitats caused by changes in temperature and salinity. Future analyses of the network, e.g. with MARXAN analyses, should take climate change into account and the network should be evaluated at regular intervals as adjustments may be needed to better support species and habitats with special needs.

The management of MPAs should also take potential impacts of climate change into account. This could include the protection of species and habitats that are currently not red-listed, but could become threatened due to changing environmental conditions.

Action: Develop balancing actions to decrease the effects of toxic pollutants due to climate change causing additional physiological pressure on organisms

The cumulative impacts of climate and pollution stressors are projected to increase with climate change; therefore, in order to reduce the pressures from toxic pollutants, balancing actions in the form of stricter measures against widespread persistent, bioaccumulating and toxic (PBT) substances pesticides and pharmaceuticals are recommended. The use of such compounds is likely to increase due to climate change which, in turn, poses a risk to the marine environment and should thus be addressed.

Action: Increase the knowledge of ocean acidification effects in the Baltic Sea

The global ocean takes up about one fourth of the anthropogenic CO2 emitted to the atmosphere, causing acidification of the marine environment. Although current knowledge indicates that acidification has not progressed alarmingly in the Baltic Sea, acidification and its effects on biota are still poorly understood and further observations, as well as research, are needed to better understand the acidification process and possible linkages to other acidifying substances in the Baltic Sea, among others.

Action: Continuing both long-term monitoring activities and the development of climate change impacts models

The changing climate and ecosystems make long-term observations more valuable than ever. Long-time series of observations are essential for detecting changes in the environment and for validating mathematical models used to create future scenarios that enable basin-wide analyses. Better and sufficient monitoring to capture the impacts of climate change should be ensured by developing indicators for monitoring change and drivers of change in the ecosystems. Increased use of novel observation tools as well as mobile monitoring stations should be encouraged.

5.3.8 Preventing the spread of alien species

Alien species are animals and plants that are introduced accidently or deliberately into an environment where they are not naturally found. Alien invasive species have been identified as one of the key causes of the loss of native species and harm to biodiversity. Under Article 8(h) of the UN Convention on Biological Diversity, contracting parties are required to prevent the introduction and control or eradicate those non-indigenous species that threaten ecosystems, habitats or species. Invasive non-indigenous species are regarded as a serious threat according to the UN CBD, the EU Biodiversity Communication, the MSFD, Habitats Directive, the Bern Convention and the Baltic Sea Action Plan, among others.

Action: Prevention of the introduction and the mitigation of negative impacts of non-indigenous species and the eradication of existing non-indigenous species

Regulations to ensure the adequate protection of aquatic habitats from the risks associated with non-indigenous species should be developed, prohibiting the deliberate introduction of non-indigenous species without permission or control.

The Contracting Parties should prevent the introduction of all non-indigenous species via different pathways (including aquaculture), specifically those via shipping by the ratification and harmonized implementation of the 2004 International Convention for Control and Management of Ships' Ballast Water and Sediments (BWM Convention).

Non-indigenous species should be accommodated in monitoring programmes to provide the early warning of newly introduced species encountered in harbours and ports, for example. There is a need to maintain a database on non-indigenous species to collect and disseminate information on invasive non-indigenous species, including plankton.

Ballast water has been identified as the vector for spreading many non-indigenous species. Photo: Maritime Office Gdynia.

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List of abbreviations

AOO – Area of Occupancy (criterion B)
BD – EU Birds Directive
BIS – Biotope Information Sheet (available at helcom.fi)
BSAP – Baltic Sea Action Plan
BSEP – Baltic Sea Environmental Proceedings, HELCOM series
CBD – UN Convention on Biological Diversity
CO – Collapsed
CR – Critically Endangered
DD – Data Deficient
EN – Endangered
EOO – Extent of Occurrence (B-criterion)
GES – Good Environmental Status (MSFD)
HD – EU Habitats Directive
HELCOM – Convention of the Protection of the Marine Environment of the Baltic Sea Area
HELCOM HUB – HELCOM Underwater Biotope and habitat classification
IUCN - International Union for Conservation of Nature
LC – Least Concern
MSFD – Marine Strategy Framework Directive
NE – Not Evaluated
NT – Near Threatened
OSPAR – Oslo Convention; Convention for the Protection of the Marine Environment of the North-East Atlantic
VU – Vulnerable

Definitions

Many of the definitions to concepts that define biotopes and habitats can be found in HELCOM HUB (HELCOM 2013c)

Alien species = Species or lower taxa occurring outside of their natural range (past or present) and dispersal potential. Some alien species have become invasive, establishing a population in the new area and then undergoing exponential growth and rapidly extending the range (HELCOM 2009b).

Anthropogenically created substrate = Substrates mainly created through underwater constructions, hard substrate constitute pylons, harbour structures, pipelines, etc.; soft anthropogenically created substrates constitute dumping-sites for dredged materials, for example.

Biomass = The weight of an organism. In the classification, biomass is used as a split rule on Level 6 and any type of biomass can be used such as dry-weight, shell-free biomass and wet weight. In the split rule, the weight of all the individuals of a species is intended.

Biotope = The functional unit comprised of a specific habitat and community

Biovolume = Relative volume. In HELCOM HUB, this is a measure applied to plants in the split rule on Level 6; the coverage of the canopy of a species of macrophyte is multiplied by the measured or average height of the species.

Category = In a Red List context, this refers to the categories of threat that biotopes are assigned to, based on how the Red List criteria are fulfilled. The categories are Collapsed (CO); Critically Endangered (EN); Vulnerable (VU); Near Threatened (NT); Least Concern (LC); Data Deficient (DD); and Not Evaluated (NE).

Coarse sediment = The grain size analysis definition of coarse sediment is < 20% mud/silt/clay fraction (<63 µm) and ≥30% grain size 2–63 mm (HELCOM HUB).

Community = Group of organisms interacting with each other and living in a delineated area and usually at the same time; a community can consist of algae, plants, animals and bacteria.

Coverage = Percentage of an area covered by the measured variable, percentage estimated, e.g. from a 1x1 m square area. In the classification, coverage is used to describe substrate and community dominance.

Criteria = In a Red List context, criteria refer to specified rules with threshold values that are used to assess the risk of collapse of a biotope

Dominance = Whichever unit/species exhibits the highest value in comparison to the others.

Emergent vegetation = Helophytes and eventual other groups of plants that emerge through the water surface and are attached to the substrate; free-floating vascular plants are not included.

Epifauna = Animals living on the surface of a substrate.

Habitat = Physical environment delineated by specific abiotic environmental factors such as substrate, salinity, temperature and wave exposure.

Infauna = Animals living burrowed into a substrate.

Macroscopic = Species that can be seen by eye and/or captured when using a sieve according to the guidelines in HELCOM COMBINE Annex C-8 'soft bottom macrozoobenthos'; i.e. in general referring to organisms >1 mm.

Maërl = Collective term for several species of calcified red algae (e.g. *Phymatolithon calcareum, Lithothamnion glaciale, Lithothamnion corallioides* and *Lithophyllum fasciculatum*) that live unattached on the seafloor.

Marl = Marlrock, a soft type of rock that consists of a mixture of mainly clay and calcium carbonate.

Microvegetation = Plants and algae <1 mm.

Muddy sediment = The grain size analysis definition of muddy sediment is ≥ 20% mud/silt/clay fraction (< 63 µm) (HELCOM HUB).

Peat bottom = Seafloor covered by neofossils, peat forms as a result of land sinking.

Pelagic = Water mass can be both off-shore and coastal.

Perennial = A concept that in the classification includes algae, plants and animals that persist in an area for more than one year. In the case of algae and plants, mainly species that serve as habitat for other macroscopic species during the winter months should be considered perennial; i.e. overwintering small plant nodules does not classify the plant as perennial.

Photic zone= The zone above the *compensation* point (where photosynthesis equals respiration). It can be estimated as from the water surface down to the depth where 1% of the light available at the surface remains or 2xSecchi depth. These measures usually correspond to the maximum (potential) depth limit of the vegetated zone.

Rooted = In the classification, this refers to vascular plants with root structures and it also includes Charales. Charales are a group of green algae with root-like structures called rhizoids which anchor the algae to the substrate and thus perform the same major function as the roots of vascular plants.

Sand = Less than 20% of volume is in mud/silt/clay fraction (<63 μm), and at least 70% is between 63 μm and 2 mm (HELCOM HUB).

Sessile macroscopic epifauna = Animals larger than 2 mm that are permanently/semi-permanently attached to the substrate surface. Sessile animals also include blue mussels that are attached to a surface but have the potential to move.

Annex 1. Red List of Biotopes and Habitats and the Red List of Biotope Complexes

The Red List of biotopes contains 59 red-listed HELCOM HUB biotopes and habitats. Biotopes categorized as CR, VU, EN or NT are considered to be red-listed. The confidence of threat assessment is indicated as High (H), Moderate (M) or Low (L). The criterion for assessment describes the criterion and the sub-criterion that places the biotope in the threat category. National concern is stated for biotopes that are ranked more threatened at the national level compared to the scale of the whole Baltic Sea.

Some of the HELCOM HUB biotopes have been grouped together, as indicated by the lines. The 38 Biotope Information Sheets have been prepared for the grouped biotopes.

Table 12. **HELCOM Red List of Baltic Sea biotopes and habitats.**

Biotope code	Biotope/Habitat name	Threat category	Confidence of threat assessment	Criterion for assessment	National concern
AB.H3L3	Baltic aphotic muddy sediment dominated by ocean quahog (*Arctica islandica*)	CR	M	A2	
AA.M1Q2	Baltic photic mixed substrate dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)	EN	L	A1	
AA.H1Q2	Baltic photic mud dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)	EN	L	A1	
AA.I1Q2	Baltic photic coarse sediment dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)	EN	L	A1	
AA.J1Q2	Baltic photic sand dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)	EN	L	A1	
AA.D	Baltic photic maerl beds (unattached particles of coralline red algae)	EN	M	B1+2a(ii)	
AB.D	Baltic aphotic maerl beds (unattached particles of coralline red algae)	EN	L	B1+2a(ii)	
AB.B1E4	Baltic aphotic hard clay dominated by *Astarte* spp.	EN	M	B2c(ii)	
AB.H3L5	Baltic aphotic muddy sediment dominated by *Astarte* spp.	EN	M	A1	
AB.H2T1	Baltic aphotic muddy sediment characterized by sea-pens	EN	M	A1	
AB.H1I2	Baltic aphotic muddy sediment dominated by *Haploops* spp.	EN	M	A1	
AE.O5	Baltic Sea aphotic pelagic below halocline oxic	EN	L	A3	
AA.G	Baltic photic peat bottom	VU	M	B2b	
AB.J3L3	Baltic aphotic sand dominated by ocean quahog (*Arctica islandica*)	VU	M	A1	
AC	Baltic Sea seasonal ice	VU	L	A1+2a	
AA.E1F1	Baltic photic shell gravel dominated by vase tunicate (*Ciona intestinalis*)	VU	L	B1a(ii)	
AB.E1F1	Baltic aphotic shell gravel dominated by vase tunicate (*Ciona intestinalis*)	VU	L	B1a(ii)	
AA.E3Y	Baltic photic shell gravel characterized by mixed infaunal macrocommunity in fine sand-like shell fragments	NT	L	B1a(ii)	
AB.E3Y	Baltic aphotic shell gravel characterized by mixed infaunal macrocommunity in fine sand-like shell fragments	NT	L	B1a(ii)	
AA.E1C4	Baltic photic shell gravel dominated by kelp	NT	L	B1a(ii)	
AA.A1H2	Baltic photic rock and boulders dominated by erect moss animals (*Flustra foliacea*)	NT	L	A1	
AB.A1H2	Baltic aphotic rock and boulders dominated by erect moss animals (*Flustra foliacea*)	NT	L	A1	
AA.M1H2	Baltic photic mixed hard and soft substrates dominated by erect moss animals (*Flustra foliacea*)	NT	L	A1	

AB.M1H2	Baltic aphotic mixed hard and soft substrates dominated by erect moss animals (*Flustra foliacea*)	NT	L	A1	
AA.H1B4	Baltic photic muddy sediment dominated by Charales	NT	M	A1	
AA.I1B4	Baltic photic coarse sediment dominated by Charales	NT	L	A1	
AA.J1B4	Baltic photic sand dominated by Charales	NT	L	A1	
AA.M1B4	Baltic photic mixed substrate dominated by Charales	NT	L	A1	
AA.H1B7	Baltic photic muddy sediment dominated by common eelgrass (*Zostera marina*)	NT	M	A1	Finland, Germany, Poland
AA.I1B7	Baltic photic coarse sediment dominated by common eelgrass (*Zostera marina*)	NT	M	A1	Finland, Germany, Poland
AA.J1B7	Baltic photic sand dominated by common eelgrass (*Zostera marina*)	NT	M	A1	Finland, Germany, Poland
AA.M1B7	Baltic photic mixed substrate dominated by common eelgrass (*Zostera marina*)	NT	M	A1	Finland, Germany, Poland
AA.H1A2	Baltic photic muddy sediment dominated by sedges (Cyperaceae)	NT	M	A1	
AA.H1B5	Baltic photic muddy sediment dominated by spiny naiad (*Najas marina*)	NT	M	A1	
AA.J1B5	Baltic photic sand dominated by spiny naiad (*Najas marina*)	NT	L	A1	
AA.H3L3	Baltic photic muddy sediment dominated by ocean quahog (*Arctica islandica*)	NT	M	A1	
AA.J3L3	Baltic photic sand dominated by ocean quahog (*Arctica island-ica*)	NT	M	A1	
AA.H3L6	Baltic photic muddy sediment dominated by Unionidae	NT	L	A1	
AA.I3L10	Baltic photic coarse sediment dominated by multiple infaunal bivalve species: *Macoma calcarea, Mya truncata, Astarte* spp., *Spisula* spp.	NT	L	A1	
AB.I3L10	Baltic aphotic coarse sediment dominated by multiple infaunal bivalve species: *Macoma calcarea, Mya truncata*, *Astarte* spp., *Spisula* spp.	NT	L	A1	
AA.J3L10	Baltic photic sand dominated by multiple infaunal bivalve species: *Macoma calcarea, Mya truncata, Astarte* spp., *Spisula* spp.	NT	L	A1	
AB.J3L10	Baltic aphotic sand dominated by multiple infaunal bivalve species: *Macoma calcarea, Mya truncata*, *Astarte* spp., *Spisula* spp.	NT	L	A1	
AA.I3L11	Baltic photic coarse sediment dominated by multiple infaunal polychaete species including *Ophelia* spp. (disregarding present bivalves)	NT	L	A1	
AB.I3L11	Baltic aphotic coarse sediment dominated by multiple infaunal polychaet species including *Ophelia* spp. (disregarding present bivalves)	NT	L	A1	
AA.J3L11	Baltic photic sand dominated by multiple infaunal polychaete species including *Ophelia* spp. and *Travisia forbesii* (disregard-ing present bivalves)	NT	L	A1	
AB.J3L11	Baltic aphotic sand dominated by multiple infaunal polychaete species including *Ophelia* spp. and *Travisia forbesii* (disregard-ing present bivalves)	NT	L	A1	
AB.A1F1	Baltic aphotic rock and boulders dominated by sea squirts (Ascidiacea)	NT	L	A1	
AB.M1F1	Baltic aphotic mixed hard and soft substrates dominated by sea squirts (Ascidiacea)	NT	L	A1	
AB.A1G2	Baltic aphotic rock and boulders dominated by sea anemons (Actiniarida)	NT	L	A1	

AB.M1G2	Baltic aphotic mixed hard and soft substrates dominated by sea anemons (Actiniarida)	NT	L	A1
AB.A1G3	Baltic aphotic rock and boulders dominated stone corals (Scleractinida)	NT	L	A1
AB.M1G3	Baltic aphotic mixed hard and soft substrates dominated stone corals (Scleractinida)	NT	L	A1
AB.A1G4	Baltic aphotic rock and boulders dominated by soft corals (Alcyonacea)	NT	L	A1
AB.M1G4	Baltic aphotic mixed hard and soft substrates dominated by soft corals (Alcyonacea)	NT	L	A1
AB.A1J	Baltic aphotic rock and boulders dominated by sponges (Porifera)	NT	L	A1
AB.M1J	Baltic aphotic mixed hard and soft substrates dominated by sponges (Porifera)	NT	L	A1
AB.H3N1	Baltic aphotic muddy sediment dominated by *Monoporeia affinis* and/or *Pontoporeia femorata*	NT	M	A1
AB.H4U1	Baltic aphotic muddy sediment dominated by meiofauna	NT	L	A1
AB.J2K7	Baltic aphotic sand dominated by striped venus (*Chamelea gallina*)	NT	L	A1

HELCOM HUB recognizes ten biotope complexes, all of which are red-listed. The complexes are defined in the EU Habitats Directive Annex 1.

Table 13. HELCOM Red List of Baltic Sea biotope complexes.

Code	Biotope complex (HD Annex 1 description, EUR 27)	Threat category	Confidence of threat assessment	Criterion for assessment
1130	**Estuaries**	CR	M	C1
1180	**Submarine structures made by leaking gases**	EN	M	B2c(ii)
1150	**Coastal lagoons**	EN	M	C1
1110	**Sandbanks which are slightly covered by sea water all the time**	VU	L	C1
1140	**Mudflats and sandflats not covered by seawater at low tide**	VU	L	C1
1160	**Large shallow inlets and bays**	VU	M	C1
1170	**Reefs**	VU	L	C1
1650	**Boreal Baltic narrow inlets**	VU	M	C1
1610	**Baltic esker islands with sandy, rocky and shingle beach vegetation and sublittoral vegetation**	NT	M	C1
1620	**Boreal Baltic islets and small islands**	NT	M	C1

Annex 2. Complete list of all considered Biotopes, Habitats and Biotope Complexes

HELCOM HUB biotope code and name	Red List category	Red List criterion	Confidence of threat assessment
AA.A1C Baltic photic rock and boulders characterized by perennial algae	NE		
AA.A1C1 Baltic photic rock and boulders dominated by *Fucus* spp.	LC	A1	
AA.A1C2 Baltic photic rock and boulders dominated by perennial non-filamentous corticated red algae	LC	A1	
AA.A1C3 Baltic photic rock and boulders dominated by perennial foliose red algae	LC	A1	
AA.A1C4 Baltic photic rock and boulders dominated by kelp	LC	A1	
AA.A1C5 Baltic photic rock and boulders dominated by perennial filamentous algae	LC	A1	
AA.A1D Baltic photic rock and boulders characterized by aquatic moss	LC	A1	
AA.A1E Baltic photic rock and boulders characterized by epibenthic bivalves	NE		
AA.A1E1 Baltic photic rock and boulders dominated by Mytilidae	LC	A1	
AA.A1E2 Baltic photic rock and boulders dominated by zebra mussel (*Dreissena polymorpha*)	LC	A1	
AA.A1F Baltic photic rock and boulders characterized by epibenthic chordates	NE		
AA.A1F1 Baltic photic rock and boulders dominated by sea squirts (Ascidiacea)	LC	A1	
AA.A1G Baltic photic rock and boulders characterized by epibenthic cnidarians	NE		
AA.A1G1 Baltic photic rock and boulders dominated by hydroids (Hydrozoa)	LC	A1	
AA.A1H Baltic photic rock and boulders characterized by epibenthic moss animals (Bryozoa)	NE		
AA.A1H1 Baltic photic rock and boulders dominated by crustose moss animals (*Electra crustulenta*)	LC	A1	
AA.A1H2 Baltic photic rock and boulders dominated by erect moss animals (*Flustra foliacea*)	NT	A1	L
AA.A1I Baltic photic rock and boulders characterized by epibenthic crustacea	NE		
AA.A1I1 Baltic photic rock and boulders dominated by barnacles (Balanidae)	LC	A1	
AA.A1J Baltic photic rock and boulders characterized by epibenthic sponges (Porifera)	LC	A1	
AA.A1R Baltic photic rock and boulders characterized by soft crustose algae	LC	A1	
AA.A1S Baltic photic rock and boulders characterized by annual algae	LC	A1	
AA.A1V Baltic photic rock and boulders characterized by mixed epibenthic macrocommunity	LC	A1	
AA.A2W Baltic photic rock and boulders characterized by microphytobenthic organisms and grazing snails	LC	A1	
AA.A2T Baltic photic rock and boulders characterized by sparse epibenthic macrocommunity	LC	A1	
AA.A4U Baltic photic rock and boulders characterized by no macrocommunity	LC	A1	
AA.B1E Baltic photic hard clay characterized by epibenthic bivalves	NE		
AA.B1E1 Baltic photic hard clay dominated by Mytilidae	LC	A1	
AA.B1V Baltic photic hard clay characterized by mixed epibenthic macrocommunity	NE		
AA.B2T Baltic photic hard clay characterized by sparse epibenthic macrocommunity	NE		
AA.B4U Baltic photic hard clay characterized by no macrocommunity	NE		
AA.C Baltic photic marl (marlstone rock)	LC	A1	
AA.D Baltic photic maërl beds	EN	B1+2a(ii)	M
AA.E1C Baltic photic shell gravel characterized by perennial algae	NE		
AA.E1C4 Baltic photic shell gravel dominated by kelp	NT	B1a(ii)	L
AA.E1E Baltic photic shell gravel characterized by epibenthic bivalves	NE		
AA.E1E1 Baltic photic shell gravel dominated by Mytilidae	LC	A1	
AA.E1F Baltic photic shell gravel characterized by epibenthic chordates	NE		

AA.E1F1 Baltic photic shell gravel dominated by vase tunicate (*Ciona intestinalis*)	VU	B1a(ii)	L
AA.E1V Baltic photic shell gravel characterized by mixed epibenthic macrocommunity	NE		
AA.E2T Baltic photic shell gravel characterized by sparse epibenthic macrocommunity	NE		
AA.E3X Baltic photic shell gravel characterized by mixed infaunal macrocommunity in coarse and well-sorted shells and shell fragments	NE		
AA.E3Y Baltic photic shell gravel characterized by mixed infaunal macrocommunity in fine sand-like shell fragments	NT	B1a(ii)	L
AA.E4U Baltic photic shell gravel characterized by no macrocommunity	NE		
AA.F Baltic photic ferromanganese concretion bottom	LC	A1	
AA.G Baltic photic peat bottoms	VU	B2b	M
AA.H1A Baltic photic muddy sediment characterized by emergent vegetation	NE	A1	
AA.H1A1 Baltic photic muddy sediment dominated by common reed (*Phragmites australis*)	LC	A1	
AA.H1A2 Baltic photic muddy sediment dominated by sedges (Cyperaceae)	NT	A1	M
AA.H1B Baltic photic muddy sediment characterized by submerged rooted plants	NE		
AA.H1B1 Baltic photic muddy sediment dominated by pondweed (*Potamogeton perfoliatus* and/or *Stuckenia pectinata*)	LC	A1	
AA.H1B2 Baltic photic muddy sediment dominated by *Zannichellia* spp. and/or *Ruppia* spp. and/or *Zostera noltii*	LC	A1	
AA.H1B3 Baltic photic muddy sediment dominated by watermilfoil (*Myriophyllum spicatum* and/or *Myriophyllum sibiricum*)	LC	A1	
AA.H1B4 Baltic photic muddy sediment dominated by Charales	NT	A1	M
AA.H1B5 Baltic photic muddy sediment dominated by spiny naiad (*Najas marina*)	NT	A1	M
AA.H1B6 Baltic photic muddy sediment dominated by *Ranunculus* spp.	LC	A1	
AA.H1B7 Baltic photic muddy sediment dominated by common eelgrass (*Zostera marina*)	NT	A1	M
AA.H1B8 Baltic photic muddy sediment dominated by spikerush (*Eleocharis* spp.)	LC	A1	
AA.H1E Baltic photic muddy sediment characterized by epibenthic bivalves	NE		
AA.H1E1 Baltic photic muddy sediment dominated by Mytilidae	LC	A1	
AA.H1E2 Baltic photic muddy sediment dominated by zebra mussel (*Dreissena polymorpha*)	LC	A1	
AA.H1E3 Baltic photic muddy sediment dominated by valve snails (*Valvata* spp.)	NE		
AA.H1K Baltic photic muddy sediment characterized by epibenthic polychaetes	NE		
AA.H1K1 Baltic photic muddy sediment dominated by tube building polychaetes	LC	A1	
AA.H1Q Baltic photic muddy sediment characterized by stable aggregations of unattached perennial vegetation	NE		
AA.H1Q1 Baltic photic muddy sediment dominated by stable aggregations of unattached *Fucus* spp. (typical form)	LC	A1	
AA.H1Q2 Baltic photic muddy sediment dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)	EN	A1	L
AA.H1Q3 Baltic photic muddy sediment dominated by stable aggregations of unattached *Furcellaria lumbricalis*	LC	A1	
AA.H1Q4 Baltic photic muddy sediment dominated by stable aggregations of unattached rigid hornwort (*Ceratophyllum demersum*)	LC	A1	
AA.H1Q5 Baltic photic muddy sediment dominated by stable unattached aggregations of lake ball (*Aegagropila linnaei*)	LC	A1	
AA.H1S Baltic photic muddy sediment characterized by annual algae	NE		
AA.H1S3 Baltic photic photic muddy sediment dominated by *Vaucheria* spp.	LC	A1	
AA.H1V Baltic photic muddy sediment characterized by mixed epibenthic macrocommunity	NE		
AA.H3L Baltic photic muddy sediment characterized by infaunal bivalves	NE		
AA.H3L1 Baltic photic muddy sediment dominated by Baltic tellin (*Macoma balthica*)	LC	A1	
AA.H3L3 Baltic photic muddy sediment dominated by ocean quahog (*Arctica islandica*)	NT	A1	M

AA.H3L6 Baltic photic muddy sediment dominated by Unionidae	NT	A1	L
AA.H3L8 Baltic photic muddy sediment dominated by *Abra* spp.	LC	A1	
AA.H3M Baltic photic muddy sediment characterized by infaunal polychaetes	NE		
AA.H3M3 Baltic photic muddy sediment dominated by *Marenzelleria* spp.	LC	A1	
AA.H3M6 Baltic photic muddy sediment dominated by various opportunistic polychaetes)	LC	A1	
AA.H3N Baltic photic muddy sediment characterized by infaunal crustaceans	NE		
AA.H3N1 Baltic photic muddy sediment dominated by *Monoporeia affinis*	LC	A1	
AA.H3N2 Baltic photic muddy sediment dominated by mud shrimps (Corophiidae)	LC	A1	
AA.H3O Baltic photic muddy sediment characterized by infaunal echinoderms	LC	A1	
AA.H3P Baltic photic muddy sediment characterized by infaunal insect larvae	NE		
AA.H3P1 Baltic photic muddy sediment dominated by midge larvae (Chironomidae)	LC	A1	
AA.H4U Baltic photic muddy sediment characterized by no macrocommunity	NE		
AA.H4U1 Baltic photic muddy sediment dominated by meiofauna (Oligochaeta, Ostracoda, Nematoda)	LC	A1	
AA.I1A Baltic photic coarse sediment characterized by emergent vegetation	NE		
AA.I1A1 Baltic photic coarse sediment dominated by common reed (*Phragmites australis*)	LC	A1	
AA.I1A2 Baltic photic coarse sediment dominated by sedges (Cyperaceae)	LC	A1	
AA.I1B Baltic photic coarse sediment characterized by submerged rooted plants	NE		
AA.I1B1 Baltic photic coarse sediment dominated by pondweed (*Potamogeton perfoliatus* and/or *Stuckenia pectinata*)	LC	A1	
AA.I1B2 Baltic photic coarse sediment dominated by *Zannichellia* spp. and/or *Ruppia* spp. and/or *Zostera noltii*	LC	A1	
AA.I1B4 Baltic photic coarse sediment dominated by Charales	NT	A1	L
AA.I1B6 Baltic photic coarse sediment dominated by *Ranunculus* spp.	LC	A1	
AA.I1B7 Baltic photic coarse sediment dominated by common eelgrass (*Zostera marina*)	NT	A1	M
AA.I1C Baltic photic coarse sediment characterized by perennial algae	NE		
AA.I1C1 Baltic photic coarse sediment dominated by *Fucus* spp.	LC	A1	
AA.I1C2 Baltic photic coarse sediment dominated by perennial non-filamentous corticated red algae	LC	A1	
AA.I1C3 Baltic photic coarse sediment dominated by perennial foliose red algae	LC	A1	
AA.I1C4 Baltic photic coarse sediment dominated by kelp	LC	A1	
AA.I1C5 Baltic photic coarse sediment dominated by perennial filamentous algae	LC	A1	
AA.I1D Baltic photic coarse sediment characterized by aquatic moss	LC	A1	
AA.I1E Baltic photic coarse sediment characterized by epibenthic bivalves	NE		
AA.I1E1 Baltic photic coarse sediment dominated by Mytilidae	LC	A1	
AA.I1Q Baltic photic coarse sediment characterized by stable aggregations of unattached perennial vegetation	NE		
AA.I1Q1 Baltic photic coarse sediment dominated by stable aggregations of unattached *Fucus* spp. (typical form)	LC	A1	
AA.I1Q2 Baltic photic coarse sediment dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)	EN	A1	L
AA.I1Q3 Baltic photic coarse sediment dominated by stable aggregations of unattached *Furcellaria lumbricalis*	LC	A1	
AA.I1S Baltic photic coarse sediment characterized by annual algae	NE		
AA.I1S2 Baltic photic coarse sediment dominated by *Chorda filum and/or Halosiphon tomentosus*	LC	A1	
AA.I1V Baltic photic coarse sediment characterized by mixed epibenthic macrocommunity	NE		
AA.I2W Baltic photic coarse sediment characterized by microphytobenthic organisms and grazing snails	LC	A1	
AA.I2T Baltic photic coarse sediment characterized by sparse epibenthic macrocommunity	NE		
AA.I3L Baltic photic coarse sediment characterized by infaunal bivalves	NE		

AA.I3L10 Baltic photic coarse sediment dominated by multiple infaunal bivalve species: *Macoma calcarea, Mya truncata, Astarte spp., Spisula spp.*	NT		
AA.I3L11 Baltic photic coarse sediment dominated by multiple infaunal polychaete species including *Ophelia* spp.	NT	A1	L
AA.I3M Baltic photic coarse sediment characterized by infaunal polychaetes	NE		
AA.I3N Baltic photic coarse sediment characterized by infaunal crustaceans	NE		
AA.I3N3 Baltic photic coarse sediment dominated by sand digger shrimp (*Bathyporeia pilosa*)	LC	A1	
AA.I3O Baltic photic coarse sediment characterized by infaunal echinoderms	NE		
AA.I3P Baltic photic coarse sediment characterized by infaunal insect larvae	NE		
AA.I4U Baltic photic coarse sediment characterized by no macrocommunity	LC	A1	
AA.J1A Baltic photic sand characterized by emergent vegetation	NE		
AA.J1A1 Baltic photic sand dominated by common reed (*Phragmites australis*)	LC	A1	
AA.J1A2 Baltic photic sand dominated by sedges (Cyperaceae)	LC	A1	
AA.J1B Baltic photic sand characterized by submerged rooted plants	NE		
AA.J1B1 Baltic photic sand dominated by pondweed (*Potamogeton perfoliatus* and/or *Stuckenia pectinata*)	LC	A1	
AA.J1B2 Baltic photic sand dominated by *Zannichellia* spp. and/or *Ruppia* spp. and/or *Zostera noltii*	LC	A1	
AA.J1B3 Baltic photic sand dominated by watermilfoil (M*yriophyllum spicatum* and/or *Myriophyllum sibiricum*)	LC	A1	
AA.J1B4 Baltic photic sand dominated by Charales	NT	A1	L
AA.J1B5 Baltic photic sand dominated by spiny naiad (*Najas marina*)	NT	A1	L
AA.J1B6 Baltic photic sand dominated by *Ranunculus* spp.	LC	A1	
AA.J1B7 Baltic photic sand dominated by common eelgrass (*Zostera marina*)	NT	A1	L
AA.J1B8 Baltic photic sand dominated by spikerush (*Eleocharis* spp.)	LC	A1	
AA.J1E Baltic photic sand characterized by epibenthic bivalves	NE		
AA.J1E1 Baltic photic sand dominated by Mytilidae	LC	A1	
AA.J1Q Baltic photic sand characterized by stable aggregations of unattached perennial vegetation	NE		
AA.J1Q1 Baltic photic sand dominated by stable aggregations of unattached *Fucus* spp. (typical form)	LC	A1	
AA.J1Q2 Baltic photic sand dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)	EN	A1	L
AA.J1Q3 Baltic photic sand dominated by stable aggregations of unattached *Furcellaria lumbricalis*	LC	A1	
AA.J1S Baltic photic sand characterized by annual algae	NE		
AA.J1S2 Baltic photic sand dominated by *Chorda filum and/or Halosiphon tomentosus*	LC	A1	
AA.J1S3 Baltic photic sand dominated by *Vaucheria* spp.	LC	A1	
AA.J1V Baltic photic sand characterized by mixed epibenthic macrocommunity	NE		
AA.J3L Baltic photic sand characterized by infaunal bivalves	NE		
AA.J3L1 Baltic photic sand dominated by Baltic tellin (*Macoma balthica*)	LC	A1	
AA.J3L2 Baltic photic sand dominated by cockles (*Cerastoderma* spp)	LC	A1	
AA.J3L3 Baltic photic sand dominated by ocean quahog (*Arctica islandica*)	NT	A1	M
AA.J3L4 Baltic photic sand dominated by sand gaper (*Mya arenaria*)	LC	A1	
AA.J3L9 Baltic photic sand dominated by multiple infaunal bivalve species: *Cerastoderma spp., Mya arenaria, Astarte borealis, Arctica islandica, Macoma balthica*	LC	A1	
AA.J3L10 Baltic photic sand dominated by multiple infaunal bivalve species: *Macoma calcarea, Mya truncata, Astarte spp., Spisula spp.*	NT	A1	L
AA.J3L11 Baltic photic sand dominated by multiple infaunal polychaete species including *Ophelia* spp. and *Travisia forbesii*	NT	A1	
AA.J3M Baltic photic sand characterized by infaunal polychaetes	NE		
AA.J3M2 Baltic photic sand dominated by lugworms (*Arenicola marina*)	LC	A1	

AA.J3M5 Baltic photic sand dominated by multiple infaunal polychaete species: *Pygospio elegans, Marenzelleria spp., Hediste diversicolor*)	LC	A1	
AA.J3N Baltic photic sand characterized by infaunal crustaceans	NE		
AA.J3N3 Baltic photic sand dominated by sand digger shrimp (*Bathyporeia pilosa*)	LC	A1	
AA.J3P Baltic photic sand characterized by infaunal insect larvae	NE		
AA.J3P1 Baltic photic sand dominated by midge larvae (Chironomidae)	LC	A1	
AA.J4U Baltic photic sand characterized by no macrocommunity	LC	A1	
AA.K Baltic photic hard anthropogenically created substrates	NE		
AA.L Baltic photic soft anthropogenically created substrates	NE		
AA.M1A Baltic photic mixed substrate characterized by emergent vegetation	NE		
AA.M1A1 Baltic photic mixed substrate dominated by common reed (*Phragmites australis)*	LC	A1	
AA.M1A2 Baltic photic mixed substrate dominated by sedges (Cyperaceae)	LC	A1	
AA.M1B Baltic photic mixed substrate characterized by submerged rooted plants	NE		
AA.M1B1 Baltic photic mixed substrate dominated by pondweed (*Potamogeton perfoliatus* and/or *Stuckenia pectinata*)	LC	A1	
AA.M1B2 Baltic photic mixed substrate dominated by *Zannichellia* spp. and/or *Ruppia* spp. and/or *Zostera noltii*	LC	A1	
AA.M1B3 Baltic photic mixed substrate dominated by watermilfoil (*Myriophyllum spicatum* and/or *Myriophyllum sibiricum*)	LC	A1	
AA.M1B4 Baltic photic mixed substrate dominated by Charales	NT	A1	L
AA.M1B7 Baltic photic mixed substrate dominated by common eelgrass (*Zostera marina)*	NT	A1	L
AA.M1C Baltic photic mixed substrate characterized by perennial algae	NE		
AA.M1C1 Baltic photic mixed substrate dominated by *Fucus* spp.	LC	A1	
AA.M1C2 Baltic photic mixed substrate dominated by perennial non-filamentous corticated red algae	LC	A1	
AA.M1C3 Baltic photic mixed substrate dominated by foliose red algae	LC	A1	
AA.M1C4 Baltic photic mixed substrate dominated by kelp	LC	A1	
AA.M1C5 Baltic photic mixed substrate dominated by perennial filamentous algae	LC	A1	
AA.M1D Baltic photic mixed substrate characterized by aquatic moss	LC	A1	
AA.M1E Baltic photic mixed substrate characterized by epibenthic bivalves	NE		
AA.M1E1 Baltic photic mixed substrate dominated by Mytilidae	LC	A1	
AA.M1E2 Baltic photic mixed substrate dominated by zebra mussel (*Dreissena polymorpha*)	LC	A1	
AA.M1F Baltic photic mixed substrate characterized by epibenthic chordates	NE		
AA.M1F1 Baltic photic mixed substrate dominated by sea squirts (Ascidiacea)	LC	A1	
AA.M1G Baltic photic mixed substrate characterized by epibenthic cnidarians	NE		
AA.M1G1 Baltic photic mixed substrate dominated by hydroids (Hydrozoa)	LC	A1	
AA.M1H Baltic photic mixed substrate characterized by epibenthic moss animals (Bryozoa)	NE		
AA.M1H1 Baltic photic mixed substrate dominated by crustose moss animals (*Electra crustulenta*)	LC	A1	
AA.M1H2 Baltic photic mixed substrate dominated by erect moss animals (*Flustra foliacea*)	NT	A1	L
AA.M1I Baltic photic mixed substrate characterized by epibenthic crustacea	NE		
AA.M1I1 Baltic photic mixed substrate dominated by barnacles (Balanidae)	LC	A1	
AA.M1J Baltic photic mixed substrate characterized by epibenthic sponges (Porifera)	LC	A1	
AA.M1Q Baltic photic mixed substrate characterized by stable aggregations of unattached perennial vegetation	NE		
AA.M1Q1 Baltic photic mixed substrate dominated by stable aggregations of unattached *Fucus* spp. (typical form)	LC	A1	
AA.M1Q2 Baltic photic mixed substrate dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)	EN	A1	L

AA.M1Q3 Baltic photic mixed substrate dominated by stable aggregations of unattached *Furcellaria lumbricalis*	LC	A1	
AA.M1Q4 Baltic photic mixed substrate dominated by stable aggregations of unattached rigid hornwort (*Ceratophyllum demersum*)	LC	A1	
AA.M1R Baltic photic mixed substrate characterized by soft crustose algae	LC	A1	
AA.M1S Baltic photic mixed substrate characterized by annual algae	NE		
AA.M1S1 Baltic photic mixed substrate dominated by filamentous annual algae	LC	A1	
AA.M1S2 Baltic photic mixed substrate dominated by *Chorda filum* and/or *Halosiphon tomentosus*	LC	A1	
AA.M1V Baltic photic mixed substrate characterized by mixed epibenthic macrocommunity	NE		
AA.M2W Baltic photic mixed substrate characterized by microphytobenthic organisms and grazing snails	LC	A1	
AA.M2T Baltic photic mixed substrate characterized by sparse epibenthic macrocommunity	LC	A1	
AA.M4U Baltic photic mixed substrate characterized by no macrocommunity	LC	A1	

AB.A1E Baltic aphotic rock and boulders characterized by epibenthic bivalves	NE		
AB.A1E1 Baltic aphotic rock and boulder dominated by Mytilidae	LC	A1	
AB.A1F Baltic aphotic rock and boulders characterized by epibenthic chordates	NE		
AB.A1F1 Baltic aphotic rock and boulders dominated by sea squirts (Ascidiacea)	NT	A1	L
AB.A1G Baltic aphotic rock and boulders characterized by epibenthic cnidarians	NE		
AB.A1G1 Baltic aphotic rock and boulders dominated by hydroids (Hydrozoa)	LC	A1	
AB.A1G2 Baltic aphotic rock and boulders dominated by sea anemones (Actiniarida)	NT	A1	L
AB.A1G3 Baltic aphotic rock and boulders dominated stone corals (Scleractinida)	NT	A1	L
AB.A1G4 Baltic aphotic rock and boulders dominated by soft corals (Alcyonacea)	NT	A1	L
AB.A1H Baltic aphotic rock and boulders characterized by epibenthic moss animals (Bryozoa)	NE		
AB.A1H1 Baltic aphotic rock and boulders dominated by corticated moss animals (*Electra crustulenta*)	LC	A1	
AB.A1H2 Baltic aphotic rock and boulders dominated by erect moss animals (*Flustra foliacea)*	NT	A1	L
AB.A1I Baltic aphotic rock and boulders characterized by epibenthic crustacea	NE		
AB.A1I1 Baltic aphotic rock and boulders dominated by barnacles (Balanidae)	LC	A1	
AB.A1J Baltic aphotic rock and boulders characterized by epibenthic sponges (Porifera)	NT	A1	L
AB.A1V Baltic aphotic rock and boulder characterized by mixed epibenthic macrocommunity	NE		
AB.A2T Baltic aphotic rock and boulders characterized by sparse epibenthic macrocommunity	LC	A1	
AB.A4U Baltic aphotic rock and boulders characterized by no macrocommunity	LC	A1	
AB.B1E Baltic aphotic hard clay characterized by epibenthic bivalves	NE		
AB.B1E1 Baltic aphotic hard clay dominated by Mytilidae	LC	A1	
AB.B1E4 Baltic aphotic hard clay dominated by *Astarte* spp.	EN	B2c (ii)	M
AB.B1V Baltic aphotic hard clay characterized by mixed epibenthic macrocommunity	NE		
AB.B2T Baltic aphotic hard clay characterized by sparse epibenthic macrocommunity	NE		
AB.B4U Baltic aphotic hard clay characterized by no macrocommunity	NE		
AB.C Baltic aphotic marl (marlstone rock)	LC	A1	
AB.D Baltic aphotic maërl beds	EN	B1+2a(ii)	L
AB.E1E Baltic aphotic shell gravel characterized by epibenthic bivalves	NE		
AB.E1E1 Baltic aphotic shell gravel dominated by Mytilidae	LC	A1	
AB.E1F Baltic aphotic shell gravel characterized by epibenthic chordates	NE		
AB.E1F1 Baltic aphotic shell gravel dominated by vase tunicate (*Ciona intestinalis*)	VU	B1a (ii)	L
AB.E1V Baltic aphotic shell gravel characterized by mixed epibenthic macrocommunity	NE		

AB.E2T Baltic aphotic hard clay characterized by sparse epibenthic macrocommunity	NE		
AB.E3X Baltic aphotic shell gravel characterized by mixed infaunal macrocommunity in coarse and well-sorted shells and shell fragments	NE		
AB.E3Y Baltic aphotic shell gravel characterized by mixed infaunal macrocommunity in fine sand-like shell fragments	NT	B1a (ii)	L
AB.E4U Baltic aphotic shell gravel characterized by no macrocommunity	NE		
AB.F Baltic aphotic ferromanganese concretion bottom	LC	A1	
AB.G Baltic aphotic peat bottoms	NE		
AB.H1E Baltic aphotic muddy sediment characterized by epibenthic bivalves	NE		
AB.H1E1 Baltic aphotic muddy sediment dominated by Mytilidae	LC	A1	
AB.H1G Baltic aphotic muddy sediment characterized by epibenthic cnidarians	NE		
AB.H1I Baltic aphotic muddy sediment characterized by epibenthic crustacea	NE		
AB.H1I2 Baltic aphotic muddy sediment dominated by *Haploops* spp.	EN	A1	M
AB.H1K Baltic aphotic muddy sediment characterized by epibenthic polychaetes	NE		
AB.H1K1 Baltic aphotic muddy sediment dominated by tube-building polychaetes	LC	A1	
AB.H1V Baltic aphotic muddy sediment characterized by mixed epibenthic macrocommunity	NE		
AB.H2T Baltic aphotic muddy sediment characterized by sparse epibenthic macrocommunity	NE		
AB.H2T1 Baltic aphotic muddy sediment dominated by seapens	EN	A1	M
AB.H3L Baltic aphotic muddy sediment characterized by infaunal bivalves	NE		
AB.H3L1 Baltic aphotic muddy sediment dominated by Baltic tellin (*Macoma baltica*)	LC	A1	
AB.H3L3 Baltic aphotic muddy sediment dominated by ocean quahog (*Arctica islandica*)	CR	A2	M
AB.H3L5 Baltic aphotic muddy sediment dominated by *Astarte* spp.	EN	A1	M
AB.H3M Baltic aphotic muddy sediment characterized by infaunal polychaetes	NE		
AB.H3M1 Baltic aphotic muddy sediment dominated by *Scoloplos (Scoloplos) armiger*	LC	A1	
AB.H3M3 Baltic aphotic muddy sediment dominated by *Marenzelleria* spp.	LC	A1	
AB.H3M6 Baltic aphotic muddy sediment dominated by various opportunistic polychaetes	LC	A1	
AB.H3N Baltic aphotic muddy sediment characterized by infaunal crustaceans	NE		
AB.H3N1 Baltic aphotic muddy sediment dominated by *Monoporeia affinis* and/or *Pontoporeia femorata*	NT	A1	M
AB.H3O Baltic aphotic muddy sediment characterized by infaunal echinoderms	NE		
AB.H3O1 Baltic aphotic muddy sediment dominated by *Amphiura filiformis*	LC	A1	
AB.H3O2 Baltic aphotic muddy sediment dominated by *Brissopsis lyrifera and Amphiura chiajei*	LC	A1	
AB.H3P Baltic aphotic muddy sediment characterized by infaunal insect larvae	NE		
AB.H3P1 Baltic aphotic muddy sediment dominated by midge larvae (Chironomidae)	LC	A1	
AB.H4U Baltic aphotic muddy sediment characterized by no macrocommunity	NE		
AB.H4U1 Baltic aphotic muddy sediment dominated by meiofauna	NT	A1	L
AB.H4U2 Baltic aphotic muddy sediment dominated by anaerobic organisms	LC	A1	
AB.I1E Baltic aphotic coarse sediment characterized by epibenthic bivalves	NE		
AB.I1E1 Baltic aphotic coarse sediment dominated by Mytilidae	LC	A1	
AB.I1V Baltic aphotic coarse sediment characterized by mixed epibenthic macrocommunity	NE		
AB.I3L Baltic aphotic coarse sediment characterized by infaunal bivalves	NE		
AB.I3L10 Baltic aphotic coarse sediment dominated by multiple infaunal bivalve species: *Macoma calcarea, Mya truncata, Astarte spp., Spisula spp.*	NT	A1	L
AB.I3L11 Baltic aphotic coarse sediment dominated by multiple infaunal polychaet-species including *Ophelia* spp.	NT	A1	L
AB.I3M Baltic aphotic coarse sediment characterized by infaunal polychaetes	NE		

AB.I3N Baltic aphotic coarse sediment characterized by infaunal crustaceans	NE		
AB.I3N3 Baltic aphotic coarse sediment dominated by sand digger shrimp (*Bathyporeia pilosa*)	LC	A1	
AB.I4U Baltic aphotic coarse sediment chracterized by no macrocommunity	NE		
AB.I4U1 Baltic aphotic coarse sediment dominated by meiofauna	LC	A1	
AB.J1E Baltic aphotic sand characterized by epibenthic bivalves	NE		
AB.J1E1 Baltic aphotic sand dominated by unattached Mytilidae	LC	A1	
AB.J1V Baltic aphotic sand characterized by mixed epibenthic macroscopic community	NE		
AB.J3L Baltic aphotic sand characterized by infaunal bivalves	NE		
AB.J3L1 Baltic aphotic sand dominated by Baltic tellin (*Macoma balthica*)	NE		
AB.J3L3 Baltic aphotic sand dominated by ocean quahog (*Arctica islandica*)	VU	A1	M
AB.J3L4 Baltic aphotic sand dominated by sand gaper (*Mya arenaria*)	LC	A1	
AB.J3L7 Baltic aphotic sand dominated by striped venus (*Chamelea gallina*)	NT	A1	L
AB.J3L9 Baltic aphotic sand dominated by multiple infaunal bivalve species: *Cerastoderma spp., Mya arenaria, Astarte borealis, Arctica islandica, Macoma balthica*	NE		
AB.J3L10 Baltic aphotic sand dominated by multiple infaunal bivalve species: *Macoma calcarea, Mya truncata, Astarte spp., Spisula spp.*	NT	A1	L
AB.J3L11 Baltic aphotic sand dominated by multiple infaunal polychaete species including *Ophelia* spp. and *Travisia forbesii*	NT	A1	L
AB.J3M Baltic aphotic sand characterized by infaunal polychaetes	NE		
AB.J3M5 Baltic aphotic sand dominated by multiple infaunal polychaete species: *Pygospio elegans, Marenzelleria spp., Hediste diversicolor*	LC	A1	
AB.J3N Baltic aphotic sand characterized by infaunal crustacea	NE		
AB.J3N1 Baltic aphotic sand dominated by *Monoporeia affinis* and *Saduria entomon*	LC	A1	
AB.J3P Baltic aphotic sand characterized by infaunal insect larvae	NE		
AB.J3P1 Baltic aphotic sand dominated by midge larvae (Chironomidae)	LC	A1	
AB.J4U Baltic aphotic sand characterized by no macrocommunity	NE		
AB.J4U1 Baltic aphotic sand dominated by meiofauna	LC	A1	
AB.K Baltic aphotic hard anthropogenically created substrates	NE		
AB.L Baltic aphotic soft anthropogenically created substrates	NE		
AB.M1E Baltic aphotic mixed substrate characterized by epibenthic bivalves	NE		
AB.M1E1 Baltic aphotic mixed substrate dominated by Mytilidae	LC	A1	
AB.M1F Baltic aphotic mixed substrate characterized by epibenthic chordates	NE		
AB.M1F1 Baltic aphotic mixed substrate dominated by sea squirts (Ascidiacea)	NT	A1	L
AB.M1G Baltic aphotic mixed substrate characterized by epibenthic cnidarians	NE		
AB.M1G1 Baltic aphotic mixed substrate dominated by hydroids (Hydrozoa)	LC	A1	
AB.M1G2 Baltic aphotic mixed substrate dominated by sea anemones (Actiniarida)	NT	A1	L
AB.M1G3 Baltic aphotic mixed substrate dominated stone corals (Scleractinida)	NT	A1	L
AB.M1G4 Baltic aphotic mixed substrate dominated by soft corals (Alcyonacea)	NT	A1	L
AB.M1H Baltic aphotic mixed substrate characterized by epibenthic moss animals (Bryozoa)	NE		
AB.M1H1 Baltic aphotic mixed substrate dominated by corticated moss animals (*Electra crustulenta*)	LC	A1	
AB.M1H2 Baltic aphotic mixed substrate dominated by erect moss animals (*Flustra foliacea*)	NT	A1	L
AB.M1I Baltic aphotic mixed substrate characterized by epibenthic crustacea	NE		
AB.M1I1 Baltic aphotic mixed substrate dominated by barnacles (Balanidae)	LC	A1	
AB.M1J Baltic aphotic mixed substrate characterized by epibenthic sponges (Porifera)	NT	A1	L
AB.M1V Baltic aphotic mixed substrate characterized by mixed epibenthic macrocommunity	NE		
AB.M2T Baltic aphotic mixed substrate characterized by sparse epibenthic macrocommunity	LC	A1	

AB.M4U Baltic aphotic mixed substrate characterized by no macrocommunity	NE		
AC Baltic Sea seasonal Ice	VU	A1, A2a	L
AD.N5 Baltic Sea Photic Pelagic above halocline oxic	LC	A1	
AE.N5 Baltic Sea Aphotic Pelagic above halocline oxic	LC	A1	
AE.N6 Baltic Sea Aphotic Pelagic above halocline anoxic	LC	A1	
AE.O5 Baltic Sea Aphotic Pelagic below halocline oxic	EN	A3	L
AE.O6 Baltic Sea Aphotic Pelagic below halocline anoxic	LC	A1	

Annex 3. Questionnaire content

The Red List assessment was carried out using two questionnaires circulated to a wide range of experts around the Baltic Sea. In addition to contact details, the respondents were asked to fill out information in the questionnaire excel file.

1st Questionnaire
Respondents were asked to answer the following questions:

1. Region: The answer covers the following 100x100 grid codes (for the biotope in question)

2. Estimate of the total area of the biotope - km^2 within your area (fill in 0 for biotopes that do not exist in your area or NC for biotopes not considered at all); uncertainty of ± x km^2

3. Common biotope with no decline in quantity or quality
   – check the column if a biotope is common in your area and it has not declined neither in quantity nor in quality and is not expected to do so in the next 50 years and disregard questions 4 – 6

4. Change in the area covered by the biotope in your area given as percentage (e.g. -50% or +10%)
   – over the past 50 years x%; uncertainty of ± x%
   – over the next 50 years x%; uncertainty of ± x%
   – over the past 150 years x%; uncertainty of ± x%

5. Qualitative decline in biotopes: proportion of area deteriorated compared to the original distribution of the biotope given as percentage for the three severity classes
   1) Quality deterioration in x% of the original distribution over the past 50 years
      – Very severe decline x%; uncertainty of ± x%
      – Severe decline x%; uncertainty of ± x%
      – Moderately severe decline x%; uncertainty of ± x%
      – Not from original but from extant distribution (mark X)
   2) Projected decline in quality in x% of the distribution over the next 50 years
      – Very severe decline x%; uncertainty of ± x%
      – Severe decline x%; uncertainty of ± x%
      – Moderately severe decline x%; uncertainty of ± x%
   3) Long term decline in quality in x% of the original distribution over the past 150 years
      – Very severe decline x%; uncertainty of ± x%
      – Severe decline x%; uncertainty of ± x%
      – Moderately severe decline x%; uncertainty of ± x%
      – Not from original but from extant distribution (mark X)

6. Rarity
   – If you assume that this biotope may be rare on the scale of the whole Baltic Sea, please, also give occurrence data in co-ordinates

7. General level of knowledge on the biotope
   1 = at least two of the following: good coverage, specific monitoring, or recent assessments
   2 = one of the following: good coverage, specific monitoring, or recent assessments
   3 = only partly covered by specific investigations
   4 = data frequently provided by non-biotope-specific investigations
   5 = data infrequently provided by non-biotope-specific investigations or no actual data

8. References
   – If your answers are based on published or unpublished data, please, give the main references or the sources of information here.

9. Comments

2nd Questionnaire
Respondents were asked to answer the following questions:

1. Region: The answer covers the following 100x100 grid codes (for the biotope in question)

2. Occurrence of initially red-listed biotopes (CR-NT): Presence/Absence.
   Presence given as grid id code numbers (where occurring), indicate absence by writing 0

3. If you agree with the initial threat assessment category, mark with an "X"

4. Suggested changed Red List category (for the whole Baltic Sea)

5. Red List criteria used in assessment

6. Suggested changed category Red List category min–max

7. National Concern

8. If the Red List category is suggested to be changed, then describe how large an area the biotope covers in your region

9. If the Red List category is suggested to be changed, then describe how well known the biotope is, how far back in time data is available in your region, and how it has changed (quantity and quality)

10. Comments

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