Coalition Clean Baltic

PROTECTING THE BALTIC SEA ENVIRONMENT - WWW.CCB.SE

Management of habitats and species in MPAs

Coastlines of the Southern Baltic Sea © NASA JSC

Coalition Clean Baltic
Researched and written by Susan Gubbay for Coalition Clean Baltic
E-mail: secretariat@ccb.se
Address: Östra Ågatan 53, 753 22 Uppsala, Sweden
www.ccb.se

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Contents

Introduction

Marine protected areas (MPAs) are an important tool for conservation management of habitats and species in the marine environment and for keeping a resilient marine ecosystem in our seas. However, as shown for example in the WWF/Sky Ocean Rescue 2019 report "Protecting our ocean – Europe's challenges to meet the 2020 deadlines"[1] very few MPAs today have management measures in place, and the practical measures to take in an MPA to protect a certain species or habitat may not always be obvious. For our MPAs to be the absolutely necessary safe-havens of truly protected marine environment, we need to make sure that we have effective measures in place to reach the conservation objectives of our sites. With this series of briefs, we aim to contribute an easily accessible source of information on some of the most important habitats and species in the Baltic Sea Region, and on the measures that can be taken in MPAs designated to protect them. Our hope is that this resource will be useful for MPA managers and other stakeholders, and that it will help us take one more step towards well-managed marine protected areas.

How to use the briefs

The briefs are all structured in a similar way: they all include a general description of the species or habitat, its distribution in the Baltic Sea Region and its conservation status. After a discussion on pressures and threats follow some suggestions about conservation and management objectives for the specific species or habitat. The practical measures section lists hands-on measures that can be taken "on the ground" to mitigate threats and improve the conservation status of the species or habitat in MPAs. Here lies the emphasis of these briefings as these are the measures that will actually improve the situation in our MPAs. The regulatory and supporting measures can support the practical measures. These sections describe the frameworks and possibilities for effective implementation of the practical measures.

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1 https://www.wwf.eu/?uNewsID=352796

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SPECIES

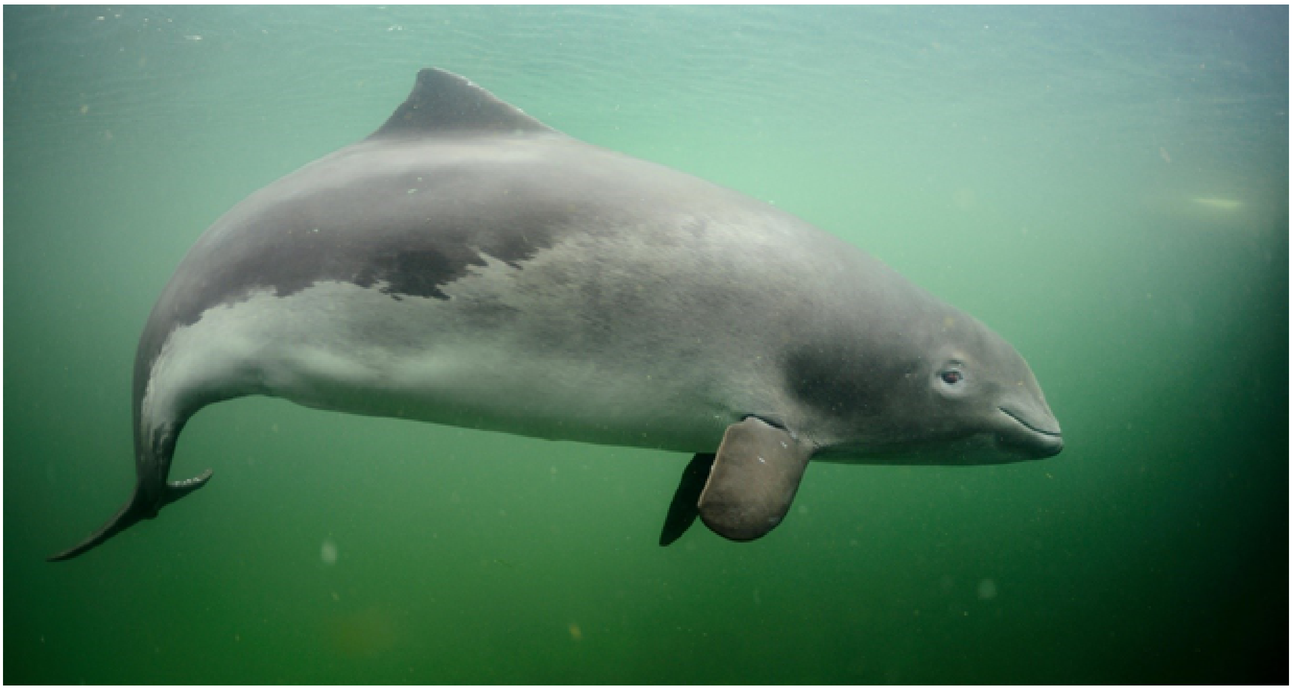
- Baltic harbour porpoise, *Phocoena phocoena*
- Harbour seal, *Phoca vitulina*
- River Lamprey, *Lampetra fluviatilis* and sea lamprey, *Petromyzon marinus*
- Sea ducks
- Terns

BALTIC HARBOUR PORPOISE, *PHOCOENA PHOCOENA*

SUMMARY OF KEY MANAGEMENT MEASURES

There are three distinct harbour porpoise populations in the Baltic Sea. One of these is confined to the Baltic Proper and has an estimated population size of around 500 animals. The main threats to this population are entanglement in fishing gear, pollution and disturbance but habitat degradation and the quality and quantity of available prey may also contribute to the lack of recovery of the population. Entanglement is mostly associated with gillnet fisheries although abandoned and lost nets may also lead to drowning of harbour porpoises. Pollutants, particularly persistent organic pollutants (POPs) and heavy metals are known to bioaccumulate in the animals' fat stores increasing their susceptibility to disease as well as affecting their reproductive health. As harbour porpoise depend on echolocation to find their prey and to communicate, underwater noise generated from sources such as construction, shipping, seismic surveys, underwater explosions and military sonars can seriously disrupt their behaviour and health.

Given the extremely small population size of the Baltic Sea harbour porpoise, and its disappearance from large parts of the inner Baltic Sea, the conservation objectives for harbour porpoise need to focus on improving the status of the population. Two types of management objectives are a priority. The first should be aimed at preventing bycatch and disturbance of porpoises, and the second to prevent the degradation and loss of suitable habitats, including the quality and availability of prey. These objectives will require regulating fisheries known to cause bycatch and controls for other maritime activities that induce anthropogenic underwater noise. More general protection of the marine environment is also required to safeguard harbour porpoise habitat and the prey species it relies on. Practical measures include modifying the design and operation of fishing gears which pose the highest risk, establishing disturbance free areas, introducing speed restrictions and possibly closed areas/re-routing for vessels, and mitigating noise including modifying construction procedures in areas where construction cannot be avoided. Measures such as these need to be underpinned by regulation, including licensing conditions, and can be promoted through the framework of Marine Protected Areas as well as national and regional species action plans which encourage joint action to achieve common conservation objectives.

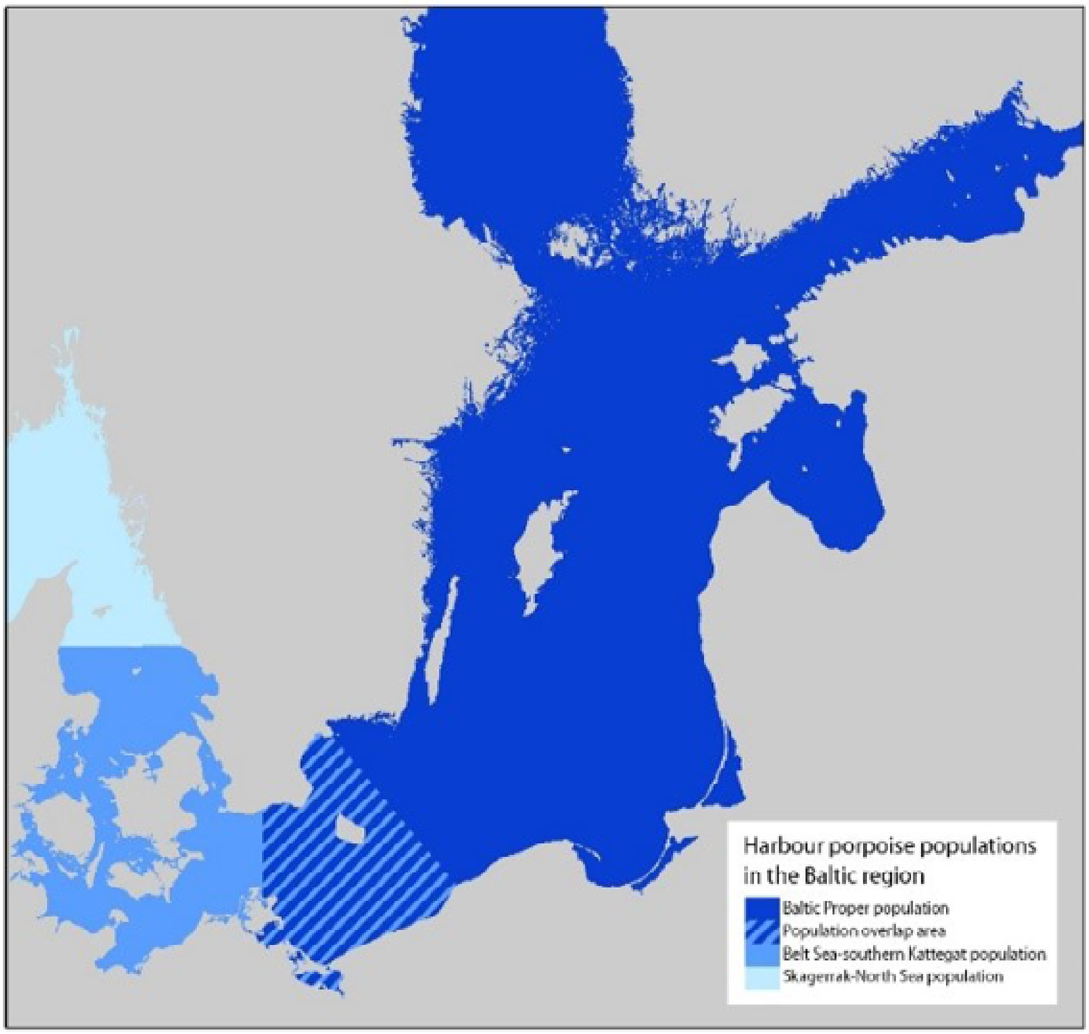


Adult harbour porpoise © Alamy

THE SPECIES

The harbour porpoise, *Phocoena phocoena*, is a small cetacean present in shelf, and sometimes open high seas waters in most of the Northeast Atlantic. In the Baltic Sea region, three distinct harbour porpoise populations are recognized[1]: one in northern Kattegat, Skagerrak and the North Sea, one in southern Kattegat, Belt Sea and western Baltic, the so-called Belt Sea population, and one in the Baltic Proper. There are estimated to be around 500 animals (c.i. 80-1091) in the Baltic Sea population[2].

Harbour porpoise prey on small fish, both demersal and pelagic, which they hunt using echolocation; the porpoise sends out clicks and listens to the echoes to form an image of its surroundings and the location of prey items. The female becomes sexually mature at age 2-5, and gives birth to one calf at the most each year. Breeding is highly seasonal with birth taking place in May-August and mating shortly after. In the wild very few individuals live to be more than 12 years old[3]. The mean age at death in the German Baltic Sea has been estimated to as low as 3.67 years[4].



Approximate distribution of the different harbour porpoise populations in the Baltic Sea Region. The overlap area between 13.5°E and the diagonal line between Sweden and Poland is thought to host some animals from the Belt Sea population during summer (May-October) and from the Baltic Proper population during the winter (November-April) (Carlén et al., 2018; Sveegaard et al., 2015).

1 E.g. Benke et al., 2014; Galatius et al., 2012 Sveegaard et al., 2013
2 SAMBAH 2016
3 Lockyer & Kinze 2003
4 Kesselring et al., 2018

Distribution in the Baltic Sea

Results from the SAMBAH project shows that the Baltic Sea population is concentrated around the three offshore banks south of the island of Gotland in the Baltic Proper during the summer breeding season (May-Oct). During winter (Nov-Apr) the distribution seems to be wider, with animals occurring as far north as southern Finnish waters, as well as along the Swedish east coast, and in Polish, Russian, Lithuanian and Latvian waters.

Historically, the harbour porpoise has occurred in the entire Inner Baltic Sea, with bycatch and hunting records from the northern Gulf of Bothnia as well as the Gulf of Finland.

Conservation status

HELCOM and IUCN list the Baltic Sea harbour porpoise as a separate population and have assessed it as being Critically Endangered[1].

Harbour porpoise has been assessed as Least Concern in Poland[2], however this has been acknowledged as a mistake, that needs to be corrected when the assessments are updated. It has been assessed as Vulnerable in Denmark and Sweden and Endangered in Germany[3] but in all three countries the Baltic Sea population is not assessed separately. In Finland the harbour porpoise was listed as Regionally Extinct in 2015[4]. It was Not Assessed in 2019[5]. The harbour porpoise is not listed in Lithuania, considered to probably be extinct in Latvian waters, and of uncertain status in the Russian Federation[6].

The harbour porpoise is on Annex II and IV of the EU Habitats Directive, indicating that its conservation requires designation of Special Areas of Conservation, i.e. MPAs, and that it should be strictly protected in EU Member States. Article 17 reports on the status of the harbour porpoise for the period 2013-2017, record it as having an Unfavourable-Bad status (U2), in Denmark, Germany, Sweden and Poland, while Finland, Estonia, Latvia and Lithuania did not report on the status of the harbour porpoise.

The HELCOM MPA database[7] records 19 MPAs (in Poland, Sweden, Finland, and Germany) where the Baltic Sea subpopulation of harbour porpoise is listed as present. In seven of these cases the presence of harbour porpoise was one of the reasons for site designation e.g. in Zatoka Pucka in Poland, Hoburgs Bank in Sweden, and Pommersche Bucht-Rönnebank in Germany. There are also 27 MPAs where the HELCOM MPA database lists the Belt Sea subpopulation of harbour porpoise is listed as present. These are in Sweden, Denmark and Germany, and 20 of these record the presence of harbour porpoise as justifying site designation (e.g. at Store Middelgrund in Denmark, Lilla Middelgrund in Sweden and the Fehmarnbelt in Germany). There are also 13 Natura 2000 sites within the distribution range of the Baltic Proper harbour porpoise population where it is on the list of species present[8].

1 http://www.helcom.fi/Red%20List%20Species%20Information%20Sheet/HELCOM%20Red%20List%20Phocoena%20phocoena.pdf; https://www.iucnredlist.org/species/17031/98831650
2 Glowacinski et al. 2002; Artdatabanken 2015; Haupt et al. 2009
3 Wind & Pihl 2004
4 Liukko, U-M et al., 2016.
5 Liukko et al. 2016
6 Andrušaitis 2000; Rašomavičius (2007); Iliashenko & Iliashenko 2000
7 http://www.helcom.fi/action-areas/marine-protected-areas/database/
8 CCB 2019

PRESSURES AND THREATS

Harbour porpoise in the Baltic Sea are under considerable pressure from human activity. Historically they were subject to commercial hunting. Today the main threats in the Baltic Sea are entanglement in fishing gear, pollution and disturbance but habitat degradation and the quality and quantity of available prey may also contribute to the lack of recovery of the population[1].

Entanglement is mostly associated with gillnet fisheries with harbour porpoise are taken as bycatch in large-mesh nets that are used to catch salmonids, cod, and other species[2]. Bycatch is also associated with drift nets. This type of fishing gear is now banned, but semi-drift nets (now logged as set-gillnets) that are anchored at one end, are considered legal and are an entanglement risk for harbour porpoise. There are records of harbour porpoise being caught by pelagic trawls although this is much less frequent. Abandoned and lost nets ('ghost nets') may also entangle and lead to drowning of harbour porpoise.

Pollutants, particularly persistent organic pollutants (POPs) and heavy metals are another serious threat to harbour porpoise populations as they are known to bioaccumulate in the animals' fat stores. This is believed to increase their susceptibility to disease by acting as an immunosuppressant, as well as affecting the reproductive health of female harbour porpoise leading to reproductive failure and passing on pollutant loads to their calves[3]. The effects are exacerbated if animals are in poor health, for example if they are suffering from starvation.

As harbour porpoise depend on echolocation to find their prey and to communicate, underwater noise can seriously disrupt their behaviour. Underwater noise may be impulsive or continuous and generated from sources such as construction, shipping, seismic surveys, underwater detonations and military sonars. The effects will vary depending on factors such as the frequency, sound pressure level and timescales over which harbour porpoise are exposed with animals responding in some cases by avoiding areas and, if severe, suffering some physiological damage[4].

The availability and quality of prey for porpoises may also be a problem that has to be taken into account when managing harbour porpoise MPAs. This has been identified as an issue for seals in the Baltic Sea where their blubber thickness is correlated to the quality of herring and sprat[5]. Given the ecosystem changes in the Baltic, with the eastern cod stock totally denuded and large-scale trawling of sprat and herring, there is a significant risk that such changes will also have a negative effect on the availability of food for the Baltic Sea harbour porpoise.

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the species. For the harbour porpoise this will include actions to be taken in the marine environment, mainly limiting anthropogenic activities which lead to bycatch or which cause disturbance, but also ensuring the availability of food for the harbour porpoise. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings, although the rarity of the species in the Baltic Sea will mean that any effects are likely to be difficult to detect through monitoring.

1 CCB http://www1.ccb.se/wp-content/uploads/2015/03/Harbour_porpoise_15_webb-vers.pdf
2 E.g. Berggren 1994; OSPAR; Scheidat, 2018.
3 E.g. Murphy et al., 2015; Desforges et al.,2016
4 E.g. Dähne et al., 2013; Kujawa & Liberman 2015; Wisniewska, D.M. et al., 2018
5 Kauhala et al., 2017

Conservation objectives

Given the extremely small population of the Baltic Sea harbour porpoise and its disappearance from large parts of the inner Baltic Sea, the conservation objectives for harbour porpoise need to focus on improving the status of the population. This is consistent with objectives under the EU Habitats Directive.

To date, no conservation objectives in the form of MSFD GES thresholds have been set, and only Sweden has set Favourable Reference Population Values under the EU Habitats Directive.

Management objectives

Two types of management objective are a priority for the harbour porpoise. The first should be aimed at preventing bycatch and disturbance of porpoises, and the second on preventing the degradation and loss of suitable habitat, including the quality and availability of prey species. This will require the regulation of fisheries known to cause bycatch and of other maritime activities that induce anthropogenic underwater noise. More general protection of the marine environment, ensuring the stability of the ecosystem and availability of suitable prey is also needed[1].

Practical measures

Fisheries technical measures
Technical measures to reduce or eliminate the risk of harbour porpoise bycatch are typically concerned with modifying the design and operation of fishing gears, increasing the visibility of nets and using Acoustic Deterrent Devices (ADDs). Methods which have been tested include changing net material to thinner twines and applying metal oxide/barium sulfate to nets but with varying degrees of success[2]. There have been trials on increasing the reflectivity of gillnets using acrylic glass spheres, but their effectiveness has still to be tested in the field[3].

ADDs work by emitting sounds and have been efficient in decreasing bycatch levels of some cetaceans in some areas but may also lead to displacement by deterring porpoises from entering foraging and feeding areas within their range. Consequently, using ADDs as a long-term solution to eliminating bycatch may not always be a suitable approach. Their use must be considered on a case-by-case basis, and regularly re-evaluated.

Alternative fishing gears
Harbour porpoise are known to be particularly vulnerable to entanglement and drowning in gillnets. The development and use of alternative gears can reduce this risk but uptake is likely to be limited unless the alternative gears are commercially viable. Possible alternatives such as traps, pots, hooks and seine nets are being investigated and, if successful, could be encouraged if there are complimentary incentives such as eco-labelling[4].

1 E.g. https://ccb.se/wp-content/uploads/2016/04/CCB_statement_on_porpoise_to_fulfill_MSFD_and_HELCOM_2015.pdf
2 Northridge et al., 2003. https://www.bycatch.org/articles/analysis-and-mitigation-cetacean-bycatch-uk-fisheries
3 ICES, 2019
4 ASCOBANS, 2016

Disturbance free areas

Some of the pressures on harbour porpoise can be reduced by having seasonal or permanent restrictions on activities which disturb cetaceans. This could include the restriction on commercial and recreational boat traffic as well as on construction works. In the latter case consideration should also be given to banning offshore windfarms within harbour porpoise MPAs, not solely because of the disturbance associated with their construction but because of disturbance associated with ongoing servicing and maintenance. No construction work, seismic activity or sonar should be allowed in or around MPAs designated for the harbor porpoise.

Codes of practice for recreational craft

Harbour porpoise can be disturbed by the activities of recreational users by the noise of vessel traffic, vessels moving unpredictably (e.g. speedboats, jet skis) and by harassment from cetacean watching activities. Codes of practice, promoted through the leisure industry for example, can be used to raise awareness of these issues and there are numerous examples of wildlife watching codes[1]. They typically cover matters such as precautionary distances and speeds in the vicinity of cetaceans.

Vessel routing and speed restrictions

The International Maritime Organisation (IMO) has developed voluntary guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life[2]. These are mainly concerned with design and maintenance but vessel speed and routing decisions to avoid well-known cetacean habitats or migratory pathways when in transit are also recommended. Noise mapping can be used to identify high risk areas where mitigation measures such as voluntary proposals for vessel routing and speed restrictions or, if appropriate, the designation of Particularly Sensitive Sea Areas (PSSAs) or rerouting of shipping lanes could be agreed through the IMO. Designation of such areas requires action at a national and international level however local managers will be able to gather the essential supporting information on threats and case for action.

The dorsal fins of two baltic harbour porpoise © Alamy

1 E.g. Inman, et al., 2016
2 IMO, 2014

Noise reduction and mitigation
Noise generated during seismic surveys, underwater detonations and the construction of offshore structures such as windfarms and oil and gas platforms, particularly when pile driving, are known to disturb harbour porpoise.

Setting noise thresholds and modelling to predict noise levels prior to construction are necessary to assess the noise emission and configure possible mitigation measures to reduce the generation, spread or exposure of harbour porpoise to underwater noise. Developing alternative pile driving methods to decrease noise emissions, as well shortening operational time or changing designs (for example foundation types or using floating structures so no pile driving is necessary) are some of the ways of reducing noise exposure. Other procedures include the use of 'soft starts' and ADDs to scare porpoises away from construction sites prior to piling operations. During constructions works piling sleeves, hydro sound dampers, noise mitigation screens and bubble curtains may also be options used for noise mitigation[1]. Appropriate and effective measures should be part of licensing conditions and should also take into account the potential cumulative effects of noise when considered alongside other noise generating activities in the vicinity of proposed works, both during and after the construction phase.

Noise from seismic surveys and underwater detonations also need to be considered in noise reduction and mitigation strategies developed. Marine vibroseis, a survey technique under development. is designed to release the same amount of energy as airgun surveys but rather than emitting all the energy at once, it does so continuously or intermittently for a longer period of time[2]. This is an example of new technology under development, but where the environment implications have still to be fully assessed.

Two baltic harbour porpoise © Alamy

1 E.g. BfN, 2018.
2 https://blogs.umass.edu/natsci397a-eross/marine-vibroseis-a-safer-alternative-to-seismic-airguns-for-the-north-atlantic-right-whale/

Regulatory measures

Licensing conditions

Apart from fisheries, activities taking place in the marine environment typically require some form of licensing. Threats to harbour porpoise can be reduced by setting licensing conditions based on the findings of mandatory Environmental Impact Assessments. For example, the season and duration of operations and the mitigation measures to be used, such as noise reduction systems. Conditions of licensing may also specify that certain areas are kept as disturbance free areas both during construction and subsequent operation. Some areas which are critical to harbour porpoise, such as MPAs designated for their protection, should be identified as unavailable for licensing.

Regulation of fisheries

An ecosystem approach to the management of fisheries, taking into account the implications of fishing practices on other wildlife is essential. In the case of the harbour porpoise, large scale fisheries, especially trawling for species such as sprat and herring can affect both the quality and quantity of this important food source for the harbour porpoise with potential detrimental effects on the health of individuals and the population. Licensing, closed areas, effort control, the length of the closed season, limiting the use of certain types of gear, and demand for use of ADDs or similar, are all measures that can be used to regulate fisheries which pose a bycatch risk to harbour porpoise. In the first instance, these should aim to keep fishing methods that pose a high risk to harbour porpoise away from critical areas for the harbour porpoise. Where this is not possible, for example if the location of such areas is not known, fisheries regulations need to set out the mitigating measures, to be used as well as how they will be monitored, enforced and reviewed.

Spatial/temporal measures to reduce/eliminate bycatch

The most effective method to reduce bycatch is to cease fishing using gear that poses a risk to the harbour porpoise. Identification of high-risk areas for bycatch and bycatch estimates can be used to evaluate the level of pressure on harbour porpoise by the fisheries industry as well as identifying areas where monitoring of bycatch needs to be intensified. Fisheries closures can then be considered as a management option to reduce bycatch but at the same time ensuring that fishing effort and cetacean bycatch are not merely displaced elsewhere[1].

Marine Protected Areas and their management

Protected areas have been established for harbour porpoise through national conservation programmes and these locations may also be recognized as Baltic Sea MPAs and Ecologically or Biologically Significant Marine Areas (EBSAs). The Habitats Directive require the designation of Special Areas of Conservation to protect harbour porpoise and its habitat. Designation provides a regulatory framework for action and needs to be operationalized through management plans which set out conservation objectives, how they might be achieved, by whom and on what timescales. Management plans should also set out procedures for enforcement, review and stakeholder involvement. Whilst practical management measures, such as prohibiting the use of bottom set gillnets and entangling nets, or regulations relating to noise and disturbance could be taken without MPA designation, the supporting mechanisms of MPAs such as conservation objectives, management planning, monitoring, and enforcement, provide a framework for effective implementation. For SACs under the Habitats Directive there is also a requirement to maintain the integrity of the site, and therefore ecosystem structure and function covering elements such as water quality and food supply.

1 Dolman et al., 2015

Supporting measures

Species action/management plans
Species action plans focus attention and can set out very specific recommendations as well as identifying who should take action to improve the status of species. Two examples relating to the harbour porpoise are the ASCOBANS Conservation Plan for Harbour Porpoise Population in the Western Baltic, the Belt Sea and the Kattegat, and the Recovery Plan for Baltic Harbour Porpoises (the Jastarnia plan)[1]. These plans set out recommendations for stakeholder involvement, assessment and mitigation of bycatch, monitoring, and ensuring habitat quality is favorable to the conservation of the harbour porpoise. Some Baltic countries have also drawn up national action plans for the conservation of the harbour porpoise e.g. Finland[2]. A key element of such plans needs to be regular reporting on actions taken and their effectiveness. They also need to be reviewed and updated to keep them relevant and to retain the momentum for action. This is also achieved if there is legal underpinning for the implementation and enforcement of such plans.

International agreements
International agreements support the introduction and enforcement of measures to protect the marine environment of the Baltic Sea and are essential to protect a species such as the harbour porpoise which moves between the waters of a number of Baltic Sea countries. This is also necessary because significant threats, such as pollution and underwater noise can best be tackled by joint action at regional or international level.

Through HELCOM, the Baltic Sea Action Plan (BSAP) provides a framework for joint actions across Baltic states as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea. HELCOM Recommendation 17/2 concerns the protection of the Harbour Porpoise in the Baltic Sea. It includes recommendations for Contracting Parties to the Helsinki Commission to give highest priority to avoiding bycatch of harbour porpoise, work co-operatively with ASCOBANS and ICES on the collection and analysis of data on the harbour porpoise populations and the threats they face as well as to considered the establishment of MPAs for harbour porpoise[3].

Marine Spatial Planning
Planning frameworks can set direction, bring together key players and involve the public in decision making. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. Maritime Spatial Plans (MSP) are more recent but equally important. The priorities and detailed provisions in such plans can have a direct impact on the harbour porpoise for example by identifying areas for development, and specifying construction methods, EIA requirements and operational constraints. MSPs need to identify areas that are critical for marine protection in general and the harbour porpoise in particular and take this into account prior to the siting, zoning and management of activities. As part of this process, MSPs can also usefully identify areas where activities likely to have a detrimental effect on harbour porpoise should be prohibited. Two examples are offshore windfarms and military exercise areas because of the impacts of associated noise on harbour porpoise.

Research and understanding
Improving our understanding of the threats to harbour porpoise is key to developing effective protection and mitigation measures, particularly in relation to bycatch and underwater noise. The pressures mentioned here are known to be detrimental to harbour porpoise but the scale and impact on harbour porpoise in the Baltic Sea remains unclear. At the same time, given the small population size of the Baltic population, there is also a need to understand whether other issues, such as the potential depletion of prey associated with high fishing pressures, might also be having an impact. Continuing research is therefore needed to better understand the risks to harbour porpoise, as well as monitoring trends in their abundance and distribution to accurately report on their status and the effectiveness of conservation measures.

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1 https://www.ascobans.org/sites/default/files/document/HarbourPorpoise_ConservationPlan_WesternBaltic_MOP7_2012.pdf
2 Loisa, & Pyöriäistyöryhmä. 2016
3 http://www.helcom.fi/Recommendations/Rec%2017-2.pdf

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HARBOUR SEAL, *PHOCA VITULINA*

SUMMARY OF KEY MANAGEMENT MEASURES

Six genetically distinct populations of harbour seal frequent European coastlines, one of which, the Kalmarsund population, is found in the Baltic proper. There are also sub-populations along the southern Danish and Swedish coasts in the southwestern Baltic and the Kattegat.

Historical hunting of the harbour seal for its skin and blubber took the population close to extinction in the 20th century. Seals, including harbour seals, have also been hunted because of their interactions with commercial fisheries. Other pressures are infertility caused by organohalogen and significant mortality events due to disease. The main threats to the harbour seal in the Baltic Sea today are entanglement in fishing gear, disease/immunosuppression associated with effects of pollution, and habitat loss/disturbance.

Given the small numbers of the Baltic Sea harbour seal population the conservation objectives for this species need to focus on maintaining and improving its status. The management objectives for harbour seal should be aimed at preventing bycatch, any degradation or loss of suitable habitat particularly at haul out sites and supporting measures to improve the water quality of the Baltic Sea. Practical measures include modification of fishing gear to reduce the risk of bycatch and codes of practice to prevent disturbance, particularly of nursing mothers. MPAs provide a valuable framework for effective conservation measures but more widespread measures, such as reducing pollutant loads are also needed.

Harbour seal (*Phoca vitulina*) © OCEANA Carlos Minguell
https://www.flickr.com/photos/oceanaeurope/5653764764/in/album-72157626572801632/

THE SPECIES

Harbour seals are a gregarious species, with regular haul-out sites used for mating, giving birth, moulting and resting. Females give birth on sheltered shorelines once a year in May and June. The pups, which suckle for around 3-4 weeks, can swim and dive almost immediately after birth. Moulting occurs in August when the seals spend more time on land to develop the new fur. Six genetically distinct populations of harbour seal frequent European coastlines, one of which, the Kalmarsund population, is found in the Baltic proper[1]. There are also sub-populations along the southern Danish and Swedish coasts in the southwestern Baltic and the Kattegat[2].

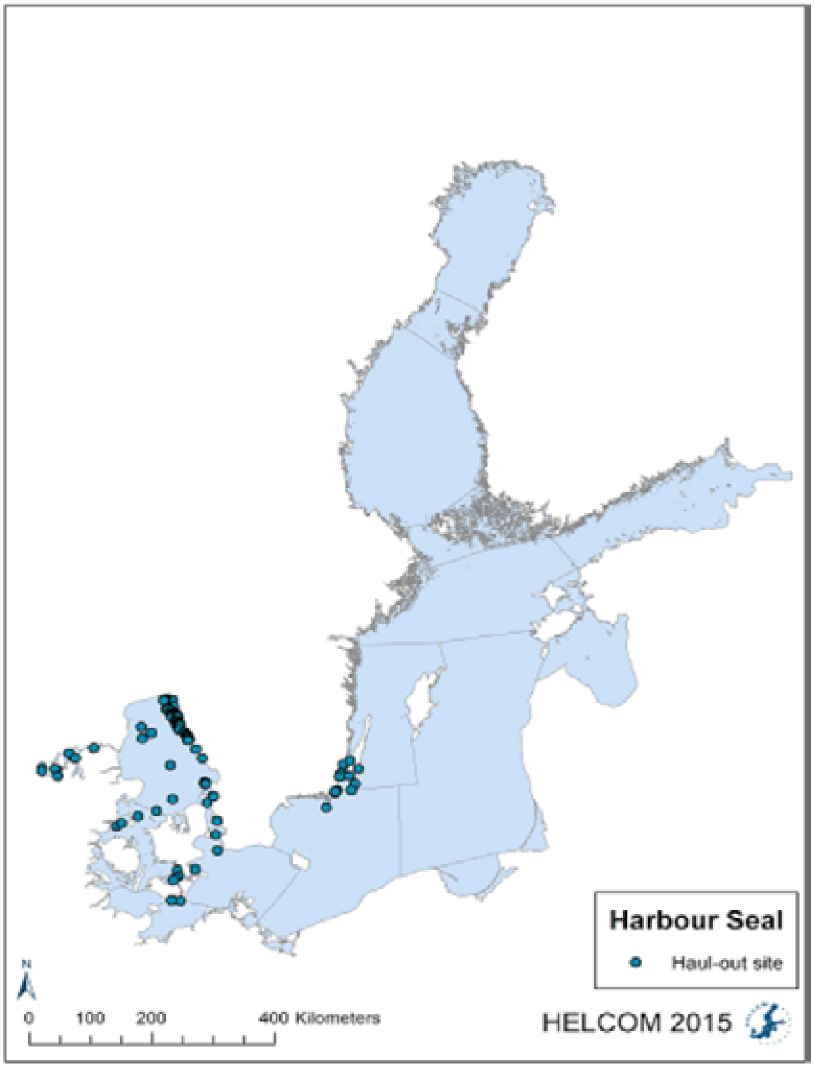
Groups of harbour seals general stay within 100 km of the shore, hauling out on undisturbed beaches and islands. They typically forage in areas shallower than 100 m although can dive deeper, and do not migrate although they may move to new areas to feed. Harbour seals are opportunistic feeders, mainly feeding on fish but with their diet varying substantially between regions. In the Kattegat the main prey are sandeels and dab, in the southwestern Baltic Sea it is dominated by small sandeel, followed by black goby and Atlantic cod, and in Kalmarsund the European eel appears to make up the largest proportion of the diet with Atlantic cod and European Flounder the next most common prey[3].

Hauled out harbour seals (*Phoca vitulina*) © Ivan Ingemansen.
http://www.undine-baltic.eu/species/index.php?id=105&lang=de

1 Andersen & Olsen, 2010.
2 Olsen et al., 2014
3 Scharff-Olsen et al., 2018.

Distribution in the Baltic Sea

Archaeological data show that the harbour seal has been confined to the southern Baltic ever since entering the Baltic Sea some 8,000 years ago. There are no records of harbour seal remains north of a line from Oskarshamn, Sweden, to Hiiumaa in Estonia[1] but it was formerly present along the southern Estonian coast, Gotland, and southern Baltic including the current Polish, German, Danish and Swedish coasts. Today the harbour seal is found in the Kalmarsund region (Sweden) and the southwestern Baltic Sea in Danish, Swedish and German waters. Although occasionally visiting other areas to feed, no regular haul-out sites are known along the coasts of any of the other Baltic countries. Haul-out sites reflect both the distribution of breeding sites as well as sites used for other activities[2].



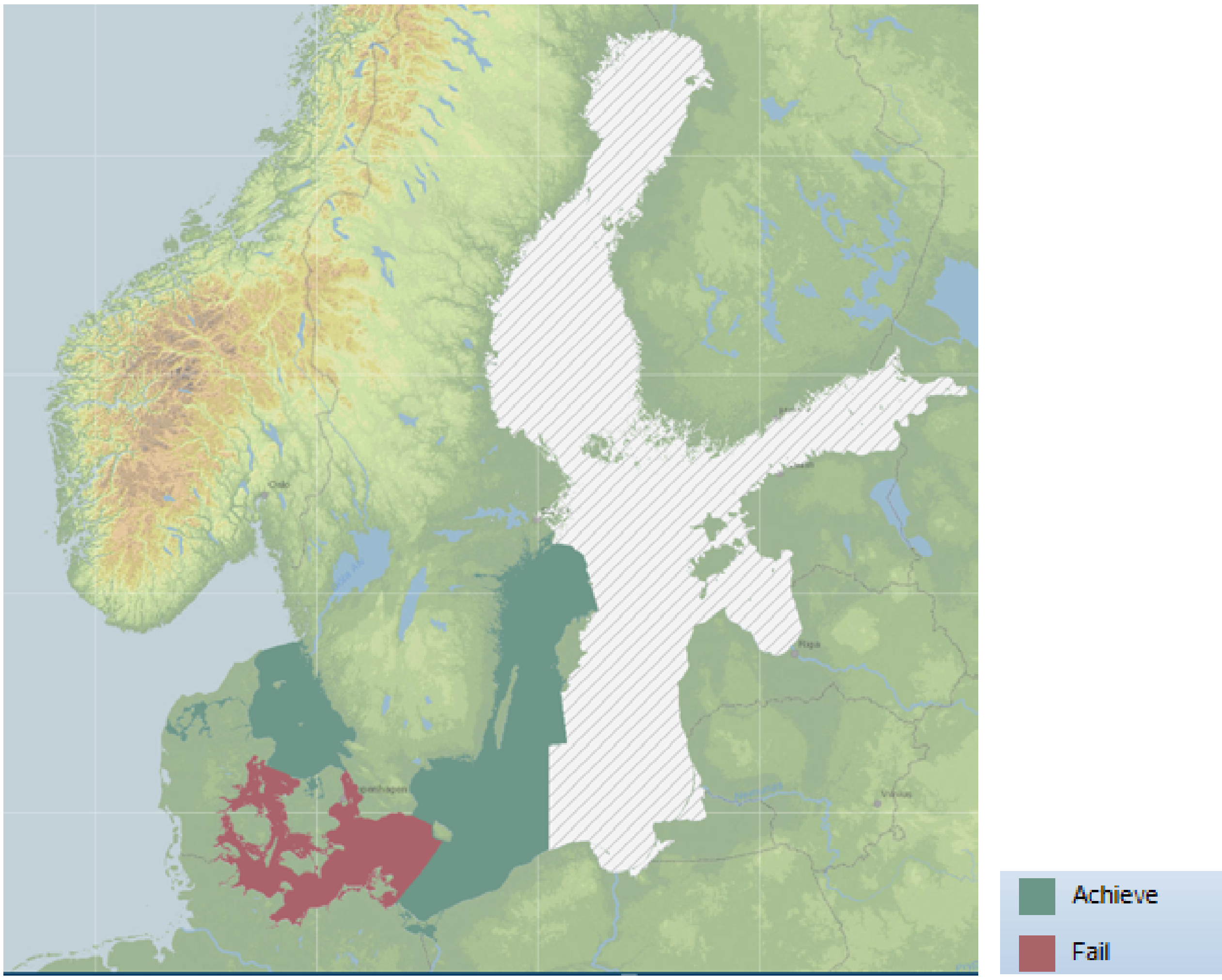
Haul out sites of Baltic harbour seals (from HELCOM, 2018, Figure 10)

1 Harkonen et al., 2005

2 http://www.helcom.fi/Core%20Indicators/Distribution%20of%20Baltic%20seals%20HELCOM%20core%20indicator%202018.pdf

Conservation status

The HELCOM core indicator for the period 2011-2016 on the state of the harbour seal (based on three components - distribution of haul-out sites, breeding sites and foraging areas) shows that the threshold for good status has not been achieved for some areas of Denmark or in the western Baltic (Arkona basin, Bay of Mecklenburg, Kiel Bay, Great Belt and Sound). Status is good in Kattegat and Limfjord.



Distribution of and status of harbour seal indicator, 2018
http://maps.helcom.fi/website/mapservice/?datasetID=386d3bcc-9338-4ab2-8013-0bb785c17742

The harbour seal is on Annex II of the EU Habitats Directive, indicating that its conservation requires designation of Special Areas of Conservation.

Article 17 reports on the status of the harbour seal in the Baltic Sea for the period 2007-2012 indicate it as having a Favourable (FV) status in Denmark, Unfavourable – inadequate status (U1) in Germany, Unfavourable-Bad status (U2) in Sweden. The overall status for the marine Baltic region is Unfavourable – Bad (U2)[1].

HELCOM have assessed the status of the Kalmarsund subpopulation of harbour seal as Vulnerable and the Southern Baltic sub-population as Least concern. Both sub-populations are listed as Vulnerable in Sweden.

1 https://www.eionet.europa.eu/article17/reports2012/species/progress/?period=3&group=Mammals&conclusion=overall+assessment

The HELCOM MPA database[1] records 2 MPAs (in Sweden) where the Kalmasund subpopulation of harbour seal is listed as a present (Värnanäs Archipelago and Torhamns archipelago) but not the reason for site designation. There are also 17 MPAs where the southern Baltic sub-population is reported as present (in Sweden, Denmark and Germany), 15 of which justify the site's designation as an MPA. The harbour seal is considered resident in three of these sites; Kullaberg-Skälderviken and Hallands Väderö (Sweden) and Fehmarnbelt (Germany). There is a breeding colony at a fourth MPA (Falsterbo Peninsula with Måkläppen, Sweden).

PRESSURES AND THREATS

Historical hunting of the harbour seal for its skin and blubber took the population close to extinction in the 20th century with the Kalmarsund subpopulation reduced to an estimated 200 seals by 1960[2]. Seals, including harbour seals, have also been hunted because of their interactions with commercial fisheries. Other pressures are infertility caused by organohalogen pollution which could have contributed to the consistently low numbers by the end of the 1970s and there have been significant mortality events due to disease. Harbour seals in the southern Baltic experienced a mass mortality caused by a Phocine Distemper virus epidemic in 2002 as did those in the Kattegat and Danish Straits in 1988 and 2002[3]. The cellular immune response of harbour seals, which is crucially important in dealing with morbillivirus infections, is known to be suppressed when exposed to environmental contaminants such as PCBs and dioxins in their diet[4].

The main threats to the harbour seal in the Baltic Sea today are entanglement in fishing gear, disease/immunosuppression associated with effects of pollution, and habitat loss/disturbance.

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the species. For the harbour seal this will include limiting anthropogenic activities which lead to bycatch, and habitat loss or degradation. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

Given the small numbers of the Kalmarsund subpopulation the conservation objectives for this species need to focus on maintaining and improving its status. This is consistent with objectives under the EU Habitats Directive.

Management objectives

The management objectives for harbour seal should be aimed at preventing bycatch, any degradation or loss of suitable habitat particularly at haul out sites and supporting measures to improve the water quality of the Baltic Sea.

1 http://www.helcom.fi/action-areas/marine-protected-areas/database/
2 Härkönen & Isakson, 2010.
3 Härkönen et al., 2006
4 De Swart et al., 1995.

Practical measures

Fisheries technical measures

Modifying fishing gear and switching to alternative gears are ways of reducing or eliminating the risk of seal bycatch and/or incidental damage to fishing gear by seal depredation. Although the primary focus in the Baltic Sea is on avoiding such interactions with grey seals, the more abundant seal species, mitigation measures will also benefit the harbour seal as both juvenile and adult harbour seals are taken as bycatch. This is primarily an issue for small-scale coastal fisheries using gillnets for flatfish and cod, and trap fisheries for salmon and eel. Mitigation measures tested include the use of cod pots instead of gillnets, but with a strong recommendation to use seal exclusion devices on pot entrances because intensive use of cod pots on the west coast of Sweden with such devices is considered likely to cause a mortality of large numbers of harbour seals[1]. Salmon traps with an outer protecting net ("pushup fish bag") also appear to have reduced interactions with seals if the entrance areas are also modified.

Avoiding disturbance

Harbour seals are vulnerable to disturbance when hauled out on land. Vessel traffic (e.g. fishing boats, speedboats), walkers on the shore, and recreational activities on the water such as swimming and canoeing are some of the potential sources of disturbance. This is likely to be most problematic when seals have newborn pups as disturbance has been shown to affect the behaviour of the nursing mothers[2]. Apart from increased vigilance, disturbance can lead seals to flush into the water and disrupt post-natal bonding. Disturbance during the moulting period can result in loss of energy, interruption of hair growth and prolongation of the moulting period[3]. Public information campaigns with codes of practice providing information such as safe approach distances of vessels and people on foot, can be used to alert the public to the issue and reduce the likelihood of disturbance.

Harbour seal (*Phoca vitulina*) © OCEANA Carlos Minguell
https://www.flickr.com/photos/oceanaeurope/35105472193/in/photolist-GruGDF-9BB2hQ-Vu9HPX-n6sKQ9-czk7r9

1 Königson et al., 2015; Westerberg et al., 2006.
2 Stein, 1989
3 https://www.pinnipeds.org/attachments/article/199/Disturbance%20for%20SCS%20-%20text.pdf

Regulatory measures

Marine Protected Areas and their management
Protected areas have been established for harbour seals through national conservation programmes and these locations may also be recognized as Baltic Sea MPAs and Ecologically or Biologically Significant Marine Areas (EBSAs). The Habitats Directive require the designation of Special Areas of Conservation to protect harbour seals and their habitat. Designation provides a regulatory framework for action and needs to be operationalized through management plans which set out conservation objectives, how they might be achieved, by whom and on what timescales. Management plans should also set out procedures for enforcement, review and stakeholder involvement. Whilst practical management measures, such as prohibiting the use of bottom set gillnets and entangling nets, could be agreed without MPA designation (the procedures depending on whether they are within territorial waters or EEZs), the supporting mechanisms of MPAs such as conservation objectives, management planning, monitoring, and enforcement provide a framework for effective implementation.

Supporting measures

Species action/management plans
Species action plans focus attention and can set out very specific recommendations as well as identifying who should take action to improve the status of species. A key element of such plans for the harbour seal needs to be long-term monitoring and research, the restoration of suitable habitats where appropriate and the establishment and proper management of seal sanctuaries. National management plans for seal conservation are recommended through the HELCOM Recommendation 27-28/2 on Conservation of Seals in the Baltic Sea Area. National authorities should co-ordinate their conservation and monitoring strategies regarding shared seal populations with neighboring countries[1].

International agreements
International agreements support the introduction and enforcement of measures to protect the marine environment of the Baltic Sea and are essential to protect a species such as the harbour seal which is present in more than one Baltic Sea country. This is also necessary because significant threats, such as pollution and disease may need to be tackled by joint action at regional or international level.

HELCOM Recommendation 27-28/2 on Conservation of Seals in the Baltic Sea Area (2006)[2] states that the long-term objectives for the management of Baltic Seals are a natural abundance and distribution and a health status that ensures their future existence. The Baltic Sea Action Plan (BSPA) further stipulated that "By 2015, improved conservation status of species included in the HELCOM lists of threatened and/or declining species and habitats of the Baltic Sea area will be achieved and by 2015 the by-catch of harbour porpoise, seals, water birds and non-target fish species has been significantly reduced with the aim to reach by-catch rates close to zero". Many of the associated actions have still to be accomplished[3].

The BSAP provides a framework for joint actions across Baltic states as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea.

1 HELCOM, 2013.
2 http://www.helcom.fi/Recommendations/Rec%2027-28-2.pdf
3 https://portal.helcom.fi/meetings/SFI%20WS%201-2019-631/Related%20Information/Presentation%201%20Haldin.pdf

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RIVER LAMPREY, *LAMPETRA FLUVIATILIS* AND SEA LAMPREY, *PETROMYZON MARINUS*

SUMMARY OF KEY MANAGEMENT MEASURES

The sea lamprey is very rare in the Baltic Sea while the river lamprey is more widespread and has been the subject of both commercial and recreational fisheries. Both species are anadromous. The main threats to these species are associated with activities that impede their progress up rivers to spawning grounds, changes to hydrographic conditions of water courses, and poor water quality, all of which can affect their spawning success.

Two types of management objective are a priority for lamprey. Firstly, preventing the degradation and loss of suitable habitat, and secondly protection and enhancement of existing populations. This requires taking action to restore the ability of rivers to support migration and spawning of lamprey, as well as conservation of the populations in river systems and coastal waters. Practical actions include habitat restoration, removal of physical obstacles to migration, and artificial restocking and reintroduction. Regulating fisheries, and measures that support collaborative initiatives such as river basin management plans are also essential. Better understanding of the biology of the species and its ecological requirements is vital for successful conservation measures.

Whilst both river and sea lamprey will benefit from these measures, the rarity of the sea lamprey in the Baltic Sea is likely to mean that any effects will be hard to detect for this species.

THE SPECIES

The river lamprey *Lampetra fluviatilis* is an anadromous species as it spends its life in both freshwater and the sea. The larvae hatch from eggs laid in rivers and burrow into the sediment. They metamorphose after 3-5 years after which the juveniles migrate downstream to the sea. After 1-2 years the adults migrate back up rivers to spawn and then die. There are two strains of river lamprey, some migrating up rivers in the spring and others in autumn[1].

The sea lamprey *Petromyzon marinus* has a similar life cycle with adults migrating up rivers in the late winter or spring. They prefer gravel bottoms and adjacent clean sandy areas for spawning[2].

During their marine life stage both species parasitize on major Baltic Sea fish species such as cod, herring, flounder and plaice.

River lamprey © Robertas Staponkus

1 Berg, 1948 in Ryszard et al., 2010.
2 Thiel et al., 2009

Distribution in the Baltic Sea

The river lamprey has a range from southern Norway to the western part of the Mediterranean. It is found in coastal waters and rivers in along the European Atlantic coast, the northwestern Mediterranean Sea, the North Sea, and throughout the Baltic Sea[1].

In the Baltic Sea it is present in numerous rivers of Sweden and Finland, in Russian rivers flowing into the Gulf of Finland, Estonia, and in the rivers of Latvia, Lithuania, Poland and Germany[2].

The sea lamprey is very rare in most basins of the Baltic Sea. Catches have occasionally been reported in Estonia, Latvia, Lithuania, Germany, and Poland. In Sweden it occurs along the west coast but is very rare. Spawning has been reported in eight Swedish and five Danish rivers flowing into the Kattegat and Öresund, and in one Swedish river in the Sound[3].

Conservation status

HELCOM has assessed the river lamprey *Lampetra fluviatilis* as being Near Threatened in the Baltic Sea[4].

The river lamprey is on Annex II and V of the EU Habitats Directive. It has been assessed as Vulnerable in Poland, Near Threatened in Finland, and Least Concern in Estonia and Sweden[5].

HELCOM has assessed the sea lamprey *Petromyzon marinus* as being Vulnerable in the Baltic Sea[6].

The sea lamprey is on Annex II and V of the EU Habitats Directive. It is listed in Red Data Book of Lithuania and has been assessed as Vulnerable in Denmark and Near Threatened in Sweden[7].

1 Ryszard et al., 2010
2 *ibid*
3 Thiel et al., 2009; http://www.helcom.fi/Red%20List%20Species%20Information%20Sheet/HELCOM%20Red%20List%20Petromyzon%20marinus.pdf
4 http://www.helcom.fi/Red%20List%20Species%20Information%20Sheet/HELCOM%20Red%20List%20Lampetra%20fluviatilis.pdf
5 HELCOM 2013. Species Information Sheet
6 http://www.helcom.fi/Red%20List%20Species%20Information%20Sheet/HELCOM%20Red%20List%20Petromyzon%20marinus.pdf
http://www.helcom.fi/Red%20List%20Species%20Information%20Sheet/HELCOM%20Red%20List%20Lampetra%20fluviatilis.pdf
7 HELCOM 2013. Species Information Sheet

PRESSURES AND THREATS

The main pressures and threats to lamprey in the Baltic Sea are from constructions on rivers that block or interfere with their migration, poor water quality, and targeted commercial fisheries.

The construction of hydroelectric power stations on rivers where lamprey migrate to the upper reaches to spawn has been a major threat. Apart from physically blocking migration routes, or creating obstacles which require fish passes, the operation of these stations can result in radical changes in water levels and the water flow of rivers. By changing conditions both upstream and downstream of facilities they can have an impact on spawning sites and spawning behaviour[1]. The construction of weirs and dams to regulate river flow also present obstacles to the migration of lamprey as well as causing sediment to build up, water temperature rises, and reduced oxygen levels where water has pooled. Dredging riverbeds can lead to erosion and increase turbidity and sedimentation, degrading spawning grounds, and there can also be a direct effect on the larvae which live buried in sediment.

Lamprey larvae require well oxygenated sandy areas of riverbed to thrive, but gravelly riffle areas to secure efficacy of spawning are also key to their success. Poor water quality associated with nutrient enrichment is detrimental to both adult and juvenile stages, and persistent organic pollutions in water courses and the riverbed are known to bioaccumulate in lamprey larvae[2].

The river lamprey has been the target of both commercial and recreational fisheries. Landings records reveal highest catch numbers from the southern Baltic in late 19th century as well as a brief period of increased catches in the 1970's[3]. There has never been a commercial fishery in the Baltic Sea for sea lamprey although individuals may have been caught in both commercial and recreation fisheries for river lamprey. River lamprey fisheries operate in Finland, Russia, Lithuania, Latvia and Estonia using fyke nets, cone traps, baskets attached to weirs, and lamprey trammel nets[4]. The types of fishing gear used depend on local conditions and traditions[5].

The sea lamprey is now very rare in the Baltic Sea. It is larger than the river lamprey, needing bigger hosts. Problems with diminishing fish stocks and sizes may therefore have been a factor in its decline.

1 Birzaks & Abersons, 2011
2 Järv et al., 2017
3 Thiel et al., 2009
4 Thiel et al., 2009
5 Sjöberg, 2013

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the species. This will include actions to be taken in the terrestrial environment as the management of river systems, construction works, and eutrophication, are some of the threats to lamprey populations. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

Given the decline in the population of lamprey and its disappearance from some river systems around the Baltic Sea, the conservation objectives for lamprey need to focus on maintaining and improving the status of the remaining populations. This is consistent with objectives under the EU Habitats Directive.

Management objectives

Two types of management objective are a priority for lamprey. The first should aim to preventthe degradation and loss of suitable habitat and the second should seek the protection and enhancement of existing populations. This requires taking action to restore the ability of rivers to support the migration and spawning of lamprey, alongside protecting the populations in river systems and coastal waters.

Practical measures

Both river and sea lamprey will benefit from the following measures but the rarity of the sea lamprey in the Baltic Sea is likely to mean that any effects will be hard to detect for this species.

Access to spawning grounds

Obstacles on water courses such as culverts, weirs and dams modify water flows and act as barriers to adults migrating up rivers to spawn. Removing these barriers and/or building natural bypass channels can restore access enabling adult lamprey to reach their spawning grounds. Lamprey may also benefit when similar works are carried out to benefit salmon migration. Fish passes at hydroelectric power stations will be beneficial, but consideration should also be given to modifying existing structures in such facilities to make them more effective, for example by reducing water flow to accommodate the passage of lamprey and reducing the likelihood of juveniles being trapped on turbine cooler screens as lamprey are not effective swimmers. Changing water levels can also desiccate and isolate habitat with ammocoetes especially vulnerable to stranding as they are burrowed into the substrate and may react slowly to changes in water levels. Manually transferring lamprey in such cases can reduce the impact. It should nevertheless be noted that other changes associated with hydroelectrical power stations such as water storage and changes in water flow, may mean that former spawning grounds have changed, making them unsuitable habitat for the lamprey. Improving access to spawning grounds therefore needs to be concurrent with actions to address other issues that have led to the decline of lamprey.

Habitat restoration
Projects such as creating off channel areas with clean water and sediment where fish can rest during migration, and restoration works on spawning grounds and soft sediment areas (ammocoete beds) inhabited by ammocoetes can help to improve damaged or degraded habitat used by lamprey.

Artificial restocking and reintroduction
Restocking of artificially bred lamprey larvae (ammocoetes) has been underway since the 1980s in some Baltic Sea countries. In Latvia, an average of 7.4 million have been released into the lower part of the river Daugava, for example, and in Finland artificial propagation became mandatory for supplementing lamprey stocks since 1997[1]. As pheromones released by juvenile lamprey appear to be an attractant to adults, restocking or reintroduction of lamprey to watercourse can support natural recolonization but this may take decades. The effectiveness of restocking as a restoration measure is difficult to determine as many other factors influence population levels such as the operation of hydroelectric power stations and changes in the cod stock which affect herring, sprat and smelt, the main food of river lamprey. Any restocking and reintroduction need to be carried out in conjunction with the restoration of migration routes and spawning habitats if these actions are to be of long-term benefit to the population.

Reducing nutrient inputs
Tackling eutrophication is one of four goals of the HELCOM Baltic Sea Action Plan with the first Nutrient Reduction Scheme, promoting a regional approach to achieving this goal, being agreed by HELCOM in 2007. The scheme established Maximum Allowable Inputs and Country-Allocation Reduction Targets compared to a reference period of 1997-2003. Reducing inputs of nitrogen and phosphorus at source is seen as key to achieving good environmental status for the Baltic Sea. Sediment conditions are crucial to the success of ammocoetes which cannot survive in anoxic sediments. Limiting excess algae growth is therefore critical to maintaining a healthy ammocoete populations. Practical actions at a local level, such as reducing the use of nutrients on land adjacent to water courses frequented by lamprey as well as water and sewage management schemes that reduce discharges to rivers and the sea[2] fit within this wider framework.

Regulatory measures

Regulation of fisheries
Licensing, closed areas, effort control and the length of the closed season, are all measures that can be used to regulate the river lamprey fishery to ensure that in areas where there is a fishery, it is operated on a sustainable basis. Technical measures are also needed to support more general regulations and should include setting operational conditions such as the maximum width of fyke nets, and the width of the river that must be left as free flow[3].

1 Greig & Hall, 2011
2 E.g. Parsęta River Basin project. https://baltcf.org/project/increasing-passability-of-ecological-corridors-in-the-parseta-river-basin/
3 Abersons & Birzaks, 2014

Supporting measures

River basin management plans
The rivers used by lamprey are likely to extend across several municipalities as well as crossing national borders. A joint integrated approach involving all the relevant parties in agreeing and setting conservation objectives and management plans is therefore essential. River basin management plans provide a framework in which to develop, promote, monitor and report on actions for the conservation of lamprey. They typically set out the objectives, consultation processes, actions, key players, timescales, and organizational structures. They cannot be developed in isolation if they are to be effective and therefore should recognize and advocate measures for the adjacent coastal land, river basins/ watershed and the adjacent sea. This is particularly helpful in the case of the lamprey which not only cross from freshwater to the sea, but which are also affected by activities taking place on adjacent land.

Planning frameworks
Planning frameworks can set direction, bring together key players and involve the public in decision making. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. The priorities and detailed provisions in such plans can have a direct impact on habitats used by lamprey, for example by identifying areas for development, methods of construction, and environmental impact assessment requirements. This is even more likely to be the case with some sector specific plans, such as those concerned with energy generation or wastewater treatment, as the decisions set out in the plans can have a significant impact on lamprey habitat as well as on the ability of the species to migrate along watercourses.

Research and understanding
Management measures for the conservation of lamprey need to be underpinned by an understanding of the biology of the species, its ecological requirements and the impacts on both. Ongoing research, for example associated with restocking programmes, tagging studies and habitat restoration initiatives provide valuable information to inform management measures. Some of this is of a general nature, but it is also essential to understand how lamprey are likely to respond at a local level so that appropriate management objectives can be set and effective measures introduced to achieve these objectives.

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SEA DUCKS

SUMMARY OF KEY MANAGEMENT MEASURES

Large numbers of sea duck winter in the Baltic Sea. The most common species are the long-tailed duck, common eider, Steller's eider, velvet scoter and common scoter. In all cases their wintering populations have been assessed as Endangered in the Baltic Sea. Bycatch and marine pollution are major concerns as well as activities such as vessel traffic and construction of offshore windfarms that disturb and displace waterbirds. Species which nest in sheltered coastal sites are also subject to additional pressures and threats such as loss of habitat and predation from native and introduced species. Some hunting of sea duck is permitted under specified conditions.

Management measures need to address the main pressures and threats to these species across their range, not just in the Baltic Sea. Beneficial practical management actions include measures to reduce or eliminate bycatch such as modifying fishing gears or establishing no fishing zones. Disturbance free zones in significant feeding and resting areas can reduce negative effects. Both pollution prevention, especially in the case of oil pollution, and emergency response/contingency planning are needed as well as sector-specific measures targeting activities that are a threat to sea duck either because of their mode of operation, their scale of operation, or location. Marine Protected Areas with specific conservation objectives, and maritime spatial planning can provide a valuable framework under which these types of measures can be introduced, regulated and monitored for their effectiveness.

THE SPECIES

Sea ducks are species that nest in coastal or inland areas but spend the non-breeding season in the marine environment. In the Baltic Sea the most common species are the long-tailed duck, common eider, Steller's eider, velvet scoter and common scoter and greater scaup. Large numbers winter in the Baltic Sea, migrating from their breeding grounds in the Arctic. They gather in lagoons, shallow coastal waters, and offshore banks, sometimes diving as deep as 20 m to feed on benthic fauna. Their main diet is molluscs such as *Mytilus* spp., *Dreissena polymorpha*, *Limecola balthica*, and *Cerastoderna glaucum* but they also feed on crustaceans, and in the shallow areas in the sounds, on small snails (e.g. Hydrobiidae) and ragworms *Hediste diversicolor*[1].

Male and Female Eider Duck ©Stefan Menzel

1 Nilsson, 2012; Waltho & Coulson, 2015

Distribution in the Baltic Sea

The Gulf of Riga, seas around Gotland, the Kattegat and the bays, islands and lagoons along the coastlines of the southern Baltic states of Denmark, Germany and Poland are recognized as being of international importance for sea birds including sea duck[1]. The southern Baltic is also one of the most important wintering sites for diving waterbirds anywhere in the Palearctic[2].

The Baltic Sea is the most important wintering area for long-tailed duck in north west Europe with the major wintering areas in Pomeranian Bay, the Irbe Strait-Gulf of Riga and Hoburgs Bank-Midsjö Banks south of Gotland[3]; the most important area for wintering Velvet Scoter is the Lithuanian-Latvian coast although Pomeranian Bay (Poland/Germany) and the central Polish coast are also important. Common eider congregates in the southern Baltic Sea although previously (in the early 1990s) this also took place in the north-western Kattegat. The most important areas for wintering Scaup are sites in south western Baltic – Szczecin Lagoon (Poland/Germany), Usedomer coast and Greifswalder Lagoon[4].

Conservation status

Steller's Eider *Polysticta stelleri*, is on Annex I of the EU Birds Directive requiring the designation of SPAs. The Common Scoter, Velvet Scoter, Common eider, Greater Scaup and Long-tailed duck are on Annex II for some Member States which permits hunting at specific times of year. Common Scoter and Common Eider are on Annex III B which allows some legal killing or capture.

HELCOM have assessed the wintering populations of Steller's eider (*Polysticta stelleri*), Common eider (*Somateria mollissima*), Common scoter (*Melanitta nigra*), Velvet Scoter (*Melanitta fusca*) and long-tailed duck (*Clangula hyemalis*) as Endangered and the breeding populations of Common Eider and Velvet Scoter as Vulnerable in the Baltic Sea. The Greater Scaup has been assessed as Vulnerable[5].

The Common eider, Steller's eider, Velvet scoter, and common shelduck are species used by HELCOM as core indicators of the abundance of waterbirds in the breeding season[6] and Common eider, Steller's eider and tufted duck as core indicators of the abundance of waterbirds in the wintering season[7].

Ninety nine percent of the world's Velvet Scoter population winters in the southern Baltic and the population has been classified as Vulnerable (VU) by the IUCN on a global scale. For this reason, Velvet Scoter is the most important species that needs to be given the attention. Global populations of Long-tailed Duck and Steller's Eider and European populations of Greater Scaup and Common Eider have also been classified as Vulnerable by IUCN.

Wintering populations of *C.hyemalis* have been assessed as Endangered in Sweden and Near Threatened in Germany; *Aythya marila* is Critically Endangered in Estonia, Endangered in Finland and Vulnerable in Sweden.

1 Skov et al., 2007
2 Durinck et al., 1996
3 HELCOM Red List Bird Expert Group, 2013; http://www.helcom.fi/Red%20List%20Species%20Information%20Sheet/HELCOM%20Red%20List%20Clangula%20hyemalis.pdf
4 Skov et al., 2011
5 HELCOM Red list of Birds https://helcom.fi/baltic-sea-trends/biodiversity/red-list-of-baltic-species/red-list-of-birds/
6 https://helcom.fi/media/core%20indicators/Abundance-of-waterbirds-in-the-breeding-season-HELCOM-core-indicator-2018.pdf
7 https://helcom.fi/media/core%20indicators/Abundance-of-waterbirds-in-the-wintering-season-HELCOM-core-indicator-2018.pdf

PRESSURES AND THREATS

Bycatch is a significant threat to sea ducks as they feed in coastal waters and shallow offshore banks in the Baltic Sea. They are especially vulnerable to becoming entangled and drowning in gill nets used in coastal fisheries to catch cod, flatfish, herring and salmon although not all species are equally susceptible. One estimate of the cumulative annual bycatch in static net fisheries the Baltic Sea and (predominantly eastern) North Sea (made up mainly of divers, grebes, sea ducks, diving ducks, auks and cormorants) is between 90,000-200,000 birds[1]. The risk of bycatch depends on factors such as the net length, mesh size, soak times and duration of the fishing season. There are also differences in the species which dominate bycatch in different parts of the Baltic Sea. Sea ducks have been reported to dominate the bycatch in the eastern Baltic, sea ducks and diving ducks in the southern Baltic, auks, particularly the common guillemot most commonly caught in the western Baltic, and diving ducks, mergansers and grebes in Lakes Ijsselmeer and Markermeer[2].

Oil pollution is another a significant threat to sea ducks in the Baltic Sea especially when it occurs in areas where birds congregate during moulting or on wintering sites because in these situations large numbers can be affected by a single incident[3]. A heavy coating of oil on the plumage of birds can cause direct mortality but they may also die from ingesting oil when preening or feeding on oil-polluted food or water[4]. Studies in southern Gotland indicate that in the central Baltic Sea, several tens of thousands of long-tailed ducks are injured by oil each year from oil spills along the main shipping routes[5].

Various activities are known to disturb and displace seabirds in the Baltic Sea. Ship traffic and offshore windfarms may temporarily or permanently displace sea ducks from favored feeding grounds[6]. In the case of loons, for example, displacement effects of decreasing abundance in formally occupied areas became significant at around 16.5 km from offshore wind farm sites and were still apparent at a distance of more than 20 km. This was considered to be the result of the combined effects of increased ship traffic associated with maintenance and servicing the wind turbines rather than risk of collision with turbine blades[7]. Fishing activities, sand and gravel extraction and dredging of shipping channels can also cause temporary disturbance and may combine with other factors (such as mussel fisheries) to reduce the food supply for sea ducks[8].

Hunting of some sea ducks is permitted under conditions specified under the EU Birds Directive. This includes hunting for the long-tailed duck, velvet scoter and common eider with several tens of thousands of birds shot around the Baltic Sea each year. Scaup may also be bagged mistakenly as tufted ducks in countries with no open season for this species[9]. Ingestion of poisonous lead shot is another cause of mortality, as has been report for breeding common eider females in the Gulf of Finland[10].

The effects of climate change on sea ducks are uncertain. They may benefit from reduced ice cover on breeding grounds helping to extend the breeding season, but the effects of changing water temperature on their prey species may have a detrimental effect.

1 Žydelis et al., 2009
2 Žydelis et al., 2009
3 Joensen & Hansen, 1977
4 HELCOM, 2012
5 Larsson & Tydén 2005, Larsson 2007
6 Schwemmer et al., 2011
7 Mendel et al., 2019
8 HELCOM Red List Bird Expert Group, 2013; EC, 2007
9 HELCOM Red List Bird Expert Group, 2013
10 Research of sea ducks in the Baltic Sea. Gotland University

Common eider and velvet scoter breed along the Baltic Sea where they are subject to additional pressures and threats such as loss of sheltered, undisturbed nesting sites, and mortality from predation by native species such as the Arctic fox as well as from introduced species such as the American Mink.

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the species. This will include actions across the range of the species concerned, not just in the Baltic Sea. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

The EU Birds Directive requires the protection, management and control of all species of naturally occurring birds in the wild state in the European territory of Member States. Measures under the EU Habitats Directive are intended to maintain or restore habitats and species at favourable conservation status. The Conservation objectives for sea ducks within MPAs should help facilitate these objectives by providing protection, as well as conditions that improve their conservation status.

Management objectives

Management objectives need to focus on removing the threats to sea ducks in the Baltic Sea. Such actions should, however, be linked to conservation and management plans for species throughout their range and developed with knowledge of the risks elsewhere.

Practical measures

Technical measures to reduce/eliminate bycatch

The main focus of bycatch reduction through technical measures is by modifying the design and operation of fishing gears, increasing the visibility of nets and using deterrent devices. Some technical bycatch mitigation measures have been tested for gillnets but with uncertain results. For example, net light trials in Puck Bay and the Pomeranian Bay did not demonstrate a statistically significant reduction in seabird bycatch but did have some deterrent effect for long-tailed duck[1]. Sound omitting pingers, green lights and buoys with visual bird deterrents on nets have also been examined as possible options for reducing bycatch[2]. Changing fishing methods, for example from set gillnets to hook and line fishery for cod is another suggestion for reducing bycatch. However, whilst this may solve the problem for sea ducks, it could potentially increase bycatch of other birds[3]. Solutions are likely to be site specific, depending on fishing practices and the species of bird at risk[4].

1 Almeida et al., 2017
2 Österblom et al., 2002; Field et al., 2019
3 Mentjes & Gabriel, 1999
4 Žydelis et al., 2009

Oil spill response
Contingency planning, including setting out actions, responsibilities and communication pathways in the event of an oil spill, are key to minimizing the effect of oil spills on the marine environment and wildlife, as well as dealing with the resulting impacts. Response preparedness and contingency plans need information on locations, species, and seasonal patterns of risk and the most appropriate responses. MPA managers are in an ideal position to identify, in advance, vulnerable locations/species/times of year and any species-specific actions required at a local level. Ensuring this information is incorporated into contingency planning and participating in joint response exercise to test systems that are intended to protect habitats and species within MPAs in the event of an oil spill, is an essential practical measure to reduce the risk of environmental damage from oil spills.

Disturbance free areas
Disturbance can affect birds in a number of ways including changing in their behaviour, their reproductive success and fitness[1]. These risks can be reduced by establishing disturbance free areas, either seasonally, to prohibit hunting during the breeding season, or on a more permanent basis to prevent disturbance on significant feeding and resting grounds. In the latter case, channeling ship traffic to avoid habitat fragmentation and allow for habituation may be beneficial and could be promoted using zoning schemes within protected areas, or ships routeing measures. Disturbance free zones should also be set up during both the construction and siting of coastal and offshore developments as well as in management of recreational activities. The sensitivities/different flush distances of different species should be taken into account to give them adequate protection.

Regulatory measures

Spatial measures to reduce/eliminate bycatch
The current best practice for minimizing bycatch is to exclude fishing methods with a high risk of associated bycatch at times of year and/or from areas where susceptible species are known to concentrate. This can be achieved, for example, by excluding gillnet fisheries in areas known to support high numbers of wintering sea ducks, as well as avoiding overlap of such fisheries with important locations used by these species when moulting or during their autumn and spring migrations[2]. One example of this approach is a voluntary scheme in the German Baltic Sea to reduce the use of gillnets in areas where seaducks occur in large numbers between November and March[3]. Such measures should be developed alongside species vulnerability maps to avoid displacement of the affected fisheries to other areas that are also important for sea duck[4].

Effort reduction to reduce/eliminate bycatch
Restricting fishing effort using fishing gears (set nets) at times of year when risk of bycatch is particularly high may lead to some reduction in bycatch. However, the overall effectiveness in removing this risk for a species is unlikely to be significant without other measures, given that some of the vulnerable species are found in high concentrations. Small numbers of nets can therefore inflict significant damage.

1 Schwemmer et al., 2011
2 HELCOM, 2012
3 https://www.ascobans.org/sites/default/files/document/AC24_Inf_2.d_2017%20National%20Report_Germany.pdf; http://www.ostseeinfocenter.de/Freiwillige_Vereinbarung_Fortschreibung_2015.pdf
4 Sonntag et al., 2012

Ships routeing
The Baltic Sea was designated a Particularly Sensitive Sea Area (PSSA) by the IMO in 2005. Various associated protected measures particularly Areas to be Avoided (ATBA) and Traffic Separation Schemes (TSS) have been established as safety measures and to reduce the risk to marine wildlife and habitats from pollution resulting from shipping accidents. The area around Norra Midsjöbanken and Hoburgs Bank, for example, is important for wintering long-tailed ducks, as well as for other bird species. With a high risk of oil spills from groundings on Norra Midsjobanken and from collisions off Gotland and the deep-water shipping route, both an ATBA and TSS have been introduced in this area to reduce the risk of collisions and consequent pollution. Establishing such measures requires agreement with the international shipping community through the IMO and is therefore not likely to be a task of MPAs managers. Nevertheless, detailed information on the threat to wildlife from shipping collected at a local level, as gathered by MPA managers, can provide essential supporting evidence for the introduction of such measures.

Protected areas
Protected areas have been established for birds through national conservation programmes and these locations may also be recognized as Baltic Sea MPAs, Ramsar sites and Ecologically or Biologically Significant Marine Areas (EBSAs). EU Directives require the designation of Special Protection Areas and Special Areas of Conservation to protect both the species and their habitat. Designation provides a regulatory framework for action. In the case of the Habitat Directive this include a requirement to achieve favourable conservation status and to prevent damage and deterioration of the habitat and its typical species. The Birds Directive provides for strict protection of birds including protection from disturbance and displacement by human activities. Protected areas can also be focal points for implementing species action plans.

Supporting measures

Action plans
International and regional Action Plans to reduce the risk to bird populations, including to populations of sea ducks, are essential for conservation of the many migratory species that overwinter in the Baltic Sea. Management of species that spend their entire life cycle in the Baltic Sea will also need the support and agreement of other Baltic States not only because of the widespread distribution of such species, but because some of the significant threats, such as oil pollution, can best be tackled by joint action at regional or international level. Three examples of taking a joint approach are the EC Action Plan for reducing incidental catch of seabirds in fishing gears[1], the international single species action plan for the conservation of the long-tailed duck[2] and the European Species Action Plan for Steller's Eider[3] Supporting the development and implementation of targeted action plans, especially where they identify lead bodies for actions, set timetables, and provide administrative and/or financial support can help MPA managers achieve site specific MPA conservation objectives for sea duck.

MPA Management plans
MPA management plans set out site specific objectives, actions, and supporting measures such as enforcement and opportunities for public participation in the process. They provide a framework for management as well as direction, and set out the reasons for the introduction of measures such as zoning schemes with time/area closures. MPAs are also a focus for activities with more wide-ranging benefits such as raising awareness about the marine environment and about the threats to marine wildlife such as sea ducks.

1 COM(2012) 665 final
2 Hearne et al., 2015
3 https://ec.europa.eu/environment/nature/conservation/wildbirds/action_plans/docs/polysticta_stelleri.pdf

Planning frameworks
Planning frameworks can set direction, bring together key players and involve the public in decision making for particular geographical areas. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent[1]. The management of bird populations cannot be undertaken in isolation of activities, demands and influences taking place around them hence the need to incorporate biodiversity objectives and associated management measures for sea ducks into Maritime Spatial Plans.

The priorities and detailed provisions in management plans can be of direct benefit to sea ducks, for example by identifying areas for development that do not impact key habitats, methods of construction that minimize or avoid disturbance, and environmental impact assessment requirements to give a view of the implications of any schemes. Management plans should also be used to identify any potential in combination effects such as increased vessel traffic associated with the maintenance of offshore wind farms that can be detrimental to sea ducks as well as longer term issues such as risk of displacement or pollution incidents.

International agreements
International agreements support the introduction and enforcement of measures to protect the marine environment of the Baltic Sea. They include designation of the Baltic Sea as a Special Area under Annex I of the MARPOL Convention to prevent oil pollution from shipping, and under Annex IV on the discharge of ships' sewage and Annex V on disposal of garbage. Bilateral agreements and international conventions also strengthen cross-board cooperation in the case of an oil spills or protective measures across the range of the species in both their breeding and wintering areas[2].
Through HELCOM, the Baltic Sea Action Plan (BSAP) provides a framework for joint actions across Baltic states as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea. Maritime Spatial Plans and prevention of pollution are some of the agreements promoted through the BSAP that can benefit sea duck and need to be maintained and potentially strengthened in the revised BSAP[3]. BaltSeaPlan and Baltic SCOPE have supported the development of MSP in the Baltic and there is a deadline of 2021 for Baltic Member States to establish Marine Spatial Plans under the EU Directive establishing a framework for MSP (EU 2014/89/EU)[4].

Sector specific measures
Where particular activities are a threat to sea duck either because of their mode of operation, scale of operation or where they take place, regulation can support bird conservation. This may, for example include restrictions on fishing and hunting, and on the siting and servicing of offshore wind farms.

Research and understanding
Bycatch mitigation has been recognized as essential to reducing the threat to sea duck and there is ongoing research into potential options supported by both nature conservation and fisheries interests. Further research is needed to determine what if any technical measures can be effective in reducing bycatch for sea ducks most especially from set nets as well as on vulnerability mapping to ensure they are deployed in areas of highest risk as the highest priority. Risk assessments will need to be informed by knowledge of changing patterns of migration and wintering in response to climate change on 'hot-spots' for sea duck.

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1 Ehler & Douvere, 2009; Kappeler et al., 2012
2 Marchowski et al., 2017
3 E.g. http://www.helcom.fi/baltic-sea-action-plan; BMEPC, 2018
4 E.g. http://www.helcom.fi/baltic-sea-action-plan; BMEPC, 2018

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TERNS

SUMMARY OF KEY MANAGEMENT MEASURES

Several species of tern breed around the Baltic Sea using on offshore islands, beaches, dunes and gravel areas. The main pressures are at nesting sites when adults, eggs and chicks are vulnerable to predation by both native and non-native mammalian predators. Disturbance associated with human activity, either directly through egg collecting or indirectly (for example when engaged in recreational activities) can result in nests being abandoned and colonies being deserted. Damage and loss of suitable nesting habitats due to coastal schemes and development, and food shortages, can also lead to breeding failure.

Management objectives need to focus on removing the threats to terns in the Baltic Sea but should also be linked to measures needed for their conservation throughout their range. Such measures include predator control at nesting sites, encouraging recolonization of abandoned nesting areas and improving or restoring suitable habitat for nesting. Disturbance free areas are also key to breeding success. These types of measures can be linked to conservation objectives, monitoring and reporting within the framework of Marine Protected Areas as well as in species specific action plans promoted through local, regional and international agreements.

THE SPECIES

Little Tern (*Sternula albifrons*), Common Tern (*Sternula hirundo*), Arctic Tern (*Sterna paradisaea*), Sandwich Tern (*Thalasseus sandvicensis*) and Caspian Tern (*Hydroprogne caspia*) are all migratory species that breed around the Baltic Sea. The Gull-billed Tern (*Gelochelidon nilotica*) used to nest on the German Baltic coast in the 19th century and was reported from Denmark until 1970 but is now considered to be regionally extinct in the Baltic Sea.

The favored habitats for breeding colonies differ between the species and whilst all use coastal areas, some also establish breeding colonies inland. Sandwich Tern nesting sites are often in areas of grassland and occasionally in dunes or gravel areas in association with Black-headed gulls[1]; Caspian Tern use more exposed locations such as outer skerries, always with other gulls or terns; Little Tern make bare scrapes in sandy and gravel banks and spits along the coast or construct their nests of shells or vegetation in inland areas along rivers, breeding in solitary pairs or small groups[2]; the Arctic Tern nests on sand or shingle beaches, ridges and spits, rocky ground and small islands in lakes and coastal lagoons.

Terns are opportunistic feeders, plunge diving for fish such as sandeels and stickleback, as well as feeding on insects and crustaceans e.g *Idotea balthica*[3]. During the breeding season they generally forage close to the breeding colonies, although some species can travel significant distances for food. Little Tern have very short foraging ranges, typically within 1 km of the shore whereas Arctic Tern have been tracked feeding up to 50 km away from colonies[4].

1 Herrmann et al., 2008

2 HELCOM Red List Bird Expert Group, 2013.

3 Lemmetyinen, 1973

4 Ratcliffe et al., 2008; del Hoyo et al., 1996

Distribution in the Baltic Sea

Breeding colonies of terns are widely distributed around the Baltic Sea with some differences between species because of their different habitat preferences. The main breeding areas of Little Tern are along the coast of the central and south-western Baltic where they favour sparsely vegetated islands and banks, dunes, and dry pastures along rivers, especially along the Vistula. The Caspian Tern breeds along the southern coasts of Finland and the Åland Islands. The breeding range of the Sandwich Tern expanded from the Atlantic into the Baltic Sea during the 20th century to the south-western, southern and central Baltic Sea. The largest colonies and the highest number of breeding pairs today are in the Danish areas of the Baltic Sea, especially in the Northern Kattegat and the Central Kattegat and Storebaelt[1].

Conservation status

Little Tern (*Sternula albifrons*), common Tern (*Sternula hirundo*), Caspian Tern (*Hydroprogne caspia*), Sandwich Tern (*Sterna sandvicensis*) and Arctic Tern (*Sterna paradisaea*) are on Annex I of the EU Birds Directive requiring the designation of SPAs.

HELCOM have assessed the Gull-billed Tern (*Gelochelidon nilotica*) as Regionally Extinct and the Caspian Tern as Vulnerable[2].

Little Tern, Common Tern, Arctic Tern, Caspian Tern and Sandwich Tern are species of surface feeding birds used by HELCOM as core indicators of the abundance of waterbirds in the Baltic Sea in the breeding season.

Both the Sandwich Tern and Little Tern are Vulnerable in Sweden and Lithuania; Near Threatened in Denmark, Estonia, and Poland, Endangered in Finland, and Critically Endangered in Germany. The populations of both species are reported as declining in Russia[3].

1 HELCOM Red List Bird Expert Group, 2013

2 https://helcom.fi/baltic-sea-trends/biodiversity/red-list-of-baltic-species/red-list-of-birds/

3 http://www.helcom.fi/Red%20List%20Species%20Information%20Sheet/HELCOM%20Red%20List%20Sternula%20albifrons.pdf; http://www.helcom.fi/Red%20List%20Species%20Information%20Sheet/HELCOM%20Red%20List%20Sternula%20albifrons.pdf

PRESSURES AND THREATS

Predation is a major threat to tern colonies as they nest on the ground in areas that can be easily accessible to mammalian predators such as foxes and wild boar. The feral American mink (Neovison vison) which escaped from fur farms in the 1920s is particularly problematic as it is now widespread and feeds on tern eggs, nestlings and adult birds. Predation on eggs and chicks by native species such as herring gulls and white-tailed eagles can also lead to significant losses and are reported to have devasted Caspian tern colonies in Sweden. Disturbance by predators can also lead to abandonment of breeding sites, one example being shifts in colonies of Caspian Tern colonies linked to disturbance by red foxes[1].

Human disturbance at nesting sites, during early courtship and incubation as well as during the weaning of chicks, can lead to nests being abandoned and whole colonies being deserted. This may be associated with recreational activities and research studies, for example, and may be the direct consequence of flushing birds as well as enabling gull predation while eggs and chicks are left exposed[2]. Egg collecting by local people, reported in Estonia and Russia, has also been a pressure[3].

Damage and loss of suitable nesting habitats associated with human activity is another pressure on breeding terns in the Baltic Sea. This is particularly the case for species that nest close to the water line, such as the Little Tern, as river regulation, coast protection and flood defense schemes can alter water levels making nesting sites more vulnerable to flooding.

Food shortages have led to breeding failure for the Arctic Tern in the North Sea and North East Atlantic and have been linked to overfishing of sandeels in areas where these fish form a major part of their diet[4]. Increasing sea temperatures in the North Sea have may also have been a factor, by reducing sandeel recruitment[5]. Sandeel are marine species they have a limited range in the Baltic Sea, being concentrated in the Kattegat. The extent to which food shortages are an issue for terns in the Baltic Sea is unclear because although there is a commercial fishery for sandeels, the state of the stocks and reliance of terns on sandeels as a food source in the Baltic Sea is unknown[6].

Common Tern (*Sterna hirundo*) © OCEANA Enrique Talledo
https://www.flickr.com/photos/oceanaeurope/32270497830/in/photolist-84cPKN-WCGAPr-RaCJHC-oweGvj

1 HELCOM, 2011 Red List of Baltic Breeding Birds
2 E.g. Fasola & Canova, 1996
3 http://datazone.birdlife.org/species/factsheet/caspian-tern-hydroprogne-caspia/text
4 Schreiber & Kissling, 2005; Mavor et al., 2004
5 Vigfusdottir et al., 2013
6 HELCOM, 2013

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the species. This will include actions across the range of the species concerned, not just in the Baltic Sea. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

The EU Birds Directive requires the protection, management and control of all species of naturally occurring birds in the wild state in the European territory of Member States. Measures under the EU Habitats Directive are intended to maintain or restore habitats and species at favourable conservation status. The Conservation objectives for terns within MPAs need to facilitate these objectives by providing protection, as well as conditions to improve the conservation status of the relevant species. They may for example, include habitat protection, protecting or increasing the breeding population and/or improving breeding success at tern nesting colonies.

Management objectives

Management objectives need to focus on removing the threats to terns in the Baltic Sea. Specific tasks may be identified within MPAs, but the actions and objectives should be linked to conservation and management plans for the species throughout their range and developed with knowledge of the risks elsewhere.

Practical measures

Predator control

Hunting, trapping and electric fences have been used to keep mammal predators away from tern nesting sites with positive results. Removal of American mink (*N.vison*) over a period of nine years from four groups of small, mainly rocky islands in the Archipelago National Park (Finland), led to a marked increase in the breeding density of Arctic Tern as well as other nesting birds. This study not only demonstrated that it is possible to remove mink from large archipelagos with many small islands but also that it can also increase the breeding density of many bird species[1]. A similar predator control programme to reduce the impact of predatory mammals in Mecklenburg-Western Pomerania in 2006 to keep bird islands and islets as well as breeding sites free of predatory mammals also had positive results. In the UK, a study on a sand spit in eastern Scotland led to a significant increase in nesting Sandwich Tern following the erection of an electric fence to separate the colony from the mainland and deter predation by the red fox *Vulpes vulpes*[2].

These and other studies have shown the benefits to tern colonies of controlling mammalian predators. However, since total eradication is unlikely, except perhaps from highly isolated islands, and because it is difficult to prevent immigration from surrounding areas especially along sections of mainland coast, control programmes will need to be carried out repeatedly and over the long term.

1 Nordström et al., 2003

2 Forster, 1975

Various methods have also been used to reduce gull predation at nesting sites. In Minnesota (USA) for example, brightly colored nylon string, in conjunction with shelters for chicks were successful deterrents to predation by ring-bill gulls[1]. Some gulls may nevertheless have a protective function such as the black-headed gulls around Sandwich Tern colonies[2].

Encouraging recolonization

Sound recordings and decoys, when combined with other necessary measures such as habitat restoration and predator control (described above), have been used successfully to encourage terns to recolonize locations that formerly supported breeding colonies. Success also depends on understanding species behaviour. For example, colonisation programmes are more likely to be effective if they are near existing colonies and are probably colonized more quickly if they were occupied recently. Successful initiatives using decoys and acoustic playbacks include the return of Arctic and Common Tern to the Isle of May (UK) ; attracting Caspian Tern, Arctic Tern and Common Tern to nesting sites around inland lakes in the USA ; and attracting Common Tern to nest around Lake Ontario (Canada).

Habitat restoration and creation

A variety of management measures can be used to maintain and restore suitable habitat for nesting terns depending on the condition of active or formerly important nesting colonies and the requirements of the different species.

They include managing vegetation to prevent overgrowth and maintain a desirable mix of open substrate with scattered cover by mechanical clearance, hand thinning, burning, tilling and periodic deposition of gravel or dredge spoil[3]. Keeping areas of bare ground, low vegetation cover and preventing erosion of islets using dredge spoil were recommended guidelines to benefit nesting Sandwich, Common and Little Tern in the Po Delta (Italy)[4]. In the Azores, artificial nest boxes were used by Common Tern chicks as shelters[5] whilst artificial islands created using dredge spoil or other materials such as shingle, have been successful in attracting breeding Common Tern and Sandwich Tern in the UK[6]. Sediment recharge of eroded narrow beaches can also be used to mitigate loss of habitat or colony flood risks[7]. Around Lake Ontario (Canada), artificial rafts were used successfully to encourage nesting Caspian Tern and Common Tern[8]. Whilst measures such as these can improve conditions for nesting terns, they may need to be supplemented by other actions such as predator control and reducing disturbance to nesting birds (described above) to support a successful breeding colony.

1 Maxson et al., 1996.
2 Herrmann et al., 2008
3 Nisbet,2002; Lamb, 2015
4 Fasola & Canova, 1996
5 Bried & Neves, 2015
6 Burgess & Hirons, 1992
7 Ratcliffe et al., 2008
8 Lampman et al., 1996; Dunlop et al., 1991

Disturbance free areas
Disturbance can affect birds in a number of ways including changing their behaviour, reproductive success and fitness[1]. These risks can be reduced by establishing disturbance free areas, either seasonally, for example during the breeding season, or on a more permanent basis to prevent disturbance on significant feeding and resting grounds. Restricting human access to tern nesting sites during the breeding season reduces the risk of disturbance and colony abandonment. In the case of Little Tern, which use small scrapes as nesting sites, restricting access also reduces the risk of trampling on eggs. Management measures include having on-site wardens, erecting warning signs and fences, and roping off breeding areas during the nesting season. A three year comparative study of Little Tern nesting sites close to human activity compared to more remote locations in the Ria Formosa Natural Park (Portugal) both with and without protective measures (signage and wardening at times when human disturbance was higher) revealed that protective measures were the most important predictor of nesting success[2]. Disturbance free zones as conditions for development schemes, should also be considered, taking account of the sensitivities/different flush distances of different species.

Regulatory measures

Protected areas
Protected areas have been established for birds through national conservation programmes and these locations may also be recognized as Baltic Sea MPAs, Ramsar sites and Ecologically or Biologically Significant Marine Areas (EBSAs). EU Directives require the designation of Special Protection Areas and Special Areas of Conservation to protect both the species and their habitat. Designation provides a regulatory framework for action. In the case of the Habitat Directive this include a requirement to achieve favourable conservation status and to prevent damage and deterioration of the habitat and its typical species. The Birds Directive provides for strict protection of birds including protection for disturbance and displacement by human activities.

Supporting measures

Action plans
International and regional Action Plans to reduce the risk to bird populations are essential for the many migratory birds that overwinter in the Baltic Sea. Management of species that spend their entire life cycle in the Baltic Sea is also likely to need the support and agreement of other Baltic States not only because of their widespread distribution but also because some of the significant threats can best be tackled by joint action at regional or international level. The Finnish Action Plan for the Caspian Tern[3] is an example of this approach. Supporting the development and implementation of targeted Action Plans, especially where they identify lead bodies, set timetables, and provide administrative and/or financial support can help MPA managers achieve the site specific MPA conservation objectives for terns.

1 Schwemmer et al., 2011
2 Medeiros et al., 2007
3 http://www.nationalredlist.org/files/2012/09/Action-plan-for-the-conservation-of-Caspian-Tern-in-Swedish-with-English-summary.pdf

MPA Management plans

MPA management plans set out site specific objectives, actions, and supporting measures such as enforcement and opportunities for public participation in the process. They provide a framework for action, direction, and explanations for the introduction of measures such as zoning schemes with time/area closures. MPA management plans are also important in giving a focus to activities with more wide-ranging benefits such as raising awareness about the marine environment and about the threats to marine wildlife such terns.

Planning frameworks

Planning frameworks can set direction, bring together key players and involve the public in decision making for particular geographical areas. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent[1]. The management of bird populations cannot be undertaken in isolation of activities, demands and influences taking place around them hence the need to incorporate the biodiversity objectives and associated management measures for terns into Maritime Spatial Plans.

The priorities and detailed provisions in management plans can have a direct impact on habitats used by terns, for example by identifying areas for development, methods of construction, and environmental impact assessment requirements.

Sector specific measures

Where particular activities are a threat to terns, particularly at nesting colonies, either because of their mode of operation, scale of operation or where they take place, regulation can support bird conservation. This may, for example include restrictions on access, and on the siting of coastal developments.

International agreements

International agreements support the introduction and enforcement of measures to protect the marine environment of the Baltic Sea. Through HELCOM, the Baltic Sea Action Plan. BSAP provides a framework for joint actions and objectives across Baltic states as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea.

1 Ehler & Douvere, 2009.

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HABITAT FORMING SPECIES

- Baltic blue mussel beds, *Mytilus* spp
- Charophytes
- Eelgrass
- Fucoids
- Maerl beds

BALTIC BLUE MUSSEL BEDS, *MYTILUS* SPP

SUMMARY OF KEY MANAGEMENT MEASURES

Blue mussels (*Mytilus edulis trossulus* complex) are a keystone species in the marine environment of the southern Baltic Sea. They can form extensive biogenic reefs and provide habitats for a wide range of both sessile and mobile species.

The main threat to this habitat is probably climate change as changes in salinity and temperature are predicted to affect growth rates and reproduction of the blue mussel. The extent and condition of mussel beds are also affected by nutrient enrichment, which can enhance mussel growth, but can also disrupt feeding particularly when there is a high sedimentation rate following plankton blooms. Increase siltation can also be caused by dredging and run-off from the land. Dredging of wild mussel beds is known to change the composition of mussel beds as well as altering the topography of the seabed.

Management measures can usefully focus on reducing nutrient inputs, and protecting areas where this habitat is present within the framework of Marine Protected Areas using tools such as fisheries regulations and zoning schemes to ensure damaging activities do not take place in the vicinity of mussel beds. Marine Spatial Planning is also helpful in this regard. A longer-term management focus should be working with partners on reducing and mitigating the effects of climate change. Mussels are already used as an indicator species for reporting on the environmental status of in the Baltic Sea and can have a similar role in relation to climate change.

Eelpout on *Mytilus* bed, Lillgrund © OCEANA Carlos Suarez
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THE HABITAT AND ASSOCIATED SPECIES

Habitat description

Baltic blue mussels are a hybrid species of *Mytilus trossulus* and *Mytilus edulis*[1] that grow in clumps forming extensive biogenic reefs. They are smaller and have a lower growth rate and thinner shells than *Mytilus edulis* mussels from the North Sea[2]. Nevertheless, they dominate the animal biomass in the Baltic[3], colonizing a zone from the algal beds down to depths of around 40 m. The shells provide a hard surface for attachment by other species, and there are also sheltered microhabitats within mussel beds, including 'mussel mud' - accumulations of sediment, waste products and shell fragments –colonized by infaunal species such as polychaetes and nemerteans. Shells of dead mussels accumulating on the seabed also create a habitat which is colonized by many species.

Blue mussels are farmed in the western Baltic in the Skagerrak and also in the Kiel Fjord, using a system of rope culture.

Mussels are a key species in the Baltic Sea, linking benthic and pelagic systems through filtration of the water column and deposition in the benthos, and speeding up the cycle of production and breakdown of organic matter through the ecosystem[4]. They are the staple food of common eiders and flounder while mussel larvae form a very important part of the diet of herring larvae and other carnivorous zooplankton[5]. Where there is a reduced abundance of invertebrate predators (e.g. the starfish *Asterias rubens* and the shore crab *Carcinus maenas*) in parts of the Baltic Sea with low salinity, blue mussel beds dominate areas of hard substrate, especially in shallow waters where they can make up more than 90% of the animal biomass[6].

The HELCOM HUB classification[7] lists 14 biotopes characterized by the Mytilidae. These are present on rock and boulders, hard clay, shell gravel, muddy sediments, coarse sediments, sand, and mixed substrates in both the photic and aphotic zone.

Distribution in the Baltic Sea

Beds of the Baltic blue mussel are present in many parts of the Baltic Sea but as their growth rate and reproduction is affected by salinity, the limit being around 4.5 ppt, their northern distribution limit is in the Quark sub-basin. The formation of pack ice also affects their survivability in the northern regions[8].

In the Baltic Sea, mussel beds generally develop on rocks and boulders at depths of between 3-12 m, although extending in deeper waters where conditions are suitable[9]. Wave exposure influences depth distribution, with mussel beds at more exposed sites being found in greater depths[10].

1 Väinölä et. al., 2011
2 Larsson et al., 2017
3 Kautsky, 1981
4 Dankers et al., 2001; HELCOM 2013; Larsson et al., 2017; Kautsky & Evans, 1987
5 Öst & Kilpi, 1997
6 Kautsky& Kautsky 1995
7 HELCOM 2013 – HELCOM HUB
8 Westerbom, 2006
9 Vuorinen et al., 2002
10 Westerbom & Jattu, 2006

Associated species

The species richness in mussel patches is similar to that of other highly diverse habitats in the Baltic Sea[1]. They provide a hard surface for attachment, sheltered interstices and soft sediment/shell debris which is a microhabitat for infauna.

A study of blue mussel beds in the northern Baltic Sea (Gulf of Finland) recorded 39 species or species groups (excluding fish species) associated with Mytilid beds[2]. In the Kattegat, 45 species of macrofauna, 23 species of macroalgae and 33 meiofaunal species were found associated with mussel beds[3]. The majority are generalist species found elsewhere in the Baltic Sea and include bryozoans, hydroids, crustaceans, bivalves, gastropods, polychaetes and nemerteans.

Blue mussels are an important source of food for a number of fish species including flounder and plaice, and for diving ducks, especially the common eider *Somateria mollissima* and long-tailed duck *Clangula hyemalis*[4].

Conservation status

Reefs are on Annex I of the EU Habitats Directive (code 1170). This biotope complex, which includes biogenic reefs such as mussel beds, have been assessed by HELCOM as being Vulnerable in the Baltic Sea.

All Baltic Sea habitats characterized by Mytilidae have been assessed as Least Concern by HELCOM[5].

Rockpool prawn (*Palaemon elegans*) on top of blue mussels (*Mytilus edulis*) © OCEANA Carlos Minguell
https://www.flickr.com/photos/oceanaeurope/25966865534/in/album-72157664774522313/

1 Norling & Kautsky, 2008
2 Koivisto et al., 2011
3 Norling & Kautsky, 2007
4 Koivisto, 2011
5 HELCOM, 2013

PRESSURES AND THREATS

Climate change is probably the main threat to Baltic blue mussel beds as this is predicated to reduce salinity and increase temperatures in the Baltic Sea. Episodes of warmer sea temperatures may have already been the cause of mortality of large mussels and the predicated changes in both temperature and salinity are considered likely to affect their distribution, growth rates and reproduction[1].

Nutrient enrichment, leading to plankton blooms, can enhance the growth of mussels, but it can also disrupt filter feeding by clogging up gills. High sedimentation rates of organic matter when the blooms die can also have a detrimental effect on the ability of mussels to filter feed. Increased siltation and organic matter associated with dredging and run-off from agricultural lands can have a similar negative effect[2].

In the southern Baltic the salinity is high enough for cultivation of mussels and, in some locations, to support commercial harvesting of wild beds.
Dredging for mussels is known to affect both the epibenthos and the topography of the seabed. A study in Limfjorden (Denmark) for example, revealed significant differences in species composition and density between fished and closed areas as well as significant reductions in the amount of shell debris and gravel, and changes in the topography of the seabed in areas subject to mussel fisheries[3].

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the habitat. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

The conservation objectives for blue mussel beds need to be concerned with maintaining and potentially improving the status of existing beds as expressed by extent, quality, structure and function. This is consistent with the objectives HELCOM MPAs and Natura 2000 sites established under the EU Habitats and Birds Directives.

Management objectives

The principle management objective for this habitat type should be to prevent degradation and loss of existing beds, although recognizing that there may be periods of depletion, associated with, for example, high predation pressures or poor recruitment years in particular locations.

1 Kautsky, 1982
2 Darr et al., 2013; Westerbom, 2006
3 Dolmer, 2002

Practical measures

Reducing nutrient inputs
The main source of nitrates and phosphates entering the Baltic Sea is a runoff from agricultural land. This has long been recognized as an issue because of the resulting risk of eutrophication. Tackling eutrophication is one of the four goals of the HELCOM Baltic Sea Action Plan with the first Nutrient Reduction Scheme, promoting a regional approach to achieving this goal, being agreed by HELCOM in 2007. The scheme established Maximum Allowable Inputs and Country-Allocation Reduction Targets compared to a reference period of 1997-2003. Reducing inputs of nitrogen and phosphorus at source is seen as key to achieving good environmental status for the Baltic Sea. Unfortunately, due to both a lack of ambition in the implementation of measures and the time-lag until the effect of a measure can be measured, the Baltic Sea is still highly eutrophic decades after the problem has been recognized.

For managers working at a local level, tackling diffuse sources of pollution will require participating in and supporting schemes outside their immediate area of operation. They should, for example, involve encouraging measures on the surrounding land or entire watersheds, joint targets with other management authorities and participation in national as well as transnational and Baltic wide initiatives. Practical actions at a local level such as modifying farming practices, establishing buffer zones along water bodies, the creation of reed beds to retain and filter nutrients and other agri-environment schemes will also help reduce nutrient inputs[1].

Blue mussel is farmed in parts of the western Baltic Sea on ropes. An expansion of cultivation has been suggested as a cost-effective way of reducing eutrophication in coastal areas but there are both environmental issues related to these proposals as well as uncertainty about their economic viability[2]. Schemes such as these should, in any case, not be a first option as they do not address the root of the problem. Even then, they should only be considered following detailed examination including Environmental Impact Assessments as they can be seriously disruptive with environmental implications in their own right.

Regulatory measures

Protected Areas
Baltic blue mussel beds are present in Natura 2000 sites in the Baltic Sea. There are also examples in protected areas designated through national conservation programmes and those which are recognized as Baltic Sea MPAs, as well as some Baltic Sea Ecologically or Biologically Significant Marine Areas (EBSAs) (e.g. in the Åland Sea). Designation provides a regulatory framework for action. In the case of the Habitat Directive this includes a requirement to achieve favourable conservation status and to prevent damage and deterioration of the habitat and its typical species. MPA management planning should include the scope for emergency measures to protect the habitats and species for which the MPA has been designated. Consideration should also be given to adopting interim measures for protection whilst formal designation is pending.

1 Baltic COMPASS project. http://www.helcom.fi/helcom-at-work/projects/completed-projects/baltic-compass/
2 Hedberg et al., 2018

Fisheries regulations

Fisheries regulations can be used to manage both wild and cultivated mussel fisheries. Where wild beds are exploited the harvesting methods as well as the scale and frequency of operation will determine the potential impact. Effort control, gear types, rotation of areas open to fishing, and mechanisms for emergency closures are important tools for operating a sustainable fishery at the same time as protecting the biodiversity interest of these habitats. Licensing and regulation of mussel cultivation, including spatial planning and zoning to ensure it does not take place over particularly sensitive habitats and establishing buffer zones around mussel beds to prevent silting from activities such as dredging or demersal fishing in adjacent areas will be important.

Blue mussels (*Mytilus* sp.) © OCEANA Carlos Minguel
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Supporting measures

Planning frameworks
Planning frameworks can set direction, bring together key players and involve the public in decision making for particular geographical areas. There is a long history of land use planning in Baltic States with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent. UNESCO describe it as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process"[1]. It is essentially a practical way to create and establish a more rational organization of the use of marine species and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems and to achieve social and economic objectives in a planned way[2]. The management of mussel beds cannot be undertaken in isolation of activities, demands and influences taking place around them hence there is the need of incorporating the biodiversity objectives and associated management measures for mussel beds, such as Marine Protected Areas and protective buffer zones around this habitat into Maritime Spatial Plans. This in turn requires knowledge and mapping of the extent of mussel beds in the Baltic Sea.

Management plans
Management plans should provide a framework in which to develop, promote, monitor and report on actions for the conservation of mussel beds. They typically set out the objectives, consultation processes, actions, key players, timescales, and organizational structures. Specific mussel beds may be the main focus but management plans for these features cannot be developed in isolation as the surrounding habitats, environmental conditions and regional or even international issues are likely to have an influence on the success of any planned measures.

HELCOM Baltic Sea Action Plan
The goals and objectives of the Baltic Sea Action plan (BSAP), and most especially those relating to eutrophication and biodiversity, are directly relevant to the management of this habitat. The BSAP provides a framework for joint actions across Baltic states as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea. Mitigating eutrophication and developing Maritime Spatial Plans are some of the agreements promoted through the BSAP that can benefit habitats characterized by blue mussels and need to be maintained and potentially strengthened in the revised BSAP[3]. BaltSeaPlan and Baltic SCOPE have supported the development of MSP in the Baltic and there is a deadline of 2021 for Baltic Member States to establish Marine Spatial Plans under the EU Directive establishing a framework for MSP (EU 2014/89/EU).

Climate change
Measures to reduce and mitigate the effects of climate change are essential and whilst nothing specific can be done at the level of mussel beds, their sensitivity to changes in temperature and salinity may be useful as an indicator species. This is the case within the Marine Strategy Framework Directive (MSFD) with the Baltic blue mussel being used as an indicator of good environmental status.

1 Ehler & Douvere, 2009
2 Defra, 2009
3 E.g. http://www.helcom.fi/baltic-sea-action-plan; BMEPC, 2018

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CHAROPHYTES

SUMMARY OF KEY MANAGEMENT MEASURES

Habitats characterized by Charophytes typically develop in shallow sheltered areas such as inlets, bays and coastal lagoons of the Baltic Sea forming submerged rooted plant communities in both brackish and freshwater conditions. Dense beds provide shelter, food, and substrate for benthic invertebrates, fish and waterfowl.

The main pressure and threat to this habitat is eutrophication which increases the growth of smothering epiphytes and reduces light levels affecting the distribution and density of charophyte meadows. Coastal works such as dredging, ditching, coast protection, and land reclamation can cause direct physical damage to the habitat. There are also pressures associated with recreational activity on land and in the water such as from the construction of piers, point source pollution from summerhouses, and anchoring in charophyte meadows. In the longer term, climate change is expected to lead to changes in habitats dominated by Charophytes by altering the distribution and balance of species present.

The management priority should be to prevent degradation and further loss of this habitat. The main actions should center around reducing nutrient inputs that lead to eutrophication. Habitat restoration projects may be an option although they require improvements in environmental conditions to be viable. Management measures, such as zoning can be used to protect charophyte meadows from direct damage by dredging and anchoring of recreational craft. These measures can usefully be promoted within the framework of Marine Protected Areas which sets conservation objectives as well as mechanisms for stakeholder involvement, review and enforcement. Zoning and regulation of damaging activities through Marine Spatial Planning is key to reducing pressures and threats from coastal development and for introducing measures which require cooperation by many authorities. Management of this habitat needs to be underpinned by an understanding of the processes that drive their development and continuance, as well as of the ecological process that support the associated biodiversity.

THE HABITAT AND ASSOCIATED SPECIES

Habitat description

Habitats characterized by Charophytes are typically found in shallow sheltered areas such as inlets, bays and coastal lagoons of the Baltic Sea. They form submerged rooted plant communities in both brackish and freshwater conditions, on coarse, sandy, and muddy sediments. Different species favour different sediment characteristics. Dense beds provide shelter, food, and substrate for benthic invertebrates and for fish and waterfowl[1], and support a diversity of associated plants, invertebrate and fish communities[2]. Charophyte dominated vegetation enhances water clarity and reduces phytoplankton growth by boosting sedimentation and reducing resuspension thus keeping sediment nutrients locked away[3]. Many species are indicators of water quality as they cannot tolerate high nutrient conditions.

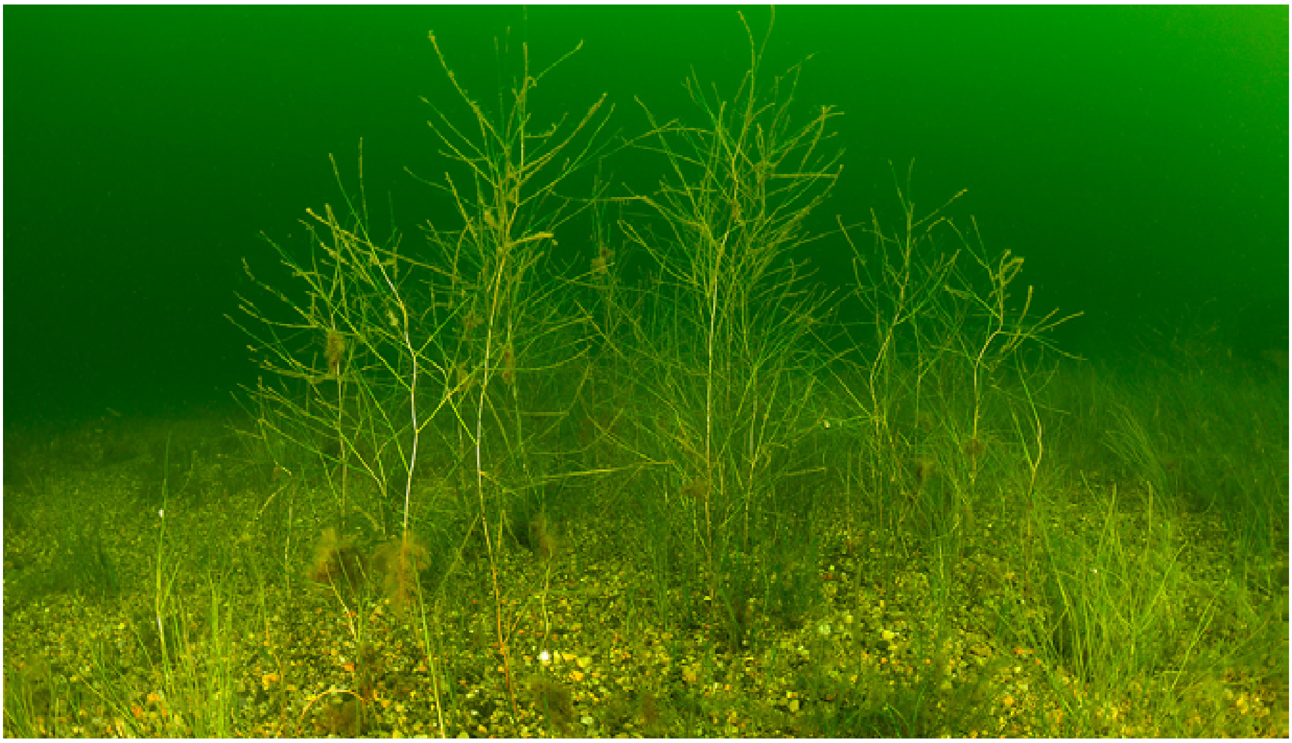
The HELCOM HUB classification[4] describes four biotope and habitat types characterized by the presence of Charales;

AA.H1B4 Baltic photic muddy sediment dominated by Charales

AA.I1B4 Baltic photic coarse sediment dominated by Charales

AA.J1B4 Baltic photic sand dominated by Charales

AA.M1B4 Baltic photic mixed substrate dominated by Charales



Seabed with fennel pondweed (*Stuckenia pectinata*) © OCEANA Carlos Minguell
https://www.flickr.com/photos/oceanaeurope/42779257380/in/album-72157697714411962/

1 Dugdale et al., 2006; Schmieder et al., 2006
2 HELCOM 2013, Biotope Information Sheet
3 Hilt et al., 2006
4 HELCOM 2013 – HELCOM HUB

Distribution in the Baltic Sea

Habitats characterized by Charophytes are distributed along the whole Baltic Sea coastline[1]. They include the German Bodden areas, the flads and coastal lagoons along the coasts of Finland and Sweden, and amongst the sheltered islands and bays of the west Estonian Archipelago Sea.

Associated species

Different species of Charales dominate this habitat depending on the salinity, sediment and season. They include *Chara aspera*, *C. baltica*, *C. canescens*, *C. horrida*, *C. tomentosa* and *Tolypella nidifica*[2]. Plants such as *Zostera* spp. *Ruppia* spp, *Zannichellia palustris* and *Stuckenia pectinata* may also be present[3]. The surfaces of the charophytes may be colonized by hydroids and byrozoans. Other associated species are gastropods, amphipods and insects such as specialized beetles. Fish species such as stickleback and pipefish live in the sheltered areas provided by this habitat and the Charophytes provide important nursery and spawning habitat for fish species, including (commercially important) pike, pikeperch and perch.

Northern pike in a *Charales* dominated habitat © OCEANA Enrique Talledo
https://www.flickr.com/photos/oceanaeurope/29694127327/in/album-72157697714411962/

1 HELCOM, 2013 Biotope information Sheet
2 HELCOM, 2013 Biotope Information Sheet
3 Berg et al.,2004.

Straight-nosed pipefish (*Nerophis ophidion*) © OCEANA Carlos Minguell
https://www.flickr.com/photos/oceanaeurope/44488716651/in/album-72157697714411962/

Conservation status

The four biotopes characterized by Charales have been assessed by HELCOM as being Near Threatened.

HELCOM has also assessed the charophyte *Lamprothamnion papulosum* as Endangered, *Chara braunii* and *Nitella hyalina* as Vulnerable and *C. horrida* and *Nitellopsis obtusa* as Near Threatened[1].

Many species of Charophytes are on the Red Lists of Baltic States. For example *Lamprothamnion papulosum* is Critically Endangered in Germany and Endangered in Sweden; *Chara braunii* is Near Threated in Estonia, and Vulnerable in Finland, Russia and Sweden; *Nitella hyaline* is Critically Endangered in freshwater lakes in Germany, and Vulnerable in Finland; *C. horrida* is Critically Endangered in Germany, Endangered in Finland and Near Threatened in Sweden; and *Nitellopsis obtuse* is Vulnerable in Finland as well as in Germany and Sweden where it is only found in freshwater.

Coastal lagoons (Habitats Directive Code 1150) and large shallow inlets and bays (Code 1160), two biotope complexes that include habitats characterized by Charales are on Annex I of the EU Habitats Directive. Coastal lagoons have been assessed by HELCOM as Endangered in the Baltic Sea and large shallow inlets and bays as Vulnerable.

The HELCOM MPA database[2] records one MPA in the Baltic Sea which includes habitats characterized by Charales (Holmö Islands, Sweden) but it is also present in many other MPAs.

1 https://helcom.fi/baltic-sea-trends/biodiversity/red-list-of-baltic-species/red-list-of-macrophytes/
2 http://www.helcom.fi/action-areas/marine-protected-areas/database/

PRESSURES AND THREATS

The main pressure and threat to habitats characterized by Charophytes is eutrophication. Charophytes are often found in sheltered or semi sheltered habitats that have very slow or limited water exchange, thus exacerbating nutrient input problems. Nutrient enrichment from intensive livestock farming, inputs from rivers, and high atmospheric nutrient loads in catchments, can act together to increase the growth of smothering epiphytes and reduce light levels in areas where this habitat is found. Knock on effects include reduction in the depth distribution limits and densities of Charophytes[1]. Some species, such as the watermillfoil (*Myriophyllum* spp.) can also outcompete Charophytes making natural re-establishment difficult once Charophytes are lost from an area.

Coastal works such as dredging, ditching, coast protection and land reclamation can directly damage the habitat as well as having indirect effects. For example, the species composition, distribution and density of the Charophytes can change in response to changes in hydrodynamics and turbidity. Boating and ferry traffic have also been identified as activities that can alter the species composition of macrophytes by increasing turbulence[2]. The sheltered areas where this habitat develops can also be popular for recreational activities. Anchoring associated with recreational fishing and point sources of eutrophication from summer houses are therefore additional localized threats.

In the longer term, climate change is expected to lead to changes in habitats dominated by Charophytes by altering the distribution and balance of species present in the Baltic Sea. The Baltic Sea is predicted to become less saline and this will most likely lead to the decline or disappearance of brackish or marine species and an increase in freshwater species[3]. Land upheaval is predicted to be cancelled out by rising sea levels therefore a key process which enables the formation of new habitats dominated by Charophytes will no longer take place. Other changes will be associated with reduced ice cover in winter which reduces the competitive advantage of Charophytes over Angiosperms. Higher storm surges and increased storm wave heights will have an effect as habitats characterized by charophytes only develop in sheltered locations[4].

1 Torn et al., 2004; Kovtun-Kante et al., 2014
2 Eriksson et al., 2004
3 Torn et al., 2019
4 Torn et al., 2019

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the habitat. While actions to benefit this habitat type will mainly be focused on the sheltered environments where they develop, a broader view is also essential. This will include actions to be taken in the terrestrial environment as eutrophication, linked to nutrient inputs, is a major threat to this habitat. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

Given the decline in quality and extent of this habitat, the conservation objectives need to be concerned with protecting remaining areas and improving their status as expressed by extent, quality, structure and function. This is consistent with the objectives HELCOM MPAs and Natura 2000 sites established under the EU Habitats and Birds Directives. At the same time the natural succession of some sheltered water bodies where this habitat is present, as well as the formation of new charales meadows needs to be accommodated. Conservation objectives will need to be framed in a way that allows for such change.

Management objectives

Two types of management objectives are a priority for this habitat type. Firstly, those aimed at preventing degradation and further loss, and secondly those which facilitate recovery in areas where the habitat has been damaged or degraded.

Practical measures

Reducing nutrient inputs

The main source of nitrates and phosphates entering the Baltic Sea is runoff from agricultural land. This has long been recognized as an issue because of the resulting risk of eutrophication. Tackling eutrophication is one of four goals of the HELCOM Baltic Sea Action Plan with the first Nutrient Reduction Scheme, promoting a regional approach to achieving this goal, being agreed by HELCOM in 2007. The scheme established Maximum Allowable Inputs and Country-Allocation Reduction Targets compared to a reference period of 1997-2003. Reducing inputs of nitrogen and phosphorus at source is vital to achieving good environmental status for the Baltic Sea. Unfortunately, due to both a lack of ambition in the implementation of measures and time-lags to see the effects of such measures, the Baltic Sea is still highly eutrophic decades after the problem has been recognized.

Practical actions are needed at a local level, such as reducing the use of nutrients on land adjacent to sheltered inlets and coastal lagoons where this habitat is found and in water courses that can carry nitrates and phosphates into such areas. Diversion of ditches and pipes that carry nutrient rich water from the farmed hinterland can also reduce nutrient inputs to sheltered embayments but will not address the root of the problem. It is also important to recognize that nutrients retained in sediments or in the water column due to a long residence time may mean that high phytoplankton production continues for a period even when nutrient inputs are reduced.

In the case of Charophyte dominated habitats, point sources of eutrophication e.g. from summer-houses built in sheltered areas, need to be tackled by introducing restrictions on the input of nutrients. Where leisure boating is popular, leading to resuspension of sediment and release of nutrients, speed restrictions need to be applied.

There is an extensive literature on management measures that can help reduce nutrient inputs and resulting eutrophication on marine habitats which can be drawn on to support the conservation of habitats characterized by Charophytes. Supporting actions by managers could include:

- Using monitoring data on the extent and condition of Charales as an indicator of water quality

- Participating in and supporting management schemes for the surrounding land e.g. Agrienvironment schemes which seek to reduce nutrient inputs

Retaining nutrients[1]
Various practical measures have been introduced to reduce loss of nutrients to water courses, some of which can end up in sheltered bays and lagoons with Charophyte dominated habitats. They include establishing or improving infrastructure for wastewater treatment for example by building purification plants and upgrading sewage farms, establishing buffer zones around agricultural land to reduce surface runoff of nutrients and soil erosion, and chemical precipitation of dissolved phosphorus from agriculture in ditches[2]. The construction of cleaning ponds that collect nutrient rich water before it enters lagoons is another example. This has been tried at several German project sites, by directing drainage and outflow from intensively farmed plots to specially created water bodies before reaching lagoons. The nutrients are converted into biomass, a rich vegetation, which is removed by grazing animals.

Removing nutrients
To complement measures aimed at overall nutrient reduction, various ideas have been put forward on ways to reduce nutrient levels in sheltered semi-enclosed coastal areas. They include dredging and removing sediment with existing nutrient loads, enlarging reed beds and extending submersed macrophyte areas. A practical example is the Interreg funding project LiveLagoons[3] which is investigating the possibility of improving the water quality of Southern Baltic lagoons using floating wetlands through a process described as 'phytoremediation'. Other ideas are establishing algae farms and lowering phosphate levels by adding Iron Chloride ($FeCl_3$). Schemes such as these should not be a first option as they do not address the root of the problem and, even then, should only be considered following detailed examination including Environmental Impact Assessments as they can be seriously disruptive with environmental implications in their own right.

1 Best practice guideline LIFE Baltcoast
2 E.g. https://www.waterprotectiontools.net/index.php/en/home-page/
3 http://www.balticlagoons.net/livelagoons/wp-content/uploads/2018/10/PolicyBrief_A4-1_LiveLagoons.pdf; Karstens, et al., 2018 Floating wetlands for nutrient removal in eutrophicated coastal lagoons:

Habitat restoration
A habitat restoration project on the Mediterranean coast of Spain (Albufera de València Natural Park) has demonstrated that Charophytes dominated habitats can be re-established through planting programmes. In this case, three different assemblages were used, *Chara hispida* alone, a mixture of *C. vulgaris, C. baltica* and *Nitella hyalina*, and a mixture of vascular plants[1]. They were collected from nearby localities and cultured to produce enough stock for transplantation into two newly created lagoons in what were formally rice fields surrounded by wetlands. When protected from predators (fish, crayfish and birds) the plants became established demonstrating that this approach can be successful.

Guidance from other trials recommend that if re-establishment is to be successful planting should be done early in the season, and in sheltered bays in depths not exceeding 1 m. Three phases are recommended; trials using test species in small exclosures during the first season; further protected planting of successful species and tests of other species if needed during the second season; and finally, natural propagation by sexual and vegetative reproduction[2]. Studies have demonstrated that Charophytes oospores in sediments can be viable for many decades, potentially supporting reestablishment programmes if present in high enough densities when conditions become suitable[3]. In the case of the Albufera Lagoon removing grazing pressure, including from exotic introduced fish species, was key to facilitating the re-establishment of planted Charophytes. Fish exclusion cages have also been used in the successful establishment of founder colonies of charophytes in freshwater situations[4]. Other potential bottlenecks for restoration are competition with eutrophic species and the availability of propagules[5]. Propagules can survive for many years in the sediment so plants may re-establish naturally if conditions become suitable.

Regulatory measures

Protected areas
Conservation of habitats characterized by Charophytes includes the protection through designation under the EU Habitats Directive (e.g. within 'lagoons' and 'shallow inlets and bays' which are listed in Annex 1) as Special Areas of Conservation and under the EU Birds Directive as Special Protection Areas. Although not the primary reason for designation, they are part of the mix of biotopes that are present in these habitats. Habitats characterized by Charophytes are also present in locations designated as protected areas through national conservation programmes, Baltic Sea MPAs, and Ramsar sites.

Coastal lagoons are also included in some of the Baltic Sea Ecologically or Biologically Significant Marine Areas (EBSAs) (e.g. in the Northern Bothnian Bay and the Åland Sea). Designation provides a regulatory framework for action. In the case of the Habitat Directive this include a requirement to achieve favourable conservation status and to prevent damage and deterioration of the habitat and its typical species.

1 Rodrigo et al., 2013
2 Smart & Dick, 1999; Hilt et al., 2006
3 Rodrigo et al., 2010; Bakker et al., 2012
4 Dugdale et al., 2006
5 Bakker et al., 2012

Supporting measures

Management plans
Management plans provide a framework in which to develop, promote, monitor and report on actions for the conservation of habitats characterized by Charales. They typically set out the objectives, consultation processes, actions, key players, timescales, and organizational structures. Specific measures could, for example, include banning leisure boats from the densest Charophyte meadows and setting out buoys as alternatives to anchoring in popular fishing locations to avoid damage and tearing up of Charophyte meadows.

A specific waterbody may be the main focus of action, but management plans for these features will need to be developed within the wider context of understanding the mosaic of habitats in which the Charaophyte dominated habitats are located because of their interconnected nature. Management plans will therefore need to advocate measures for the adjacent coastal land, river basins/watershed and sea. For waterbodies which extend across more than one municipality or national border, a joint integrated approach to setting conservation objectives and management will be needed. This has been recognized and is evident in the joint Russian-Lithuanian planning for the Curonian Lagoon, and joint Russian-Polish planning for the Vistula Lagoon.

Planning frameworks
Planning frameworks can set direction, bring together key players and involve the public in decision making for particular geographical areas. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent. UNESCO describe it as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process"[1]. It is essentially a practical way to create and establish a more rational organization of the use of marine species and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems and to achieve social and economic objectives in a planned way[2]. The management of waterbodies that include Charales dominated habitats cannot be undertaken in isolation of activities, demands and influences taking place around them or in their hinterland hence the need to incorporate the biodiversity objectives and associated management measures for such habitats into Maritime Spatial Plans.

Examples of measures that can be promoted through planning frameworks are considerations of this habitat in development schemes, limiting dredging in sheltered areas where this habitat is present and setting out conditions or prohibiting construction works. This should apply to both large developments and their ongoing maintenance works such as channel dredging, as well as small-scale construction such as private piers to avoid changes in water flow which will alter the conditions in which this habitat thrives.

Sector specific measures
Where particular activities are a threat to waterbodies supporting Charales communities, either because of their mode of operation, scale of operation or location, regulation should support their conservation. This may, for example include restrictions of development, dredging, and zoning of tourism activities.

1 Ehler & Douvere, 2009.
2 Defra, 2009

Research and understanding
Management of this habitat needs to be underpinned by an understanding of the processes that drive their development and continuance as well as and the ecological process that support the associated biodiversity. The driving forces may be known in general terms but, given the range of types of water-bodies that have Charophyte dominated habitats and their different conditions across the Baltic Sea, it is also essential to understand these at a local level so that appropriate management objectives can be set and effective measures introduced to achieve these objectives. There are also gaps in knowledge of the distribution of this habitat type and the associated fauna and flora.

HELCOM Baltic Sea Action Plan
The goals and objectives of the Baltic Sea Action plan (BSAP), and most especially those relating to eutrophication and biodiversity, are directly relevant to the management of this habitat. The BSAP provides a framework for joint actions across Baltic states as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea. Mitigating eutrophication and developing Maritime Spatial Plans are some of the agreements promoted through the BSAP that can benefit habitats dominated by Charophytes and need to be maintained and potentially strengthened in the revised BSAP[1]. BaltSeaPlan and Baltic SCOPE have supported the development of MSP in the Baltic and there is a deadline of 2021 for Baltic Member States to establish Marine Spatial Plans under the EU Directive establishing a framework for MSP (EU 2014/89/EU).

1 E.g. http://www.helcom.fi/baltic-sea-action-plan; BMEPC, 2018

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EELGRASS

SUMMARY OF KEY MANAGEMENT MEASURES

Eelgrass beds act as nursery and feeding areas as well as stabilizing soft substrates and protecting against coastal erosion. Sometimes also referred to as seagrasses, these plants also improve water clarity and reduce phytoplankton growth by enhancing sedimentation and reducing its resuspension which keeps sediment nutrients locked away. The most common species in the Baltic Sea, *Zostera marina*, forms pure stands or grows intermixed with Charophytes or other higher plants.

The main threat to habitats characterized by *Zostera* spp. in the Baltic Sea is eutrophication. Nutrient enrichment increases the growth of smothering epiphytes and reduces light levels affecting the depth distribution and density of *Zostera* plants. Activities which increase turbidity, such as construction works and dredging, or which result in shading, also affect the growth and survival of eelgrass. Eelgrass loss has been linked to changes in food webs associated with overfishing and a reduction of mesograzers. Higher water temperatures, changes in salinity, and increased storminess associated with climate change, are also predicted to change the distribution of *Z. marina* in the Baltic Sea.

Given the decline in quality and extent of this habitat, conservation objectives need to be concerned with protecting remaining areas and improving their status. Measures need to be taken to reduce nutrient inputs and habitat restoration by planting eelgrass is possible. Practical measures such as eco-moorings may also be useful to prevent anchor damage on eelgrass beds. Regulatory measures can be focused on specific sectors, such as recreational users, or by a more comprehensive approach through Marine Spatial Planning. Site designation with associated MPA management plans that set conservation objectives, as well as establishing programmes for monitoring and enforcement needs to be undertaken.

THE HABITAT AND ASSOCIATED SPECIES

Habitat description

Eelgrass, also referred to as seagrass, is an aquatic rooted angiosperm which grows mainly on sandy and muddy sediments in the photic zone. The dominant species in the Baltic Sea is *Zostera marina* which forms pure stands or grows intermixed with Charophytes or other higher plants depending on salinity and exposure[1]. It is a perennial plant with large variations in shoot density, morphology and biomass production in response to light and temperature[2]. The narrow leaved eelgrass, *Zostera noltii*, is also present in the Baltic Sea. It is generally not intermixed with *Zostera marina* which grows in deeper waters, but may be amongst *Zannichellia palustris* or some Charophytes as well as the widgeon grasses *Ruppia maritima* and *R. cirrhosa* which favour more brackish waters.

Eelgrass beds act as nursery and feeding areas. They provide spawning grounds for fish and shelter for fry such as pike and pike-perch, as well as stabilizing soft substrates and protecting against coastal erosion. They also improve water clarity and reduce phytoplankton growth by enhancing sedimentation and reducing its resuspension so keeping sediment nutrients locked away[3]. Eelgrasses play an important role in the production, storage and export of organic carbon[4]. They efficiently retain carbon and nutrients during the growing season and support long-term storage in the sediment. The plants reproduce both sexually and vegetatively, with populations usually consisting of several clones.

1 HELCOM, 2013; den Hartog, 1970
2 Clausen et al., 2014
3 Eg. Boss et al., 2005
4 Röhr et al., 2016; Asmala et al.,2019

Naturally isolated eelgrass beds, in the inner Baltic and some lagoons have a low genetic diversity, and at the northern edges of their distribution many large meadows consist of one or a few clones that have survived low salinity, ice cover, eutrophication and turbidity.

The HELCOM HUB classification[1] describes eight biotope and habitat types characterized by the presence of eelgrass;

AA.H1B2 Baltic photic muddy sediment dominated by *Zannichellia* spp.and/or *Ruppia* spp. and/or *Zostera noltii*.

AA.H1B7 Baltic photic muddy sediment dominated by common eelgrass (*Zostera marina*)

AA.I1B2 Baltic photic coarse sediment dominated by *Zannichellia* spp.and/or *Ruppia* spp. and/or *Zostera noltii*.

AA.I1B7 Baltic photic coarse sediment dominated by common eelgrass (*Zostera marina*)

AA.J1B2 Baltic photic sand dominated by *Zannichellia* spp.and/or *Ruppia* spp. and/or *Zos tera noltii*.

AA.J1B7 Baltic photic sand dominated by common eelgrass (*Zostera marina*)

AA.M1B2 Baltic photic mixed substrate dominated by *Zannichellia* spp.and/or *Ruppia* spp. and/or *Zostera noltii*.

AA.M1B7 Baltic photic mixed substrate by common eelgrass (*Zostera marina*)

© Dietmar Reimer.
https://www.bund.net/fileadmin/user_upload_bund/publikationen/meere/eutrophierung-broschuere.pdf

1 HELCOM 2013 – HELCOM HUB

Distribution in the Baltic Sea

Within the Baltic Sea, habitats characterized by *Zostera marina* are most abundant in the Kattegat and Belt Sea, followed by the Skagerrak and the North Eastern Baltic. There are extended belts along moderately exposed Danish and Swedish coasts as well as the inner parts of brackish estuaries and sheltered bays. Eelgrass beds are present in the Baltic proper and southern Baltic Sea off the coasts of Estonia, Sweden, south west Finland, Germany and Poland[1]. The northern and eastern limits correlate with the 5psu salinity gradient of surface seawater[2]. In terms of depth distribution, *Z. marina* grows fully submerged in depths of 1-10 m. Exposure, desiccation and ice scour may reduce its abundance in shallow water while the depth limit is strongly influenced by light levels.

Zostera marina occurs along a salinity gradient from fully marine areas to low salinity water. Biomass and productivity are higher in higher salinity, nutrient rich, but not eutrophic, conditions compared to the more brackish and oligotrophic parts of the Baltic Sea. In some areas, such as the Oresund, the eelgrass beds are very dense (reaching 2000 shoots/m^2 in shallow water). In contrast, in the inner Baltic the above-ground biomass tends to be sparse with small shoots compared to those in the Skagerrak and the Kattegat/Belt Sea region[3].

Z. noltii grows in the shallow sheltered areas of the Baltic Sea. In the Atlantic it is a species of the intertidal zone. In the Baltic Sea, where tides are absent, it is permanently submerged, although in shallow water (0.5-1 m) and occasionally exposed to the air. *Z. noltii* is present along Baltic Sea coasts of Denmark and Germany and the west coast of Sweden. It has not been found east of the Darss Sill in the Arkona basin and is therefore restricted to the western Baltic[4]. On the Swedish east coast, *Zostera noltii* extends to southern Sweden and to Lithuania in the eastern Baltic Sea. In Germany it is present in the shallower waters of coastal lagoons along the German Baltic Sea coastline such as the Saaler Bodden and Greifswalder Bodden.

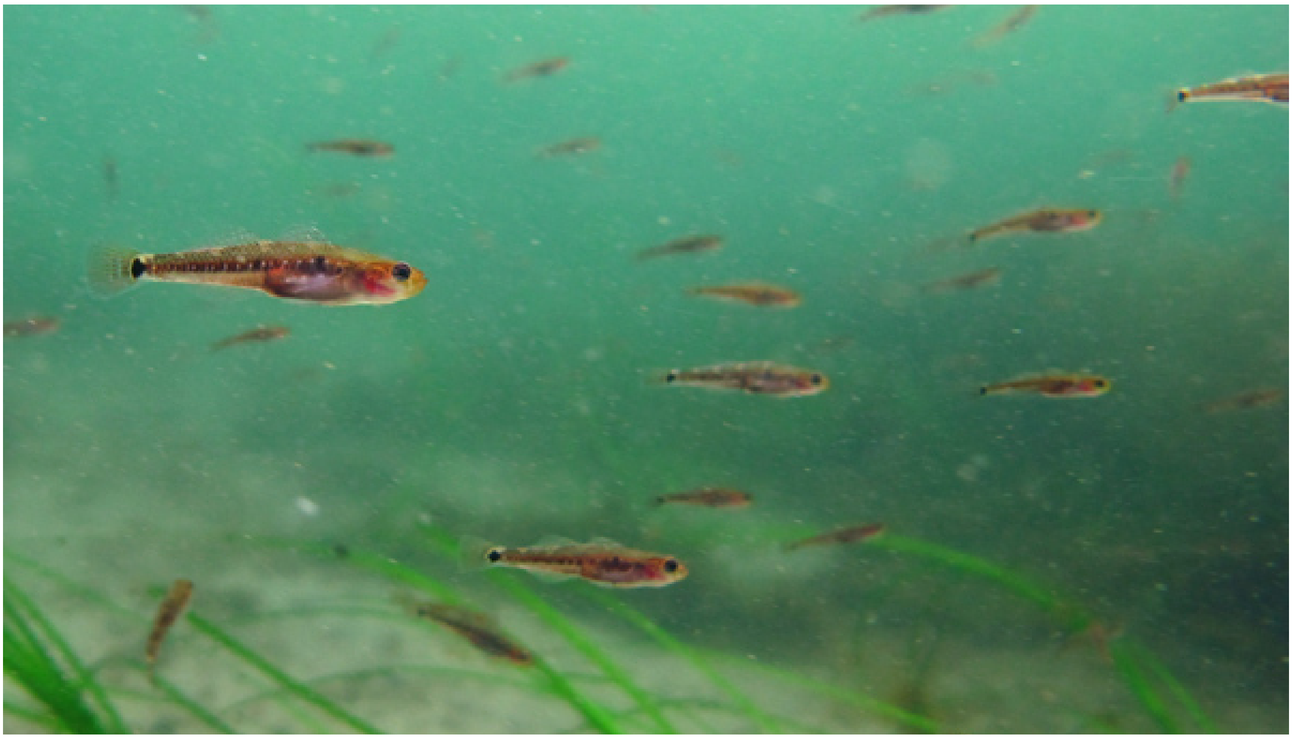
Associated species

Z.marina is the dominant species of Baltic eelgrass beds but in mixed stands Charophytes such as *Tolypella nidifica*, *Chara baltica* and other aquatic angiosperms like *Zannichellia palustris*, *Ruppia* spp., *Stuckenia pectinata*, or *Myriophyllum spicatum* may be present[5]. In Estonia, at the north eastern tolerance limit of salinity for eelgrass, the most common associated invertebrate species include *Cerastoderma glaucum*, *Limecola balthica*, *Mya arenaria* and *Idotea chelipes*[6]. In some areas, eelgrass beds may also be interspersed with patches of the blue mussel (*Mytilus edulis*).

The leaves support a rich epifauna as well as crustacean and gastropod grazers which feed on the eelgrass and associated epiphytes. They include isopods (*Idotea* spp.) and gastropods such as *Rissoa membranacea* as well as *Littorina littoria*, *Tehodoxus fluviatilis* and *Hydrobia* spp. In the stabilized sediments there is an infauna of polychaetes and nematodes, as well as tube-building amphipods and a mobile epifauna which include shrimps, crabs and predatory fish such as the black goby *Gobius niger*, two-spotted goby *Gobiusculus flavescens* and the three-spined stickleback *Gasterosteus aculeatus*[7].

1 Boström et al., 1992; Boström et al,2014
2 Möller, 2008
3 Boström et al., 1992
4 HELCOM Red List of Species 2013
5 HELCOM, 2013 biotope information sheet
6 Möller et al., 2014
7 E.g. Bostrom & Bonsdorff, 1977

Northern Baltic eelgrass communities lack crabs and echinoderms. Their role as nursery areas for economically important fish species is also limited but nonetheless, they serve as feeding grounds for fish[1].



Two-spotted goby (*Gobiusculus flavescens*) amongst eelgrass © Anke Hofmeister
http://www.undine-baltic.eu/species/index.php?id=158&lang=de

Conservation status

The four biotopes characterized by *Zostera marina* have been assessed by HELCOM as being Near Threatened[2].

HELCOM has also assessed *Zostera noltii* as Vulnerable[3]. It is also Critically Endangered in Germany.

Coastal lagoons (Code 1150) and large shallow inlets and bays (Code 1160), two biotope complexes that include habitats characterized by *Zostera* are on Annex I of the EU Habitats Directive. Coastal lagoons have been assessed by HELCOM as Endangered in the Baltic Sea and large shallow inlets and bays as Vulnerable.

The HELCOM MPA database[4] records two MPAs which includes *Zostera* biotopes (Kungsbackafjorden and Holmö Islands, Sweden) and three Danish MPAs in the Baltic Sea where the presence of *Z. noltii* has been part of the reason for designation (Sejerø Bugt og Saltbæk Vig, Sydfynske Øhav and the Ålborg Bugt, Randers Fjord and Mariager Fjord, Bird protection sites).

1 Bostrom et al., In Green & Short 2003. World Atlas of Seagrasses.
2 http://www.helcom.fi/Red%20List%20of%20biotopes%20habitats%20and%20biotope%20complexe/HELCOM%20Red%20List%20AA.H1B7,%20AA.I1B7,%20AA.J1B7,%20AA.M1B7.pdf
3 https://helcom.fi/baltic-sea-trends/biodiversity/red-list-of-baltic-species/red-list-of-macrophytes/
4 http://www.helcom.fi/action-areas/marine-protected-areas/database/

PRESSURES AND THREATS

The main threat to habitats characterized by *Zostera* spp. is eutrophication. Nutrient enrichment from intensive livestock farming, inputs from rivers, and high atmospheric nutrient loads in catchments, act together to increase the growth of smothering epiphytes and reduce light levels in areas where this habitat is found. Knock on effects include reduction in the depth distribution limits and densities of *Z. marina*, as well as shifts from eelgrass meadows to communities dominated by fast-growing macroalgae[1].

Activities which increase turbidity such as construction, dredging, and coastal defence works, or directly disturb seabed sediments also affect the growth and survival of eelgrass. Shading, such as that associated with floating docks or marinas, can also be a problem as well as localized scouring associated with anchoring and moorings[2]. *Zostera* is generally not physically robust, as the root systems are typically located within the top 20 cm of the sediment and can therefore be dislodged easily[3].

There have been large-scale losses of eelgrass meadows at the entrance to the Baltic Sea as a result of the eelgrass wasting disease and eutrophication. Declines have been particularly apparent in areas where water clarity is low and nutrient concentrations high, such as in Danish coastal waters, the Swedish west coast, and the Puck lagoon, Poland.

Eelgrass loss has also been linked to changes in food webs such as changes associated with overfishing and reduction of mesograzers. These changes can lead to macroalgal blooms and more epiphytic growth which reduce light levels and smother the leaf blades of *Zostera* plants. Reduced light levels can also reduce the depth penetration of eelgrass.

Increased water temperature, changes in salinity and more stormy weather associated with climate change are also a threat to eelgrass beds. For example, climate change is predicted to lower the salinity level in the northern parts of the Baltic Sea due to an increase of precipitation. In the future *Z. marina* may therefore decline in the northernmost areas where it currently exists on the limits of its salinity tolerance.

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the habitat. While actions to benefit this habitat type will mainly be focused on the sheltered environments where they develop, a broader view is also essential as eelgrass beds are part of a mosaic of different habitats and are affected by issues such as eutrophication, linked to nutrient inputs from many sources in both the surrounding waters as well as from land. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

1 HELCOM, 2013; OSPAR, 2009

2 Eriander, 2016; Collins et al., 2010

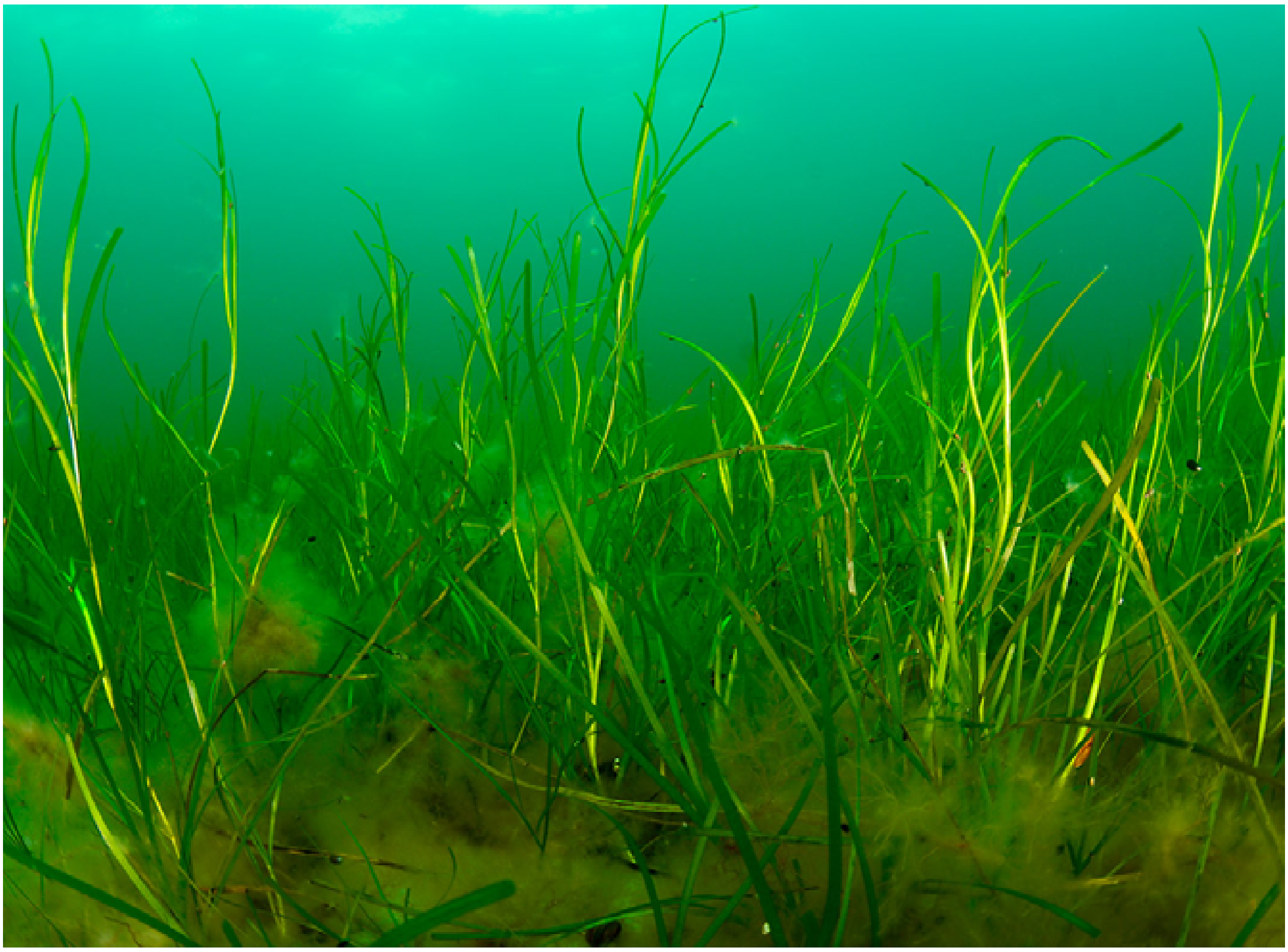
3 Fonsea, 1992

Conservation objectives

Given the decline in quality and extent of this habitat, the conservation objectives need to be concerned with protecting remaining areas and improving their status as expressed by extent, quality, structure and function. This is consistent with the objectives HELCOM MPAs and Natura 2000 sites established under the EU Habitats and Birds Directives.

Management objectives

Two types of management objectives are a priority for this habitat type. Firstly, those aimed at preventing degradation and further loss, and secondly those which facilitate recovery in areas where the habitat has been damaged, degraded or lost.



Eelgrass (*Zostera* sp.) meadrow © OCEANA Carlos Minguell
https://www.flickr.com/photos/oceanaeurope/26084536354/in/album-72157664774522313/

Practical measures

Reducing nutrient inputs

The main source of nitrates and phosphates entering the Baltic Sea is runoff from agricultural land. This has long been recognized as an issue because of the resulting risk of eutrophication. Tackling eutrophication is one of four goals of the HELCOM Baltic Sea Action Plan with the first Nutrient Reduction Scheme, promoting a regional approach to achieving this goal, being agreed by HELCOM in 2007. The scheme established Maximum Allowable Inputs and Country-Allocation Reduction Targets compared to a reference period of 1997-2003. Reducing inputs of nitrogen and phosphorus at source is seen as key to achieving good environmental status for the Baltic Sea. Unfortunately, due to both a lack of ambition in the implementation of measures and the time-lag until the effect of a measure can become apparent, the Baltic Sea is still highly eutrophic decades after the problem has been recognized.

Practical actions are needed at a local level to reduce the use of nutrients on land adjacent to eelgrass beds, around the lagoons and sheltered areas where this habitat is found, and in water courses that can carry nitrates and phosphates into such areas. Diversion of ditches and pipes that carry nutrient rich water from the farmed hinterland can also reduce nutrient inputs to sheltered embayments, for example, but will not address the root of the problem. It is also important to recognize that nutrients retained in sediments or in the water column due to a long residence time may mean that high phytoplankton production continues for a period even when nutrient inputs are reduced.

Point sources of eutrophication, such as that from summerhouses built in sheltered areas also need to be tackled, for example by putting restrictions on the input of nutrients. Where leisure boating is popular leading to resuspension of sediment and release of nutrients, speed restrictions need to be applied.

There is an extensive literature on management measures that can help reduce nutrient inputs and resulting eutrophication on marine habitats which can be drawn on to support the conservation of eelgrass beds. Supporting actions by managers could include:

- Using monitoring data on the extent and condition of *Zostera* as an indicator of water quality

- Participating in and supporting management schemes for the surrounding land e.g. Agri-environment schemes which seek to reduce nutrient inputs

Nutrient reduction is critical in eutrophicated areas, nevertheless it may not be all that is needed for the recovery of eelgrass beds. This is clear from observations that reduced nutrient loads have not resulted in any general positive trends in eelgrass distribution and abundance in Danish, Swedish and German coastal waters[1]. Possible reasons which have been suggested are regime shifts from clear waters with high eelgrass cover to turbid waters with plankton dominance[2], negative feedbacks such as sediment resuspension maintaining the turbid state, and lack of apex predators and therefore control of epiphytes and filamentous macroalgae.

1 Nyqvist, et al., 2009
2 Krause-Jensen et al., 2012

Retaining nutrients[1]

Various practical measures have been introduced to reduce loss of nutrients to water courses, some of which can end up in sheltered bays and lagoons with *Zostera* dominated habitats. They include establishing or improving infrastructure for wastewater treatment for example by building purification plants and upgrading sewage farms, establishing buffer zones around agricultural land to reduce surface runoff of nutrients and soil erosion, and chemical precipitation of dissolved phosphorus from agriculture in ditches[2]. The construction of cleaning ponds that collect nutrient rich water before it enters lagoons is another example. This has been tried at several German project sites, by directing drainage and outflow from intensively farmed plots to specially created water bodies before reaching lagoons. The nutrients are converted into biomass, a rich vegetation, which is removed by grazing animals.

Removing nutrients

To complement measures aimed at overall nutrient reduction, various ideas have been put forward on ways to reduce nutrient levels in sheltered coastal areas. They include dredging and removing sediment with existing nutrient loads, enlarging reed beds, extending submersed macrophyte areas, establishing algae farms, lowering phosphate levels by adding Iron Chloride ($FeCl_3$), and introducing mussel cultivation and harvesting. Schemes such as these should not be a first option as they do not address the root of the problem and even then, should only be considered following detailed examination including Environmental Impact Assessments as they can be seriously disruptive with environmental implications in their own right.

Habitat restoration

There have been successful trials and longer-term projects mitigating losses and helping the recovery of eelgrass beds through restoration schemes. They include examples from the USA and the Netherlands as well as the Baltic Sea[3]. In general, larger scale projects generally show a higher success rate with site selection as well as the chosen restoration methods being key factors. The latter may involve transplanting shoots with sediment or bare rooted, and with or without anchoring. Understanding the conditions at the proposed restoration site is also essential.

Lessons learnt from work on *Z. marina* in Sweden between 2010-2015 have been summarized in a technical handbook for restoration of eelgrass in Scandinavian waters[4]. This provides guidance on site selection, the permitting processes for harvesting and planting eelgrass, and methods for monitoring and evaluating results. Experience from these trials shows that restoration of eelgrass beds can be a very labour intensive and expensive process with uncertain outcomes, especially if the physical and biological environment has changed following loss of former beds. Furthermore, in the inner parts of the Baltic Sea, where eelgrass reproduction is primarily vegetative, recovery would have to involve transplantation of genetically 'suitable' strains.

The technical handbook recommends evaluating the existing environmental conditions and test-planting at least 12 months prior to selecting a restoration site, and only proceeding in locations where light availability at the planting depth is at least 25% of the surface irradiance and where test-planted shoots have shown positive growth after one year. Based on this research, the recommendation for large scale restoration along the Swedish NW coast includes harvesting and planting single adult shoots by hand, without any attached sediment from the donor meadow.

1 Best practice guideline LIFE Baltcoast
2 E.g. https://www.waterprotectiontools.net/index.php/en/home-page/
3 Busch et al., 2010
4 Moksnes et al., 2016

Restoration of eelgrass bed using seeds rather than plants has also been investigated including options for mechanical harvesting to collect seeds from donor beds with high densities of flowering shoots, separating out seedbearing shoots for later seed collecting, and the conditions for viable seed storage. The very high losses of seeds, particularly in shallow areas as a result of transport by currents, bioturbation and predation, as well as low rate of establishment with current methods suggests that restoration with seeds is inefficient[1].

Eco-moorings
Recreational swing moorings, where large blocks are placed on the seabed with heavy chains linking them surface buoys can scour the seabed leading to loss or damage of eelgrass beds by dislodging plants as well as increasing the exposed edge of eelgrass beds. Movement of the chain can also increase sediment resuspension and reduce light levels around such swing moorings. Alternative systems with helical anchors screwed into the substrate and a strong elastic rod fixed to the anchor replacing the chain to prevent dragging have been installed to protect *Zostera* beds although recovery can be slow, especially if the seabed remains shaded[2]. Moving anchoring away from eelgrass beds by providing alternative moorings elsewhere is a more direct way to remove this type of pressure from eelgrass beds[3].

Regulatory measures

Protected areas
Conservation of habitats characterized by *Zostera* includes the protection through designation as Special Areas of Conservation under the EU Habitats Directive (e.g. within 'lagoons' and 'shallow inlets and bays' which are listed in Annex 1), and under the EU Birds Directive as Special Protection Areas. Habitats characterized by *Zostera* are also present in locations designated as protected areas through national conservation programmes, Baltic Sea MPAs and Ramsar sites. Designation provides a regulatory framework for action. In the case of the Habitat Directive this include a requirement to achieve favourable conservation status and to prevent damage and deterioration of the habitat and its typical species.

Supporting measures

Management plans
Management plans (including MPA management plans) provide a framework in which to develop, promote, monitor and report on actions for the conservation of habitats characterized by *Zostera*. They typically set out the objectives, consultation processes, actions, key players, timescales, and organizational structures. A specific waterbody may be the main focus but management plans for eelgrass beds need to be developed within the wider context of understanding the mosaic of habitats in which the *Zostera* dominated habitats are located because of their interconnected nature. Management plans should therefore also advocate measures for the adjacent coastal land, river basins/watershed and sea.

For waterbodies or those which extend across more than one municipality or national border a joint integrated approach to setting conservation objectives and management will be required.

1 Eriander, 2016, Marion & Orth, 2010
2 Swan, 2012
3 Parry-Wilson, et al., 2019

Planning frameworks

Planning frameworks can set direction, bring together key players and involve the public in decision making for particular geographical areas. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent. UNESCO describe it as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process"[1]. It is essentially a practical way to create and establish a more rational organization of the use of marine species and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems and to achieve social and economic objectives in a planned way[2]. Projects such as BaltSeaPlan and Baltic SCOPE have supported the development of MSP in the Baltic and there is a deadline of 2021 for Baltic Member States to establish Marine Spatial Plans under the EU Directive establishing a framework for MSP (EU 2014/89/EU). The management of waterbodies that include *Zostera* dominated habitats cannot be undertaken in isolation of activities, demands and influences taking place around them or in their hinterland hence the need to incorporate the biodiversity objectives and associated management measures for such habitats into Maritime Spatial Plans.

Sector specific measures

Where particular activities are a threat to waterbodies supporting *Zostera* communities, either because of their mode of operation, scale of operation or location, regulation can support their conservation. This may, for example include restrictions on development, dredging, demersal fisheries with towed gears and zoning of tourism activities. Codes of conduct, for example on mooring and recreational use of areas where *Zostera* is present will also be beneficial, especially as the recreational use is more common close to the coast where also *Zostera* habitats are located.

Research and understanding

Management of this habitat needs to be underpinned by an understanding of the processes that drive their development and continuance as well as the ecological process that support the associated biodiversity. The driving forces may be known in general terms but, given the range of types of waterbodies that have *Zostera* dominated habitats and their different conditions across the Baltic Sea, it is also essential to understand these at a local level so that appropriate management objectives can be set and effective measures introduced to achieve these objectives. Eelgrasses are also being used as an indicator species as they are sensitive to eutrophication and reflect and integrate water quality over longer time periods[3].

HELCOM Baltic Sea Action Plan

The goals and objectives of the Baltic Sea Action plan (BSAP), and most especially those relating to eutrophication and biodiversity, are directly relevant to the management of this habitat. The BSAP provides a framework for joint actions across Baltic states as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea. Mitigating eutrophication and developing Maritime Spatial Plans are some of the agreements promoted through the BSAP that can benefit habitats dominated by eelgrass and need to be maintained and potentially strengthened in the revised BSAP[4]. BaltSeaPlan and Baltic SCOPE have supported the development of MSP in the Baltic and there is a deadline of 2021 for Baltic Member States to establish Marine Spatial Plans under the EU Directive establishing a framework for MSP (EU 2014/89/EU).

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1 Ehler & Douvere, 2009.

2 Defra, 2009

3 Krause-Jensen et al., 2008

4 E.g. http://www.helcom.fi/baltic-sea-action-plan; BMEPC, 2018

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FUCOIDS

SUMMARY OF KEY MANAGEMENT MEASURES

Fucoids are keystone species in the Baltic Sea providing food and shelter for many associated species. There are three species in the Baltic Sea, including one of which can survive as a free-floating form rather than growing attached to the seabed. The main pressure leading to deterioration and decline of *Fucus* habitats has been eutrophication leading to enhanced growth of filamentous algae, decreased light levels, and increased sedimentation and siltation. Physical damage from coastal works has also led to deterioration and loss of this habitat. Climate change effects on salinity, temperature and light levels are predicted to affect the distribution of *Fucus* in the future.

Two types of management objectives are a priority for this habitat type; those aimed at preventing degradation and further loss, and those which enhance the chances of recruitment to maintain and potentially facilitate recovery in areas where it has been lost. Reducing nutrient inputs is vital and whilst actions can be taken at a local level, in an open system such as the Baltic Sea, a broader view, including actions focused on the terrestrial environment is also essential. Habitat damage needs to be prevented because, although re-introduction schemes may be considered, there is uncertainty about the likelihood of their success. Management measures can be introduced within the framework of Marine Protected Areas and Maritime Spatial Planning as well as sector specific regulations such as restrictions on dredging where it might affect *Fucus* beds. Research and better understanding of the structure and function of this habitat will also improve the likelihood of successful management interventions.

THE HABITAT AND ASSOCIATED SPECIES

Habitat description

Fucoids are important habitat-forming macroalgae which grow in temperate waters. They are a keystone species in the Baltic Sea providing shelter and food for many organisms. The associated species can be found on the hard substrate under the seaweed canopy as well as attached to the alga as epiphytes, grazing and sheltering amongst the fronds.

Three species of Fucoids occur in the Baltic Sea. *Fucus serratus* the serrated wrack, *F. vesiculosus* the bladderwrack, and *F. radicans* the narrow wrack. The latter was considered to be a dwarf morph of *F. vesiculosus* until described as a different species in 2005[1].

F. vesiculosus is the most common wrack in the Baltic Sea where it is widespread, often dominating shallow macroalgal communities on hard substrates. It is a perennial species which needs a firm substrate and low to moderate exposure to ice and waves to form stable and healthy attached communities. An unattached form occurs in sheltered areas such as bays, lagoons and inlets where the seabed may be sandy or a muddy sand. *F. serratus* may be present mixed with *F. vesiculosus* particularly in shallow waters. It is less tolerant of low salinity whereas *F. radicans* is endemic to the Baltic Sea and only present in lower salinity waters mainly in the Gulf of Bothnia. *F. radicans* can reproduce by fragmentation with almost 80% of the individuals along the Swedish coast being one clone[2].

1 Bergstrom et al., 2005

2 https://balticseaweed.com/2013/01/28/fucus-radicans-narrow-wrack/

The HELCOM HUB classification[1] describes nine biotope and habitat types characterized by the presence of *Fucus* spp.;

AA.A1C1 Baltic photic rock and boulders dominated by *Fucus* spp.

AA.H1Q1 Baltic photic muddy sediment dominated by stable aggregations of unattached *Fucus* spp. (typical form)

AA.H1Q2 Baltic photic muddy sediment dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)

AA.I1Q1 Baltic photic coarse sediment dominated by stable aggregations of unattached *Fucus* spp. (typical form)

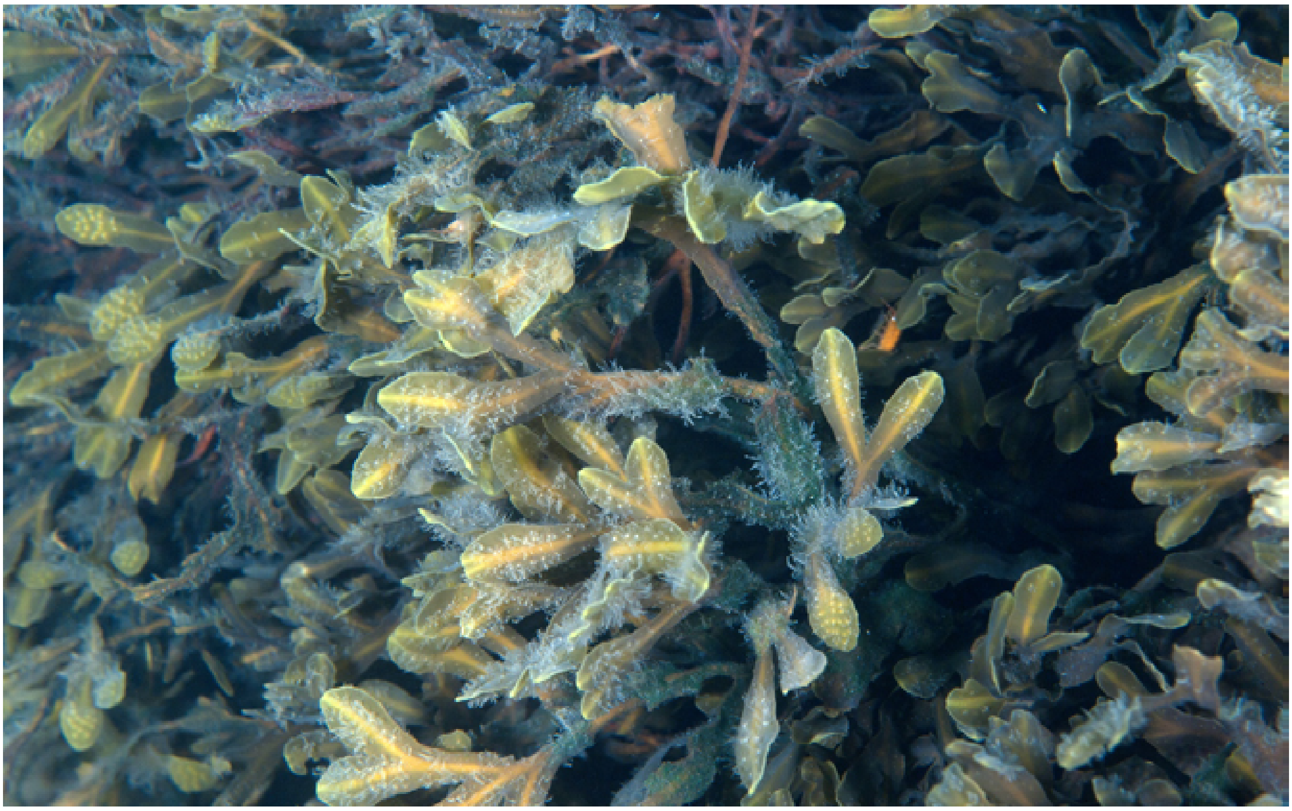
AA.I1Q2 Baltic photic coarse sediment dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)

AA.J1Q1 Baltic photic sand dominated by stable aggregations of unattached *Fucus* spp. (typical form)

AA.J1Q2 Baltic photic sand dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)

AA.M1Q1 Baltic photic mixed substrate dominated by stable aggregations of unattached *Fucus* spp. (typical form)

AA.M1Q2 Baltic photic mixed substrate dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)



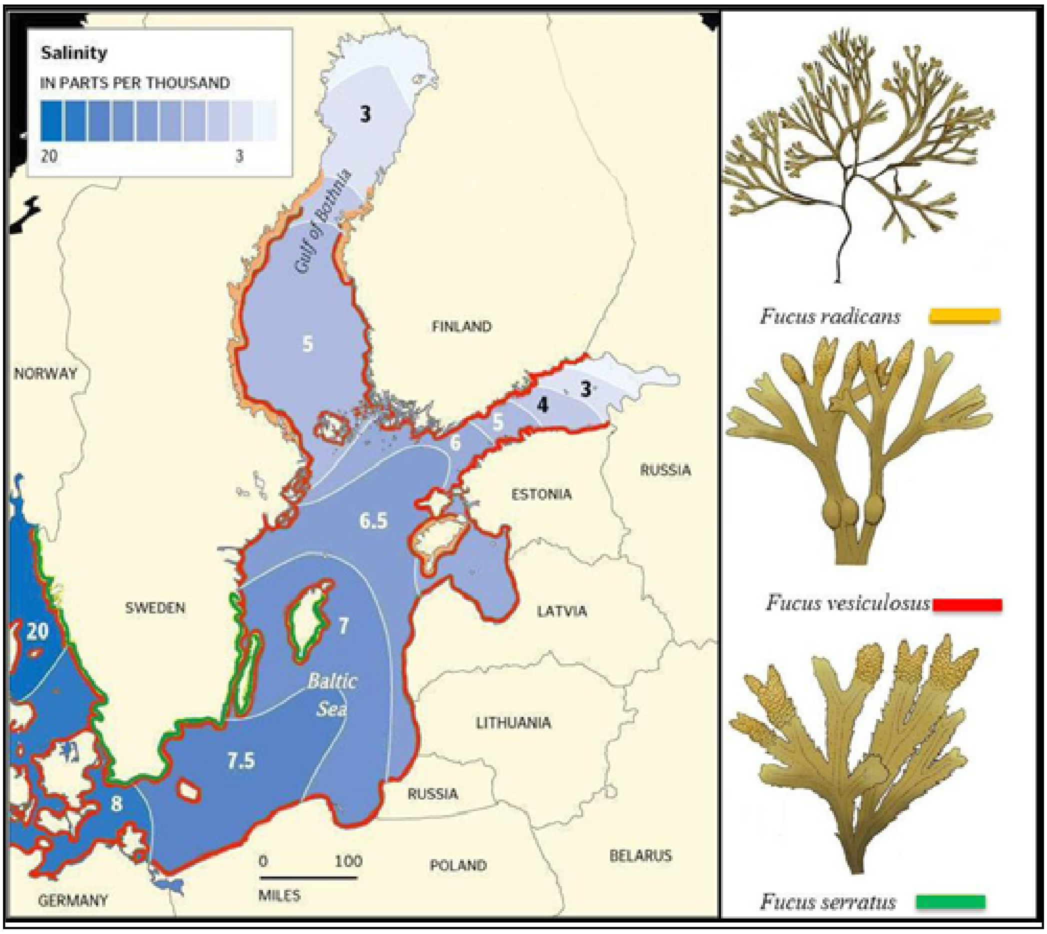
Algae (*Fucus* sp.) in the Bothnian Sea, Sweden © OCEANA Carlos Suárez
https://www.flickr.com/photos/oceanaeurope/20055578246/

1 HELCOM 2013 – HELCOM HUB

Distribution in the Baltic Sea

F. vesiculosus is widely distributed in the North Atlantic. In the Baltic Sea it extends from the Kattegat into Bothnia Bay and has been found in all riparian countries[1]. As it can successfully reproduce in salinities as low as 4 psu[2], this reduces competition from other less tolerant algal species enabling it to occur as far north as the Gulf of Bothnia and as far east as the Gulf of Finland[3]. *F. radicans* is endemic to the Baltic Sea being present in the Gulf of Bothnia, around the Estonian island of Saaremaa, and in the eastern Gulf of Finland[4]. *F. serratus* is present in the Kattegat and along southern Swedish Baltic coastlines.

Although predominantly an intertidal habitat in the North Atlantic, habitats characterized by *F. vesiculosus* extend into the shallow sublittoral in the Baltic Sea and *F. serratus* is essentially a sublittoral species in the Baltic Sea. Light is the main factor regulating depth distribution although other strong influences are competition with other macroalgae, grazing pressures, and sedimentation. *F. vesiculosus* has been recorded between 1.5-5.5 m depth and, on occasion, down to 7 m generally extending into deeper water in the central and inner Baltic Sea[5]. *F. serratus* although historically recorded down to 15 m is now more typically found at a depth limit of around 6 m. Ice scouring in winter often sets the upper limit of the *Fucus* zone in the northern Baltic Sea.



Surface water salinities (psu) and the distribution of Fucoids in the Baltic Sea. It should be noted that it is not a continuous distribution of *Fucus*, but the map shows where the species may be found if rocky substrate is available (Figure 1, from Schagerström, 2013).

1 HELCOM 2013 Species information sheet
2 Malm et al., 2001
3 Torn et al., 2006
4 Rinne & Salovius-Lauren, 2019
5 Torn et al., 2006

Associated species

Habitats characterized by *F. vesiculosus* host a large variety of species. They include epiphytic organisms such as micro and macroalgae as well as sessile and mobile invertebrates. Byrozoans, polychaetes, crustaceans, nemeritine worms, molluscs, and hydroids as well as green, brown and red macroalgae have been recorded in this habitat. The species composition is influenced by the degree of wave exposure but there are also distinct differences compared to the North Sea *Fucus* beds, which has been attributed to the different salinity regime in the Baltic Sea[1].

Wandering snail (*Radix balthica*) on brown algae (*Fucus radicans*) © OCEANA Carlos Minguell
https://www.flickr.com/photos/oceanaeurope/29674335887/in/album-72157697714411962/

Conservation status

As a species, *F. vesiculosus* has been assessed as Least Concern for the Baltic Sea, Least Concern in Sweden, Vulnerable in Germany, and Endangered in the Leningrad Region of Russia. It is Extinct in Poland. *F. serratus* has been assessed as Least Concern for the Baltic Sea, Least Concern in Sweden and Endangered in the German Baltic Sea.

The four biotopes characterized by the dwarf form of *Fucus* have been assessed by HELCOM as being Endangered[2]. Benthic habitats characterized by *Fucus* spp. have also been assessed as Endangered in Finland[3].

The HELCOM MPA database[4] records that one of the biotopes characterized by *F. vesiculosus* is present in a Baltic sea MPA (Kungsbackafjorden, Sweden [AA.A1C1]). It is also likely to be present in other MPAs, as are other *Fucus* biotopes, but they are not recorded in this database at the present time.

1 Kersen et al., 2011
2 HELCOM 2013, Biotope Information Sheet
3 Kontula & Raunio 2018
4 http://www.helcom.fi/action-areas/marine-protected-areas/database/

PRESSURES AND THREATS

Habitats characterized by *Fucus* are not threatened at the scale of the whole Baltic Sea but there have been local and regional historic declines since at least the 1950s, including rapid declines in some areas in the 1980s of both *F. serratus* and *F. vesiculosus*[1]. The decline has manifested itself as loss of wrack communities from some areas as well as reduction in their depth distribution. The most threatened biotopes are currently those characterized by the unattached (dwarf) form of *F. vesiculosus*.

The main pressures and threats leading to deterioration and/or decline of this habitat are eutrophication and physical damage.

Eutrophication is a significant threat because of associated effects, in particular reduced light penetration, massive growth of filamentous algae, and increased sedimentation/siltation[2]. There may also be a link to grazing pressure by the isopod *Idotea balthica* as it has been suggested that populations of this isopod may have been favoured by continuing eutrophication in the Baltic. Nutrient enrichment may have led to improving quality of *Fucus* as food, thereby causing overgrazing by this species[3]. The eutrophication effects on the depth limits of *Fucus* appear to be less associated with higher nutrient concentrations than the result of increased sediment and decreased water transparency[4].

Direct physical damage from coastal works such as ditching, and deepening harbour access, and from point source pollution have also been implicated in the loss of this habitat whilst other activities, such as nearby aquaculture facilities can change the composition of the associated species with possible implications for habitat quality, structure and function[5].

Climate change effects such as mild winters, lowered salinity, changes in light levels associated with ice cover and increased sea water temperature are also expected to have consequences for this habitat type. Potential effects include changes in the distribution of *Fucus* species, and a mismatch between the timing of the settlement of *F. vesiculosus* zygotes and the cover of competing filamentous algae, preventing successful establishment of *Fucus*[6].

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the habitat. In an open system such as the Baltic Sea it is also the case that while some actions to benefit this habitat type can be focused on the habitat, a broader view is essential. This must include actions to be taken in the terrestrial environment because eutrophication, resulting from nutrient inputs, is a major threat to this habitat. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

1 Vogt & Schramm 1991; Vahteri & Vuorinen, 2016
2 Bergstrom et al., 2003
3 E.g. Engkvist et al., 2000: Rinne & Salovius-Lauren, 2019.
4 Eriksson & Bergstorm, 2005; Rinne et al., 2011
5 E.g. Ronnberg et al., 1992
6 E.g. Kraufvelin et al., 2012; Johannesson et al., 2011

Conservation objectives

Given the historical changes in this habitat such as its decline in some areas, and decline followed by recovery elsewhere, the conservation objectives need to be concerned with maintaining and potentially improving its status as expressed by extent, quality, structure and function. This is consistent with the objectives HELCOM MPAs and Natura 2000 sites established under the EU Habitats and Birds Directives.

Management objectives

Two types of management objectives are a priority for this habitat type. Firstly, those aimed at preventing degradation and further loss, and secondly those which enhance the chances of recruitment to maintain and potentially facilitate recovery in areas where habitats characterized by Fucoids have previously been present.

Practical measures

Reducing nutrient inputs
The main source of nitrates and phosphates entering the Baltic Sea is runoff from agricultural land. This has long been recognized as an issue because of the resulting risk of eutrophication. Tackling eutrophication is therefore one of the four goals of the HELCOM Baltic Sea Action Plan. Numerous schemes, projects and management measures have been introduced at local, regional and transnational levels to try and address the problem.

For managers working at a local level, tackling diffuse sources of pollution will require participating in and supporting schemes which are not limited to the MPA. They will involve encouraging measures on the surrounding land or entire watersheds, joint targets with other management authorities and participation in national as well as transnational and Baltic-wide initiatives. Practical actions at a local level can also help bring about change such as modifying farming practices, buffer zones along water bodies, the creation of reed beds to retain and filter nutrients, and other agri-environment schemes[1]. Schemes such as these will however need to be subject to Environmental Impact Assessments as they have environmental implications in their own right. It is also important to recognize that as nutrients can be retained in sediments or in the water column, high phytoplankton production may continue for a period even when nutrient inputs are reduced.

There is an extensive literature on management measures that can help reduce nutrient inputs and resulting eutrophication on marine habitats which can be drawn on to support the conservation of habitats characterized by *Fucus*. Supporting actions by managers could include:

- Using monitoring data on the extent and condition of the bladderwrack and the associated biotopes as an indicator of environmental quality (NB. Already used as a WFD biotic indica tor)
- Participating in and supporting management schemes for the surrounding land e.g. Agri-environment schemes which seek to reduce nutrient inputs
- Participation in local projects e.g. Urban Oasis (constructed wetland)

1 Baltic COMPASS project, http://www.helcom.fi/helcom-at-work/projects/completed-projects/baltic-compass/

Re-introduction and enabling recruitment
Artificial resettling of bladderwrack communities to areas previously occupied may be an option to enhance the recovery of *Fucus*[1]. Two possibilities are transplanting adult reproductive plants attached to stones, and seeding zygotes by transferring fertile structures. Whilst both approaches have worked elsewhere, consideration of the prevailing conditions is necessary to assess the likelihood of success. Continuing eutrophication, turbid waters and high sedimentation may mean that some areas have largely lost their potential to host *Fucus*. For example, very little suitable photic hard substrate remains in the innermost Archipelago Sea[2]. Whilst practically possible, reintroduction is unlikely to be a sustainable and practical solution to reversing the decline of this habitat type.

Preventing habitat damage
Coastal construction, dredging in shallow coastal lagoons, and aquaculture are all activities that can have an impact on this habitat. This is particularly the case for the biotopes associated with unattached *Fucus* as are typically in sheltered locations where limited flushing means that if water quality has deteriorated it can take a long time to recover. Management schemes need to include clear policies on these and other potentially damaging activities, as well as setting out the Environmental Impact Assessment procedures and thresholds to safeguard *Fucus* habitats.

Regulatory measures

Protected areas
Habitats characterized by *Fucus* are present in Baltic Sea Marine Protected Areas including at least one, which is also a Natura 2000 site under the EU Habitats Directive (Kungsbackafjorden, Sweden). *Fucus* beds are also included in some of the Baltic Sea Ecologically or Biologically Significant Marine Areas (EBSAs) (e.g. in the Åland Sea). Designation provides a regulatory framework for protection of biodiversity within MPAs, typically through an MPA management plan which sets out conservation objectives, actions to be taken, and opportunities for stakeholder involvement as well as establishing a system for monitoring and reporting on progress.

Sector specific regulations
Where particular activities are a threat to this habitat type, either because of their mode of operation, scale of operation or where they take place, regulation can support conservation measures. This may, for example include restrictions on dredging and construction works that can increase turbidity and therefore have a detrimental effect on *Fucus* beds.

1 Berger et al., 2004
2 Rinne & Salovius-Lauren, 2019.

Supporting measures

Planning frameworks
Planning frameworks can set direction, bring together key players and involve the public in decision making for particular geographical areas. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent. UNESCO describe it as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process"[1]. It is essentially a practical way to create and establish a more rational organization of the use of marine species and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems and to achieve social and economic objectives in a planned way[2].

The management of *Fucus* habitats cannot be undertaken in isolation from activities, demands and influences taking place around them or in their hinterland. There is therefore a need to incorporate biodiversity objectives and associated management measures for marine habitats such as these into Maritime Spatial Plans. Such plans may, for example, include guidance on the siting of offshore windfarms, outfall pipes or channel dredging operations all of which can affect nearby *Fucus* habitats. The participation of MPA managers in the development of relevant MSPs is a practical way to influence such plans.

HELCOM Baltic Sea Action Plan
The goals and objectives of the Baltic Sea Action plan (BSAP), and most especially those relating to eutrophication and biodiversity, are directly relevant to the management of this habitat. The BSAP provides a framework for joint actions across Baltic countries as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea. Mitigating eutrophication and developing Maritime Spatial Plans are some of the agreements promoted through the BSAP that can benefit habitats characterized by fucoids and need to be maintained and potentially strengthened in the revised BSAP[3].

BaltSeaPlan and Baltic SCOPE have supported the development of MSP in the Baltic and there is a deadline of 2021 for Baltic Member States to establish Marine Spatial Plans under the EU Directive establishing a framework for MSP (EU 2014/89/EU).

Research and understanding
Management of habitats characterized by *Fucus* needs to be underpinned by an understanding of the ecological processes that create and maintain their structure and function; the pressures, threats and resulting effects on the habitats, and where intervention is possible and desirable. Research on the occurrence of *Fucus* species in the Baltic Sea and how they are affected by environmental parameters such as salinity, light levels and nitrogen and phosphorus concentrations, as well as by climate change is therefore valuable in both using it as an indicator of environmental quality (e.g. for the WFD) as well as improving the likelihood of success of any management interventions.

1 Ehler & Douvere, 2009.
2 Defra, 2009
3 E.g. http://www.helcom.fi/baltic-sea-action-plan; BMEPC, 2018

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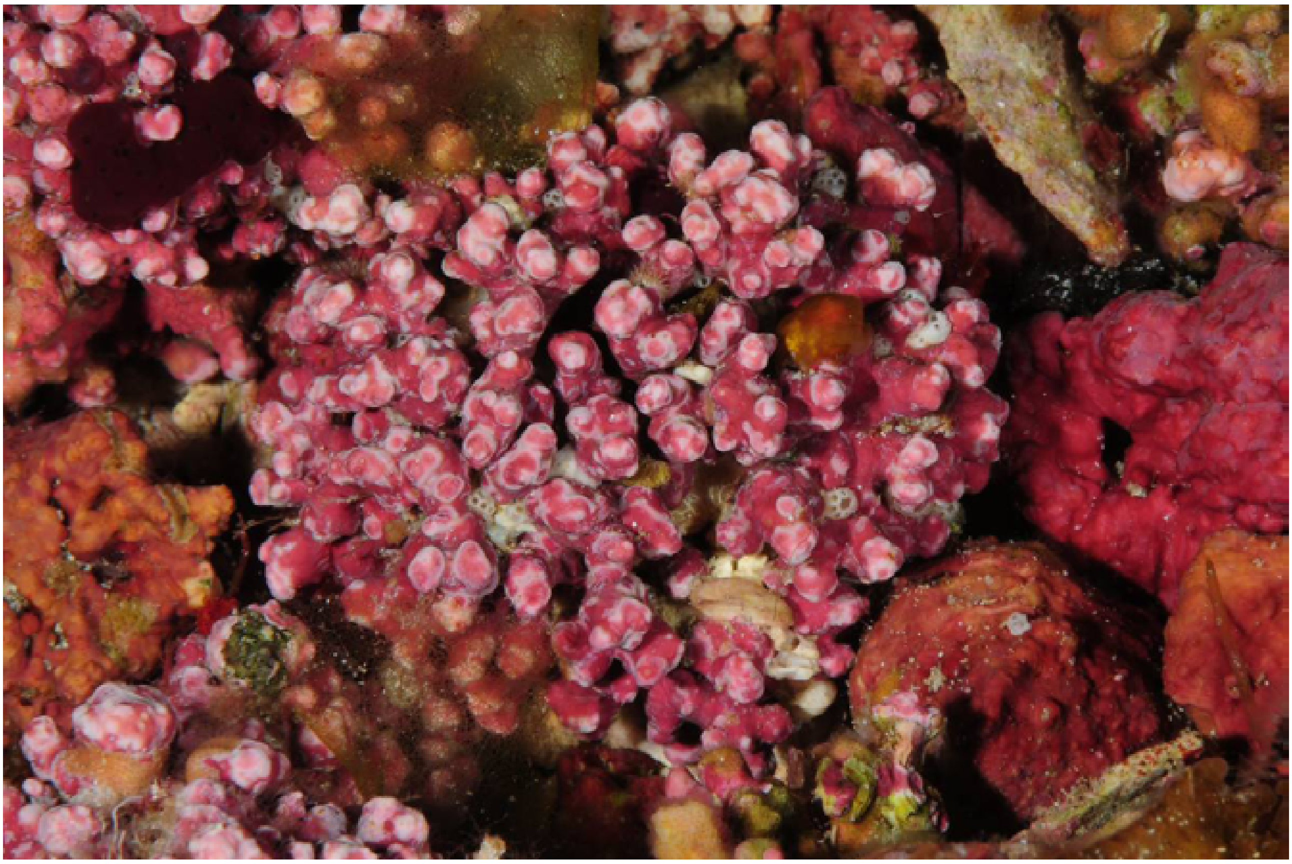
MAERL BEDS

SUMMARY OF KEY MANAGEMENT MEASURES

Maerl beds are rare in the Baltic Sea due to the reduced salinity. They are currently only reported from the Kattegat where conditions are suitable, in depths of up to 20 m. The main pressures are from activities that physically disturb areas of the seabed where maerl is present, and those which increase turbidity or alter water flows on and around maerl beds. Demersal fisheries as well as eutrophication are therefore issues of concern. Rising sea temperature and ocean acidification may also alter the distribution and condition of maerl beds in the Baltic Sea.

Given the slow growth rate of maerl, the principle management objective for this habitat type should be to prevent degradation and loss of existing beds. Management measures can usefully focus on preventing physical disturbance, and on maintaining or improving water quality. This can be within the framework of Marine Protected Areas or sector specific regulations such as restrictions on dredging, dumping and activities which disturb the seabed. Planning processes, including Integrated Coastal Zone Management can be supportive of management measures by regulating the siting and operation of aquaculture facilities, offshore windfarms, cables & pipelines and dredging operations (channel dredging or sand and gravel extraction). Plans and procedures for construction projects, including Environmental Impact Assessments, need to take account of the risks to maerl beds, like changing currents, sedimentation, and turbidity.



Maerl rhodoliths © OCEANA Carlos Minguell
https://www.flickr.com/photos/oceanaeurope/6846997087/in/photolist-oJ15pL-qdjC3k-9qgY6K-289TRqf-dwooAk-NirMQy-Nt3PFE-jQqmF2-idZeXH-br3DFV/

THE HABITAT AND ASSOCIATED SPECIES

Habitat description

Maerl is a collective term for various species of non-jointed coralline red algae (*Corallinaceae*) that live unattached. Accumulations can form extensive beds, mostly in coarse clean sediments of gravels and clean sands or muddy mixed sediments, which occur either on the open coast, in tide-swept channels or in sheltered areas of marine inlets with weak current[1]. Small individuals are twig-like but as they grow, they tend to form irregular clumps. Fragments may break free and survive as nodules.

Maerl beds may contain both living and dead maerl. Where present, living maerl is restricted to the surface layers as light is required to support photosynthesize. Light levels influenced by factors such as the turbidity of the water will also determine the depth limits of living maerl beds. The living alga is pink red in colour but when dead erodes down to a white coarse gravel or sand.

Two species of algae form maerl beds in the Baltic Sea, *Lithothamnion glaciale* and *Phymatolithon calcareum* and although both living and dead maerl beds are present they are relatively rare.

The HELCOM HUB classification[2] describes two biotopes characterized by the presence of maerl;

AA.D Baltic photic maerl beds (unattached particles of coralline red algae)

AB.D Baltic aphotic maerl beds (unattached particles of coralline red algae)

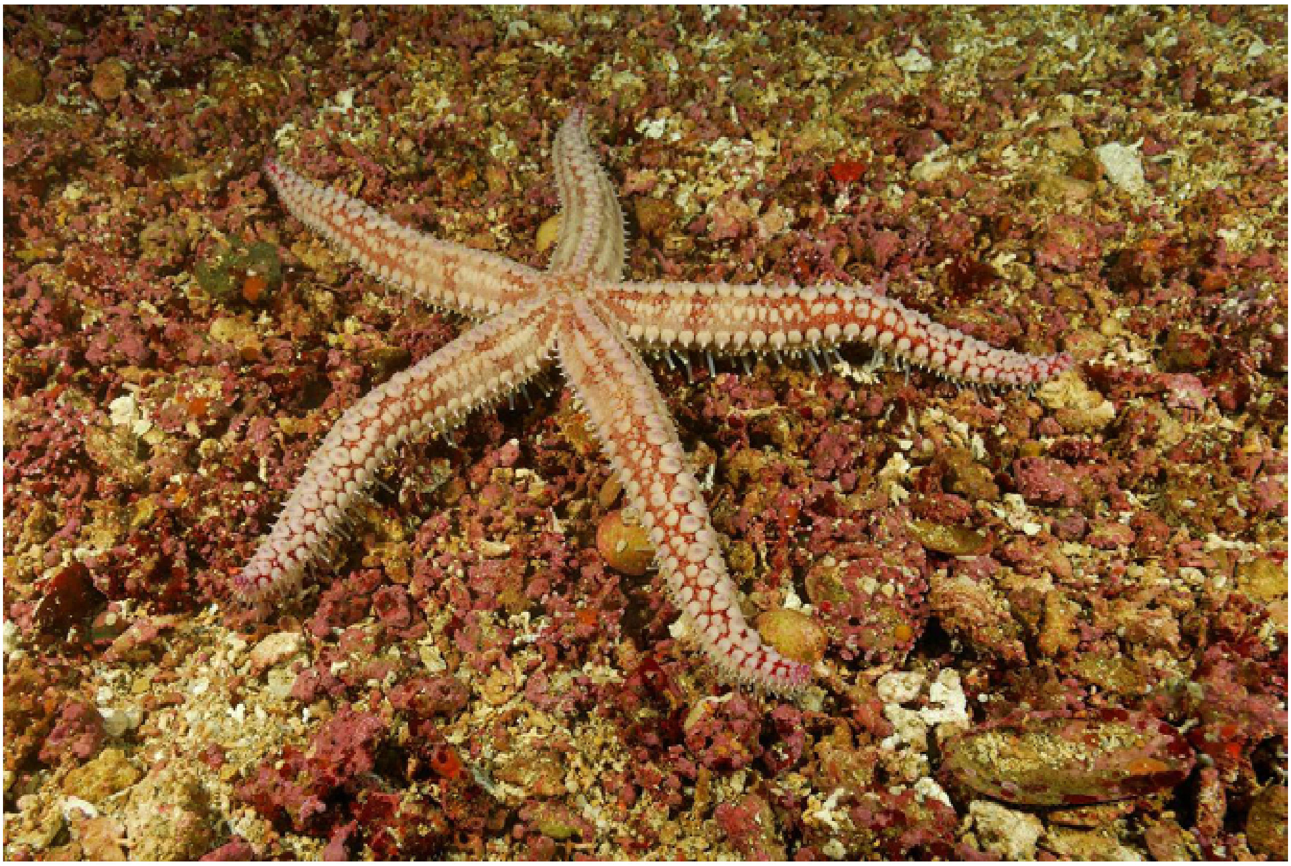
Distribution in the Baltic Sea

Maerl beds have been reported from fewer than 20 locations in the Baltic Sea, all within the Kattegat[3]. The best described are the living maerl beds at Lilla Middelgrund and Fladen (Sweden) but there is also reference to offshore banks of dead maerl in the Kattegat. On the Fladen reef the maerl is found between 18-20 m forming a layer 5-10 cm deep[4]. A lack of tolerance to reduced salinity is considered to be the most likely reason for this restricted distribution.

Associated species

Two species of maerl form this habitat in the Baltic Sea *Lithothamnion glaciale* and *Phymatolithon calcareum*. The structural complexity of maerl beds means they support a rich assemblage of both plants and animals including acting as nursery grounds for some fish and shellfish. Animals associated with maerl beds in the Kattegat include rare crustaceans, such as *Corystes cassivelaunus* and *Thia scutellata*, and echinoderms, such as *Ophiothrix fragilis* and *Ophiocomina nigra*[5]. Species found on the maerl beds of the Fladen reef include the crustaceans *Pisidia longicornis* and *Liocarcinus pusillus,* and the echinoderms *Asterias rubens*, *Marthasterias glacialis*, *Ophiocomina nigra* and *Ophiopholis aculeata*[6]. Beds of dead maerl may also support many species although the communities in such areas may be more similar to those of a fine shell gravel.

1 OSPAR, 2010
2 HELCOM, 2013 – HELCOM HUB
3 HELCOM, 2013 Biotope information sheet
4 Nilsson & Gustafsson, 2001.
5 OCEANA, 2011
6 Nilsson & Gustafsson, 2001



Spiny starfish (*Marthasterias glacialis*) on maerl bed. © OCEANA Juan Carlos Calvin https://www.flickr.com/photos/oceanaeurope/12362365863/in/photolist-oJ15pL-qdjC3k-9qgY6K-289TRqf-dwooAk-NirMQy-Nt3PFE-jQqmF2-idZeXH-br3DFV/

Conservation status

Phymatolithon calcareum is listed in Annex V of the Habitats Directive (species whose exploitation is subject to management). In some locations maërl beds are present within sandbanks which is on an Annex I habitats of the Directive and therefore given some protection through the designation of Special Areas of Conservation.

The two biotopes characterized by maerl beds have been assessed by HELCOM as being Endangered. Maerl beds are also listed as a threatened and declining habitat type by OSPAR in OSPAR Region II which includes the Kattegat[1].

1 https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats

PRESSURES AND THREATS

Maerl is slow growing and fragile with an infrequent reproductive life cycle and the integrity of maerl habitats depends upon the survival of a surface layer of growing algae[1].

Commercial collection, removal in sand and gravel extraction operations, fishing methods which disturb the seabed, and eutrophication (which stimulates excessive growth of algae), have all been identified as threats to this habitat type. Coastal development that modifies water flows and increases sediment loads can also be detrimental. These activities can result in physical, chemical and biological impacts such as removal and burial of live maerl, clogging of maerl interstices by fine particles, reduced growth, and decreased habitat complexity[2].

Maerl is also expected to be affected by climate change through the effects of rising sea temperature and ocean acidification.

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the habitat. This will include actions to be taken in the terrestrial environment as eutrophication, linked to nutrient inputs, is one potential threat to this habitat. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

The conservation objectives for maerl beds need to be concerned with maintaining and potentially improving the status of existing beds as expressed by extent, quality and structure and function. This is consistent with the objectives HELCOM MPAs and Natura 2000 sites established under the EU Habitats and Birds Directives.

Management objectives

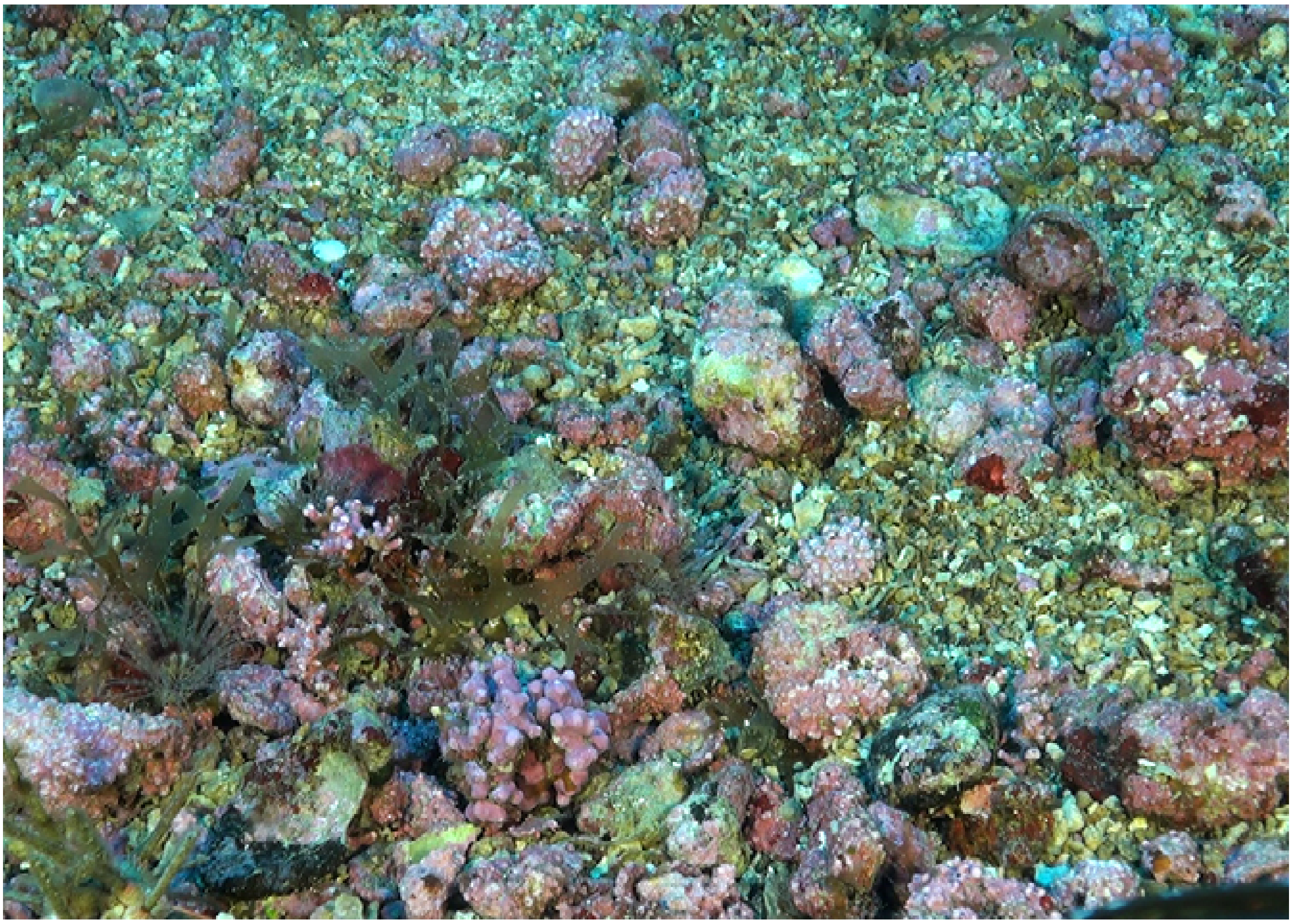
Given the slow growth rate of maerl, the principle management objective for this habitat type should be to prevent degradation and loss of existing beds.

1 Hall-Spencer & Moore, 2000
2 Barbera et al., 2001; Hall-Spencer et al., 2003

Practical measures

Protection from physical damage
The detrimental effects of bottom-towed fishing gears on maerl beds include smothering, abrasion, damage to the structure of the maerl beds, and the removal and damage of associated epifauna and infauna. Physical damage can also result from sand and gravel extraction, construction works and dredging operations. Prohibiting such activity on maerl beds, as well as in a buffer zone around the habitat, is a direct way of protecting maerl beds from physical damage caused by human activity. Short term protection is unlikely to be enough as because of the slow growth rate of maerl which can take decades to recover[1].

Improving water quality
Where there are clearly identifiable, local activities that affect water quality around maerl beds e.g. from sewage outfall pipes or industrial discharges, practical measures to reduce or remove point source pollution may be possible. For diffuse sources of pollution, or point sources far removed from but affecting maerl beds, regulatory and supporting measures such as those described below will provide a framework for tackling water quality problems in a variety of ways.



Maerl rodoliths © OCEANA
https://www.flickr.com/photos/oceanaeurope/42763838842/in/photolist-oJ15pL-qdjC3k-9qgY6K-289TRqf-dwooAk-NirMQy-Nt3PFE-jQqmF2-idZeXH-br3DFV/

1 Hall Spencer & Moore, 2000; OSPAR, 2010

Regulatory measures

Marine Protected Areas

Living Maerl beds are present in the Fladen and Lilla Middelgrund Natura 2000 sites designated by Sweden. In both cases the maerl beds lie within proposed “no-take zones” which provides protection from any direct physical impact and all fishing activities. They have also been designated as protected areas through national conservation programmes, are recognized as Baltic Sea MPAs included a Baltic Sea Ecologically or Biologically Significant Marine Areas (EBSAs) (Fladen and Stora and Lilla Midelgrund). Whilst “no-take zones” could be created without MPA designation, the supporting mechanisms of MPAs such as conservation objectives, management planning, monitoring, and enforcement provide a framework that supports implementation.

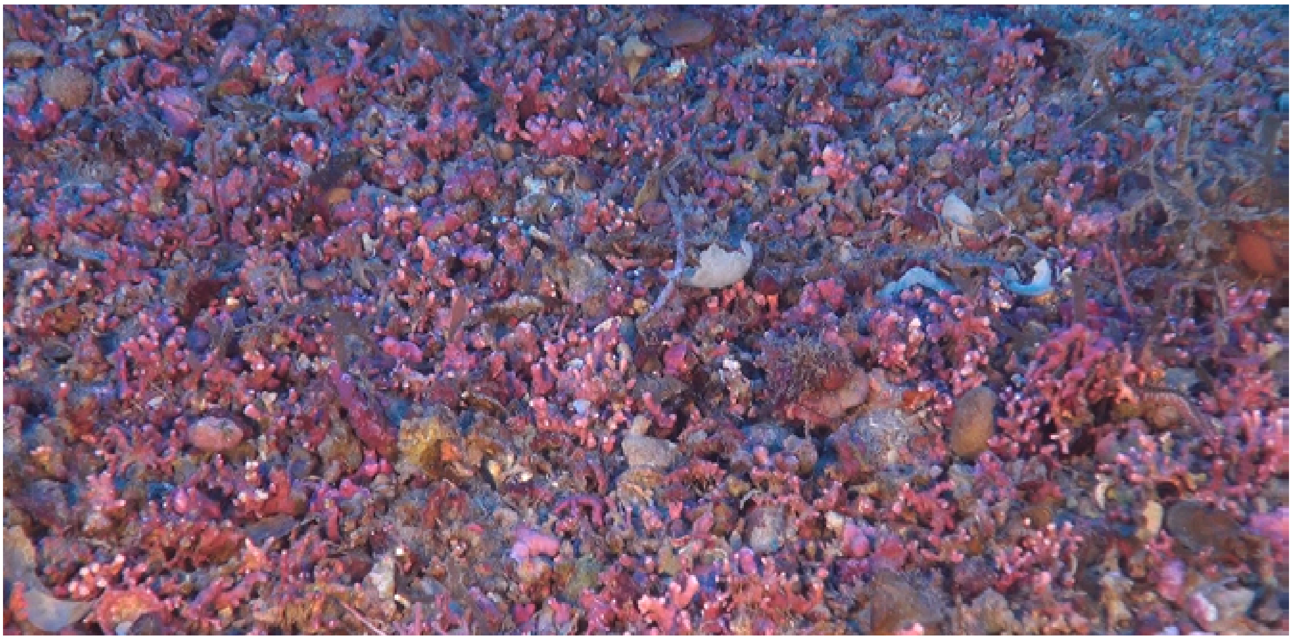
MPA management planning should include the scope for emergency measures to protect the habitats and species for which the MPA has been designated. Consideration should also be given to adopting interim measures for protection whilst formal designation is pending.

Prohibiting commercial extraction

Maerl has been described as a non-renewable resource that cannot sustain direct exploitation[1]. There is no commercial extraction from maerl beds in the Baltic Sea at the present time and the habitat is currently protected within “no-take zones” in Marine Protected Areas. Provisions such as these, backed by regulation, are needed to safeguard maerl habitats in the Baltic Sea.

Fisheries regulation

Protection of maerl beds from the impacts of demersal fishing gears such as scallop dredgers can be achieved through fisheries regulations. They include regulations that prohibit damaging gears from operating on and near maerl beds, limiting fishing effort e.g. the number of passes or number of dredges per vessel, specifying gear type e.g. skid dredges or modified otter trawls, and controlling access as even a single pass with damaging gear can cause long term damage to a maerl bed[2].



Maerl bed © OCEANA
https://www.flickr.com/photos/oceanaeurope/30389823756/in/photolist-oJ15pL-qdjC3k-9qgY6K-289TRqf-dwooAk-NirMQy-Nt3PFE-jQqmF2-idZeXH-br3DFV

1 Barbera et al., 2003
2 https://cdn.naturalresources.wales/media/681796/scallop-queen-dredge-on-maerl.pdf

Supporting measures

Planning frameworks

Planning frameworks can set direction, bring together key players and involve the public in decision making for particular geographical areas. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent. UNESCO describe it as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process"[1]. It is essentially a practical way to create and establish a more rational organization of the use of marine species and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems and to achieve social and economic objectives in a planned way[2]. The management of maerl beds cannot be undertaken in isolation of activities, demands and influences taking place around them hence the need to incorporating the biodiversity objectives and associated management measures for maerl beds into Maritime Spatial Plans.

Sector specific measures

Aside from measures related to mobile fisheries, which are discussed above, the conservation of maerl beds will require supportive measures in the planning and management of other activities such as the siting and operation of aquaculture facilities, offshore windfarms, cables & pipelines and dredging operations (channel dredging or sand and gravel extraction). Plans and procedures for construction projects, including Environmental Impact Assessments, need to take account of the risk to maerl beds, for example from changing currents, sedimentation and turbidity.

1 Ehler & Douvere, 2009.

2 Defra, 2009

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PHYSICAL HABITATS

- Coastal lagoons
- Deep mud
- Gravel beds

COASTAL LAGOONS

SUMMARY OF KEY MANAGEMENT MEASURES

Coastal lagoons exhibit a natural cycle of development and loss, but this cycle has been disrupted by human activities to the point where they are an endangered habitat in the Baltic Sea. Activities that have altered the hydrology, water quality and physical characteristic of lagoons and the habitat complexes of which they are a part include drainage works, flood protection schemes, and changes in agricultural practices. Threats to lagoon habitats can be highly local as well as diffuse, most especially in relation to eutrophication. There is therefore a need for action to be taken at regional, national and Baltic Sea scale as well as at the local level, for this habitat to benefit.

Reducing nutrient inputs and habitat creation schemes are practical actions that can improve the conservation status of coastal lagoons whilst protected areas and sector specific regulations will provide a legal framework for management which can be used to target specific threats. Planning processes, including Integrated Coastal Zone Management can also be supportive of management measures. The Baltic Sea Action Plan has established high level targets on eutrophication and biodiversity conservation that also provide a framework for actions at various administrative levels that will benefit the conservation of coastal lagoons.

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THE HABITAT AND ASSOCIATED SPECIES

Habitat description

Lagoons are shallow coastal bodies of water separated from the sea by a barrier. They show considerable variation in size and are highly susceptible to changes in precipitation and wind because of their shallow nature. Depending on the tidal exchange and freshwater inflows, the water can range from fresh to brackish to hypersaline[1]. In undisturbed situations lagoons are part of a mosaic of habitats or habitat complex which can include saltmarshes, sand dunes, beaches and open sea.

Several types of lagoons have been described in the Baltic Sea[2]. The majority are bay-like features or coastal lakes separated from the sea by sandbanks or land thresholds. These are termed Bodden or barrier lagoons. Smaller features known as flads are formed gradually by a combination of rising land and siltation and follow a succession whereby shallow bays with a threshold at the entrance become isolated flads and then landlocked gloe lakes. They are in a continuous state of development.

Lagoons may have well-developed reedbeds and luxuriant submerged vegetation with different several morphological and botanical development stages.

Distribution in the Baltic Sea

Coastal lagoons are widely distributed around the Baltic Sea. Lagoons in the western and southern Baltic are typically formed on wave eroded coasts whereas those in the northern and eastern Baltic are the result of uplift which creates lagoons by separating shallow bights from the sea.

Associated species

The flora and fauna of lagoons must be able to withstand variations in salinity, fluctuations in temperature, and limited water movement. They support species of marine origin as well as having a freshwater element of reed beds, reed maces and sedges. Pondweeds and tasselweeds are found in freshwater areas along with hemipteran bugs, beetles and some snails. In more saline area, seagrass may be present, and the macrofauna is predominantly polychaetes, crustaceans and molluscs. Lagoons also support a variety of fish, birds, acting as nursery and spawning ground for fish and resting areas for birds. For example, 57 fish species, 7 of which are of marine origin, have been recorded in the Curonian Lagoon[3].

1 Miththapala, S. 2013.
2 HELCOM, 2013 Biotope Information Sheet; Salomonson et al., 2006.
3 CBD, 2018

Conservation status

Coastal lagoons are on Annex I of the EU Habitats Directive (code 1150). They have been assessed by HELCOM as Endangered in the Baltic Sea.

The HELCOM has assessed *Lamprothamnion papulosum*, the foxtail stonewort, a species found in some coastal lagoons as Endangered[1].

The HELCOM MPA database[2] records 87 MPAs in the Baltic Sea which include coastal lagoon habitats. In the majority of cases the presence of this habitat was one of the reasons for site designation.

Many species found in lagoons are also on national 'Red Lists'. For example, in Sweden the foxtail stonewort is Endangered and the eelgrass *Zostera noltii* is Vulnerable; the 2006 Red List for Poland recorded the stonewort *Chara connivens* as probably extinct. New records were made in the Vistula Lagoon and Szczecin Lagoon in 2014 but it is still extremely rare in Polish waters[3].

PRESSURES AND THREATS

Lagoons are affected directly and indirectly by activities that change their hydrology, water quality, physical structure, and biodiversity. In the Baltic Sea such changes have been linked to eutrophication, contaminant pollution, construction activities, disturbance of wildlife, and unsustainable fishing.

Nutrient enrichment from intensive livestock farming, inputs from rivers and high atmospheric nutrient loads in catchments, can act together to increase vegetation growth and alter water quality of lagoons and the surrounding land. Changes in traditional agricultural practice such as cattle grazing can also result in salt meadows being overgrown by reed beds altering the ecosystem dynamics. In the lagoon itself, eutrophication can affect the associated fauna and flora, for example by leading to an increase in the abundance of polychaetes, cyanobacteria blooms and fish kills due to hypoxia[4].

Non-native species have been shown to significantly alter the ecosystems of some Baltic Sea coastal lagoons[5]. In the Vistula Lagoon (Russia/Poland), for example the invasive polychaete *Marenzelleria neglecta* has become the dominant species, making up 95% of the total community biomass in the mid-1990s[6]; invasive amphipods make up 100% of the total amphipod species in the Szczecin Lagoon (Germany/Poland)[7]; and dense stands of the Canadian waterweed *Elodea canadensis* have outcompeted sensitive nature species in shallow lakes and slow flowing water in Finland[8].

Physical changes can be brought about by intensification of land use, dredging and flood protection schemes, including the construction of dikes and operation of pumps; regulating or halting inflow from rivers; and altering the connection with the sea.

1 https://helcom.fi/baltic-sea-trends/biodiversity/red-list-of-baltic-species/red-list-of-macrophytes/
2 http://www.helcom.fi/action-areas/marine-protected-areas/database/
3 Brzeska et al., 2015
4 Dolch & Schernewski, 2003.
5 Olenin & Leppakoski, 1999
6 Olenin & Leppakoski, 1999
7 Wittfoth & Zettler, 2013; Grabowski et al., 2007; Gruszka & Woźniczka, 2008
8 Huotari et al., 2011

The resulting changes in hydrodynamics can include variations in water levels and in the salinity of the lagoon, as well as changing sedimentation patterns which can, in turn, lead to changes in species composition[1].

Climate change effects have been investigated in some lagoons showing warming trends with water temperatures in the lagoons rising at a faster rate than on Baltic Sea shores[2].

Three Baltic Sea lagoons have been identified as pollution 'hot spots' by HELCOM where heavy metal contamination is an issue[3]. These are the Curonian Lagoon (Lithuania/Russia). Vistula Lagoon (Russia/Poland) and Szczecin/Oder Lagoon (Germany/Poland).

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the habitat. Coastal lagoons are in a continual state of development and part of a habitat complex therefore while some actions to benefit this habitat type can be focused on particular lagoons, a broader view is essential. This will include actions to be taken in the terrestrial environment as eutrophication, linked to nutrient inputs, is a major threat to this habitat. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

Given the decline in quality and extent of this habitat, the conservation objectives need to be concerned with protecting remaining areas and improving their status as expressed by extent, quality and structure and function. This is consistent with the objectives HELCOM MPAs and Natura 2000 sites established under the EU Habitats and Birds Directives. At the same time the natural development of lagoons from open water bodies to naturally reclaimed land needs to be accommodated. Conservation objectives will need to be framed in a way that allows for such change and, consequently, focus on more than just the lagoon in its existing form.

Management objectives

Two types of management objectives are a priority for this habitat type. Firstly, those aimed at preventing degradation and further loss, and secondly those which facilitate recovery in areas where lagoon habitat has been damaged. However, as there is a need to accommodate the natural processes which drive lagoon formation and senescence, management objectives will need to incorporate the habitat complexes in which coastal lagoons develop and evolve, as well as having detailed objectives for the habitats themselves.

1 Ezhova et al., 2005
2 Dailidiene et al., 2011
3 http://www.helcom.fi/action-areas/industrial-municipal-releases/helcom-hot-spots

Practical measures

Reducing nutrient inputs

The main source of nitrates and phosphates entering the Baltic Sea is runoff from agricultural land. This has long been recognized as an issue because of the resulting risk of eutrophication. Tackling eutrophication is one of four goals of the HELCOM Baltic Sea Action Plan with the first Nutrient Reduction Scheme, promoting a regional approach to achieving this goal, being agreed by HELCOM in 2007. The scheme established Maximum Allowable Inputs and Country-Allocation Reduction Targets compared to a reference period of 1997-2003. Reducing inputs of nitrogen and phosphorus at source is seen as key to achieving good environmental status for the Baltic Sea. Unfortunately, due to both a lack of ambition in the implementation of measures and the time-lag until the effect of a measure can be measured, the Baltic Sea is still highly eutrophic decades after the problem was recognized.

Practical actions are needed at a local level, such as reducing the use of nutrients on land adjacent to coastal lagoons or water courses that can carry nitrates and phosphates into coastal lagoons and prohibiting discharges from summerhouses on lagoon shores. Point sources of eutrophication, such as discharges from summerhouses built in sheltered areas need to be tackled by restrictions on the input of nutrients. Where leisure boating is popular, leading to resuspension of sediment and release of nutrients, speed restrictions need to be applied.

Diversion of ditches and pipes that carry nutrient rich water from the farmed hinterland can also reduce nutrient inputs to lagoons but will not address the root of the problem. It is also important to recognize that nutrients retained in sediments or in the water column due to a long residence time may mean that high phytoplankton production continues for a period even when nutrient inputs are reduced.

Retaining nutrients[1]

Various practical measures have been introduced to reduce loss of nutrients to water courses, some of which can end up in coastal lagoons. They include establishing or improving infrastructure for wastewater treatment by building purification plants and upgrading sewage farms, establishing buffer zones around agricultural land to reduce surface runoff of nutrients and soil erosion, and chemical precipitation of dissolved phosphorus from agriculture in ditches[2]. The construction of cleaning ponds that collect nutrient rich water before it enters lagoons is another example. This has been tried at several German project sites, by directing drainage and outflow from intensively farmed plots to specially created water bodies before reaching lagoons. The nutrients are converted into biomass, a rich vegetation, which is removed by grazing animals.

Removing nutrients

To complement measures aimed at overall nutrient reduction, various ideas have been put forward on ways to reduce nutrient levels in coastal lagoons such as enlarging reed beds and extending submersed macrophyte areas.

A practical example is the Interreg funding project LiveLagoons [3] which is investigating the possibility of improving the water quality of Southern Baltic lagoons using floating wetlands through a process described as 'phytoremediation'.

1 Best practice guideline LIFE Baltcoast

2 E.g. https://www.waterprotectiontools.net/index.php/en/home-page/

3 http://www.balticlagoons.net/livelagoons/wp-content/uploads/2018/10/PolicyBrief_A4-1_LiveLagoons.pdf; Karstens, et al., 2018

The initiative consists of establishing floating islands of native emergent macrophytes in large lagoons so the plant roots can adsorb phosphorus and nitrogen and enhance particle settlement by reducing water flows. The floating islands help to improve water quality but also act as habitats for fish, birds and insects as well as creating conditions for bathing inside the lagoons. To be most effective the plants need to be harvested in late summer as perennial macrophytes move their nutrients into the roots when senescence starts in the autumn. Pilot projects are being undertaken in the Curonian Lagoon, Darss-Zingst and Szczecin Lagoon in Lithuania, Poland and Germany.

Other ideas include dredging and removing sediment with existing nutrient loads, establishing algae farms, enlarging existing mussel beds, and introducing mussel cultivation and harvesting. Schemes such as these should not be a first option as they do not address the root of the problem and even then, should only be considered following detailed examination (including Environmental Impact Assessments) as they can be seriously disruptive with environmental implications in their own right.

Habitat restoration

A combined coastal realignment and natural protection project[1] carried out at Geltinger Birk in Germany is an example of restoration of a wetland area including restoration of coastal lagoons. Through water management and rewetting, the scheme reversed the effects of dikes and pumps that were used to drain the wetland areas in the 20th century and convert it for agricultural use. The process, which was carried out over 20 years, re-established brackish lagoons, as well as salt meadows and reedbeds. The project has the support of stakeholders today but there was considerable opposition at the outset. Criticism of the process, especially at the beginning, when there was no local consultation prior to the announcement of the scheme, emphasizes the need for restoration projects, whatever their scale, to have clear and inclusive stakeholder participation, and good communication throughout. Today it is a tourist attraction with a very positive response from visitors, and good acceptance in the local population. A further example is the Glydensteen strand area in Denmark where land that had been drained for agricultural use in the 1870s was reflooded in 2014. This is part of a large-scale coastal realignment project with the coastal lagoons that have been created helping to act as a buffer against sea level rise[2]. Schemes such as these have the combined benefit of linking coastal protection with nature conservation.

Regulatory measures

Protected areas

Lagoons are a priority habitat for protection under the EU Habitats Directive and many in the Baltic Sea have been designation as Natura 2000 sites. They have also been designated as protected areas under the EU Birds Directive, through national conservation programmes and are recognized as Baltic Sea MPAs and Ramsar sites. Coastal lagoons are present in some of the Baltic Sea Ecologically or Biologically Significant Marine Areas (EBSAs) (e.g. in the Åland Sea). Designation provides a regulatory framework for action. In the case of the Habitat Directive this includes a requirement to achieve favourable conservation status and to prevent damage and deterioration of the habitat and its typical species.

Lagoon habitats are affected by large schemes as well as many small incremental activities. Practical measures to protect lagoon habitats include prohibiting activities which result in significant changes to the hydrography, especially water exchange with the open sea. This may require regulating or prohibiting anything from large scale dredging operations to the construction of small piers.

1 Schernewski et al., 2018

2 Panadevo et al., 2015

In lagoons that are popular recreational areas, the provision of buoys for small craft to avoid anchor damage, for example, can help protect benthic flora. Whilst measures such as these could be taken without designation, the supporting mechanisms of protected areas such as conservation objectives, management planning, monitoring, and enforcement provides a statutory framework for implementation.

Supporting measures

Management plans
Management plans provide a structure in which to develop, promote, monitor and report on actions for the conservation of lagoon habitats. They typically set out the objectives, consultation processes, actions, key players, timescales, and organizational structures. A specific lagoon or lagoons may be the main focus but management plans for these features will need to be developed within the wider context of understanding the mosaic of habitats in which lagoon features are located because of their interconnected nature. Management plans may therefore also advocate measures for the adjacent coastal land, river basins/watershed and the adjacent sea.

In the case of large lagoons or those which extend across more than one municipality or national border a joint integrated approach to setting conservation objectives and management will be essential. This has been recognized and is being promoted in joint Russian-Lithuanian planning for the Curonian Lagoon, joint Russian-Polish planning for the Vistula Lagoon and joint Poland-German planning for the Szczecin/Oder Lagoon.

Planning frameworks
Planning frameworks can set direction, bring together key players, and involve the public in decision making for particular geographical areas. In the case of lagoons, they may for example regulate or prohibit shoreline developments or recommend zoning schemes for recreational facilities and aquaculture. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent. UNESCO describe it as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process"[1]. It is essentially a practical way to create and establish a more rational organization of the use of marine species and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems and to achieve social and economic objectives in a planned way[2]. The management of coastal lagoons cannot be undertaken in isolation of activities, demands and influences taking place around them or in their hinterland hence the need to incorporating the biodiversity objectives and associated management measures for coastal lagoons into Maritime Spatial Plans.

In the case of coastal lagoons, responsibility for planning may lie with local authorities, sometimes involving more than one authority, or may even lie across national boundaries. For a consistent approach, joint planning and management objectives are essential as well as cross-border communication and co-ordination over implementation of measures. This need has been particularly well illustrated in the case of the management of fisheries in the Szczecin Lagoon, Vistula Lagoon and Curonian Lagoon[3].

1 Ehler & Douvere, 2009.
2 Defra, 2009
3 Stybel & Skor, 2014

Sector specific measures
Where particular activities are a threat to lagoons, either because of their mode of operation, scale of operation or location, regulation can support the conservation of lagoon habitats. This may, for example include restrictions including closed seasons for fishing and hunting, specified routes for access, and zoning of tourism activities such as bathing areas and anchoring zones.

Research and understanding
Management of coastal lagoons needs to be underpinned by an understanding of the processes that drive their development and continuance as well as and the ecological process that support the associated biodiversity. The driving forces may be known in general terms but, given the range of types of lagoons and their condition across the Baltic Sea, it is also essential to understand these at a local level so that appropriate management objectives can be set and effective measures introduced to achieve these objectives.

HELCOM Baltic Sea Action Plan
The goals and objectives of the Baltic Sea Action plan (BSAP), and most especially those relating to eutrophication and biodiversity, are directly relevant to the management of lagoon habitats. The BSAP provides a framework for joint actions across Baltic states as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea. Mitigating eutrophication and developing Maritime Spatial Plans are some of the agreements promoted through the BSAP that can benefit coastal lagoons[1]. BaltSeaPlan and Baltic SCOPE have supported the development of MSP in the Baltic and there is a deadline of 2021 for Baltic Member States to establish Marine Spatial Plans under the EU Directive establishing a framework for MSP (EU 2014/89/EU).

1 E.g. http://www.helcom.fi/baltic-sea-action-plan; BMEPC, 2018

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DEEP MUD

SUMMARY OF KEY MANAGEMENT MEASURES

The Baltic Sea is relatively shallow but deep mud habitats are present in the central Baltic Sea most notably in Bornholm Deep, Bornholm Furrow, Gdansk Deep, Gotland Deep and Slupsk Furrow. Some of these areas are relatively species poor due to low oxygen and salinity but elsewhere they can support benthic communities including seapens, bivalves, and brittlestars as well as crustaceans and fish.

The main threats to this habitat are from the use of mobile demersal fishing gears and from eutrophication. Demersal gears affect the physical characteristics of the seabed as well as reducing biomass and biodiversity, depending on the type of gear, intensity of use, and the sensitivity of the seabed and benthic ecosystems present. Physical disturbance may also result from more localized activities such as the laying of cables and pipelines.

Oxygen depletion occurs naturally in some of the deep water of the Baltic Sea and eutrophication adds to this effect as oxygen is depleted by the decay of organic matter which has been enhanced by nutrient enrichment. Climate change can exacerbate these effects in a number of ways.

The conservation objectives for deep mud need to focus on maintaining and improving their status. The most direct practical measure is to remove pressures associated with the use of mobile bottom towed fishing gears. Reduction of such pressure is another option but given the long-term effects, this approach is likely to be less satisfactory. Regulatory measures may be sector specific, for example, focused on fisheries, but also within the framework of establishing MPAs where supporting mechanisms such as conservation objectives, management planning, monitoring, and enforcement provide a framework for implementation. Requirements in licensing systems as well as Marine Spatial Planning, which can zone potentially damaging activities will support conservation of this habitat. Tackling sources of eutrophication which affect deep mud habitats will require cooperative working across a range of bodies as envisaged by the Baltic Sea Action Plan.

THE HABITAT AND ASSOCIATED SPECIES

Habitat description

Sediment accumulation areas cover approximately one-third of the Baltic seafloor[1]. These areas may be classified as 'muddy' where more than 90% of the seabed is soft sediment and more than 20% of the sediment is grain sizes of less than 63 μm[2].

In the Baltic Sea deep mud habitats are found in the aphotic zone, below the permanent halocline, in a range of environmental conditions. The salinity of the overlying water column can range from 14-21 ppt and oxygenation levels can be as low as 3% or as high as 80%. Where oxygen levels are permanently low there may be anoxic areas with virtually no macrofauna and an extremely impoverished meiofauna dominated by nematodes[3]. The Slupsk Furrow (Poland), is unusual and at the other end of the spectrum, with a relatively high salinity and no oxygen depletion in the near bottom waters. Species once common in the deeps of the Southern and Central Baltic such as Astarte borealis and A.elliptica are present here as well as many harpacticoid species[4].

1 Kaskela A., 2017
2 HELCOM, 2013 HELCOM HUB Technical Report
3 https://forum.eionet.europa.eu/european-red-list-habitats/library/marine-habitats/baltic-sea/61.-communities-baltic-lower-circalittoral-soft-sediments-mud-and-sand
4 Drzycimski, 2000

The HELCOM HUB classification[1] identifies deep mud biotopes, characterized by epibenthic and infaunal communities of bivalves, crustacea, polychaetes or infaunal echinoderms, and biotopes where epibenthic macrocommunities are sparse or absent. Former mollusc dominated communities that were still present in the deep mud habitats of the southern Baltic in the early 1950s have been replaced by communities dominated by polychaetes.

Water movement is relatively limited in deep muddy areas and this creates a favourable environment for small tube-building amphipods such as *Haploops* spp. which can be visible as a dense mat of tubes on the surface of the sediment. These are important feeding grounds for many species of fish including cod. Where seapens such as Virgularia mirabilis and Pennatula phosphorea dominate the epibenthos, for example in parts of the Kattegat trench and the Djupa Rännan trench, they also provide food and shelter for many other species, including commercially important fish[2].

Deep mud habitat with tube worms and brittle stars. © OCEANA

1 HELCOM, 2013 – HELCOM HUB

2 EU Habitats Red list. Habitats 56 & 61

Distribution in the Baltic Sea

The Baltic Sea is relatively shallow with an average depth of around 54 m. Deeper areas are found in the southern and central Baltic Sea e.g. Bornholm Deep, Bornholm Furrow, Gdansk Deep, Gotland Deep, and Slupsk Furrow. They include the Lågskär Deep (220 m) in the Åland Sea, and the Landsort Deep (459 m) in the western Gotland Basin[1].

Deep mud habitats are found below the halocline, which is a seasonal or semi-permanent feature of the central Baltic Sea forming at depths of between 70-100 m.

Associated species

In the deep mud habitats of Bothnian Bay, benthic communities are generally species poor due to the low salinity and oxygen. They are dominated by the isopod *Saduria entomon* and the amphipod *Pontoporeia affinis*. Other species present include the shrimp *Neomysis integer,* common seasnails *Liparis liparis* and the fourhorn sculpin *Myoxocephalus quadricornis*[2].

Where there is sufficient oxygen and elevated salinity, copepods including *Laophonte baltica*, *Amphiascoides dispar* and *Kliopsyllus constrictus* may be present and in the deeps around Gotland the polychaetes *Scoloplos armiger*[3]. Depending on the biotope other associated species include *Mytillus* spp. *Hediste diversicolor, Gammarus* spp., *Haploops* spp., the ostracod *Philomedes brenda*, the brittlestar *Ophiura robusta*, several polychaete species from the taxa Maldanidae and Terebellida, and the seapens *Virgularia mirabilis* and *Pennatula phosphorea*.

Conservation status

The biotope 'Baltic aphotic muddy sediment dominated by ocean quahog (*Arctica islandica*) [AB.H3l3]' has been assessed by HELCOM as being Critically Endangered.

A further three biotopes have been assessed as Endangered:

AB.H3L5 Baltic aphotic muddy sediment dominated by *Astarte* spp.

AB.H2T1 Baltic aphotic muddy sediment characterized by sea-pens

AB.H1I2 Baltic aphotic muddy sediment dominated by *Haploops* spp.

Three species associated with deep mud habitats have been assessed by HELCOM as threatened;

Haploops tenuis - Endangered,

Haploops tubicola - Vulnerable

Euspira pallida - Vulnerable

1 Gubbay et al., 2016

2 Oceana, 2011.

3 https://forum.eionet.europa.eu/european-red-list-habitats/library/marine-habitats/baltic-sea/61.-communities-baltic-lower-circalittoral-soft-sediments-mud-and-sand

PRESSURES AND THREATS

The main pressures and threats to this habitat from human activity are physical damage caused by bottom trawling, and eutrophication as a result of nutrient enrichment.

Mobile demersal fishing gears can alter the structure of the seafloor and reduce biomass and biodiversity depending on the type of gear, engine power, intensity of use, and sensitivity of the seabed and benthic ecosystem present. Physical effects including mobilising sediment, increasing turbidity and altering the microhabitats. Biological effects including shifting species composition from long-lived suspension feeding taxa to opportunistic detritus feeders and predators[1]. Increased levels of benthic trawling may also lead to an overall reduction in biomass[2]. The highest intensity of bottom trawling in the Baltic, where significant areas are trawled more than 10 times a year, is in the Skagerrak-Kattegat. It includes trawling in water depths of more than 200 m where deep mud habitats are found. Analysis of fishing activity using data for the period 2010-2012 revealed that the footprint of bottom trawling has occurred over 63% of the seabed in depths of up to 200 m. Just over 51% of the seabed at depths of over 200 m have also been subject to bottom trawling[3]. An analysis of trawling activity in Danish waters of the Kattegat notes that this area has been trawled for at least 80 years and considered that it has been impacted to an extent where areas with reference conditions for certain habitats below 22 m no longer exist making it difficult to describe an undisturbed state[4]. The effects of demersal seines have not been as extensively studied but observations and predictive studies indicate that the subsurface and surface impact of fly-shooting is similar to several types of otter trawling and that it has a bigger surface and subsurface footprint that some types of otter trawling and Danish seining. Adverse effects are expected on fragile biogenic habitats and benthic taxa[5]. Localised physical disturbance to deep mud habitats can also result from other activities such as laying pipelines and offshore construction e.g. Oil and gas platforms and offshore windfarms.

Oxygen depletion occurs naturally in the deep waters of the Baltic Sea because of the infrequent and sometimes low inflow of well oxygenated, saline water from the North Sea. Eutrophication adds to this effect because oxygen is depleted by the subsequent decay of organic matter which has been enhanced by nutrient enrichment. Climate change can exacerbate these effects as higher water temperatures decrease oxygen solubility, increase stratification, and enhance respiration processes[6]. Bottom water and sedimentary areas with low oxygen concentrations have been spreading in the Baltic Sea during the latter part of the 20th century with H2S now a permanent feature of the Gdansk, Bornholm and Gotland Deeps. Analysis of historical data has revealed that the area of hypoxia in the Gotland and Bornholm basins has increased from around 5,000 km^2 to over 60,000 km^2 in the past 115 years and this is believed to be mainly the due to enhanced nutrient inputs.

1 Kaiser et al., 2002: Kaiser et al., 2006; Skold et al., 2018
2 Jennings, 2001
3 Eigaard et al., 2017
4 Pommer et al., 2016
5 Bureau Waardenburgh, 2017; Rijnsdorp et al., 2019.
6 Carstensen et al., 2014; Rabalais et al., 2009

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the habitat. This should include actions to be taken in the terrestrial environment as eutrophication, linked to nutrient inputs, is one of the threats to this habitat. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

The conservation objectives for deep mud biotopes need to be focused on maintaining and improving the status of these habitats as expressed by extent, quality, structure and function. At the same time there is a need to recognize that naturally occurring hypoxia can affect the associated species and communities. Conservation objectives should therefore also aim to improve resilience and scope for recovery following such events.

Management objectives

The principle management objective for this habitat type should be to prevent degradation and loss of existing deep mud biotopes. The aim should be to reduce and remove threats associated with human activity.

Phosphorescent sea pen (*Pennatula phosphorea*) on muddy sediment © OCEANA
https://www.flickr.com/photos/oceanaeurope/7112206379/in/album-72157629882116921/

Practical measures

Protection from physical damage
The detrimental effects of bottom-towed fishing gears on deep mud habitats have been well documented[1]. Relevant management measures to consider are permanent, temporary or seasonal closure, restrictions on the use of specific gear types and/or reduced effort. Gear modification or substitution to reduce impact may be a possibility in some cases.

Given the decades of bottom trawling in the Baltic, if unfished areas exist on deep mud habitats, they are likely to have been considered uneconomic for some reason, such as difficulty of access. Considerable emphasis should be put on prohibiting the use of bottom towed gears in such areas. At the same time, it is vital to enable recovery of areas that are already degraded by mobile demersal fisheries which in the Baltic Sea is mostly otter trawl and Danish seine[2]. Temporary/seasonal bans on the use of mobile bottom gears on deep mud habitats could be considered but as the impacts by trawls at intervals of 4-5 years may be enough to cause habitat loss and structural change[3] this is unlikely to be a viable long-term conservation measure.

Restrictions on the use of bottom towed gears should be introduced as part of an MPA zoning scheme, either directly or as part of the establishment of "no-take zones" that apply to all extractive activities. Both voluntary and statutory approaches have been used (see below).

Improving water quality
Where there are clearly identifiable local activities that affect water quality around deep mud biotopes e.g. from sewage outfall pipes, industrial discharges, or disposal of contaminated dredge spoil, practical measures to reduce or remove point source pollution may be possible. However, in the case of this habitat, diffuse sources of pollution are likely to be more of an issue. Regulatory and supporting measures such as those described below are therefore likely to be more effective.

Blue whiting (*Micromesistius poutassou*) © OCEANA
https://www.flickr.com/photos/oceanaeurope/33491173171/in/album-72157679344351372/

1 E.g. Jennings & Kaiser, 1998: ICES, 2000, Thrush & Dayton, 2002
2 http://www.helcom.fi/Red%20List%20of%20biotopes%20habitats%20and%20biotope%20complexe/HELCOM%20Red%20List%20AB.H3L3.pdf
3 Kaiser et al., 2002

Regulatory measures

Protected Areas

According to the HELCOM MPA database deep mud habitats are present in MPAs in Sweden and Finland including within some Natura 2000 sites although not designated for this reason in the latter case. Examples are High Coast, Sora Middelgrund och Röde Bank, and Morups Bank in Sweden, and the Uusikaupunki archipelago, Bothnian Bay National Park, and the open sea area southeast from Hanko in Finland . On the other hand, the Slupsk Furrow which is one of the most significant areas in the Baltic Sea for deep mud is currently not covered by MPA designation.

Protected areas have also been designated through national conservation programmes and may be recognized as Baltic Sea MPAs as well as Baltic Sea Ecologically or Biologically Significant Marine Areas (EBSAs) (e.g. the Eastern Gulf of Finland).

Some Baltic Sea MPAs include proposed “no-take zones” which provide protection from demersal trawling. Whilst such measures could be taken without MPA designation, the supporting mechanisms of MPAs such as conservation objectives, management planning, monitoring, and enforcement provide a framework that supports implementation.

MPA management planning should also include the scope for emergency measures to protect the habitats and species for which the MPA has been designated and scope for adopting interim measures for protection whilst formal designation is pending.

Fisheries regulations

Statutory backing for restrictions on damaging fishing activities is likely to be more effective than a voluntary approach. Where an MPA is entirely within territorial waters this can be achieved through the national legislature. For areas beyond 12 nm but within EEZs, and under the jurisdiction of an EU Member State, Joint Recommendations need to be developed with Member States that have a direct management interest in the area affected, in accordance with Article 18 of the CFP.

Regulation and prohibition of the use of mobile demersal fishing gears in some areas is essential for the conservation of deep mud habitats (see above). There is also value in taking an integrated approach to fisheries management. In the Slupsk Furrow, for example, a practical example would be considering fisheries management measures for cod which spawn in this area together with the management of deep mud habitat for mutual benefit.

Licensing

Offshore activities such as oil and gas exploration and production, and offshore windfarms are typically subject to a system of licensing. The involvement of MPA managers, from the earliest stages of identifying potential licensing areas through to their operation, can support MPA management measures in many ways. These could include influencing the scoping of environmental impact assessments, the proposed operating conditions and the monitoring requirements. As some of the agreements will apply over the lifetime of the operation, the influence of MPA managers in the licensing process will have long-term benefits.

Supporting measures

Planning frameworks
Planning frameworks can set direction, bring together key players and involve the public in decision making for particular geographical areas. There is a long history of land use planning in Baltic Sea countries with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent. UNESCO describe it as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process".[1] It is essentially a practical way to create and establish a more rational organization of the use of marine species and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems and to achieve social and economic objectives in a planned way[2].

The management of deep mud habitats cannot be undertaken in isolation of activities, demands and influences taking place around them hence the need to incorporate the biodiversity objectives and associated management measures for these habitats into Maritime Spatial Plans (MSPs). Such plans may, for example, include guidance on the routing of cables and pipelines to avoid areas of deep mud habitat. The participation of MPA managers in the development of relevant MSPs is a practical way to influence such plans.

Sector specific measures
Aside from measures related to mobile fisheries, which are discussed above, the conservation of deep mud habitats will require supportive measures in the planning and management of other activities such as the siting of offshore windfarms, cables & pipelines, dredging operations, mineral extraction and disposal of spoil. Plans and procedures for construction projects, including Environmental Impact Assessments, need to take account of the risk to deep mud habitats and the associated species within the footprint of the proposed works as well as from adjacent operations.

Management measures introduced for shipping can also incidentally support the conservation of deep mud habitats. This has been the case in The Sound where there has been a ban on trawling since 1932 to reduce the risk of shipping collisions.

Baltic Sea Action Plan
The goals and objectives of the Baltic Sea Action plan (BSAP), and most especially those relating to eutrophication and biodiversity, are directly relevant to the conservation of deep mud habitats. The BSAP provides a framework for joint actions across Baltic states as well as added incentive for national initiatives aimed at reaching good environmental status for the Baltic Sea. Mitigating eutrophication and developing Maritime Spatial Plans are some of the agreements promoted through the BSAP that can benefit this habitat and need to be maintained and potentially strengthened in the revised BSAP[3]. Projects such as BaltSeaPlan and Baltic SCOPE have supported the development of MSP in the Baltic and there is a deadline of 2021 for Baltic Member States to establish Marine Spatial Plans under the EU Directive establishing a framework for MSP (EU 2014/89/EU).

1 Ehler & Douvere, 2009.
2 Defra, 2009
3 E.g. http://www.helcom.fi/baltic-sea-action-plan; BMEPC, 2018

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GRAVEL BEDS

SUMMARY OF KEY MANAGEMENT MEASURES

The gravel habitats of the Baltic Sea are present in high energy environment often associated with other coarse sediments and sands. The main pressures on them are from activities that result in direct extraction and physical disturbance, and activities which alter the hydrology and water quality in areas where they are present. In the longer term, increasing acidity of seawater may affect the viability of this habitat where there is a high proportion of shell gravel.

Management measures can usefully focus on managing extraction, preventing physical disturbance, and maintaining or improving water quality. This can be within the framework of Marine Protected Areas or with sector specific regulations e.g. by restricting dredging, dumping, and activities which disturb the seabed. Planning processes, including Integrated Coastal Zone Management, can be supportive of management measures as not all the pressures and threats to this habitat are localized. Maintaining good water quality is an example.

THE HABITAT AND ASSOCIATED SPECIES

Habitat description

Gravel beds are typically found in areas of high energy. The seabed sediment is coarse and, in the case of shell gravel, may include well sorted fragments of the mussel *Mytilus trossulus*, *Mya arenaria*, *Limecola balthica* and *Cerastoderma glaucum*[1]. The gravel may also be interspersed with coarse sand such as on the Odra Bank, in the Pomeranian Bay, which is mainly an area of fine sand enriched with a significant amount of shell gravel[2]. In such situations, shelly material accumulates on top of other substrates, both hard and soft, as well as being mixed with sand or gravel.

The HELCOM HUB classification[3] describes fifteen shell gravel biotopes variously characterized by epibenthic chordates, mixed or sparse epibenthic macrocommunity, mixed infaunal macrocommunities, or not supporting any macrocommunities. The habitat is present in both the photic and aphotic zone.

Baltic clam (*Limecola balthica*) © Hans Hillewaert www.commons.wikimedia.org

1 Kontula & Raunio, 2018

2 Zettler & Gosselck, 2004.

3 https://maps.helcom.fi/website/hub/PDF/AA.E.pdf

Distribution in the Baltic Sea

Gravel beds have been deposited by meltwaters during periods of ice retreat and are limited in extent and volume in the Baltic Sea, being found mostly in the south and south-west. In these areas they form a thin veneer on top of till deposits in water depths of 5-15 m along the coasts and on the submarine sills and shoals[1]. The largest known resource (of sand and gravel) in the Baltic Sea is in the Ronne Bank-Alder Ground shoal.

Shell gravel biotopes have a restricted and patchy distribution in the Baltic Sea. Current records identify areas in the southern Baltic Sea in the Bay of Mecklenburg, Kiel Bay, Great Belt, and The Sound. Gravel bed habitats have not been extensively investigated in Finland, but initial surveys show that those consisting of bivalve mollusc shells appear to be in slightly deeper water than those of other molluscs (10 m and 8 m respectively)[2], whilst pebble-gravel deposits are general found on the coastal slope[3], with patches down to 60 m.

Associated species

Shell gravel can support many different animals including non-burrowing animals but where the interstitial space is smaller burrowing polychaetes and amphipods can build tunnels using the small grains[4].

Species present on coarse sediments, including on shell gravels include *Mytilus edulis*, *Cerastoderma glaucum*, the polychaete *Hediste diversicolor* and the amphipods *Gammarus salinus* and *G. oceanicus*[5]. Where light levels and salinity are favourable, the kelp *Saccharina latissima* may be present and specialized fauna in the interstitial species such as *Branchiostoma* spp.[6] In some areas the vase tunicate *Ciona intestinal*is can cover more than 10% of the seafloor making up at least 50% of the biomass[7]. Shell gravel communities in the Baltic Sea are still to be studied in detail.

1 Schwarzer, 2010
2 Kontula & Raunio, 2018
3 Olenin, 1997
4 https://forum.eionet.europa.eu/european-red-list-habitats/library/marine-habitats/baltic-sea/21.-infaunal-communities-baltic-infralittoral-shell-gravel/download/en/1/21.%20Infaunal%20communities%20on%20Baltic%20infralittoral%20shell%20gravel.pdf?action=view
5 Rousi et al., 2011
6 https://maps.helcom.fi/website/hub/PDF/AA.E.pdf
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Conservation status

The two biotopes characterized by gravel have been assessed by HELCOM as being Vulnerable:

AA.E1F1 Baltic photic shell gravel dominated by vase tunicate (*Ciona intestinalis*)

AB.E1F1 Baltic aphotic shell gravel dominated by vase tunicate (*Ciona intestinalis*)

The crustacean *Atelecyclus rotundatus*, which has a preferred habitat of gravel bottoms with sand has only been reported from one locality in the Baltic Sea (Fladen bank). It has been assessed by HELCOM as being Vulnerable[1].

Shell gravel habitats may be present on shallow sandbanks which are on Annex I of the EU Habitats Directive (code 1110), a habitat type that has been assessed by HELCOM as Vulnerable in the Baltic Sea.

In the German Baltic Sea, coarse sediment habitats have been assessed as Near Threatened and in Finland shell gravel habitats are currently Data Deficient[2].

PRESSURES AND THREATS

Eutrophication and increase in atmospheric CO_2 leading to ocean acidification, are the major threats to shell gravel habitats. Aggregate extraction is a more direct pressure on areas of coarse gravel with the largest quantities extracted by Denmark followed by Germany. Minor quantities are dredged in Finland and from the St. Petersburg area of Russia.

Eutrophication has an adverse effect on gravel bed habitats by increasing the organic load in the overlying water. This can result in considerable growth of algae smothering the surface of the gravel beds as well as siltation and oxygen depletion as the increased organic matter decays.

Many of the gravel deposits in the Baltic Sea are of fossil origin and therefore non-renewable[3]. Commercial dredging of gravel and the use of mobile bottom gears causes direct physical damage to gravel beds, as well as increasing turbidity and sedimentation and removal of infauna and epifauna. Pits may also be created, depending on the method of extraction in dredging operations. Recolonization by benthic species is possible if the substrate is not completely removed or its character is not changed, for example with a shift to finer infill sediments[4].

Ocean acidification is assumed to increase the dissolving rate of the calcium carbonate in mollusc shells but the likely effects on shell gravel biotopes type are unclear. The higher acidity may result in shell gravel being ground down to a sand-like substrate at increasing rates, possibly making the sand-like shell gravel more common. Alternatively, the increased acidity may increase the dissolving rate of the grains thus decreasing the amount of sand-like shell gravel[5].

1 http://www.helcom.fi/Red%20List%20Species%20Information%20Sheet/HELCOM%20Red%20List%20Atelecyclus%20rotundatus.pdf

2 Fink et al., 2017; Kotilainen et al., 2018

3 Schwarzer, 2010.

4 http://stateofthebalticsea.helcom.fi/pressures-and-their-status/seabed-loss-and-disturbance/#sand-and-gravel-extraction; Barrio Frojan et al., 2008; Kubicki et al., 2007; Krause et al., 2010

5 HELCOM Biotope information sheets. http://www.helcom.fi/Red%20List%20of%20biotopes%20habitats%20and%20biotope%20complexe/HELCOM%20Red%20List%20AA.E3Y,%20AB.E3Y.pdf

MANAGEMENT MEASURES

Management measures need to be linked to conservation objectives and to address the main pressures and threats to the habitat. This will include actions to be taken in the terrestrial environment as eutrophication, linked to nutrient inputs, is a threat to this habitat. Although not considered below, monitoring the effects of management measures is also essential to review progress, and to modify actions in light of the findings.

Conservation objectives

The conservation objectives for gravel beds need to focus on maintaining and potentially improving the status of existing beds as expressed by extent, quality, structure and function. This is consistent with the objectives HELCOM MPAs and Natura 2000 sites established under the EU Habitats and Birds Directives.

Management objectives

The principle management objective for this habitat type should be to prevent degradation and loss of existing gravel habitat, particularly those biotopes which have been assessed as Vulnerable i.e. shell gravel habitats. As there is limited knowledge of the distribution of shell gravels in the Baltic Sea, management objectives need to include gaining a better understanding of its occurrence in the waters of Baltic Sea states.

Practical measures

Protection from physical damage
Areas of gravel are generally robust, being present in high energy areas, frequently subject to strong currents and regular disturbance. The detrimental effects of the use of bottom-towed fishing gears on gravel beds include smothering, abrasion, damage to the structure of the bed and removal and damage of associated epifauna and infauna. Physical damage can also result from sand and gravel extraction, construction works and dredging operations. Prohibiting such activity within MPAs and on shell gravel beds, as well as within buffer zones around the habitat, is a direct way of preventing physical damage caused by human activity.

Improving water quality
Where there are clearly identifiable local activities that affect water quality around gravel beds e.g. discharges from sewage outfall pipes or industrial discharges, practical measures should be introduced to reduce or remove point source pollution. In the case of diffuse sources of pollution, or point sources far removed from but affecting gravel beds, regulatory and supporting measures such as those described below will provide a framework for tackling water quality problems.

Regulatory measures

Marine Protected Areas
Areas of shell gravel are present in Natura 2000 sites designated by Germany (e.g. Odra Bank in the Pomeranian Bay). Designation provides a regulatory framework for protection of biodiversity within MPAs, typically through an MPA management plan which sets out conservation objectives, actions to be taken, and opportunities for stakeholder involvement as well as establishing a system for monitoring and reporting on progress.

Prohibiting commercial extraction
Commercial extraction of gravel has a direct physical impact on this habitat. Although not currently an activity on the shell gravel beds, regulations that prohibit such activity in these areas will help safeguard the habitat. Elsewhere, aggregate extraction should be prohibited within MPAs and regulated elsewhere through licensing, EIAs and conditions which allow the recovery of macrofaunal communities and the seabed profile.

Sector specific regulations
Where particular activities are a threat to gravel habitats, either because of their mode of operation, scale of operation, or location, regulation can support their conservation. This may, for example include restrictions on the use of particular types of fishing gear or defining zones where the commercial extraction of gravel is prohibited.

Supporting measures

Planning frameworks
Planning frameworks can set direction, bring together key players, and involve the public in decision making for particular geographical areas. There is a long history of land use planning in Baltic States with responsibility typically falling to local and regional authorities. Maritime Spatial Planning is a more recent idea and is the marine equivalent. UNESCO describe it as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process"[1]. It is essentially a practical way to create and establish a more rational organization of the use of marine species and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems and to achieve social and economic objectives in a planned way[2]. Projects such as BaltSeaPlan and Baltic SCOPE have supported the development of MSP in the Baltic and there is a deadline of 2021 for Baltic Member States to establish Marine Spatial Plans under the EU Directive establishing a framework for MSP (EU 2014/89/EU). The management of shell gravel habitats cannot be undertaken in isolation of activities, demands and influences taking place around them hence the need to incorporating the biodiversity objectives and associated management measures for shell gravel habitats into Maritime Spatial Plans.

1 Ehler & Douvere, 2009.
2 Defra, 2009

Research and understanding

Management of gravel habitats needs to be underpinned by an understanding of the ecological processes that create and maintain their structure and function, of the pressures, threats and resulting effects on the habitat, and when intervention is possible and desirable. There have been studies on the effects of gravel extraction on the benthos but few studies on shell gravel habitats and the associated fauna and flora in the Baltic Sea. Improving knowledge of this habitat type is therefore important in order to understand its characteristics as well as to improve the likelihood of success of any management interventions.

Snail shells in the seabed © OCEANA Carlos Minguell
https://www.flickr.com/photos/oceanaeurope/44017823364/in/album-72157697714411962/

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MANAGEMENT OF HABITATS AND SPECIES IN MPAS

CONTACTS

ÖSTRA ÅGATAN 53,
753 22 UPPSALA
SWEDEN

+46 18 71 11 70
WWW.CCB.SE

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