2017

The Sound: Biodiversity, threats, and transboundary protection

SVENSKA POSTKOD STIFTELSEN

OCEANA

Windmills near Copenhagen. Denmark.
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Credits & Acknowledgments

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Blue mussels (*Mytilus edulis*).
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ROV manoeuvre. Southern Sound, Sweden. © OCEANA/ Carlos Minguell

Executive summary

The waters of the Sound – the shared strait that lies between Denmark and Sweden – host a high level of biodiversity, and a unique mosaic of marine communities and habitats, including stone reefs, seagrass beds, horse mussel beds, and kelp forests. This diversity is due to the specific characteristics of the area, the combined influence of the North and Baltic Seas, and a longstanding prohibition on towed fishing gear (including bottom trawls) that has greatly benefitted marine life in the region, including vulnerable species and communities that have disappeared from adjacent waters.

The Sound also plays a major role in the lives of the people on its shores. It provides a wide array of valuable ecosystem services to local communities and the economy, including the provisioning of food (through both commercial and recreational fisheries), water filtration, tourism, recreation, and other cultural services. Yet human pressure in the densely populated Sound region also represents a threat to marine life and the services it provides. Ongoing activities like unsustainable fishing, sand dredging, land reclamation, and heavy maritime traffic threaten species and habitats, and some key communities (like horse mussels and *Haploops*) have declined in recent decades.

For Oceana, the Sound has been a priority area for protection since 2011. To help advance this process, we carried out a three-week expedition in 2016, aimed at documenting healthy areas with high biodiversity, and areas that have been disturbed, both historically and recently. We observed diverse marine life across the varied depths and substrates in the region, and recorded nine broad types of habitats and communities and approximately 200 species. Worryingly, we observed only fragmented clusters of horse mussel beds, and found no *Haploops* communities, which may have disappeared entirely from the Sound. We also found marked evidence of lasting damage to the seabed, particularly in sand dredging areas, some of which showed no signs of recovery or life, even decades after the removal of sand from the seafloor.

"Effective protection could best be achieved by establishing a single transboundary MPA, with specific measures to protect priority species and habitats"

To secure the long-term survival of key species and habitats, it is essential that Denmark and Sweden put in place stronger, transboundary protection measures across the entire Sound, and address the need for better, more coherent management and control. Effective protection of the area could best be achieved by establishing a single transboundary marine protected area, with specific measures to protect priority species and habitats and to limit the damage caused by three main threats: unsustainable fishing, sand dredging, and maritime traffic. This type of protection would also safeguard the natural heritage of this unique area, and would further support the local economies that depend on the waters and resources of the Sound.

Introduction

Oceana vessel *Popp* in Swedish waters.
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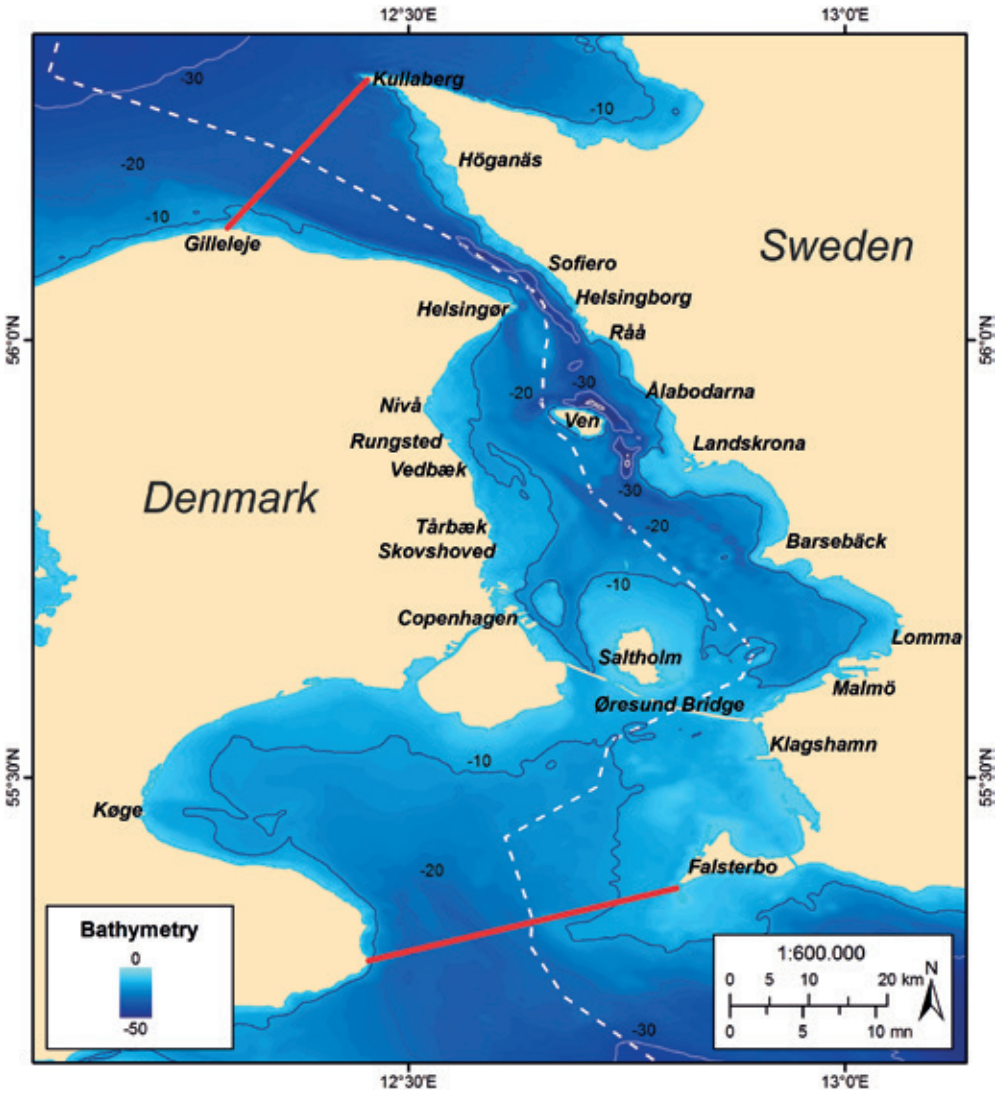
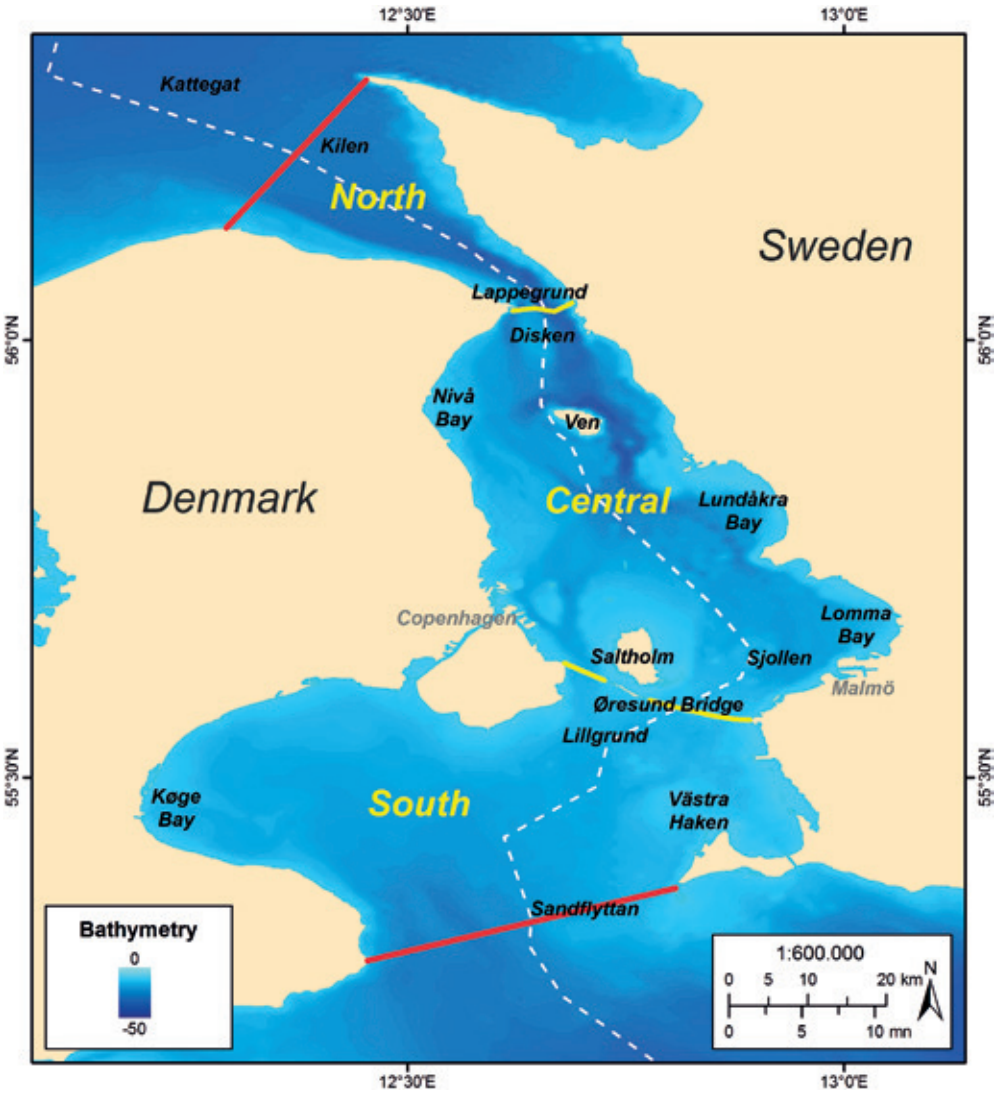
The Sound (*Øresund* in Danish, and *Öresund* in Swedish) is a narrow strait – just 4 km at its narrowest point – that lies between Denmark and Sweden (Figs. 1 and 2). Together, it, the Little Belt, and the Great Belt comprise the Danish straits, which form the gateway between the Baltic Sea and Kattegat. With an area of 2,278 km^2, it is the smallest sub-basin of the Baltic Sea (HELCOM 2012).

Figure 1. Study area, the Sound, with the main municipalities in the region. Data sources: EEA, EMODnet.



The waters of the Sound are shallow, averaging 12 m and reaching a maximum of just 53 m in the Landskrona Deep, to the southeast of the island of Ven. Yet, despite its small size and limited depth, the Sound is a complex area. It is strongly stratified by depth, with brackish water from the Baltic Sea typically flowing northwards at the surface, while denser, saline bottom water from the North Sea and Kattegat flows southwards, below a permanent halocline at 10-12 m (Diekmann & Möllmann 2010). As a result of these two different water masses, the Sound is characterised by wide variation in surface salinity, ranging from roughly 10 PSU at its southern end, to more than 15 PSU at its northern end, where it opens into Kattegat (Boström *et al.* 2014).

Figure 2. The three sub-regions of the Sound: the northern, central, and southern Sound, and the main marine areas referred to in this report. Data sources: EEA, EMODnet.



The joint influence of the North Sea and the Baltic Sea is also apparent on the marine biodiversity of the Sound, which shows a transition in community types from north to south. For example, 'Atlantic' marine communities, such as those characterised by sea pens, horse mussels, and *Haploops*, reach their distribution limit in the Sound and do not extend beyond it into the western Baltic Sea (HELCOM 2007; 2013a). The biodiversity of the area is relatively high, reflecting two main factors: the connection to both seas, with strong currents

bringing nutrients and species, and maintaining salinity at higher levels than in the Baltic Sea; and a high diversity of marine landscape types (HELCOM 2009) that, in turn, support a rich mosaic of communities and habitats.

In addition to these factors, marine life in the Sound has benefitted from a policy that was jointly agreed by Denmark and Sweden in 1932: a prohibition on towed fishing gear (including bottom trawls) that was introduced in the interest of maritime safety, due to the high volume of ship traffic passing through the strait (Anon. 1932). Although it was not conceived of as an environmental protection measure, this prohibition is credited with having helped to support the diverse benthic community (including vulnerable species that have declined or vanished from adjacent waters) and having maintained commercial fish stocks at healthier levels than in Kattegat or the Baltic Sea (Diekmann & Möllmann 2010; Svedäng 2010). For all of these reasons, the Sound is clearly a special place, and has been described as "a kind of 'island' in a vast deteriorated sea" (Olesen 2011).

Yet the Sound is also subject to heavy human use. Approximately 3.8 million inhabitants live in the Sound region, which comprises the Capital Region of Denmark and Region Zealand on the Danish side, and the county of Skåne on the Swedish side (Örestat 2012). The region includes Denmark's capital and largest city, Copenhagen, and Sweden's third-largest city, Malmö, and is the most densely populated metropolitan area of the Nordic countries. The benefits of the Sound for both Danes and Swedes are extensive; it provides a wide array of ecosystem services to local communities and the economy, including the provisioning of food (through both commercial and recreational fisheries), water filtration, tourism, recreation, and other cultural services. At the same time, the intensity of human pressure in and around the Sound represents a threat to marine life. Activities like unsustainable fishing, sand dredging, land reclamation, and pollution continue to threaten species and habitats, and some key communities (like horse mussels and *Haploops*) have declined over the past few decades.

Hermit crabs (*Pagurus bernhardus*).
Northern Sound, Sweden.

"The expedition aimed to document marine biodiversity, particularly vulnerable species and habitats, and the impacts of historic and ongoing threats to marine life"

Given the high importance of the Sound for both marine biodiversity and society, its protection should be a priority. In 2013, Oceana proposed the protection of the Sound as a single transboundary marine protected area (MPA), based partly on our findings from three at-sea expeditions carried out in 2011, 2012, and 2013 (Oceana 2014). The proposal concluded that a transnational MPA was justified both in terms of the ecological value of the area, and from a management point of view. It argued that the Sound was a prime area for protection, given its unique set of species and communities, and the worrying state of some of the life it supports. It recommended that the smaller Natura 2000 (N2000) sites should be combined with seal sanctuaries and other small marine reserves in the Sound, to form a larger, more inclusive area either as part of the N2000 network or protected through national legislation. In relation to management, the proposal further recommended that the same rules and practices should be applied on both the Danish and Swedish sides of the Sound, and noted that having the entire Sound managed under one plan would also facilitate the enforcement of control and regulation measures.

Since that time, interest in protecting the area has grown even stronger amongst local authorities and stakeholders. In the interest of helping to advance the process, Oceana carried out a three-week research expedition in April 2016 that was focused entirely on the Sound. The expedition aimed to document marine biodiversity, particularly vulnerable species and habitats, and the impacts of historic and ongoing threats to marine life.

This report presents the findings of the Oceana 2016 Sound expedition, in relation to the key benthic marine ecosystems, and the impacts of the main activities that threaten them. Based on these results, and other available information, it presents a new proposal for a shared, Danish-Swedish transboundary MPA in the Sound, with specific recommendations for its management.

Michael Palmgren (SEA-U) with Oceana divers, on board *Elias*
© OCEANA/ Carlos Minguell

Biodiversity of the Sound

Dead man's fingers (*Alcyonium digitatum*). Kullaberg, Sweden.
© OCEANA/ Carlos Minguell

The transition in the Sound from saline to brackish waters, combined with its other hydrological characteristics, and a wide variety of benthic substrates, have enabled the formation of a unique set of species and communities. In total, 1,044 macro-species have been documented from the waters of the Sound (HELCOM 2012). This relatively high diversity, combined with the small area of the Sound, means that it has the highest density of species of all of the sub-basins of the Baltic Sea (0.46 species/km^2).

The Sound is home to many benthic communities, including vulnerable and threatened soft-bottom communities characterised by horse mussels, *Haploops*, and sea pens with burrowing megafauna. Vast sandy bottoms and sandbanks host eelgrass, sandeels and flatfish, while stone reefs with diverse macroalgal forests provide habitats for a myriad of other, small creatures. Many of the habitats are known to be essential fish habitats for key commercial stocks (Sørensen *et al.* 2016). For example, the deep, soft-bottom areas in the northernmost Sound and to the northeast of Ven host high numbers of spawning cod in the winter months and early spring.

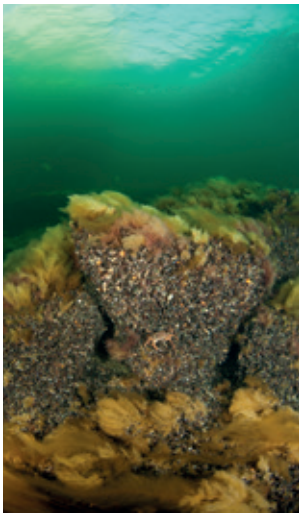
What makes the Sound especially valuable from a biological perspective is not any one particular species, habitat, or community type – it is the combination of all the habitats, and all the forms of marine life that co-occur within its waters.

Below are described the key habitats and communities in the Sound, and the marine life that they support.

Stone reefs

Stone reefs are hard structures made of boulders, stones, and rocks, which rise from the sea bottom. In the Baltic Sea and Kattegat, most stone reefs are found at depths of between 2-20 m. They sustain a high diversity of fish, invertebrates, plants and birds, and are considered hotspots for biodiversity in the Baltic Sea (HELCOM 1998). Typically, stone reef tops host diverse communities of red, brown and green macroalgae and other plants. Animals like soft corals, sea anemones, bivalves, hydroids, ascidians, barnacles, bryozoans, and molluscs are also attached to the reef. The reef environment attracts mobile animals as well, such as crustaceans, like edible crab (*Cancer pagurus*), and fish, like cod (*Gadus morhua*). Reefs represent important spawning and feeding grounds for many commercially important fish species, and also provide feeding areas for diving birds that feed on molluscs and crustaceans. Thus, stone reefs play a significant role in the broader marine food web (Dahl *et al.* 2003).

Macroalgae on stones with blue mussel (*Mytilus edulis*) bed under a wind generator. Lillgrund , Sweden.
© OCEANA/ Carlos Minguell

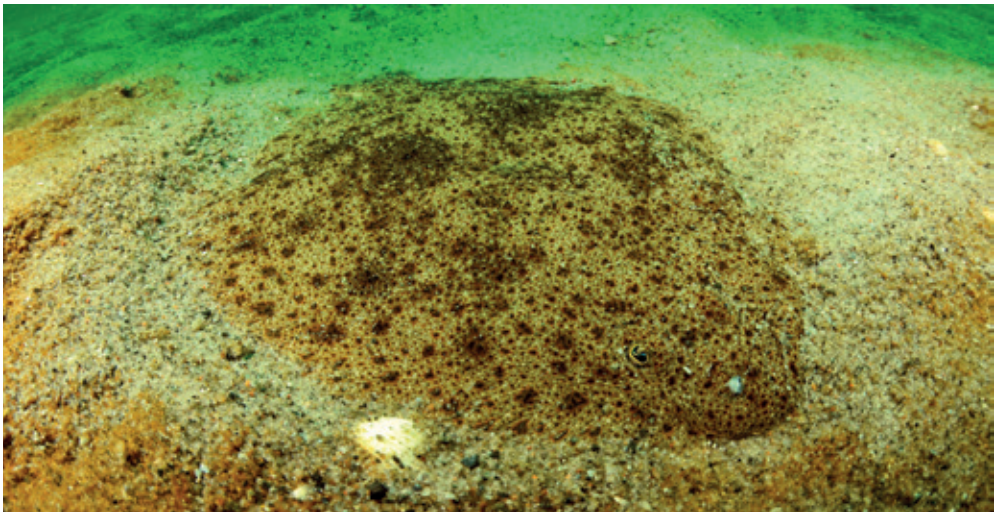


All reef sub-types throughout the Baltic Sea and Kattegat are categorised as Vulnerable (HELCOM 2013a) but the reefs in the southern Baltic are particularly threatened (HELCOM 1998; 2007; 2013a). Reefs are protected under the EU Habitats Directive (habitat code: 1170). Human activities, like construction, dumping, pollution, fishing, and mineral extraction, are the main threat to reefs because they increase environmental pressure and result in physical damage. In the case of stone reefs, the extensive removal of boulders and stones between 1930-1990 for harbour construction and coastal protection resulted in their widespread degradation. On the coast of Denmark, this resulted not only in the destruction of cavernous reefs and removal of hard bottom, but also the loss of local fish populations and changes in macroalgal cover resulting from a loss of substrate (Støttrup *et al.* 2014). The removal of larger boulders also increases the average depth, which may hinder benthic macroalgal and plant growth due to reduced light penetration, and in turn reduce the complexity and quality of the habitat.

In 2010, the removal of boulders and stones from the Danish seabed was prohibited (Naturstyrelsen 2013a), and the Danish government participated in a collaborative EU project aimed at restoring stone reefs in Kattegat. One of the outcomes of that project is a set of guidelines on stone reef restoration that could be applied to other sites (Dahl *et al.* 2016). Reef restoration has also taken place in the Sound. In December 2016, an artificial reef was created outside the northern harbour of the city of Copenhagen. Furthermore, the Danish government plans to re-establish a stone reef in the Natura 2000 area *Gilleleje Flak*, by 2019 (Miljø- og Fødevareministeriet 2016).

Sandbanks

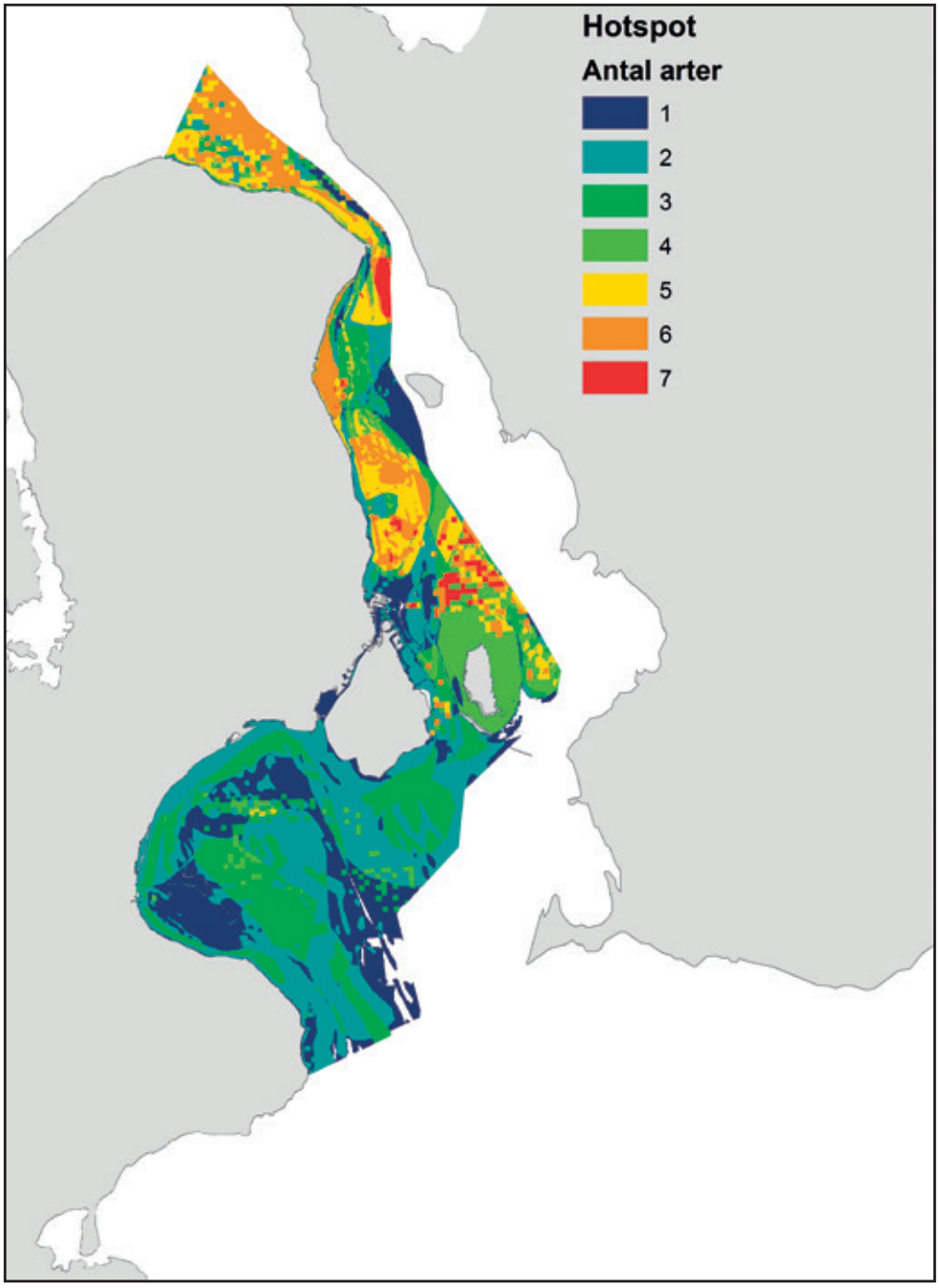
Sandbanks are widespread throughout the Baltic Sea and Kattegat. They are considered to be of Baltic-wide importance because they serve as important fish spawning grounds, and as feeding and wintering areas for water birds. In shallow coastal areas, sandbanks usually have no vegetation, as the sand there is washed continuously by the waves. Common animals are those that can burrow into the sand, like some species of mussels, worms, crustaceans, etc. Sandbanks in more sheltered areas form rich communities, and are characterised by different plant species, like *Zostera* sp., *Ruppia maritima*, *Potamogeton* sp., or charophytes.



Semi-buried turbot (*Scophthalmus maximus*). Ellekilde Hage, Denmark.

Sandbanks are listed by HELCOM as Vulnerable throughout the Baltic Sea (HELCOM 2013a), and are also protected under the Habitats Directive (habitat code: 1110). They are particularly threatened and/or declining in the southern Baltic Sea. The main threats to sandbanks include eutrophication, fisheries (e.g., bottom trawling), mineral extraction, offshore construction, dredging, and dumping of dredged material. In the Sound, sand dredging poses a particularly severe threat to the sandbanks which serve as essential fish habitats for many commercially important species. For example, they act as nursery areas for cod, plaice, turbot, brill, and sole (Fig. 3; Sørensen *et al.* 2016).

Figure 3. Map reproduced from Sørensen et al. (2016) illustrating how many of the project's seven key fish species use a given part of the Danish Sound as habitat during their life cycles. The species included in the study were cod, plaice, turbot, brill, sole, eel and lumpsucker. The key habitat areas for these species overlap with areas that are of high interest to the sand dredging industry.



Blue mussel beds

The blue mussel (*Mytilus edulis*) is one of the most common and the main colony-forming species in the Sound, and in the Baltic Sea in general, contributing greatly to ecosystem structure and function. They often form extensive beds, composed of both live mussels and dead shells, and are found on many types of substrates (excluding soft sediments), usually up to 30 m depth. Blue mussels enhance biodiversity by providing substrate and refuge for a number of other species, including algae, barnacles, hydroids and bryozoans. They also provide feeding and hiding places for fishes. As important habitat builders for many other species, blue mussel beds have relatively high biodiversity, and are thus quite resilient to disturbances (Gundersen *et al.* 2017). The blue mussel is also considered to be an important link between benthic and pelagic habitats, through its filtration activities (Newell 2004). Filtration by blue mussel beds is also important for removing phytoplankton from the water, including toxic algae (Kautsky & Kautsky 2000). In fact, the large populations of blue mussels (and other mussels) in the Sound have been described as being of crucial importance to water treatment and water quality in the Baltic Sea and Skagerrak (Gundersen *et al.* 2017).

Blue mussels (*Mytilus edulis*) and barnacles. Råå, Sweden. © OCEANA/ Carlos Minguell

Horse mussel beds

The horse mussel (*Modiolus modiolus*) is a large, arctic-boreal marine bivalve. In the Baltic Sea, it is only found in Kattegat and in the Sound. It has been suggested that within the Sound, the area close to Knähaken/Sofiero could be a potential breeding area for this species (A. Brand, pers. comm., 2016). Horse mussel beds can occur on a range of substrata, including cobblestones, muddy gravel, and sand. The mussels can form dense beds at depths of over 100 m, but usually reside in shallower areas. Horse mussel beds have a stabilising effect on the seabed, particularly in softer bottom areas (OSPAR Commission 2009), and the species forms ecologically important biogenic habitats (Dinesen & Morton 2014).

Modiolus beds attract a range of species which attach to the top of horse mussel shells, such as sea anemones (*Metridium senile*), bryozoans (*Electra crustulenta*) and hydroids (*Obelia geniculata*). Together with the *Haploops* community, the *Modiolus* community is the most distinctive in the Sound and supports a wide variety of other species (Göransson *et al.* 2010).

Hermit crab (*Pagurus bernhardus*), whelk (*Buccinum undatum*) and horse mussels (*Modiolus modiolus*). Grollegrund, Sweden. © OCEANA/ Carlos Minguell

The horse mussel is particularly sensitive to human disturbance, because it grows slowly, is long-lived (up to roughly 100 years), and does not reach sexual maturity until 5 to 6 years of age (Dinesen & Morton 2014). HELCOM (2013b) has assessed this species as Vulnerable. It is assumed that *Modiolus* beds used to be more common in Kattegat, but because of destructive fishing practices (i.e., bottom trawling) these beds have now mostly disappeared (M. Olesen, pers. comm., 2012). During the past few decades, horse mussels have also declined in the Sound, despite the ban on bottom trawling (Göransson *et al.* 2010). In April 2012, Oceana surveyed an area 30 m deep close to island of Ven that was once rich in this species, and found only a few living horse mussels and many empty shells. Besides seabed trawling, other threats to *Modiolus* beds include dredging, the extension of harbours, dumping, the emission of pollutants, and a lack of oxygen in bottom waters (Göransson *et al.* 2010). Damage to *Modiolus* habitats have wider detrimental effects than just on the species itself; their destruction puts the broader ecosystem functioning at stake, and post-impact recovery times are slow (Dinesen & Morton 2014).

Haploops communities

Haploops communities are formed by tube-dwelling crustacean amphipods (*Haploops tenuis* and *H. tubicola*). In the Baltic Sea region, they occur in the deep, firm mud bottoms of Kattegat, the Great Belt and, particularly, the Sound. These communities are found 25 m below the surface and deeper (Göransson *et al.* 2010). Dense *Haploops* communities constitute feeding grounds for many commercially important fish species, like plaice (*Pleuronectes platessa*) and halibut (*Reinhardtius hippoglossoides*). Tubeworms (*Sabella penicillus*), sea urchins (*Brissopsis lyrifera*) and brittle stars (*Ophiura robusta*) are also commonly found in association with *Haploops*.

Mud bottom with tubeworms and brittle stars (*Ophiura albida*). North of Ven, Sweden. © OCEANA

Recent studies in the Sound show that there has been a significant decline in the abundance of this community (HELCOM 2013c), which is now at a tenth of its former distribution (Göransson *et al.* 2010). HELCOM (2013a) has listed the habitat type '*Baltic aphotic muddy sediment dominated by Haploops spp.*' as Endangered, on the basis of this decline. Both of the *Haploops* species are also considered threatened, with *H. tenuis* listed as Endangered, and *H. tubicola* considered Vulnerable (HELCOM 2013b). Regular sampling in the Sound has indicated that the community is still declining, and the only stable populations appear to be those found in a restricted area north of the island of Ven. Oceana documented this area in 2011 and 2012. In 2011, *Haploops* were still present; in 2012, fewer tubes were found, and most of these were empty. Instead, we found various species of brittle stars, suggesting a change in the community type.

The reason for the observed decline of *Haploops* is not fully understood. Bottom trawling disturbs the seafloor and can play a negative role, but given the long-standing prohibition on bottom trawling in the Sound, it is unlikely to have been the primary driver of decline in these waters. Eutrophication and/or climate change may also be key factors behind the species' decline (HELCOM 2013c). Göransson *et al.* (2010) highlighted that the biggest threats to *Haploops* include eutrophication, fishing, ecosystem changes and increased water temperature.

Seagrass beds

Eelgrass (*Zostera marina*) meadow. Saltholm, Denmark. © OCEANA/ Carlos Minguell

Eelgrass (*Zostera marina*) is associated with the sandbanks, and is the most common marine flowering plant, covering large areas in sheltered places, mostly at depths of 2-6 m. It can grow to one metre in height and in suitable environments forms dense meadows, providing habitat (including nursery and feeding areas) for a number of other marine creatures (Boström *et al.* 2014). Eelgrasses are also important indicator species for water quality because they are sensitive to eutrophication (Krause-Jensen *et al.* 2008) and also help to reduce coastal erosion as the roots stabilise the sediment and reduce movements (Carneiro & Nilsson 2013). Other important ecosystem services they provide include nutrient recycling, primary productivity and carbon sequestration and storage (Duarte 2002; Spalding *et al.* 2003).

The Sound is one of the key eelgrass areas in Denmark, even though today the estimated present coverage is only 20-25% of what it used to be in 1900 (Boström *et al.* 2003; Boström *et al.* 2014). In the Sound, the largest current eelgrass extensions are in Nivå and Køge Bays, and the areas around Tårbæk, Copenhagen and Saltholm in Danish waters, and north of Helsingborg, between Landskrona and Ålabodarna and around Falsterbo on the Swedish side (Carneiro & Nilsson 2013). The disappearance of the eelgrass meadows in the Sound, like elsewhere in the world, is human-induced, due to factors such as habitat destruction, eutrophication and overfishing. Globally, the alarming rate of decline illustrates that eelgrass meadows are among the most threatened ecosystems on the planet (Orth *et al.* 2006; Waycott *et al.* 2009).

Kelp forests

Kelps are important primary producers, and the forests that they form are regarded among the most productive systems on earth (Gundersen *et al.* 2017). They also enhance secondary production in other surrounding communities and are remarkably resilient to natural disturbances, and are therefore essential for the safeguarding of ecosystem functions. The main species that create kelp forests in the Sound are oarweed (*Laminaria digitata*) and sugar kelp (*Saccharina latissima*). Oarweed can be found only in the northernmost Sound, as it requires higher salinities; sugar kelp tolerates brackish water, and can be found throughout the Sound, and all the way to Bornholm waters in the Baltic Proper. These brown algae form dense forests which serve as important habitat, nursery grounds and food for numerous other species, including mobile pelagic species, like fish, and benthic organisms (e.g., Køie *et al.* 2000, Gundersen *et al.* 2017). Kelp forests are important for sustaining healthy fish stocks.

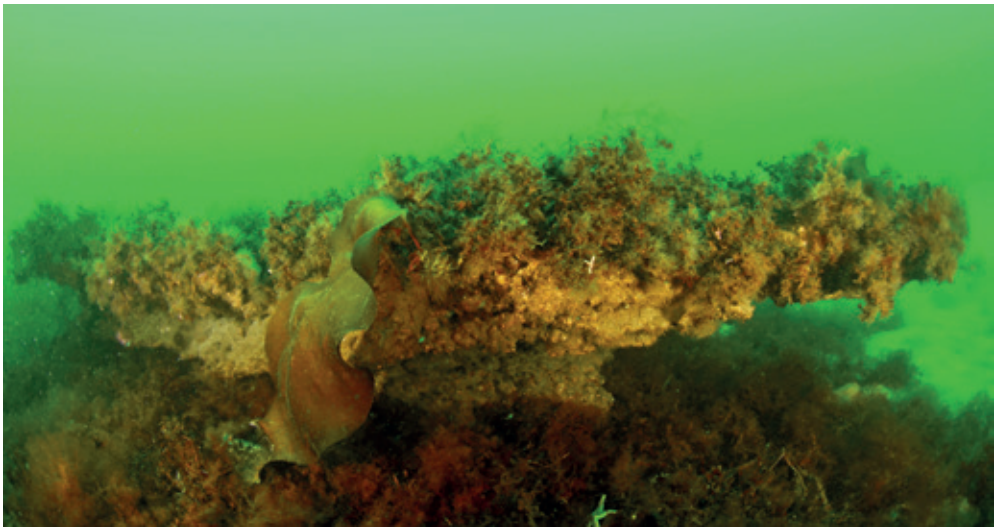
Sugar kelp (*Saccharina latissima*) on horse mussel (*Modiolus modiolus*). Northern Sound, Sweden.
© OCEANA/ Carlos Minguell

Bubbling reefs

Bubbling reefs are submarine structures, formed through the aggregation of carbonate cement and other particles resulting from the microbial oxidation of gas emissions, mainly methane. These formations may be essentially level with the seafloor, or they may form pillars that reach up to 4 m above the surrounding seabed. They serve as a habitat for a large number of species of fish and invertebrates (such as sponges, sea anemones, algae, crustaceans and more) (Jensen *et al.* 1992).

Bubbling reefs can be found scattered in Kattegat and in the Danish part of the Skagerrak. They are protected under the Habitats Directive (habitat code: 1180), and HELCOM (2013a) has assessed them as Endangered. Due to their fragility, strict prohibitions on any type of fishing in their immediate vicinity have been introduced within all Natura 2000 areas where these

features occur. In 2012, a small bubbling reef was identified by the Danish Nature Agency in the southern part of Kattegat, north of Gilleleje near the border of the Sound (Naturstyrelsen 2013b). This newly found bubbling reef lies inside the *Gilleleje Flak* Natura 2000 area, but no fisheries restrictions have been put in place yet. The area is relatively shallow, at around 10 m depth, and so bottom trawling does not represent an immediate threat to the bubbling reef. It should be noted that the area is not well-documented, and it is suspected that more small bubbling reefs may exist in the area.



Carbonate-cemented rock in the bubbling reef. Gilleleje, Denmark. © OCEANA/ Carlos Minguell

Sea pens and burrowing megafauna

This biotope is characterised by populations of sea pens (typically *Pennatula phosphorea* and *Virgularia mirabilis*) scattered over muddy seafloor, with less than 10% coverage (HELCOM 2013d). It requires high salinities and typically occurs at around 15-200 m depth; its distribution in the Sound is therefore limited to the northernmost and deepest waters.

This deep-water community is of key importance for the functioning of the ecosystem. It provides food and shelter for many other species, including commercially important fish (HELCOM 2013d). This community type is considered threatened in the North-East Atlantic (OSPAR Commission 2008) and the Baltic Sea, where '*Baltic aphotic muddy sediment dominated by sea pens*' is Red Listed as Endangered (HELCOM 2013a).

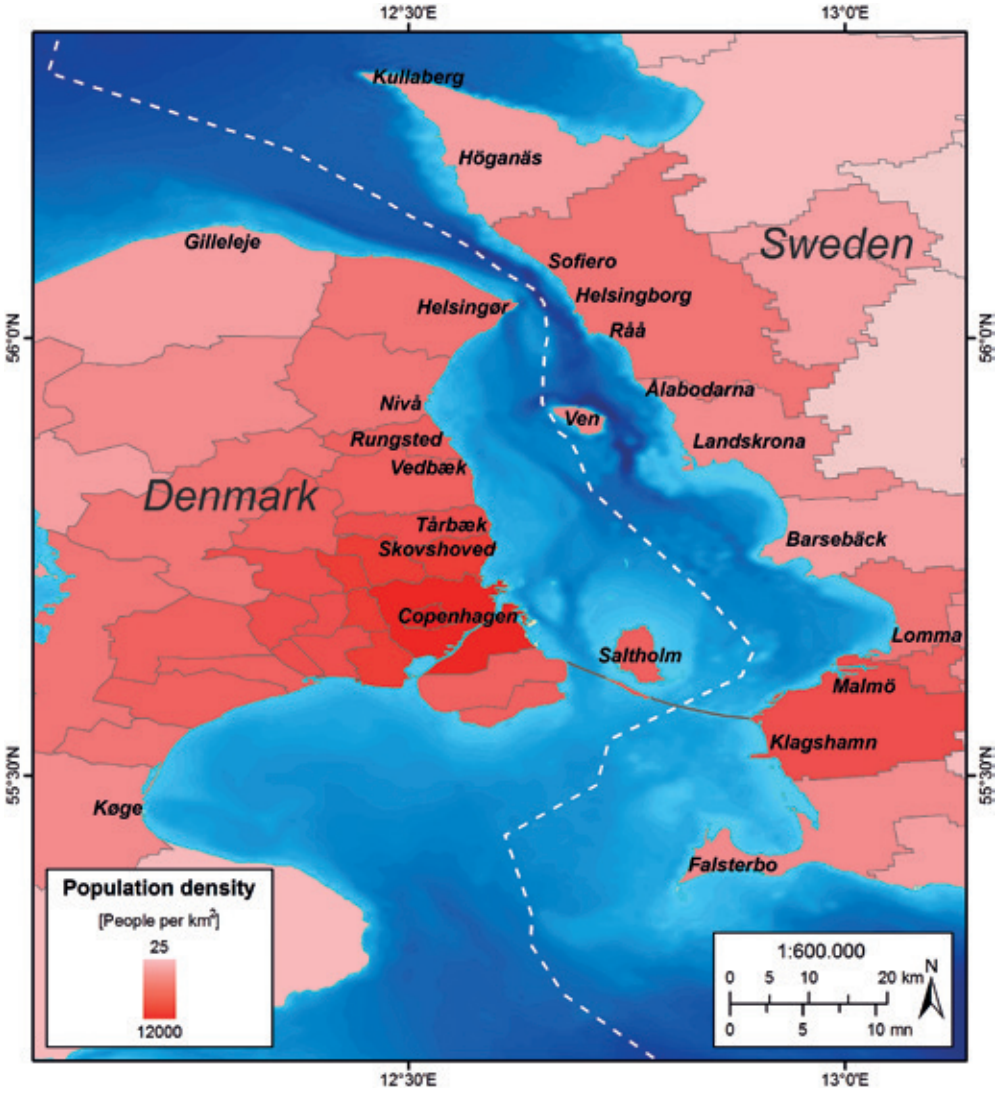
This community type is primarily threatened by bottom trawling, and also by oxygen depletion events caused by eutrophication. Bottom-contact fishing gear has two major impacts on these communities; it extensively disturbs the sediment, and it directly removes the fragile sea pens, significantly lowering the quality of the habitat (OSPAR Commission 2008). The sea pen biotope is negatively affected by the direct physical disturbance of the fishing activities, and is also likely to be affected indirectly by increased siltation following fishing activities (HELCOM 2013d).

Human uses and threats

Cargo ship near the shore. Ven Island, Sweden. © OCEANA/ Carlos Minguell

The Sound lies at the heart of a densely populated region (Fig. 4), and its shorelines, waters, and marine resources support a wide range of human activities, which are concentrated in a relatively small area. Commercial uses of the Sound are varied and include extractive activities (such as fisheries and the extraction of sand from the seafloor), maritime shipping, aquaculture, and offshore wind farms. Recreational uses are also significant; outdoor recreation is an import element of Danish and Swedish culture in the region, and depends heavily on the marine environment (SwAM 2012; Kaae *et al.* 2016). The most popular maritime leisure activities in the Sound

Figure 4. Population density in the Sound region. Data sources: EEA, EMODnet, Danmarks Statistik, Statistics Sweden (SCB).



are recreational fishing and boating (Carneiro & Nilsson 2013), as well as swimming, watersports, and spending time along the coasts and many beaches, on both the Danish and Swedish sides.

The high human pressure on the catchment area and waters of the Sound also clearly poses a series of threats to marine life in the Sound. Like much of the Baltic Sea, the waters of the Sound have been strongly affected by eutrophication, although improvements to waste water treatment have both reduced nutrient loads and improved water quality over time (SEPA 2009; Diekmann & Möllmann 2010). Intense maritime activity has driven extensive coastal development and infrastructure, including ports and harbours, shipyards, fish landing sites, and marinas; these developments have, in turn, brought either changes or damage to coastal and marine ecosystems (Carneiro & Nilsson 2013). In general, the greatest ongoing threats to the marine environment in the Sound are: unsustainable fishing, including bottom trawling where it is still permitted; sand dredging and land reclamation; and heavy maritime traffic. Managing and reducing these threats represents a serious and growing challenge, particularly given the fact that the population of the Sound region is projected to grow by an additional 10% by 2030 (Örestat 2012).

Fisheries

"The herring fishery in the western Baltic, and in particular the Sound, was once the largest medieval fishery in Europe"

Fisheries in the Sound have been an essential part of the region's culture and society for centuries, providing food and supporting a lucrative trade. The herring fishery in the western Baltic, and in particular the Sound, was once the largest medieval fishery in Europe, with estimated catches of up to 50,000 t annually before its eventual decline in the 1600-1700s (Mackenzie *et al.* 2002). The resulting trade in salted herring created the very foundation on which the development of the city of Copenhagen was built. Nowadays, catches of all species combined are more than an order of magnitude lower than at the peak of the herring fishery, but the Sound nevertheless continues to support significant commercial and recreational fishing. Its waters are characterised by relatively larger fishes, in greater densities, and of more species than fish communities in adjacent areas where trawling is ongoing (Popescu 2010). This is the case of the cod population in the Sound, which is relatively more abundant, and in a healthier state than cod in the Kattegat, which has significantly declined (Svedäng 2010).

Port of Gilleleje, Denmark.
© OCEANA/ Claus Koch

These differences are generally attributed to the ban on trawling, because it has meant lower fishing pressure on local stocks (Lindegren *et al.* 2010), and the protection of key benthic habitats from the direct impacts of towed fishing gear. Positive effects have also been observed on other demersal fish species in the Sound, such as haddock, plaice, and whiting (Bergström *et al.* 2007).

Commercial fisheries

The commercial fishery in the Sound is carried out almost entirely by vessels from Denmark and Sweden (Table 1). The total fleet size is fewer than 200 vessels; in 2012, there were 122 Danish vessels and 62 Swedish vessels that landed fish from the Sound (Carneiro & Nilsson 2013). These numbers have been declining over time in the region, mirroring a general decreasing trend in fleet size in both Denmark and Sweden.

Table 1. Reported fisheries catches (live weight rounded to the nearest ton) from the Sound (ICES area 27.3.b.23), by country. Sources: ICES and Eurostat.

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Denmark	5,028	6,091	7,884	4,459	4,692	3,303	1,549	1,516	1,729	1,198
Germany	0	0	1,214	631	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	6	12
Sweden	1,560	0	1,125	1,322	1,602	1,125	1,177	1,129	1,111	857
Total	**6,588**	**6,091**	**10,223**	**6,412**	**6,294**	**4,428**	**2,726**	**2,645**	**2,846**	**2,067**

Small scale fishing vessel in northern Sound, close to Kullaberg, Sweden.
© OCEANA/ Carlos Minguell

This fishery is a predominantly mixed fishery, that mainly uses gillnets, and to a lesser extent, pots and traps. The main species targeted in the Sound are cod, lumpfish, flatfishes, herring, garfish, and eels (Table 2), while the most valuable commercial fishes are cod, sole, and lumpfish (caught for their roe, which is sold as 'caviar'). For Danish ports alone, the total annual value of fish landings from the Sound was more than DKK 20 million in 2014 (Sørensen *et al.* 2016).

Table 2. Reported commercial fisheries catches from the Sound (ICES area 27.3.b.23), by species. Values are based on live weight, rounded to the nearest ton. Source: ICES and Eurostat.

Latin name	English name	Average catch (2013-2015)
Gadus morhua	Atlantic cod	1,163
Clupea harengus	Atlantic herring	824
Anguilla anguilla	European eel	128
Pleuronectes platessa	European plaice	105
Platichthys flesus	European flounder	94
Cyclopterus lumpus	Lumpfish	80
Belone belone	Garfish	51
Trachinus draco	Greater weever	12
Limanda limanda	Common dab	12
Scophthalmus maximus	Turbot	10
Solea solea	Common sole	7
Scophthalmus rhombus	Brill	7
Crangon crangon	Common shrimp	6
Scomber scombrus	Atlantic mackerel	5
Salmo trutta	Sea trout	3
Pollachius virens	Saithe	2
Brachyura	Marine crabs	2
Nephrops norvegicus	Norway lobster	2
Melanogrammus aeglefinus	Haddock	1
Merlangius merlangus	Whiting	1
Mugilidae	Mullets	1
Perca fluviatilis	European perch	1
Microstomus kitt	Lemon sole	0.7
Cancer pagurus	Edible crab	0.3
Chelon labrosus	Thicklip grey mullet	0.3
Molva molva	Ling	0.3
Oncorhynchus mykiss	Rainbow trout	0.3
Palaemon serratus	Common prawn	0.3
	Total	**2,519**

By weight, the most important species fished in the Sound is cod (*Gadus morhua*), which accounted for nearly half of average reported catches from 2013-2015 (Table 2). The Sound cod population has become a subject of particular interest, in light of the critical state of the cod stocks in Kattegat. Due to the decline of Kattegat cod, the local stock in the Sound has become the main source of cod recruitment to Kattegat and the Skagerrak. The Sound cod contribute nearly half (46%) of the cod larvae that settle in those waters, while adult cod also swim from the Sound into Kattegat (Jonsson *et al.* 2016). Thus, a healthy population of cod in the Sound is not only essential for supporting local fisheries, but also for surrounding seas.

Commercial fisheries in the Sound are managed under the EU Common Fisheries Policy (Regulation (EU) No 1380/2013), through a combination of limitations on catch and effort, and technical management measures, with additional complementary regulations under Danish and Swedish national fisheries policies. For example, minimum landing sizes and closed seasons for some species differ on either side of the border (Carneiro & Nilsson 2013).

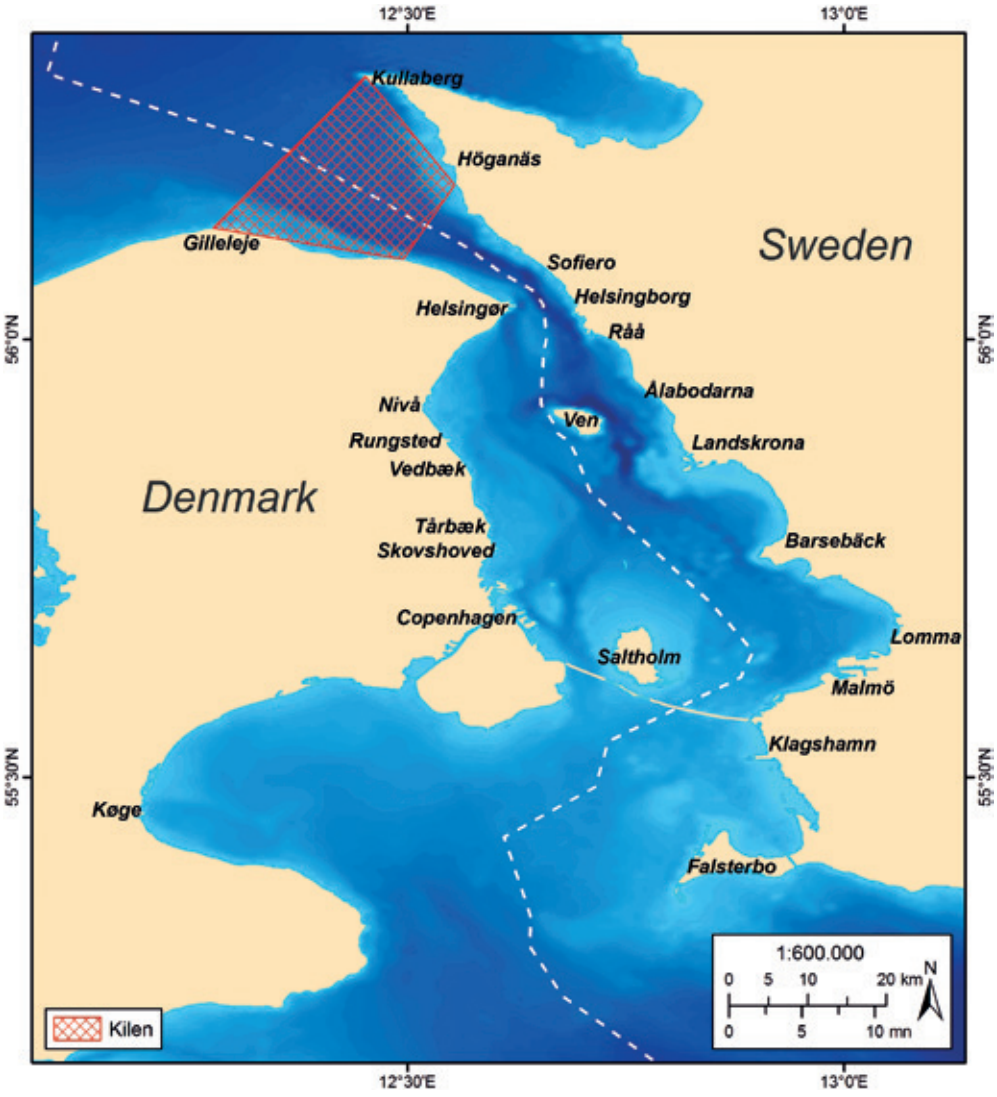
Stock assessments for fisheries in the Sound are carried out by the International Council for the Exploration of the Sea (ICES). Currently, assessments are produced for eleven stocks that are wholly or partially distributed in the Sound (i.e., brill, cod, dab, flounder, herring (spring-spawners), herring (autumn-spawners), mackerel, plaice, sole, sprat, and turbot). Of these eleven stocks, only herring, mackerel, plaice, and sprat are assessed as being in good condition (ICES 2016b). The cod and sole stocks are overfished, while the status of brill, dab, flounder, and turbot is uncertain, due to data limitations. In October 2016, EU fisheries ministers agreed on a 56% reduction for the cod fishery (for the Western Baltic stock, which includes the Belt Sea, the Sound, and the western part of the Baltic Sea) for 2017 (Council Regulation (EU) 2016/1903). This reduction reflected the critically poor state of the stock, although it fell short of the 93% reduction advised by ICES scientists.

Trawl net in the port of Gilleleje, Denmark.
© OCEANA/ Carlos Minguell

For cod and other demersal fishes in the Sound, the most effective fisheries management measure has been the prohibition on towed fishing gears (i.e., otter and midwater trawls, purse seines, and Danish seines) that was jointly agreed by Denmark and Sweden in 1932 (Anon. 1932). It should be noted, however, that this ban does not apply to the entire Sound. An exception is the wedge-shaped area known as 'Kilen', which is located

at the northern border of the Sound (Fig. 5). There, trawling is allowed year-round, except from 1 February to 31 March. This two-month prohibition on all targeted fishing for cod was implemented in 2009, in order to protect them during the spawning season (ICES 2014b).

Figure 5. The area known as 'Kilen' where bottom trawling is allowed year-round, except from 1 February to 31 March. Data sources: EEA, EMODnet, Danish Ministry of Environment and Food (Ministerial Order 391 of 16/04/2010).



Lack of compliance with spatial restrictions on trawling (in the Sound as a whole, and in Kilen) has been an ongoing issue, with accounts of some Danish vessels trawling illegally (e.g., Linde-Laursen 2010), largely due to tighter controls on the part of the Swedish coastguard than their Danish counterparts. According to local sources, illegal trawling has become less frequent over time, and is not as significant a problem as in the past. Nevertheless, it still reportedly occurs, despite the requirement introduced under EU law in 2011 that all vessels over 12 m length must use a vessel monitoring system (VMS). Particular areas that have been a concern include waters to the east of Ven and the northern part of Kilen, during the closed period there.

Recreational fisheries

In addition to the commercial fisheries of the Sound, an extensive recreational fishery is also very active, and makes a significant contribution to the local economy of the region. At the national scale, recreational fishing is a popular pastime in both countries, and is estimated to involve approximately 17% of the Danish population, and 33% of the Swedish population (Carneiro & Nilsson 2013). For both countries, the Sound is a major area for this activity, which has become increasingly popular over time.

The recreational fishery in the Sound mainly involves angling, but also includes passive gear (gillnets and fyke nets) (Svedäng 2010; Sparrevohn & Storr-Paulsen 2012), and targets a mix of species, including cod, dab, eel, flounder, garfish, herring, mackerel, plaice, and sea trout. Fishing is carried out along the coastline, on private boats, and on chartered boats fishing offshore. There are 33 large charter boats and ten smaller ones that are registered in Denmark or Sweden and operate in the Sound (N.E. Nielsen, pers. comm., 2016). Together, they take out approximately 250,000-300,000 people per year, and have an estimated combined revenue of DKK 50,000,000-80,000,000 annually. One traditional activity carried out by anglers in the Sound is the targeting of cod spawning aggregations (e.g., in the deeper waters in the northern Sound or to the northeast of Ven). This '*bulefiskeri*' ('bump fishing') is named after the bumps that are visible on an echo sounder in places where the cod aggregate on the seafloor.

Atlantic cod (*Gadus morhua*).
Gilleleje, Denmark.
© OCEANA/ Carlos Minguell

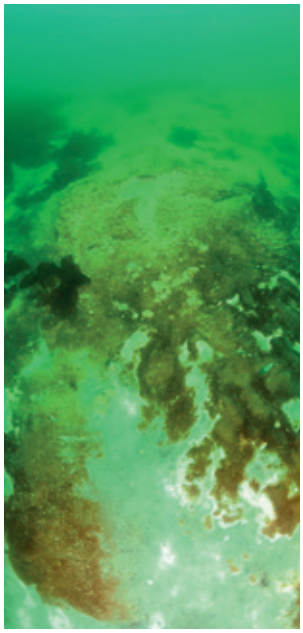
Historically, the management of recreational fishing in the Sound has not been very stringent, and has differed between Denmark and Sweden. For example, recreational use of gillnets and fyke nets is allowed on both sides, but restrictions differ as to when and where they can be used. More importantly, while licenses are mandatory for any saltwater recreational fishing (both angling and passive gear) in Denmark (Oleson & Storr-Paulsen 2015), licenses are only required in Sweden for using nets, and not for sea angling (SEPA 2013). This difference creates a discrepancy in the available data about the scale of recreational fishing in the Sound, because without a requirement for licenses, there is no obligation for anglers to register with the Swedish authorities. As a result, official Swedish data on marine recreational fishing are instead based on surveys, which are likely to be less accurate.

More recently, stricter management measures have been introduced for recreational fishing, specifically in relation to cod. Recreational fishing that targets cod in the Kilen area is subject to the same restrictions as commercial fisheries, with a closure during the spawning season. Across the entire Western Baltic cod stock (including the Sound), a bag limit came into effect in January 2017 for the recreational fishery (Council Regulation (EU) 2016/1903). For the majority of the year, each person is now allowed to retain five cod per day, except in the spawning season for cod (1 February - 31 March), when the daily maximum is reduced to three cod per day per person.

Given the intensity of recreational fishing in the Sound, it is not surprising that the fishery has significant impacts on some targeted species, such as cod. According to DTU Aqua, Danish recreational fisheries catch more cod in the Sound than in any other area. In 2012, an estimated 365 tons of cod were caught in the Sound by Danish recreational fishers, representing 33% of all cod catches (both commercial and recreational) from those waters (Olesen & Storr-Paulsen 2015). The Sound is also the most important area for recreational cod fishing in Sweden (ICES 2017). The most recent ICES stock assessment of the Western Baltic cod stock noted the importance of accounting for recreational fisheries, but it was not possible to factor either Danish or Swedish recreational catches into the assessment, because of insufficient data (ICES 2016d). Without this information, it is extremely difficult to estimate total catches, which in turn increases the uncertainty in the assessment results and limits management effectiveness.

Sand dredging

Sand and gravel extraction has been carried out for decades in the Sound, removing sediment from shallow sandbanks that were formed at the end of the last ice age, approximately 10,000 years ago. Dredging has been carried out at various scattered sites throughout the northern, central, and southern Sound. It currently takes place only on the Danish side, and is the subject of controversy, due to widespread concern about its impacts on the marine environment.



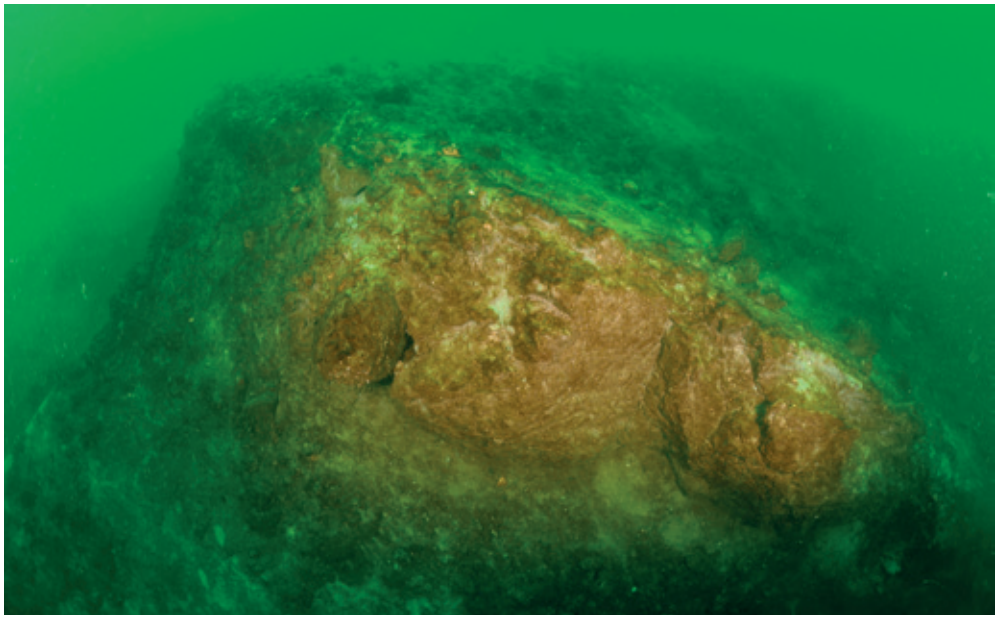
Blanket of sulphur bacteria in a hole produced by sand dredging. Vedbæk, Denmark.
© OCEANA/ Carlos Minguell

Sweden has carried out marine sand and gravel extraction in the Baltic Sea since the beginning of the 20th Century (HELCOM 1999). By the 1980s, the Sound was the most important area for Swedish marine aggregate extraction, with quantities of up to 547,334 m^3 dredged from Disken central Sound), Västra Haken (southern Sound) and Sandflyttan (southern Sound) (ICES 1991). In 1993, dredging at Västra Haken (the last extraction area at that time) ended when the site was included within a marine protected area that was established around the Falsterbo Peninsula (ICES 1996). Since that time, marine aggregate extraction has generally not been permitted on the Swedish side of the Sound (1993-1997, 1999-2006, and 2008-2015). It has been allowed only for two specific, large-scale infrastructure projects: in relation to building the Øresund Link between Denmark and Sweden (in 1998), and the Lillgrund offshore wind farm (in 2007) (ICES 2016a). Sweden does, however, continue to import marine aggregates that are dredged by Denmark (NIRAS 2015).

In contrast to Sweden, the volume of marine aggregate extration from Danish waters has been increasing in recent years (Addington 2016). In annual reports submitted to ICES, Denmark has repeatedly noted its expectation that marine sand and gravel would increasingly be used in place of land-sourced materials, citing increasing environmental conflicts on terrestrial sites as one of the reasons for this shift (e.g., ICES 1996). In 2015, a total of 2,707,071 m^3 of marine aggregates were extracted from Danish waters in the HELCOM area, mainly for the purposes of construction and road-building, as well as for construction fill and land reclamation, and beach replenishment (ICES 2016c). In the Sound, specifically, the sharpest increase in dredging was seen from 2011-2012, when quantities of extracted sand and gravel rose from 400,000 m^3 to 1,400,000 m^3, to supply the expansion of the port in Copenhagen (Carneiro & Nilsson 2013). Among the main sites that have been dredged on the Danish side are Lappegrund (northern Sound), Disken (central Sound), and Køge Bay (southern Sound).

Dredging impacts

Intensive dredging practices in the Sound have raised concerns due to their known and significant effects on the marine environment. Direct impacts include: removal of surface layers of seabed sediment, thereby destroying benthic organisms and their habitat; altered topography of the seabed; damaged seabed integrity; and increased turbidity through the production of sediment plumes in the water column (Uścinowicz *et al.* 2014; ICES 2016a). High turbidity can impede primary production, place shellfish under added stress as they filter silt from the water, and harm planktonic eggs and larvae (HELCOM 1999). Sediment plumes later settle on the seabed, where they can effectively smother benthic organisms. Following dredging, benthic communities typically show a significant reduction in species number, and in particular, abundance and biomass (see Newell *et al.* 1998; HELCOM 1999; ICES 2016a). These community changes can then have broader knock-on effects on marine ecosystems, for example, affecting food availability for birds, fish, and mammals (ICES 2016a), adding to impacts on species that may have previously relied on dredged habitat for spawning or nursery areas.

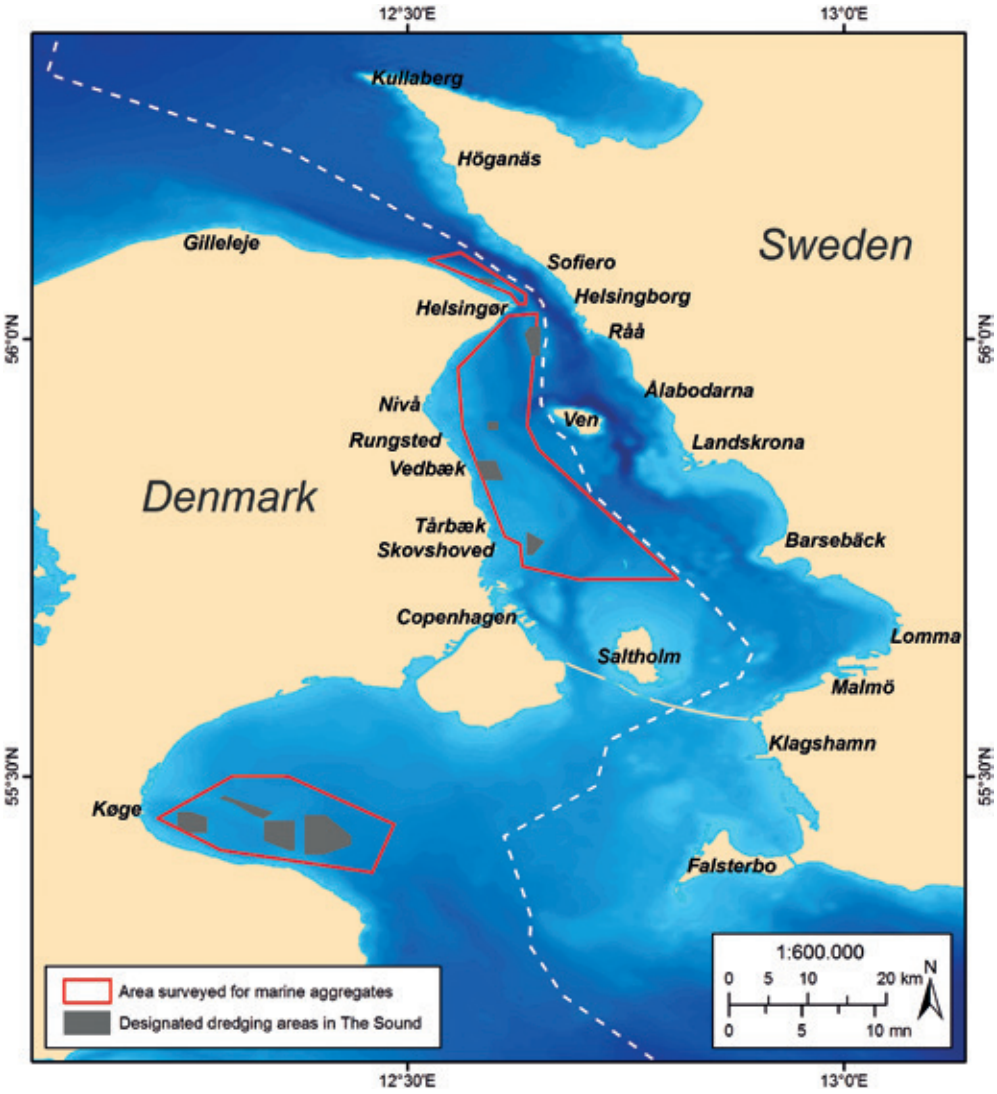


Slope of a hole produced by sand dredging. Vedbæk, Denmark.
© OCEANA/ Carlos Minguell

The precise impacts of dredging – and the likelihood of recovery – in any particular area depend heavily on the specific factors involved, including the method of dredging, quantity of aggregates removed, local hydrodynamics, and benthic community composition (Newell *et al.* 1998; HELCOM 1999; Krause *et al.* 2010; ICES 2016). According to ICES (2016), the timescale for recovery in an area of low hydrodynamics (such as the Baltic Sea) following intensive dredging of sandy sediments can range from more than 10 years to "never". In the Sound, there are no data available on potential rates of re-sedimentation, thus it is not possible to estimate when, if ever, sandbanks are likely to recover once removed.

Studies of sand dredging in the Sound have highlighted lasting effects on benthic ecosystems. A recent government-commissioned survey of current and potential dredging areas in Danish waters showed that where dredging had been carried out, the seafloor showed obvious damage, and that habitats had been destroyed or severely disturbed in the areas designated for dredging (Fig. 6; Lomholt *et al.* 2015). It also noted the deterioration in environmental quality and natural capital that would result from future dredging impacts on seagrass, macroalgae, and blue mussels in the southern Sound.

Figure 6. Areas in the Sound surveyed by Lomholt *et al.* for marine aggregates, and designated dredging areas. Data sources: EEA, EMODnet, Lomholt *et al.* 2015.



An earlier study focused specifically on Køge Bay, historically one of the most intensively dredged areas, and found that deep (>7 m) holes left in the seabed from anchor dredging had filled with organic detritus and become anoxic, making the recovery of macrofauna impossible (Norden Andersen *et al.* 1992). The risk of such anoxic zones is particularly high in the Sound, with its low salinity levels and hydrodynamics (ICES 2016a).

In summary, the removal of metres of sediment from sandbanks in the Sound is likely to cause significant damage – destroying and removing benthic habitat and organisms, increasing the water depth, and creating anoxic zones. These areas have already been identified as essential fish habitats for commercial fish stocks in the area (Fig. 3), including the iconic Sound cod (Sørensen *et al.* 2016), and continued dredging of the sandbanks has worrying implications for both fish populations and the fisheries they support. According to participants at the stakeholder gathering in October 2016, Danish commercial fishers have reported that herring in Køge Bay have disappeared from dredged areas that previously served as spawning sites, that the abundance of sandeels has decreased, and that the sole fishery has also been negatively affected by the dredging.

Management of dredging

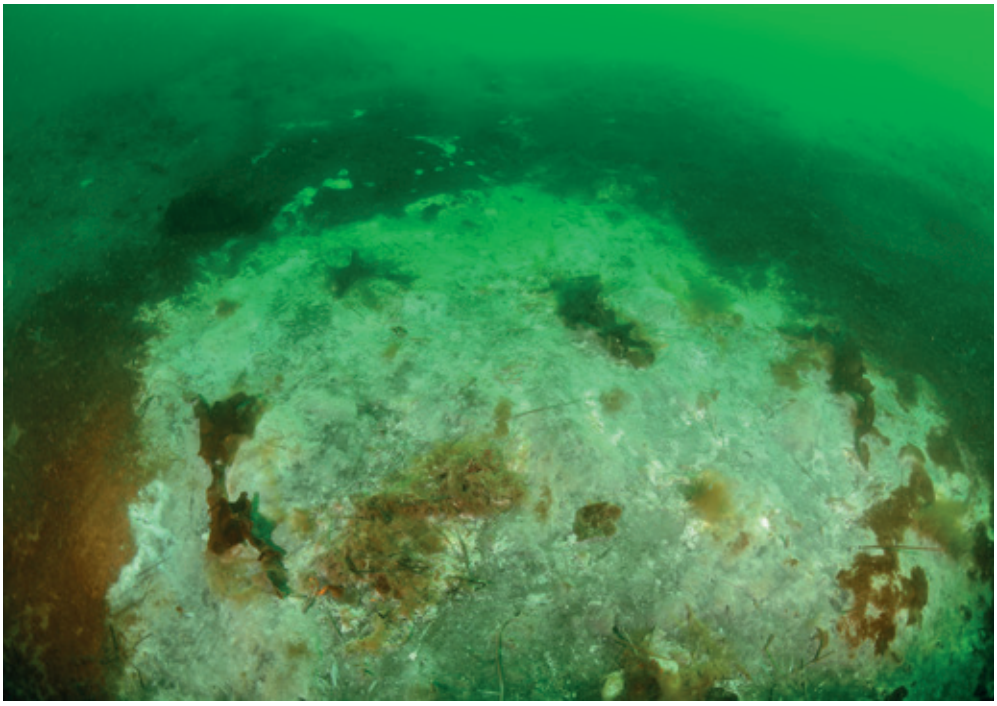
On both sides of the Sound, the extraction of marine aggregates is regulated at the national level. In Sweden, it is overseen by the Geological Survey of Sweden, in consultation with other relevant authorities (e.g., the Swedish Agency for Marine and Water Management, and the Swedish Environmental Protection Agency) (Carneiro & Nilsson 2013). Environmental impact assessments (EIAs) have been required for all extraction applications since 1992 (ICES 1995).

In Denmark, authorisations are granted by the Environmental Protection Agency (Miljøstyrelsen), and regulation has been much less stringent than in Sweden. Prior to 1997 there was no regulation on dredging areas or volumes, and EIAs for new licenses were only made mandatory in 2010 (Addington 2016). Following protests by fishers, NGOs, and divers in 2014, due to concerns about the sudden increase in dredging intensity in areas considered as key habitats for fish (Sørensen *et al.* 2016), regulations were strengthened. In 2015, extraction limits were imposed in 35 sites throughout the Danish marine territory, including the areas designated in the Sound. At the same time, the requirements for EIAs were made more specific, including the fact that potential fisheries interests should be taken into consideration prior to issuing new permits.

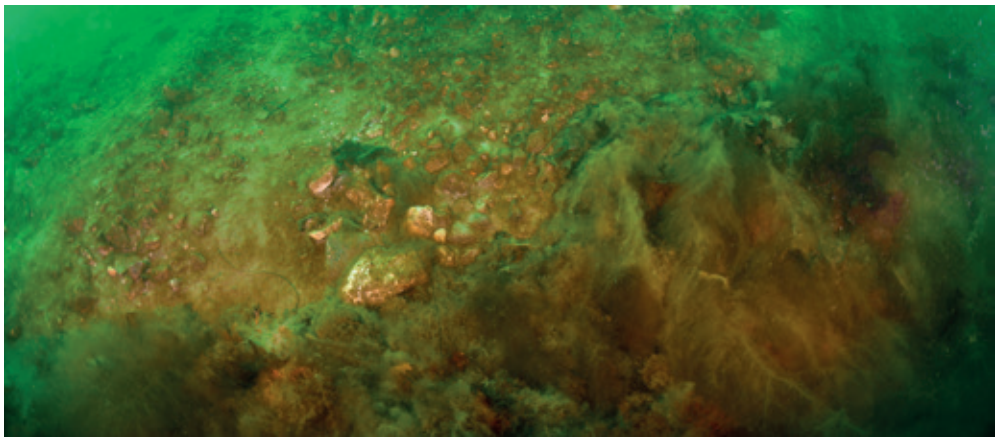
"Continued dredging of the sandbanks has worrying implications for both fish populations and the fisheries they support"

The Danish government recently commissioned a series of studies examining the potential – and potential impacts – of continued dredging in the Sound. One of these studies showed that the sandbanks in the Sound where dredging has been proposed or carried out, serve as valuable habitat for commercial fishes (such as cod and plaice) (Sørensen *et al.* 2016). Another study mapped sediment composition on the Danish side, the occurrence of 'suitable' resources for extraction, and selected habitats, and also attempted to assess potential impacts on local fauna (Lomholt *et al.* 2015). However, even though the report recognised that organisms that live within the sediment are at greatest risk from dredging, the assessment of impacts did not include those species. An additional study focused on the dredged area known as Disken, and did assess impacts on infaunal composition and abundance (Kjellerup *et al.* 2014). However, the basis for the assessment was questionable, because the benthic community was compared to a 'control' area that itself is a former dredging site where significant impacts of dredging were still visible on the seafloor.

The final study assessed the economic consequences of reducing dredging operations in the Sound, or closing them altogether (NIRAS 2015). The analysis indicated that if dredging in the Sound were to be prohibited, it would imply an increase in costs of 12 million DKK/year, which is roughly equivalent to only 0.03% of the total cost of materials sold for the building and construction sector in the Capital Region in 2013 (NIRAS 2015). The report concluded that even if these costs were passed on to the construction sector, it would not lead to reduced demand, because the cost of sand and gravel alone represents only a very minor share of total building costs. Given the economic and recreational value of the fisheries in the Sound, the potential benefits of a dredging ban to protect the sandbanks – and the essential habitat that they represent for fishes – far outweigh the relatively minor added costs that such an initiative would imply for the construction sector.



Bacteria in a hole produced by sand dredging, with some macroalgae and seagrass. Vedbæk, Denmark.



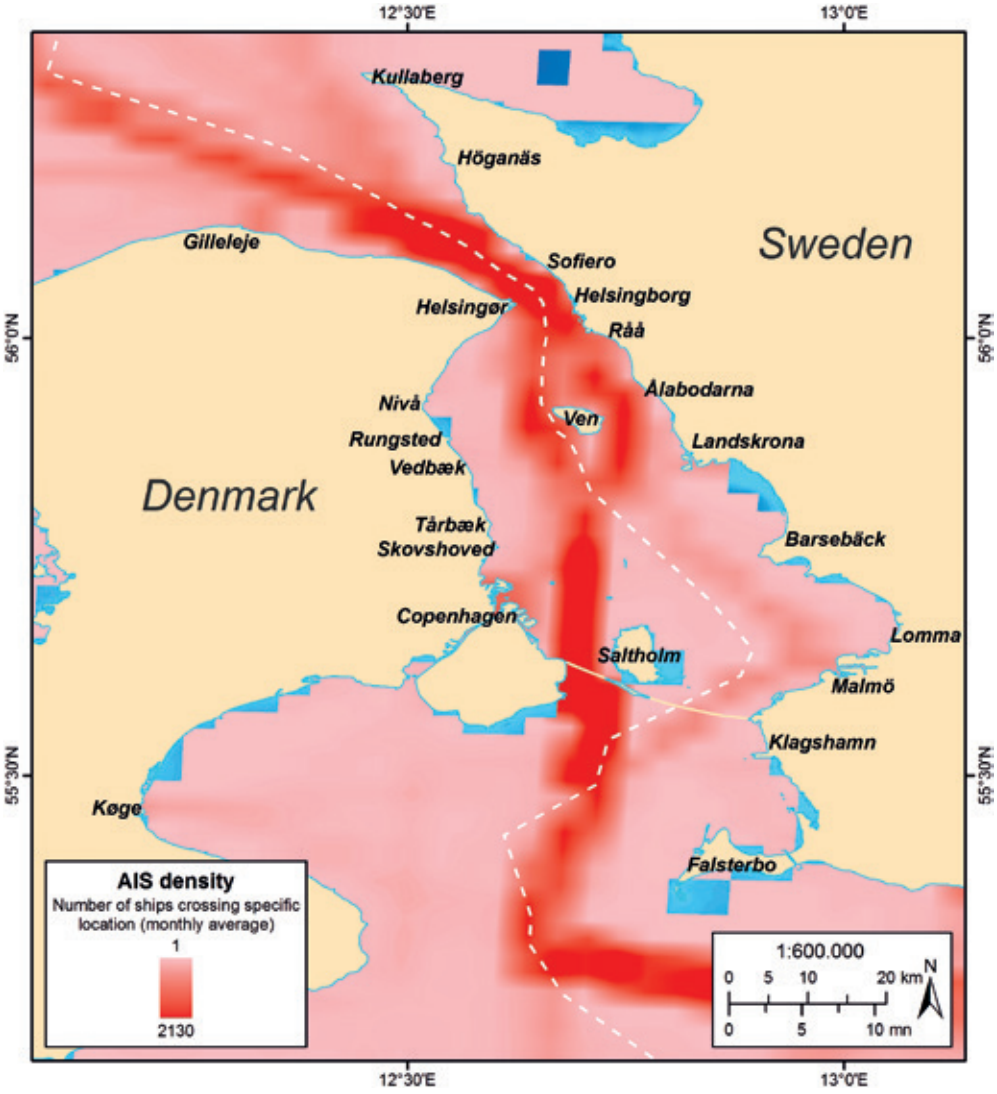
Slope of a hole produced by sand dredging. Vedbæk, Denmark. © OCEANA/ Carlos Minguell

Political support for prohibiting dredging in the waters of the Sound has been growing in recent years. In May 2016, members of three opposition parties in the Danish parliament jointly presented a proposal to protect the Sound from dredging. More recently, the city council of Gribskov municipality, at the northern end of the Sound, decided against using any sand dredged from the Sound or close to a Natura 2000 area for local coastal protection, in order to avoid damaging vulnerable habitats (Fishing Zealand 2016). At the national level, however, there does not yet appear to be a shift in position of the Danish government. When asked in 2016 whether the government would put an end to dredging in the Sound in the interests of biodiversity protection, fisheries, and tourism, the Minister of the Environment, Esben Lunde Larsen, replied that the government would not impose any additional restrictions on the practice, because of the need for raw materials in the Copenhagen area. The possibility of future large-scale dredging projects remains very real, with new land reclamation projects expected to be carried out on both sides of the Sound. In Denmark, an extension of Avedøre Holme has been suggested as way of securing Copenhagen from flooding, and expanding the industrial area there. This proposed extension is rumoured to be three times the size of the North Harbour extension, which was the main driver behind intensive dredging in 2012. In Sweden, an extension of Malmö is expected to be carried out. Projects such as these raise concerns not only because of the possibility of extensive sand dredging, but also because of the impacts of associated land reclamation on coastal habitats, particularly eelgrass meadows.

Maritime traffic

The Sound is one of the busiest waterways in the world, with more than 33,000 passages by ships of various types recorded in 2014 (SMA 2015) and on average over 2,000 passages per month (Fig. 7). Although the number of ships passing through the Sound has varied over time, it has nevertheless increased significantly over the past few decades. For example, ship traffic increased by 42% from 1990 to 1997, reaching 40,000 reported passages in that year (Carneiro & Nilsson 2013). Today, the Sound is one of four entry points to the Baltic Sea for ships coming from the North Sea and Kattegat, together with the Great and Little Belts in Denmark and the Kiel Canal in Germany. Given predictions for continued increases in maritime transportation in the Baltic Sea in general (HELCOM 2010), it is likely that the intensity of traffic through the Sound will remain high.

Figure 7. Monthly average number of ships passing through the Sound. Data sources: EEA, EMODnet, HELCOM.



The characteristics of the Sound make it a challenging place to navigate; it is both narrow (just 4 km wide at its narrowest) and shallow, with detached shoals, and the current is often strong. These factors, combined with busy traffic lanes, require skilful navigation. For this reason, there are several rules to be followed. For instance, it is a requirement that local pilotage services must be used for large oil tankers, or vessels carrying chemicals, gas or shipments of irradiated nuclear fuel, plutonium and nuclear waste (HELCOM 2016). There are also two traffic separation schemes which have been put in place in the Sound by the International Maritime Organization. These schemes are designed to minimise collision risks in two particularly congested areas, one where the Sound narrows between Helsingør and Helsingborg, and one at the southern end of the Sound, near Falsterbo (DMA 2017).

The movement of large vessels causes physical disturbances to marine ecosystems along traffic routes, both in the form of underwater noise and stirring of bottom sediments (Carneiro & Nilsson 2013). This type of disturbance can be particularly threatening to stationary species, such as *Haploops*. This point was also highlighted in the stakeholder event. Particular concern was raised in relation to the east coast of the island of Ven, where both turbulence and bow waves created by large commercial ships disturb

Ro-Ro cargo ship in the Sound. Sweden.
© OCEANA/Carlos Minguell

seafloor organisms and cause erosion. Such impacts of intense maritime traffic on benthic ecosystems in the Sound were clearly visible following changes that were made to the shipping routes in the late 1990s, in relation to the construction of the Øresund bridge (M. Palmgren, pers. comm., 2017). The seabed in the new shipping channel had previously been characterised by eelgrass and kelp; after just one and a half months, the seafloor was mostly bare. Meanwhile, the previous channel, which had been mostly barren after a decade of shipping traffic, gradually recovered.

In addition to the effects of vessel movement on marine life in the Sound, additional environmental risks may be posed by anchored vessels in designated anchoring areas. For example, concerns have been raised that vessels undertaking maintenance work in these areas are not sufficiently monitored, and are releasing chemical pollutants (e.g., paint and fuel) directly into the sea (M. Palmgren, pers. comm., 2016).

Beyond commercial shipping traffic, the Sound attracts a growing number of tourists coming on cruises (Carneiro & Nilsson 2013). Copenhagen is the largest cruise port in the Baltic Sea, and receives nearly one million cruise passengers and crew members annually (Cruise Copenhagen 2017), usually as part of cruises that also include other major Baltic Sea ports. Numbers of cruise ships visiting Copenhagen rose by 100% between 2004 and 2013 (Carneiro & Nilsson 2013), and the 2014 opening of a new cruise ship port in the city's North Harbour increased capacity to accommodate more and larger ships. Relatively low numbers of cruise ships also visit three other ports in the Sound (i.e., Helsingør, Helsingborg and Malmö).

In addition to maritime traffic passing through the Sound, there is a significant volume of local vessel traffic. Ferries make the crossing between Helsingør and Helsingborg every 15 minutes, and in 2015, they transported 7.4 million passengers and 1.4 million cars across the Sound (HH Ferries 2016). The Sound is also trafficked by a large number of leisure boats, particularly in summertime, as people in both Denmark and Sweden have the right to sail freely, and do not typically require a specific license for pleasure craft. However, recreational sailors must still follow international rules and guidelines on navigation, and their boats must adhere to construction, safety, and environmental requirements for recreational craft, as laid out under EU Directive 94/25/EC (Carneiro & Nilsson 2013).

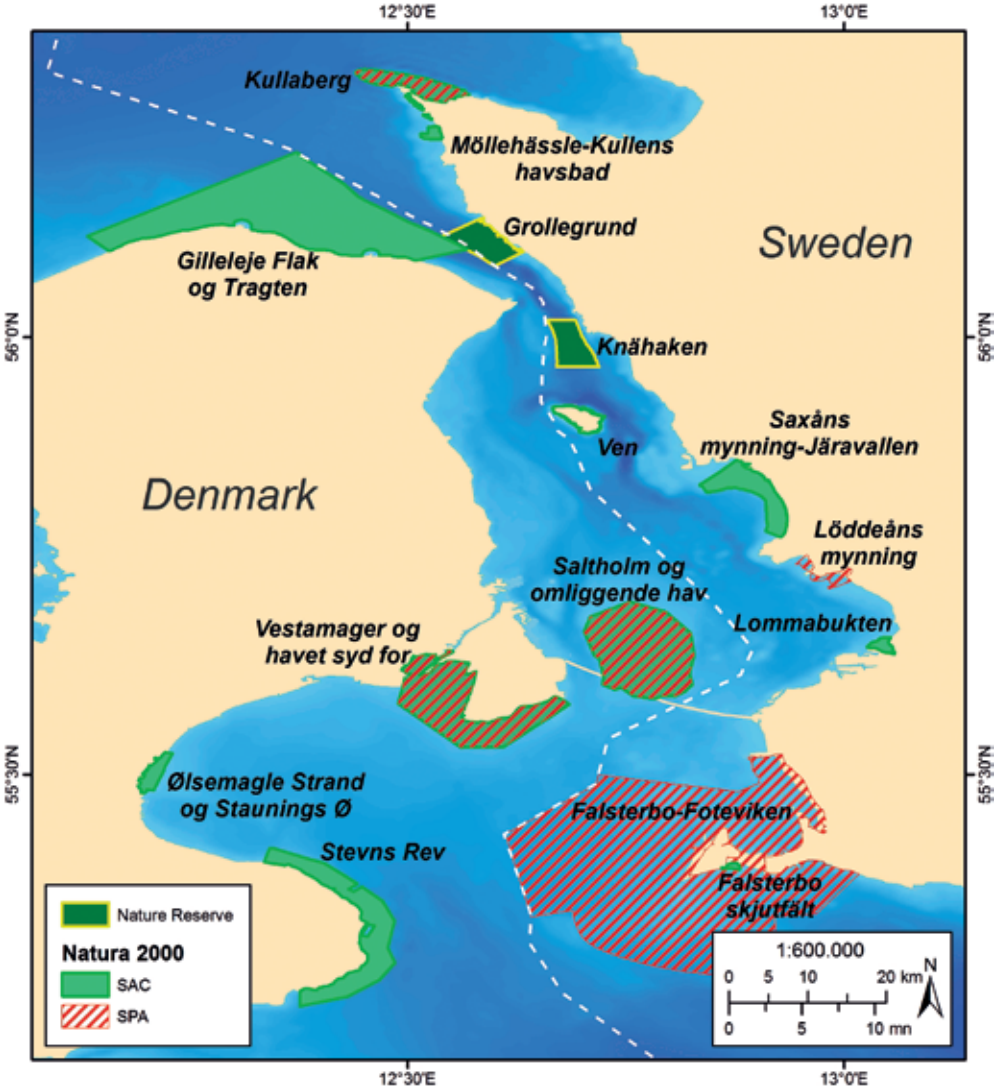
"The seabed in the new shipping channel had previously been characterised by eelgrass and kelp; after just one and a half months, the seafloor was mostly bare"

Eelgrass (*Zostera marina*.) meadow. Southern Sound, Sweden.
© OCEANA/ Carlos Minguell

Protection and management

The single most notable measure for the management and protection of marine life in the Sound is the prohibition on bottom trawling – despite the fact that it was originally established as a shipping safety measure, and not with the aim of environmental protection. This ban is one of the main reasons behind the number of rare and diverse benthic communities found in the area today. However, many other intense human uses, most notably sand dredging, continue to threaten the biodiversity and health of the area – sometimes even inside marine protected areas or in close proximity to them.

Figure 8. Nature reserves and Natura 2000 areas in the Sound. Natura 2000 areas include Special Areas of Conservation (SACs) that are protected under the Habitats Directive and Special Protection Areas (SPAs) that are protected under the Birds Directive. Data sources: EEA, EMODnet.



Currently, approximately 33% of the Sound is protected by 15 marine protected areas, some of which are partly overlapping (Fig. 8). The average size of the marine area of the sites is around 52 km^2, with the largest ones being the bird protection area of *Falsterbo-Foteviken* (marine area 425 km^2) in the southern Sound in Sweden, and *Gilleleje Flak og Tragten* (151 km^2) in the northern Sound in Denmark (Annex 1). The smallest site, *Falsterbo Skjutfält*, lies within the *Falsterbo-Foteviken* bird protection area, and covers a marine area of just 0.15 km^2. The protection provided to marine ecosystems and species across these 15 fragmented areas is not consistent; they have varying conservation objectives, and most of them do not take benthic communities into account.

The Sound acts as a refuge for a variety of vulnerable and valuable species such as cod, horse mussels, and sea pens, and could play an important role in maintaining fish stocks in adjacent areas, such as has been the case with the cod population in Kattegat (Jonsson *et al.* 2016). Although the existing protected areas offer some protection to key species and habitat types, large parts of the open water areas remain mostly unprotected, and human activities are not managed to the extent to which they should. For instance, much of the area of the northern Sound is open for bottom trawling during most of the year, yet there are unique and vulnerable benthic habitats in the area, such as sea pens with burrowing megafauna.

Denmark has five Natura 2000 sites in its waters, scattered along the coast, while Sweden has eight such areas, as well as five nature reserves, of which three are part of the Natura 2000 areas (Appendix 1). A severe shortcoming is that a large part of the seafloor in the Sound is covered by soft-bottom sediments and associated species and communities, which are not covered by the Annexes of the Habitats Directive. As a result, these features often fall outside any kind of protection inside marine protected areas. The Swedish MPAs *Grollegrund* and *Knähaken* are the only areas that protect soft-bottom habitats.

Hermit crab (*Pagurus bernhardus*).
Grollegrund, Sweden.

Danish MPAs focus their protection only on features listed in the annexes of the Habitats and Birds Directives. The most common marine features protected include reefs and sandbanks. The largest Danish MPA, *Gilleleje Flak*, protects reefs, sandbanks and harbour porpoise. Inside the area is also a small bubbling reef (Naturstyrelsen 2013b), which has also been documented by Oceana. Part of the area is open for bottom trawling, in the northern end of the site. The second largest, *Saltholm*, surrounds the island after which it is named. It protects a marine area of 55 km^2, and is known in particular for its seals. The three other areas, *Vestamager*, *Ølsemagle Strand* and *Stevns Rev* are located along the coast in Køge Bay. *Stevns Rev* covers reefs and sandbanks, while the two other are more shallow and host rich bird life. Management plans exist for all of the sites but mostly cover only the terrestrial and coastal parts of the sites and do not, for instance, restrict fishing.

Aerial view of the coast and *Elias*. Kullaberg, Sweden. © OCEANA/ Enrique Talledo

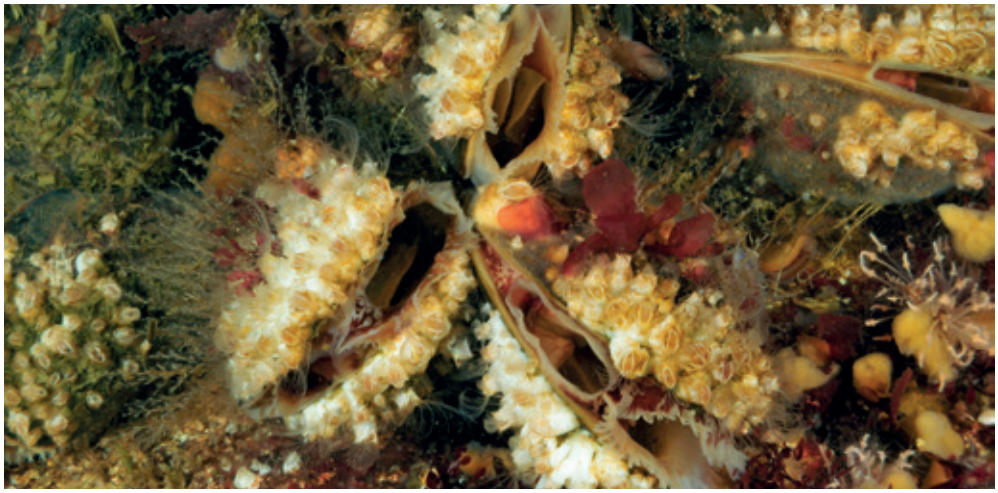
The Swedish side of the Sound encompasses a wider variety of marine protected areas than the Danish side. All of the Swedish sites have a management plan in place. These plans primarily consider the protected features, but some also have restrictions, for instance, on fisheries and construction, which secure the health of the wider ecosystem as well. *Falsterbo*, consisting of a large bird protection area and a small (0.16 km^2) habitat protection area, is designated to protect birds, seals, reefs, and sandbanks, among others. It is the single largest MPA in the entire area and reaches outside the sub-region to the Baltic Proper. What is also noteworthy in Swedish waters is the fact that there are six nature reserves in the Sound. One of those, *Höganäs* at the northern end of the area, was established all the way back in 1965 and is part of the *Kullaberg* Natura 2000 site for the protection of birds, reefs and harbour porpoise. Sweden also has strictly protected reserves in its waters, *Knähaken* and *Grollegrund*, with the main purposes of protecting the valuable seabed environment and biodiversity within the area. *Knähaken* in particular has rich animal life, largely due to the presence of strong currents, a varied seabed environment, and stable salinity and temperature. The horse mussel (*Modiolus modiolus*) forms dense banks there, making it one of the most species-rich habitats along the Swedish coast. The area is also historically

one of the important areas for *Haploops*, and this kind of combination of *Modiolus* and *Haploops* is very rare. In both of these areas, human activities are strictly controlled and it is not allowed, for instance, to anchor or moor, to collect animals or plants, or to arrange any form of competition or training using motorised boats/vessels. Recently the Swedish government also took the decision to propose new areas for the conservation of natural habitats and wild animals and plants[1], including harbour porpoise. One of these areas is in the Sound, in the waters of Helsingborg, Höganäs, Ängelholm and Båstad.

In general, most of the MPAs in the Sound are focused on fulfilling the objectives of the Natura 2000 network. The exceptions are the nature reserves on the Swedish side, which have wider objectives, and in general the restriction of human activities is stricter in Swedish waters. The Swedish municipality of Helsingborg has also investigated the possibility of expanding the coverage of *Knähaken* to the south and to the north, towards *Grollegrund* (A. Brand, pers. comm., 2016).

Management and protection of the Sound are likely to be influenced by broader-scale developments in marine planning. Maritime spatial planning has emerged on both sides of the Sound during recent years. At the time of writing this report, the process of the Marine Spatial Planning (MSP) in Denmark had just begun, and so no specific aims or goals were available, but it was anticipated that the plans will be ready by 2021. Similarly, the process had also just started in Sweden, where three distinct marine spatial plans are under development for Swedish territorial waters and the exclusive economic zone. These plans are expected to be ready in 2019. In both Denmark and Sweden, most spatial planning takes place at the municipal level (Carneiro & Nilsson 2013). Municipalities own the exclusive right to plan for the use of land and water resources within their territories, provided national – and in some instances regional – interests are taken into consideration. These plans, when established, will hopefully aid in better managing the numerous human activities in the Sound. Given the small size of the area, intense human use, and high natural biodiversity, integrated planning and management is desperately needed in order to preserve the natural environment and ecosystems of the Sound.

1 Regeringsbeslut 2016-12-14 M20 15/02273/N m (delvis). Förslag till nya områden för bevarande av livsmiljöer samt vilda djur och växter

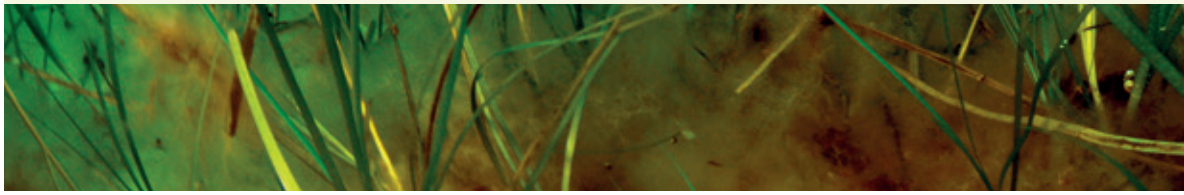


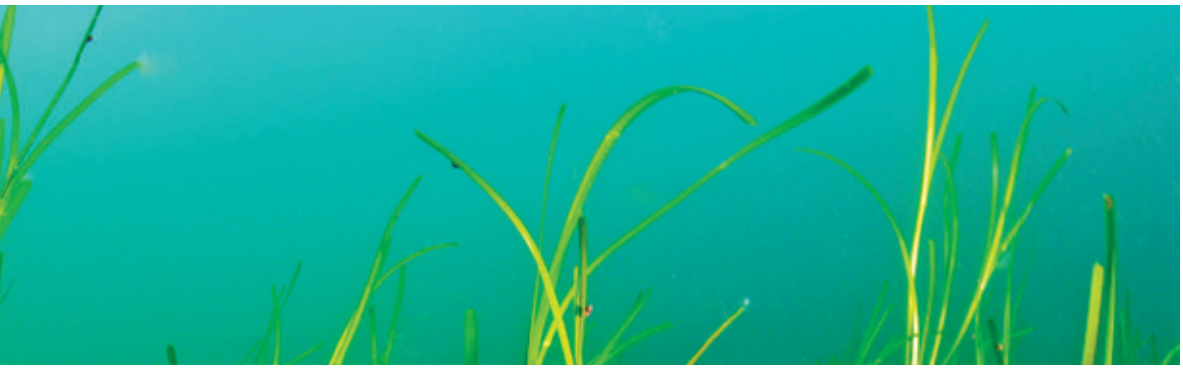
Barnacles (*Balanus crenatus*) and hydrozoans (*Clava multicornis*) on horse mussels (*Modiulus modiolus*). Ven, Sweden. © OCEANA/ Carlos Minguell

BOX 1. Biodiversity monitoring in the Sound.

Monitoring is the backbone of any efficient protection and management measure. Information gathered via these programmes reveals short- and long-term changes in the marine environment and helps managers to adapt the needed measures. Monitoring programmes, for instance for water quality, pelagic productivity, macroalgae, benthic fauna, reefs, sandbanks and fish exist in both countries and some of these are carried out jointly, such as those for commercial fish stocks. These existing monitoring programmes could form a solid foundation for a coherent programme covering the entire Sound.

In Danish waters, monitoring of marine habitats and invertebrates is carried out under the NOVANA programme (Naturstyrelsen 2016). Coverage and distributions of seagrass and macroalgae are assessed annually. Soft-bottom fauna are surveyed every second year and the reefs and bubbling reefs found in the Sound every six years. Physiochemical parameters, plankton, pelagic productivity, and occurrence of environmentally dangerous substances in biota and sediments are monitored annually. In Sweden, a similar monitoring programme is carried out by Öresunds vattenvårdsförbund (ÖVF, The Sound Water Management Union), administrated by the county of Skåne. The programme includes annual monitoring of hydrography, plankton growth, bottom fauna, sediment, seagrass distribution, and environmentally dangerous substances in biota, as well as outlets from Swedish waterways into the Sound. In addition to these, Helsingborg has its own coastal control programme with 13 stations for monitoring the status of the bottom fauna, measurements of redox potential in sediment, organic hazardous substances and metals in sediment and organisms. The aim of these programmes is to follow environmental conditions and monitor how they develop. The results also help in identifying the main load sources and the underlying environmental problems, which can be used to direct management actions. For example, in Helsingborg, the programme has revealed a variety of issues, including

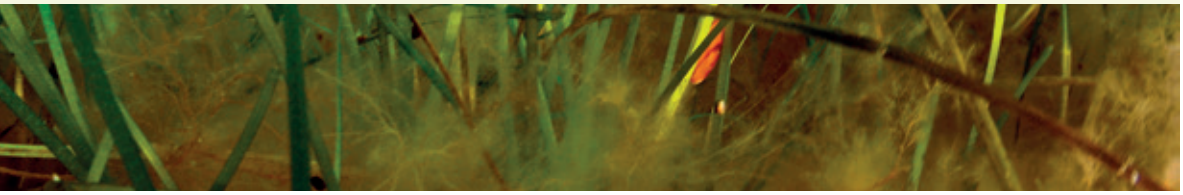




discharges of environmentally hazardous substances, lack of oxygen due to over-fertilisation, and the introduction of invasive species.

Commercial stocks of demersal fishes are surveyed twice per year as part of the Baltic International Trawl Survey (BITS), a standardised programme of bottom trawl surveys across the waters of the Baltic Sea. Surveys are carried out by countries' national research vessels. The main target species of these surveys are commercial demersal species, such as cod, flounder, and other flatfishes, although data about the abundance and distribution of other species have also been analysed as part of broader ecosystem studies (ICES 2014a). On average, three stations are sampled in the Sound during the first and fourth quarters of each year.

No monitoring programmes targeting non-commercial fish species and diversity exist, either in Denmark or Sweden, although two broad programmes include non-commercial fish within their scope. A volunteer project managed by National Institute of Aquatic Resources at the Technical University of Denmark (DTU Aqua) has been running since 2002, in which 2-3 stations have been fished annually in the Sound, with standardised gill and fyke nets that are normally used in recreational net fisheries (Kristensen *et al.* 2015). In addition, since 2009, a joint project managed by the Natural History Museum of Denmark (University of Copenhagen) in collaboration with DTU Aqua has focused on mapping all of the marine fish species in Danish waters (Atlas of Danish Fishes; fiskeatlas.dk). In Sweden, there is a coastal fish monitoring programme that covers a number of reference areas, including in the Sound. The purpose of this monitoring is to map the status of fish populations in these areas, to reveal natural variations in the populations and to capture changes that might indicate large-scale environmental threats like eutrophication, fishing, environmental pollutants and climate change (Svärd *et al.* 2016).



Eelgrass (*Zostera marina*) meadow. Southern Sound, Sweden.

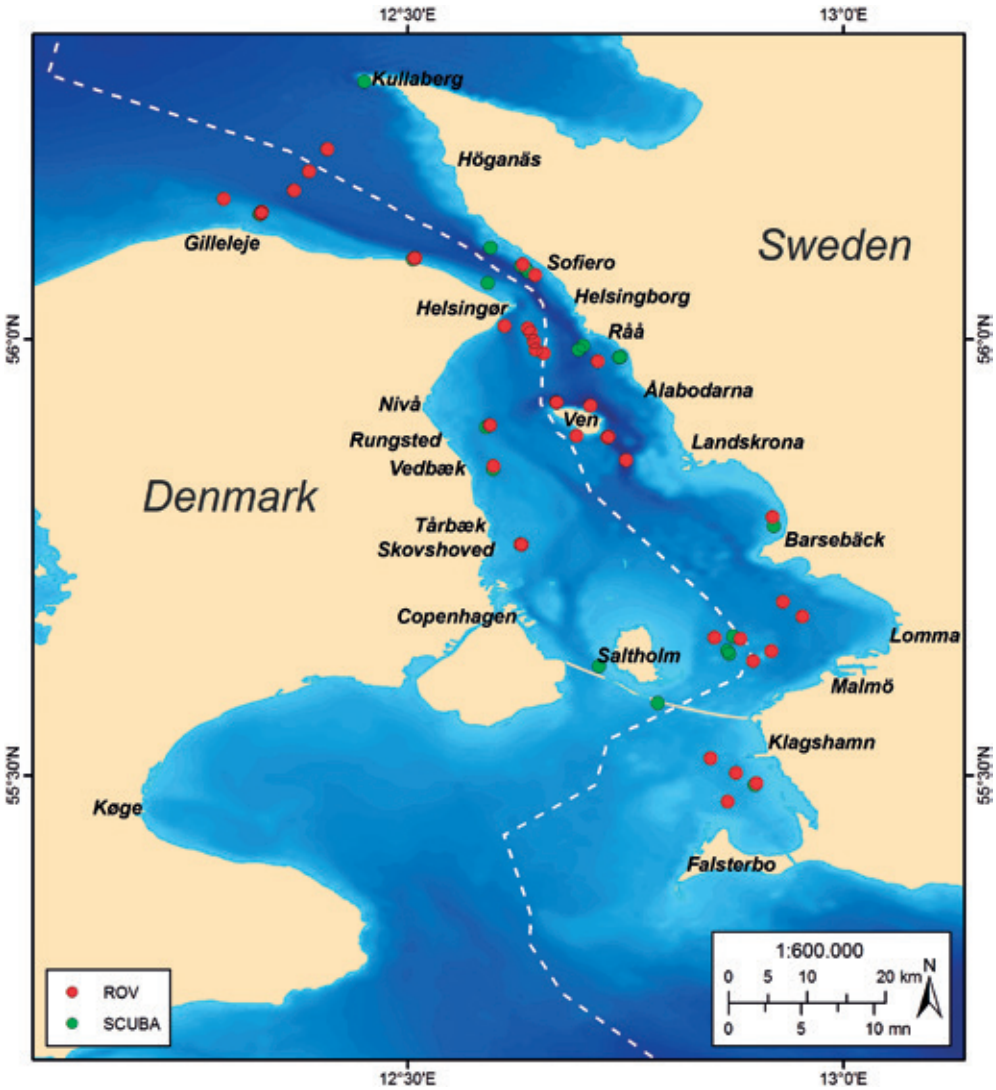
Methods

ROV hauling manoeuvre. Port of Malmö, Sweden. © OCEANA/ Carlos Minguell

Oceana surveyed the Sound during a three-week period (12-30 April 2016), in collaboration with SEA-U Marint Kunskapscenter (SEA-U) in Malmö.

Surveys covered 63 sites, from *Kullaberg* and Gilleleje in the North, to Falsterbo in the South (Fig. 9). Potential sites were chosen prior to the expedition based on scientific literature, grey literature, and consultation with local experts. This selection was aimed at capturing a diversity of areas and community types, including sites that were known or believed to be ecologically important (i.e., with high biodiversity or in good condition), and others where specific threats

Figure 9. Survey sites (n=63) from the Oceana 2016 expedition, where a total of 113 dives were carried out using a remotely operated vehicle (ROV) and SCUBA divers. Data sources: EEA, EMODnet.



were known or suspected to have occurred in the past or were ongoing. Unfortunately, due to poor conditions at sea during part of the sampling period, the time available for working in the southernmost part of the Sound was restricted; we were unable to survey as many southern sites as was originally planned, particularly around Køge Bay.

A total of 113 dives were carried out, at depths ranging from 2.8 m to 51.5 m, using two vessels, a remotely operated vehicle (ROV), and SCUBA divers, as described below:

a. ROV surveys

Surveys of the seabed and water column were carried out on-board the vessel *Popp*, a converted trawler measuring 12.96 m in length. Data were collected using a *Saab Seaeye Falcon DR* ROV, equipped with two forward-facing video cameras: (1) a high-definition camera with 1920x1080 resolution; 1/2.9" Exmor R CMOS Sensor, minimum scene illumination of 3-11 Lux, and a 4-48 mm, f/1.8-3.4 zoom lens; and (2) a low-definition camera with resolution of 540 TVL, 1/2" interline transfer CCD sensor, sensitivity of 0.35 Lux, and a 1/2" aspherical, wide-angle, fixed-focus lens. During ROV transects, *Popp* sailed at an average speed of 0.1-0.2 knots, filming both in high- and low-definition and simultaneously recording position, depth, course and time. Scientists on-board the *Popp* viewed the video feed in real time, to carry out preliminary species identification, and to select species, habitats, and seabed features of interest for more detailed investigation. In total, 41 dives were carried out, which yielded 18.5 hours of video of the seabed, over a distance of more than 9 km.

In one case, the robotic arm of the ROV was used to take a sample of a benthic organism (i.e., a mussel) to confirm the preliminary species identification done based on the live video feed.

b. SCUBA surveys

Visual data were also gathered by a team of professional SCUBA divers, working from the SEA-U dive vessel *Elias*. The team was composed of a photographer, a videographer, and three safety divers, and dives were done in teams of either two or four divers at a time. A total of 72 dives were done, producing high-definition video footage and 652 high-resolution (24 MP) still images.

Following the expedition, Oceana scientists analysed the high-definition videos from the ROV, and the video and still images from the SCUBA divers. All of the visible species were identified to the highest level of taxonomic resolution possible.

On 11 October 2016, Oceana held a stakeholder gathering in Malmö, in collaboration with SEA-U. Twenty-one participants attended, including representatives of municipal authorities, non-governmental organisations, small-scale fisheries, recreational fisheries, and academic institutions. During the gathering, the preliminary findings from the Oceana 2016 Sound expedition were presented, and participants discussed their implications, particularly in relation to how best to improve the management and protection of the Sound. The issues raised during the gathering are reflected in various sections of this report.

Whelk (*Buccinum undatum*). Grollegrund, Sweden. © OCEANA/ Carlos Minguell

Findings and Discussion

During the expedition, we documented nine broad types of habitats and communities and recorded approximately 200 species (Annex 2). This represents roughly one-fifth of the 1044 macro-species (i.e., species that are visible to the human eye) that have been registered in the Sound to date (HELCOM 2012). Taking into account that the use of ROVs and divers only permits identification of macrofauna and macrophyte flora, and is highly selective towards benthic and demersal species, the expedition has clearly provided a significant insight into the richness of marine life in the Sound. Among the documented species are many of significant ecological, commercial and recreational importance. Such species include fish such as cod, which has both commercial and recreational fisheries value, and habitat-building species such as horse mussels and blue mussels, which support a wide variety of marine life.

Our findings illustrate the unique composition of habitats and hydrology in the area, underlining the role of the Sound as a transition zone between the brackish Baltic Sea and saline North Sea. This transition can be seen from our observations ranging from the northern stone reef areas dominated by sugar kelp, oarweed, and nudibranchs that also inhabit the North Sea, to the southern sandbanks covered in seagrass and brackish water Hydrobiid snails, nine-spined sticklebacks, and Palaemonid shrimps.

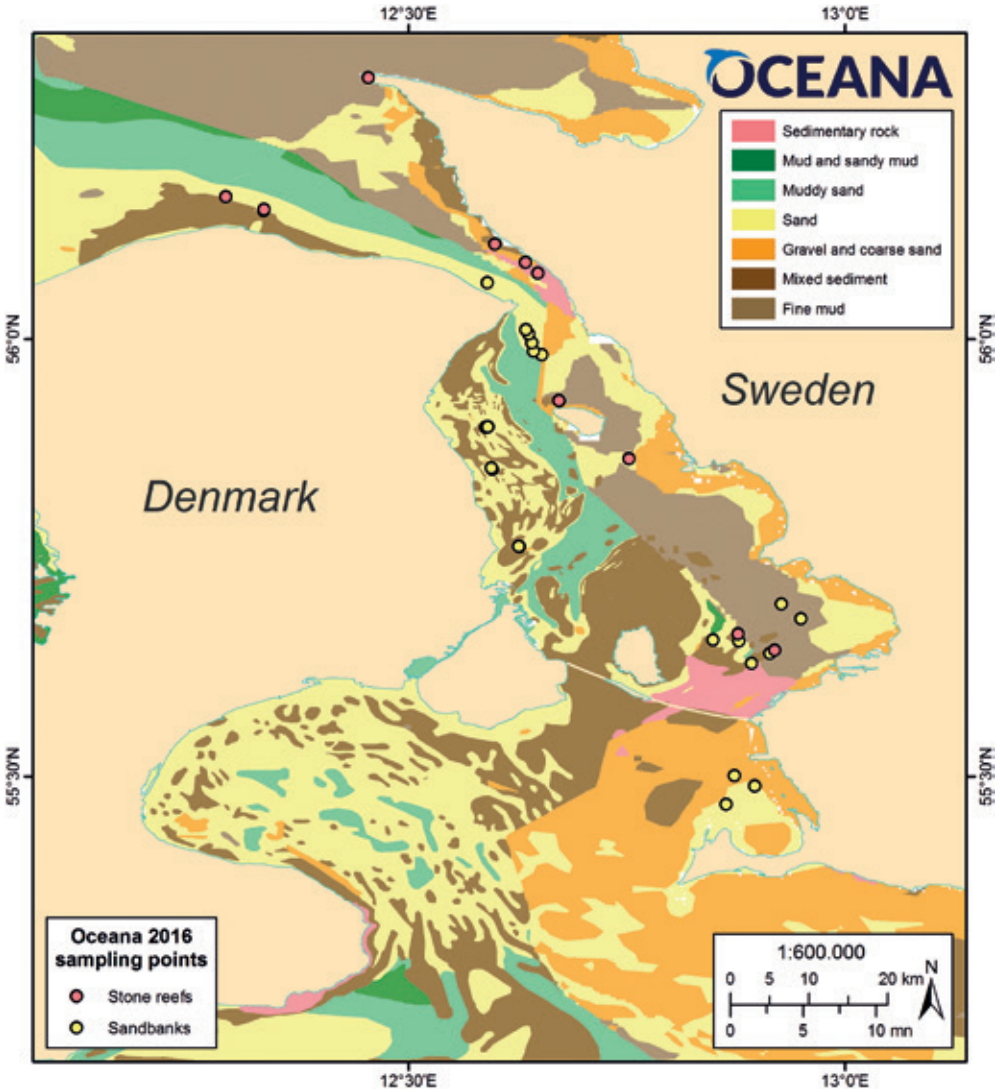
Ocean quahog (*Arctica islandica*). Gilleleje, Denmark. © OCEANA/ Carlos Minguell

Main habitats and communities recorded

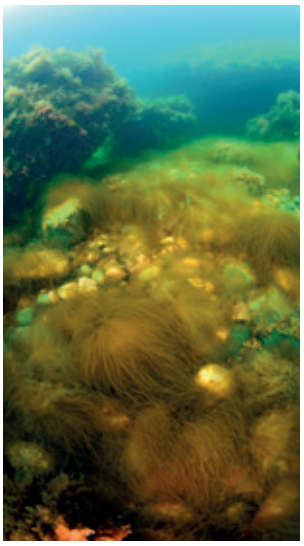
Stone reefs

We documented stone reefs off the Danish and Swedish coasts of the northern Sound by Gilleleje, *Kullaberg*, *Grollegrund*, and Sofiero, and in the central Sound around the island of Ven and to the east of Saltholm (Fig. 10). Most reefs are situated at 7-17 m depth, though the stone reefs to the southeast of Ven were found at depths of up to 46 m, close to the maximum depth of the Sound (53 m).

Figure 10. Oceana sampling points where stone reefs and sandbanks were recorded during the 2016 expedition. Data sources: EEA, EMODnet, Geological Survey of Denmark and Greenland.



On both the Danish and Swedish coasts, the stone reefs support dense kelp forests and other macroalgae. They provide living spaces for a variety of animals, like sea sponges, and mussels. The stone reefs serve as important refuge and feeding sites for fish, providing complex structures where shoals of cod (*Gadus morhua*), for example, gather (Støttrup *et al.* 2014). According to Almada *et al.* (1999), species of wrasses (Family Labridae) serve as a good indicator of reef quality, as they depend on this substrate for reproduction. Wrasses also serve as prey for commercially important fish, like cod, mackerel (*Scombrus scombrus*), saithe (*Pollachius virens*),



Stone reef with different species of algae in shallow water. Kullaberg, Sweden. © OCEANA/ Carlos Minguell

and whiting (*Merlangius merlangus*). During our surveys, we recorded the highest numbers of wrasses (*Ctenolabrus rupestris*, *Symphodus melops*) from reef areas near Gilleleje and Ven.

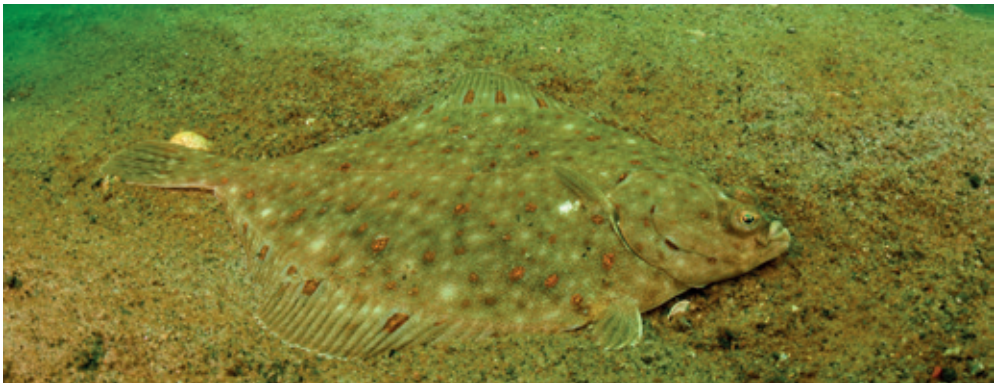
The deep reefs around Ven are surrounded by muddy seafloor, and harboured several species associated with hard-bottom substrate, such as dead man's fingers (*Alcyonium digitatum*) and sea urchins (*Echinus esculentus* and *Gracilechinus acutus*). The stone reefs, particularly those in the north and around *Grollegrund*, are well-recognised as being among the last remaining stone reefs in relatively good condition, which have been only slightly affected by human activities (Angantyr & Nordell 2007). The reefs also hosted dense kelps forests and blue mussel beds (see those sections for details of other species found from those areas).

As shown by Støttrup *et al.* (2014), loss or degradation of stone reefs may result in changes in trophic dynamics and impact trophic integrity in and around these habitat types. Therefore, it is important to ensure that these areas remain in good condition, as they may serve as key areas for many species in the Sound, and are central to producing and maintaining ecosystem services such as healthy fish stocks.

Sandbanks

Sandbanks were observed along the Danish coast from Lappegrund in the north to the island of Saltholm, and along the Swedish coast, from Lomma Bay to Falsterbo (Fig. 10). In addition, the bank known locally as 'Disken' (The Disc), situated just south of Helsingør and Helsingborg on the border between Danish and Swedish waters, was also surveyed. The sandbanks in the Sound were the shallowest areas visited during the expedition, with depths as shallow as 2.8 m.

The characteristics of the sandbanks differed between regions, and varied with the bathymetry. Epifauna of the sandbanks in the northern and central Sound were dominated by blue mussels, while the southern banks were dominated by seagrass and associated fauna (see *Seagrass* and *Blue mussels* for more details of associated species). During our surveys of the shallow sandbanks, we observed plaice (*Pleuronectes platessa*), dab (*Limanda limanda*), flounder (*Platichthys flesus*) and turbot (*Scophthalmus maximus*). The areas in and around Lappegrund and Disken are known hotspots for fishing for flatfishes, particularly plaice, flounder and dab. Brill and turbot are also frequently caught there (Sørensen *et al.* 2016). Both recreational and commercial fishers visit these areas in search of fish.



European plaice (*Pleuronectes platessa*). Ellekilde Hage, Denmark. © OCEANA/ Carlos Minguell

Surveyed sandbanks along both the Danish and Swedish coasts showed clear signs of human impacts, in particular from sand dredging. Along the Danish coast, more recent signs could be seen in Lappegrund, Disken, Rungsted, Vedbæk, and Skovshoved, while in Swedish waters, obvious signs of dredging could still be seen near Barsebäck (Lundåkra Bay), where dredging ceased in the 1950s. The approximately 7 m deep hole left in the seafloor was still intact. Similar holes in the seafloor from the dredging at Lappegrund were up to 10 m deep, increasing the depth from 7 m to 17 m below sea level. We observed an accumulation of algal debris in many of these holes. Such rotting algae can cause oxygen depletion, followed by the release of toxic hydrogen sulphide (Norkko & Bonsdorf 1996), which appears as white blankets of sulphuric bacteria covering the seafloor: the only visible life in these areas. In the Barsebäck site, the detritus that had accumulated over time made any visual investigation impossible in the dredging hole, because suspended particles reduced the visibility to zero. The coastal areas close to Barsebäck, Lundåkra and Lomma Bay are important breeding and nursery areas for fish, with the most abundant ones in the area being eel, eelpout, cod, and flounder (Sundqvist & Tärnlund 2015). Given that the hole near Barsebäck remains clearly visible sixty years after the dredging occurred, it seems highly unlikely that it will refill with sand and serve once again to support marine life, thus permanently devaluing this valuable fish habitat.

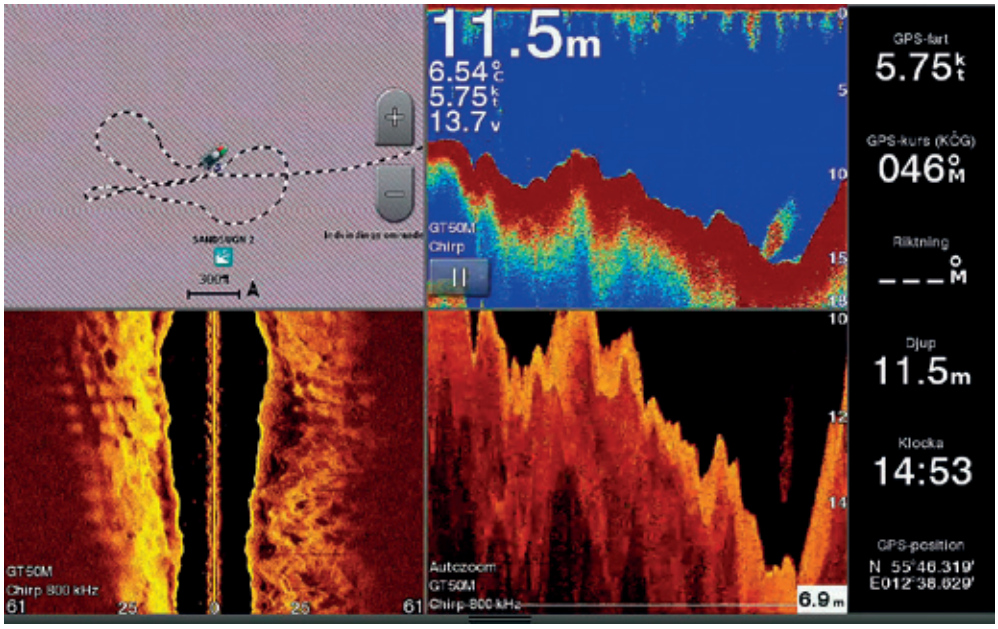


Image from the *Elias* depth sounder in a dredged area. The display in the lower right quadrant clearly shows the abrupt increase in depth at the edge of a dredging hole. © SEA-U Marint Kunskapscenter

In another site, we observed that even where sand has been removed in smaller quantities, the effects can nevertheless be lasting. In the Swedish waters of the southern Sound, we surveyed the seabed where a trench had been dug in 1980 to cover a gas pipe coming from the coast at Klagshamn. The trench, which in some places was 2 m deeper than the natural seabed, looked as though it had been created only recently. The seafloor there was mostly barren sand, in sharp contrast to the surrounding areas covered by blue mussels and eelgrass.

For many years, monitoring of dredged areas has been insufficient, both prior to and after dredging has taken place. As a result, it has been virtually impossible to quantify the real impacts of this destructive activity, To the best of our knowledge, Oceana's expedition was the first to obtain detailed visual documentation across so many historically and more recently dredged areas in the Sound. Counter to what has been suggested by some proponents of dredging – that dredged areas will simply refill with sand and recover over time – our findings point towards impacts that in some cases may last for at least decades. This observation is consistent with estimated timescales for recovery from intensive sand dredging in areas of low hydrodynamics as being on the order of decades, or not at all (ICES 2016a). Overall, our findings highlight the high risks associated with damaging, destroying, or entirely removing essential fish habitats that support the rich fish stocks of the Sound, including the iconic Sound cod and an array of flatfishes.

Blue mussel beds

Blue mussels (*Mytilus edulis*) were found throughout the survey area from north to south, on all kinds of substrates, excluding only the softest sediments. In some areas, blue mussels formed very dense beds, including the area near the Øresund bridge, Sjollen, and Ven in the central Sound, and *Grollegrund* in the northern Sound (Fig. 11). Smaller patches of mussel bed were also found in Skovshoved and Disken.

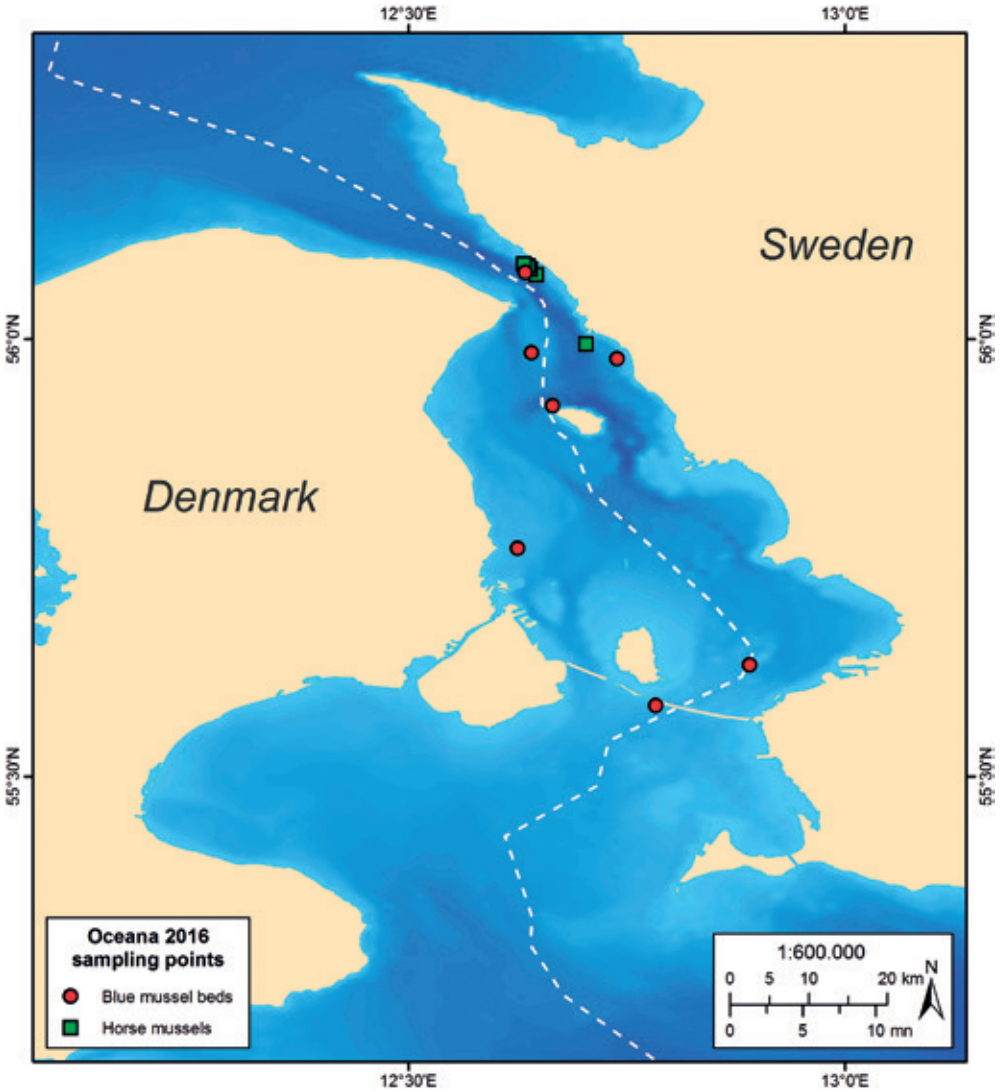
Rockpool prawn (*Palaemon elegans*) on top of blue mussels (*Mytilus edulis*). Øresund Bridge. © OCEANA/ Carlos Minguel

The most striking and extensive area of dense blue mussel bed was close to the Øresund bridge, where the mussels covered the entire seafloor and the submerged part of the bridge structure itself. In that area, the mussel beds appeared to be mostly in good health, and the visibility was very high due to the mussels filtering the water. Other species found there included shrimp (*Palaemon elegans*), isopod (*Idotea balthica*), bryozoan (*Membranipora membranacea*), hydroid (*Clava multicornis*), crab (*Carcinus maenas*), sea stickleback (*Spinachia spinachia*), two-spotted goby (*Gobiusculus flavescens*), flounder (*Platichthys flesus*), macroalgae (*Saccharina latissima*, *Pylaiella littoralis*, *Fucus vesiculosus*, *Chorda filum*, *Ulva lactuca*, *Litosiphon laminariae)* and barnacles.

Swedish waters to the north of Ven in the central Sound host a stone reef covered with blue mussels and red algae (*Delesseria sanguinea*, *Polysiphonia* sp.). We documented a variety of other species recorded on this mussel/stone reef, including sponge (*Halichondria panicea*), hydrozoan (*Obelia longissima*), goldsinny wrasse (*Ctenolabrus rupestris*), two-spotted goby (*Gobiusculus flavescens*) and eel (*Anguilla anguilla*).

We observed mixed blue mussel and seagrass beds (i.e., mixed *Zostera*/*Mytilus* stands) in both Sjollen and Råå in the central Sound. In Sjollen, these mussel beds were particularly dense. The association of eelgrass and blue mussels is a widespread occurrence, particularly in shallow waters such as those surveyed at the site (3-4 m) (Boström *et al.* 2003). Refer to the *Seagrass* section for a description of the other species observed in those areas.

Figure 11. Oceana sampling points where blue mussel (*Mytilus edulis*) beds and horse mussels (*Modiolus modiolus*) were recorded during the 2016 expedition. Data sources: EEA, EMODnet.



Horse mussels (*Modiolus modiolus*) with barnacles and algae. Northern Sound, Sweden. © OCEANA/ Carlos Minguell

Horse mussel beds

Horse mussels (*Modiolus modiolus*) were identified only from two locations in Swedish waters: *Knähaken* in the central Sound and Sofiero to the north, at depths of 14-26 m (Fig. 11). They were found only in fragmented clusters or as single specimens. In these places they formed biogenic reef substrates supporting a number of species such as sugar kelp (*Saccharina latissima*) and red algae (*Delesseria sanguinea* and *Polysiphonia* spp). Sofiero was characterised by species such as crabs (*Carcinus maenas*, *Pagurus bernhardus*); the shells of the latter species were accompanied by hydroids (*Hydractinia echinata*), sea snails (*Tritea reticulata*, *Neptunea antiqua*), common starfish (*Asterias rubens*), barnacles (*Balanus crenatus*), flounder (*Platichthys flesus*) and lesser pipefish (*Syngnathus rostellatus*). Brown algae, like *Chorda filum* and *Fucus serratus*, were also plentiful.

In *Knähaken* we recorded, among others, different species of nudibranchs (*Flabellina lineata*, *Eubranchus tricolor*, *Cuthona nana*), as well as echinoderms (*Asterias ruben*, *Crossaster papposus*, *Ophiura albida*), hermit crabs (*Pagurus bernhardus*) and barnacles (*Balanus crenatus*). Other species included skeleton shrimp (*Caprella linearis*), sea snails (*Neptunea antiqua*, *Buccinum undatum*), queen scallop (*Aequipecten opercularis*), and dragonet (*Callionymus maculatus*).

Horse mussel reefs have been in decline in the Sound (HELCOM 2013e). The precise reasons are yet to be determined, but apart from bottom trawling, this community is threatened by eutrophication and climate change. The last remains should be effectively protected and their distribution regularly monitored. Our findings point towards the importance of expanding protection in Swedish waters to include the area off of Sofiero, which is not currently protected. For the long-term survival of this community type, it is also important to identify and study better the characteristics of potential nursery areas, as has been suggested may be the case for Sofiero.

Haploops communities

We documented *Haploops* during earlier Oceana expeditions in 2011 and 2012, from an area northeast of the island of Ven. During the 2016 expedition, we revisited the area but did not find traces of this endangered and important community (neither living individuals nor empty tubes). Instead, the area now appears to be dominated by brittle stars (*Amphiura filiformis* and *Ophiura albida*). Other species in this area at around 42-44 m depth included the soft coral dead man's fingers (*Alcyonium digitatum*), crabs (for instance, *Hyas coarctatus*, and *Pagurus bernhardus*), sea cucumber (*Psolus phantapus*), ocean quahog (*Arctica islandica*) and echinoderms like sea stars and sea urchins. We also recorded flatfish and cod in this deep area that resembles a much more 'typical' marine environment than other areas in the Sound.

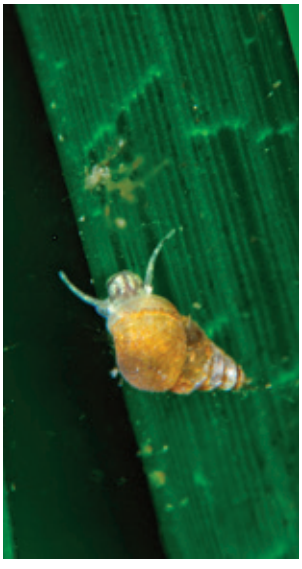
Though the area appeared to be diverse and full of life, our findings add to an already worrying trend about the decline of the *Haploops* community type in this area. During two previous Oceana surveys in the area surrounding Ven (the site of the only confirmed populations of *Haploops* in the area), we found contrasting results. Whereas we had documented the presence of these amphipods in 2011, in 2012, we found no sign of them, instead observing a potential community shift towards brittle stars. Our observations from the 2016 expedition appear to confirm this trend. This apparent community shift is consistent with earlier observations from the Sound and southeastern Kattegat, where associations dominated by *Amphiura filiformis* have replaced *Haploops* and other communities over time (Göransson 2002).

The current decline is not fully understood but it has been linked with a variety of anthropogenic factors such as nutrient enrichment and other pollution (Göransson *et al.* 2010). Beyond the known negative impacts of pollution and nutrient loading, a period with a sudden decline in *Haploops* distribution in the Sound around 2010-2011 coincided with an unprecedented abundance of subadult dab (*Limanda limanda*), for which *Haploops* is a valuable prey item. Thus, the sudden increase in predator density is thought to have induced the sudden decline of *Haploops* (Olesen *et al.* 2011). The decline was also discussed in the stakeholder conference, and one point raised was that the recruitment of the *Haploops* species might depend on communities in Kattegat, where they have been diminished by bottom trawling.

As the reasons for the *Haploops* decline are not fully understood, the situation deserves to be closely monitored, not only in the Sound but also in the known *Haploops* locations in Kattegat. The last remaining communities should be effectively protected, and potential restoration activities should be considered.

Seagrass beds

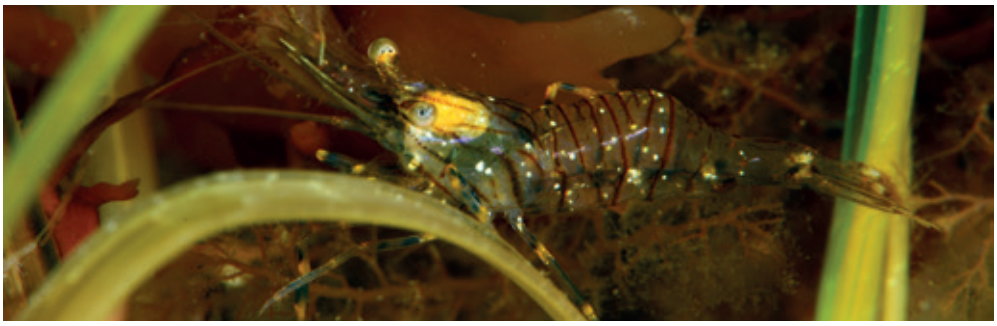
We documented seagrass beds in areas close to Råå, Barsebäck, Falsterbo, Klagshamn and Øresund bridge in Sweden, and Saltholm in Denmark, from depths ranging from 2.8-8.4 m (Fig. 12). In most suitable areas, and when in healthy condition, seagrass (*Zostera marina*) forms dense meadows, which provide essential habitats for other species, including various fish and birds (Gundersen *et al.* 2017). This could also be seen from our observations of the abundance of newly settled blue mussels and Hydrobiid snails



Sea snail on eelgrass (*Zostera marina*). Ålabodarna, Sweden.
© OCEANA/ Minguell

attached to the blades of the seagrass, as well as gobies, and crustaceans such as *Palaemon adspersus*, *Crangon crangon* and mysid shrimps. These meadows also hosted a range of specially adapted fishes, such as the needle fishes *Syngnathus rostellatus*, *S. typhle* and *Nerophis ophidion*.

Healthy seagrass meadows were recorded in the southern Sound, from the area between Klagshamn and Falsterbo, and were characterised by blue mussels (*Mytilus edulis*, mostly juveniles), common shrimp (*Crangon crangon*), isopods (*Idotea balthica*), lugworms (*Arenicola marina*) and red algae, like *Polysiphonia* sp., *Ahnfeltia plicata*, *Chondrus crispus*, *and Furcellaria lumbricalis*. Fish, such as sticklebacks (*Gasterosteus aculeatus*, *Pungitius pungitius*), pipefish (*Nerophis ophidion*, *Syngnathus typhle*) and gobies (*Pomatoschistus microps*, *Gobiusculus flavescens*) were also observed swimming amongst the plants.



Rockpool prawn (*Palaemon elegans*) in eelgrass (*Zostera marina*). Saltholm, Denmark. © OCEANA/ Carlos Minguell

In the central Sound around the island of Saltholm, we carried out surveys in two different types of seagrass habitats. The shallower waters (2-4 m) were characterised by healthy seagrass on blue mussel beds. Other species found from this area included red algae (*Polysiphonia* sp., *Delesseria sanguinea*, *Ahnfeltia plicata*) and brown algae (*Desmarestia aculeata*,) flounder (*Platichthys flesus*), and two-spotted goby (*Gobiusculus flavescens*). The Saltholm area also hosts dense seagrass meadows settled on sandbanks, and in these areas we recorded a number of other species as well, like various red algae (*Chondrus crispus*, *Furcellaria lumbricalis*, *Ceramium tenuicorne*), brown algae (*Desmarestia viridis*, *Pylaiella littoralis*), fish (*Zoarces viviparus*, *Platichthys flesus*, *Limanda limanda*), shrimp (*Palaemon elegans*), isopod (*Idotea balthica*), and common shrimp (*Crangon crangon*). The waters around Saltholm are included within a Natura 2000 area that is designated for the protection of sandbanks, reefs and seals, among other features.

On the Swedish side, also in the central Sound, seagrass meadows were also surveyed close to Råå. The seagrass in this area was found together with blue mussel beds and was smaller than some of the other areas where seagrass was filmed during this survey. Nonetheless, several other species were recorded, like flatfishes (*Platichthys flesus*, *Limanda limanda*), cockle (*Cerastoderma glaucum*), red algae (*Pylaiella littoralis*), and brown algae (*Chorda filum*), as well as hydrozoans and barnacles.

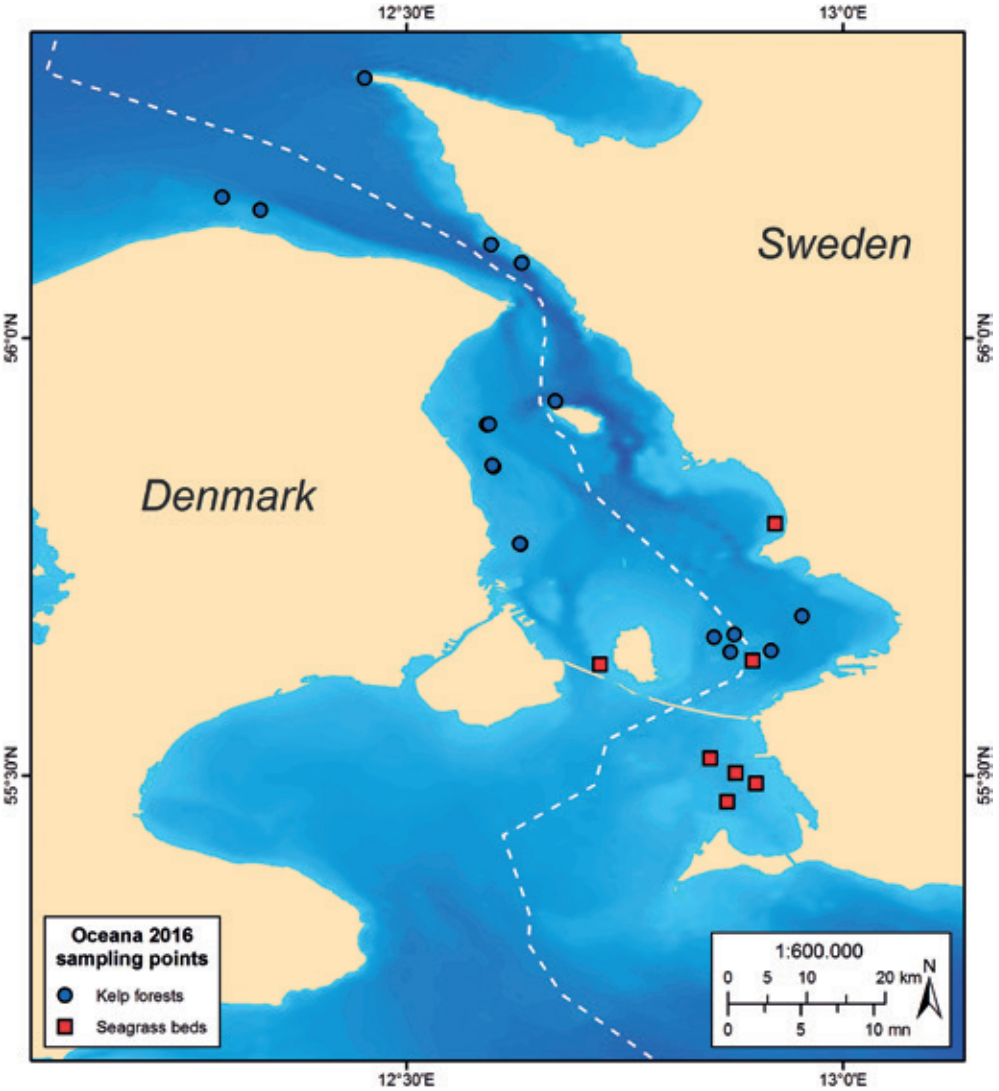
We also documented the presence of seagrass in areas that had been recently dredged (Lappegrund) and historically dredged (Barsebäck). In Lappegrund, where dredging still takes place, we only found sparse seagrass, and mostly bottoms dominated by sulphur bacteria. In Barsebäck, on the other hand, apart from the old dredged hole that still showed no visible life, we recorded many of the same species found from other seagrass areas, as well as a lumpfish (*Cyclopterus lumpus*).

Given the importance of seagrass beds as breeding, resting and feeding grounds for number of species, special consideration should be given to the protection of this habitat type. Seagrass beds are associated with sandbanks and therefore are granted some protection under the Natura 2000 network, but many areas where eelgrass thrives are not banks, but simply sandy bottoms, which therefore fall beyond the scope of the protection under the Habitats Directive.

Kelp forests

We recorded kelp forests in the northern and central regions, in both Danish and Swedish waters, and found individual kelp plants throughout the Sound (Fig. 12). Two species of kelp were recorded, oarweed (*Laminaria digitata*) and sugar kelp (*Saccharina latissima*). Oarweed requires higher salinities and was found only in the North, at depths of 11-17 m, from areas close to Gilleleje in Denmark and *Kullaberg* in Sweden. Sugar kelp was recorded in all regions and was also the most abundant species in those areas inhabited by both species. It was found at depths from 4-20 m, with an average depth of 11.6 m.

Figure 12. Oceana sampling points where seagrass beds (*Zostera marina*) and kelp forests (*Laminaria digitata, Saccharina latissima*) were recorded during the 2016 expedition. Data sources: EEA, EMODnet.



Goldsinny wrasse (*Ctenolabrus rupestris*) on kelp. Sjollen, Sweden. © OCEANA/ Carlos Minguell

We documented rich kelp forests at the stone reefs close to Gilleleje, where we also filmed the bubbling reef. The area was characterised by sandy bottom with patches of stones that hosted, apart from kelps, various other algae, including *Polysiphonia* sp., *Delesseria sanguinea*, *Dilsea carnosa*, *Chondrus crispus*, *Dilsea carnosa*, *Phycodrys rubens*, *Halidrys siliquosa*, *Phymatolithon laevigatum*, and *Ceramium virgatum*. Other abundant species included starfishes (*Asterias rubens*, *Henricia sanguinolenta*), hermit crab (*Pagurus bernhardus*), polychaetes (*Arenicola marina*, *Spirorbis spirorbis*, Serpulidae), sponges (*Halichondria panicea*, *Haliclona oculata*), whelk (*Buccinum undatum*), hydroids (*Hydractinia echinata*, *Dynamena pumila)*, barnacles *(Balanus balanus)*, jellyfishes *(Cyanea lamarckii*, *Aurelia aurita*), comb jelly *(Bolinopsis infundibulum*), goldsinny wrasse (*Ctenolabrus rupestris*), gobies (*Gobiusculus flavescens*, *Pomatoschistus minutus*, *P. microps*, *P. pictus*, *Gobius niger*), and dab (*Limanda limanda*). Also in the northern Sound, in *Grollegrund* and Sofiero, we documented dense sugar kelp forests mixed in places with blue mussels and other macroalgae (in particular *Fucus serratus*, but also *Phycodrys rubens*, *Delesseria sanguinea*, and *Polysiphonia* sp.). Other species found here included flounder (*Platichthys flesus)*, longspined bullhead (*Taurulus bubalis*), crabs (*Carcinus maenas*, *Pagurus bernhardus*), whelk (*Buccinum undatum*), periwinkle (*Littorina littorea*), bryozoan (*Electra pilosa*) and barnacles (*Balanus crenatus*).

In the central Sound, kelps formed dense forests in the areas of Ven, Lomma and Sjollen in Swedish waters. Other species recorded in these areas included other algae (*Delesseria sanguinea*, *Membranoptera alata*, *Phycodrys rubens*, *Coccotylus brodiei*, *Polysiphonia* sp., *Pylaiella littoralis*, *Polyides rotundus*, *Furcellaria lumbricalis*, *Hildenbrandia rubra)*, mussels *(Mytilus edulis)*, hydrozoans *(Obelia longissima*, *Halecium halecinum*, *Clava multicornis*), polychaetes (*Spirorbis spirorbis*), sponges (*Suberites ficus*, *Halichondria panacea*), shrimps (*Crangon crangon*, *Palaemon* sp.), periwinkle (*Littorina littorea*), wrasses *(Ctenolabrus rupestris*, *Symphodus melops*), and gobies (*Gobiusculus flavescens*, *Gobius niger*, *Pomatoschistus microps*).

Long-spined sea scorpion (*Taurulus bubalis*). Northern Sound, Sweden. © OCEANA/Carlos Minguell

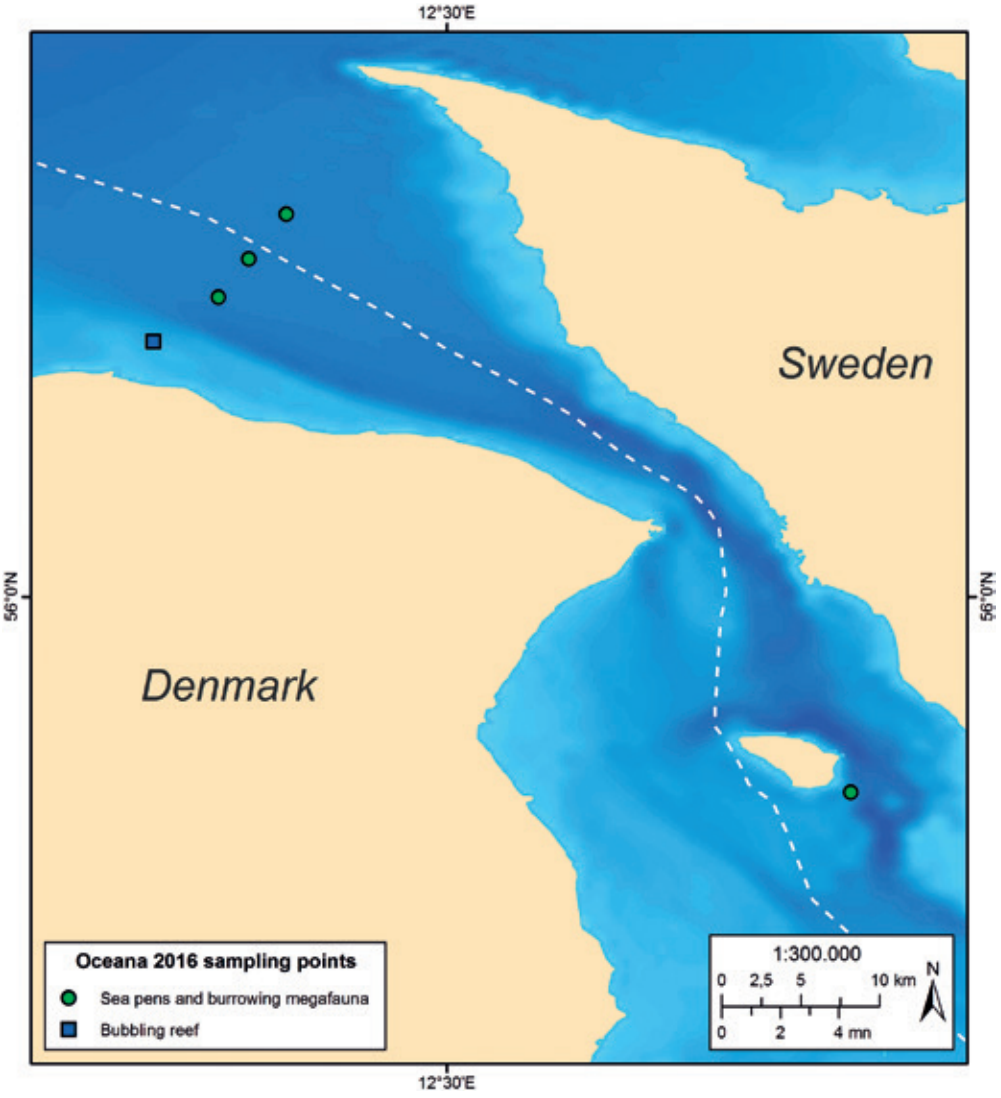
Smaller patches of sugar kelp forests were also recorded in Nivå Bay, outside Rungsted on the Danish side, with other macroalgal species (*Phycodrys rubens*, *Delesseria sanguinea*, *Ceramium virgatum)*, ocean quahog *(Arctica islandica*), polychaete (*Spirorbis spirorbis*), tunicate (*Ciona intestinalis*), starfishes (*Asterias rubens*, *Luidia atlantidea*), brittle star (*Ophiura albida*), sponge (*Halichondria panicea*) and gobies (*Pomatoschistus* sp., *Gobiusculus flavescens*). In the dredged area outside Vedbæk, we recorded some small patches of sugar kelps with few other creatures. Instead, we recorded a lot of algae debris and sulphur bacteria. Similar smaller patches were recorded in the area outside Skovshoved.

Like the seagrass beds that are associated with sandbanks, kelp forests are associated with a habitat type that is listed under the Habitats Directive: stone reefs. However, not all rocky bottoms where kelps are found are reefs, and therefore this habitat type is at risk of being under-represented in the current protected area network in the Sound. Due to their important role in sustaining and maintaining the functioning of the ecosystem, special attention should be given to kelp forests when developing and implementing protection measures and management plans.

Bubbling reef and surrounding area

We documented a small bubbling reef outside Gilleleje, which lies inside the *Gilleleje Flak* Natura 2000 area (Fig. 13). We also searched for other potential bubbling reefs in the area, but were unsuccessful. The area consists mainly of sandy bottom, scattered small stone reefs, and stones that host dense kelps (mostly oarweed, *Laminaria digitata*) as well as other algae at around 10 to 20 m depth. Sandy bottoms hosted seagrass (*Zostera marina*) meadows, flatfish (*Limanda limanda* and *Platichthys flesus*) as well as blue mussels (*Mytilus edulis*). Softer bottoms were home to species like common whelk (*Buccinum undatum*), hermit crab (*Pagurus bernhardus*), common littoral crab (*Carcinus maenas*), and flounder (*Platichthys flesus*).

Figure 13. Oceana sampling points where bubbling reef and sea pen and burrowing megafauna communities were recorded during the 2016 expedition. Data sources: EEA, EMODnet.



All in all, this area is rich in biodiversity with a variety of habitats in a relatively small area, making it unique and in need of proper management. The trawling ban that is currently in place in the Sound does not cover the bubbling reef or the area around it, as it lies just outside the northern limit of the Sound, in southern Kattegat. Because of their fragility, Denmark has already prohibited all types of fishing in the immediate vicinity of bubbling reefs within other Natura 2000 areas. Similar protection should be granted to the bubbling reef in *Gilleleje Flak*, as well as any others that may also occur in the same vicinity.

Sea pens and burrowing megafauna

We documented sea pen communities formed by both common and slender sea pens (*Pennatula phosphorea* and *Virgularia mirabilis*) at the northernmost part of the Sound, in the area known as 'Kilen' (see Fig. 13), at depths of 23-26 m. We also recorded common sea pens in the area next to Ven in the central Sound, at 24 m depth, which is consistent with what is known about the depth and salinity limitations of this community type.

As is characteristic of sea pen communities, the Kilen area was inhabited by burrowing megafauna, such as Norway lobster (*Nephrops norvegicus*), with many holes visible in the seabed. Besides these characteristic species, various species of fish were recorded in this area, of which the most numerous were dab (*Limanda limanda*) and different species of dragonets (*Callionymus* sp). One of the dragonet species observed was *C. reticulatus*, which has only been recorded in Danish waters a few times previously (H. Carl, pers. comm., 2016).

Despite the known vulnerability of sea pens to physical disturbances, and in particular, bottom trawling, the main area in which they were found is the only part of the Sound that is excepted from the long-standing ban on trawling. At one site we surveyed within this area, trawling marks were clearly visible on the seabed. Given the rarity and importance of this community in the Sound, we recommend extending the year-round bottom trawling ban also to the Kilen area, in order to conserve the only known, large sea pen and burrowing megafauna community in the Sound.

"During the expedition, we recorded species typical of both marine and brackish waters, underscoring the nature of the Sound as a transition zone between the Kattegat and the North Sea, and the Baltic Sea"

Other species of interest

During the expedition, we recorded species typical of both marine and brackish waters, underscoring the nature of the Sound as a transition zone between Kattegat and the North Sea, and the Baltic Sea.

For example, marine species such as oarweed, common sea pens and sea anemones, nudibranchs (*Flabellina lineata*, *Dendronotus frondosus* and *Eubranchus tricolor*), prawns (*Pandalus montagui*) and fishes such as the reticulated dragonet (*Callionymus reticulatus*), Norway pout (*Trisopterus esmarkii*) and poor cod (*T. minutus*), were found only as far south as the area around Ven Island. Here, in the deepest part of the Sound, the snakeblenny (*Lumpenus lampretaeformis*) was also found. This species is mostly associated with marine waters, but also has a relict population in

the Baltic Sea. On the other hand, species adapted to brackish waters such as lagoon cockle (*Cerastoderma glaucum*), Hydrobiid snails and sticklebacks (*Pungitius pungitius*, *Gasterosterus aculeatus* and *Spinachia spinachia*) were observed in the central and southern Sound.

We documented various species of commercial interest, from sites and habitat types throughout the Sound. Fishes such as cod (*Gadus morhua*), plaice (*Pleuronectes platessa*), turbot (*Scophthalmus maximus*), flounder (*Platichthys flesus*), lemon sole (*Microstomus kitt*), dab (*Limanda limanda*) and lumpfish (*Cyclopterus lumpus*) were recorded, and alternative target species as shrimps (*Palaemon adsperus*, *P. elegans* and *C. crangon*) and whelk (*Buccinum undatum*) were commonly encountered. The importance of the Sound's variety of habitats for commercial fish is well-recognised, with some species using different habitats during different life history stages. As noted by Sørensen *et al.* (2016), there are very few areas in the Sound that do not represent fish habitat for at least one of the major commercial species at any given time.

Male lumpfish (*Cyclopterus lumpus*) swimming in eelgrass (*Zostera marina*) meadow. Central Sound, Sweden.
© OCEANA/ Carlos Minguell

We also documented the invasive round goby (*Neogobius melanostomus*) on the Swedish coast, just south of the Øresund Bridge. Since it was first recorded in the Gulf of Gdansk, Poland, in 1990 (Skóra & Stolarski 1993), this fish has spread throughout the Baltic Sea, including to the Sound (Azour *et al.* 2015; H. Carl, pers. comm., 2016). Throughout its distribution range in the Baltic Sea, it has established dense populations, with negative impacts on local shrimp fisheries, and on commercial and recreational eel catches (Azour *et al.* 2015). During our stakeholder event, it was discussed that commercial fishermen have speculated that increased turbot catches from Køge Bay are due to increased food availability, as a result of the high densities of round goby.

Recommendations

Nudibranch (*Eubranchus tricolor*).
Central Sound, Sweden.
© OCEANA/ Carlos Minguell

The Sound is widely recognised as being unique and valuable, due to its rich mosaic of habitats within a relatively small area. For this reason, it has been a priority area for protection for Oceana for the last six years. With the aim of supporting conservation and management, we have gathered data across a range of depths, substrates, and marine community types in the Sound, during four at-sea research expeditions since 2011. Even within this short time frame, we have witnessed worrying trends, such as the apparent disappearance of the *Haploops* community, and the poor status of horse mussel communities.

In order to secure the survival of these and other key species and habitats, it is essential that Denmark and Sweden put in place stronger, transboundary protection measures. This need was reconfirmed by the participants of the stakeholder gathering, where it was concluded that current monitoring and protection are not sufficient to ensure the protection of the Sound's marine biodiversity, and that protection and management should be based on a holistic approach that will safeguard all of the key species. It was recommended that this would best be achieved by establishing a transboundary MPA to protect not only the special marine environment, but also the ecosystem goods and services that it provides, including fisheries, recreation, tourism, and cultural values, for the people who live on both sides of the strait.

Specifically, this joint Danish/Swedish MPA should:

- Be built on existing measures of protection, like the long-standing trawl ban and existing MPAs, but consolidate these within one overarching framework.

- Be underpinned by a transnational management plan that covers all of the key habitats and species (not only the ones required by the Habitats Directive) and addresses all human activities.

- Cover the entire Sound. There is a general consensus that the central and northern Sound are the most valuable zones, but that the southern Sound should also be included in the MPA, to ensure the conservation of the full range of biodiversity throughout the area.

- Ensure consistent management, such that the same rules are followed on both sides of the Sound. At present, management of the area is done primarily by the local and regional authorities. It was the view of stakeholders that Sweden has carried out this duty better than Denmark, where the communes do not have similar management or regulatory powers, and economic interests are often valued over protection.

The expected benefits of the transboundary MPA include:

- Extending protection to marine species and habitats that are also valuable but not explicitly protected by most of the MPAs in the Sound (e.g., soft-bottom habitats and associated species).
- Ensuring the survival and recovery of threatened species and habitats, including the horse mussel and *Haploops* communities.
- Maintaining abundant and healthy fish stocks on a long-term basis, through the protection of essential fish habitats, thereby also supporting sustainable fisheries in the Sound and, in some cases, adjacent waters.
- Enhancing tourism and recreational activities in the area.
- Maintaining the cultural values and identity of the region, which have developed over centuries and depend on the ecosystem services provided by the Sound.

Specific recommendations

1. Species and habitats

One conclusion made at the stakeholder event was that better coherence among the protected areas is crucial, and will enhance the protection of habitats and species that are not covered by the Habitats Directive, and are therefore underrepresented in the existing protected areas, like the soft-bottom habitats. Our expedition findings also support the need to safeguard these areas and it is recommended that:

- The conservation of *Haploops* and horse mussels should be a high priority, because both of these habitat-building species are under stress.
- In order to save the last remnants of the *Haploops* and horse mussel communities, as well as other important communities and species present in the Sound, they should be protected from all forms of impacts to the seafloor.
- The suspected breeding area for horse mussels near Knähaken and Sofiero should be strictly protected and better studied.
- The year-round prohibition on towed fishing gear should be extended to Kilen, to protect the threatened sea pen and burrowing megafauna community.

Whelk (*Buccinum undatum*) eggs. Kullaberg, Sweden.

European flounder (*Platichthys flesus*) in eelgrass (*Zostera marina*). Saltholm, Denmark. © OCEANA/Carlos Minguell

For features that are covered by the Habitats Directive, the main recommendations include:

- Prohibit all fishing in the area around the bubbling reef in Gilleleje Flak, such as has already been done for other bubbling reefs inside Danish Natura 2000 areas, to ensure the persistence of this fragile habitat.
- Continue to restore stone reefs that have been damaged or destroyed, as they form one of the most important fish habitats in the Sound.
- Prohibit sand extraction from the sandbanks, given that the damage and destruction of this important habitat may be permanent.

Identified needs for better research and monitoring of species and habitats include:

- Research to better understand the drivers of decline in *Haploops* and horse mussel communities, and to search for possibilities for rebuilding and recovery.
- Further studies in the northern Sound to locate other potential bubbling reefs.
- Better monitoring in general, including all of the keystone features and shallow water habitats; this was one of the recommendations raised in the stakeholder event.
- Make better use of the data collected through the current suite of monitoring programmes, in order to identify trends and changes in the environment, to be able to quantify the impacts of various human activities, and to design appropriate management measures.

2. Fisheries

At the stakeholder event, it was agreed that the current fisheries management measures in the Sound are generally sufficient to protect local stocks, but that fisheries pose a threat towards certain other species and habitats. Therefore, it is recommended to:

- Extend the trawling ban to include Kilen year-round, rather than only during two months of the year. This area hosts threatened sea pens and burrowing megafauna communities and is the only known location in the Sound where this community is thriving.
- Implement strict fisheries management measures, first for all existing MPAs, and second, to areas outside MPAs that are known to host key species and habitats, such as the ones discussed in this report, to ensure their long-term persistence.
- Improve monitoring and information about recreational fishing on both sides of the Sound. Data on numbers of fishers and their catches are needed in order to be able to more accurately assess the status of stocks and inform management.
- Maintain and strengthen control of illegal trawling in the Sound.

3. Sand dredging

Sand dredging is considered to be the single most destructive human impact in the Sound, causing severe physical damage to the seafloor. Moreover, there is a strong overlap between essential fish habitats and the main dredged areas in the Sound (Sørensen *et al.* 2016). Dredged holes may remain intact even for decades, and it appears likely that the recovery of this habitat is slow or non-existent. Therefore, it is recommended to:

- End all dredging in the Sound, to safeguard the shallow water sandbanks and the valuable habitat they provide. This point was the main conclusion from the stakeholder gathering.
- Protect and effectively manage the sandbanks that remain in a natural condition.
- Better monitor the established dredging areas, to identify measures that could be taken for restoring the habitat.

"It is recommended to end all dredging in the Sound, to safeguard the shallow water sandbanks and the valuable habitat that they provide"

4. Maritime traffic

To better manage the threats and impacts posed by the intensive maritime traffic in the Sound, it is recommended to:

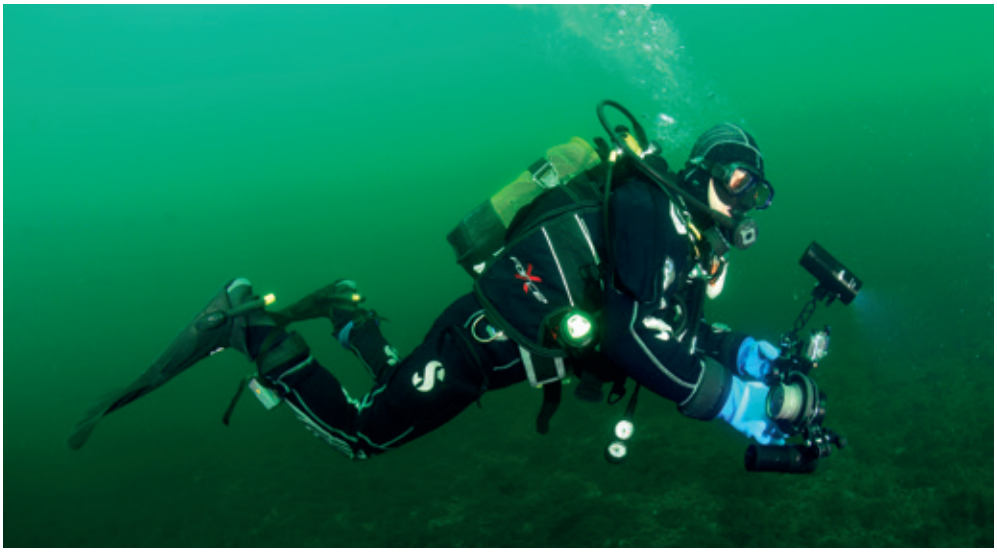
- Improve traffic control by imposing speed limitations on maritime traffic in the entire Sound, and increasing the allowed sailing distance from the coast, to minimise physical impacts on the coast and seafloor habitats. This was one of the recommendations put forward at the stakeholder event. It was noted, though, that precaution must be applied, so that the problem is not simply shifted to the Great Belt.

- Re-evaluate current anchorage areas, and prohibit anchorage in highly valuable or sensitive ecological areas.
- Restrict and better monitor the activities carried out on-board anchored vessels, to avoid the release of pollutants to the water (e.g., from maintenance work).
- Raise awareness among leisure sailors, making them more aware of their impacts on nature.
- Assess the potential impacts of growing cruise tourism in the Sound, to ensure that undue stress is not placed on the marine environment as a result of this sector.

Achieving effective protection

There is growing public momentum for the protection of the Sound. At the stakeholder event it was evident that there is a lot of political will in both countries, but that closer communication between stakeholders and authorities in the region is needed in order to push this project through. From a broader perspective, this momentum provides a valuable opportunity for both Denmark and Sweden to leverage their profile as leaders in transnational marine protection and management, in Europe and worldwide. Globally, there are few examples of this type of transboundary marine protection, and the Sound could serve as a stellar model for the creation of other similar areas in the Baltic and North Seas, and throughout Europe.

The well-established transboundary collaboration between Denmark and Sweden (Nauwalaers *et al.* 2013) and their long-lasting tradition of cooperation on the Sound environment would form a solid foundation for this work. For instance, for over 30 years the Danish and Swedish municipalities, counties and provinces that surround the Sound have been collaborating under a joint agreement, first under the Sound Commission, and since 1995 under the 'The Sound Water Cooperation'. The aim of this agreement is to work towards a healthy marine environment in the Sound.



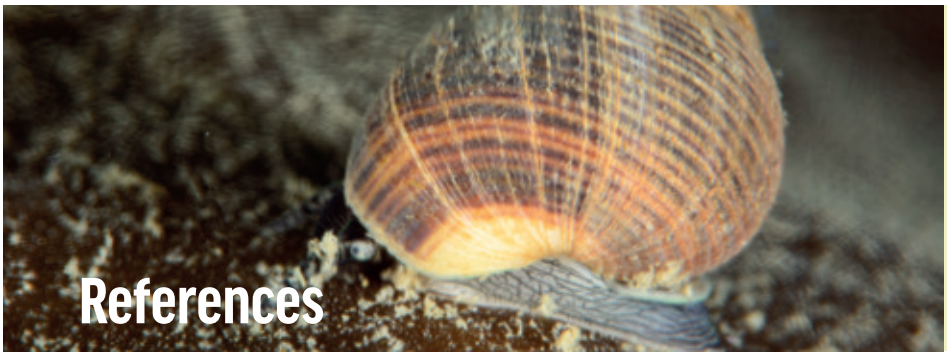
Oceana videographer in Sjollen, Sweden.
© OCEANA/ Carlos Minguell

Green crab (*Carcinus maenas*). Gilleleje, Denmark.
© OCEANA/ Carlos Minguell

A more informal consortium, the 'Öresunds group', has also been developing joint proposals for the protection and improved management of the Sound. Oceana is a member of this group, alongside Danish and Swedish representatives from different fields. It includes: other environmental NGOs, like Danmarks Naturfredningsforening, WWF and Greenpeace; fisheries organisations, like small-scale coastal fisheries (Skånsomt kystfiskeri), recreational fisheries organisations, and fishing tour operators; tourism and private business representatives, like the Blå Planet aquarium in Copenhagen and the outdoor activity board (Friluftsrådet); scientific institutions, like the University of Copenhagen; educational organisations, like SEA-U Marint Kunskapscenter; and local and regional authorities, such as from the city of Copenhagen and from Skåne county administration. The aim of the group is to develop recommendations by consensus that can be used as a basis for conservation and management.

The Natura 2000 sites, and other, already-established protected areas in the Sound make up the core for the proposed MPA, both in the proposal put forward by Oceana and the one produced jointly by the Öresunds group. The legal protection of the entire strait, however, could be achieved through a variety of frameworks, and various potential modes of protection were put forward at the stakeholder gathering. One option under consideration is to designate the Sound under the UN Biosphere Reserves programme. Sweden also has experience in managing the transnational Kosterhavet marine national park with Norway, and this option should also be further studied. Other alternatives include the Natura 2000 network, which covers a limited number of species and habitats, although it does offer them strict protection. Denmark and Sweden also have the opportunity to improve protection of the Sound under the EU Marine Strategy Framework Directive; many of the aims of this directive offer good implementation opportunities in the region. These different protection modes are not necessarily mutually exclusive, but some practical problems could arise, for instance, due to different protection levels granted to national parks under Danish and Swedish laws. Another potential challenge relates to the differences in competence in Denmark and Sweden; in Sweden, the local and county administrations hold significant power over their marine areas, while in Denmark, those are mostly governed by the national government. Whatever protection scheme is finally decided it must also be clarified how the area is to be jointly designated, managed and monitored, given the differences in the governance structures in these two countries.

The aims of this collaborative effort should ultimately be to secure the ecological value of the entire Sound on a long-term basis, and to meet the need for better and coherent management and control of human activities across the region. Effective protection of the area could best be achieved by establishing a single transboundary marine protected area. This type of protection would also best safeguard the natural heritage of this unique area. It would also further support the local economies that depend on the waters and resources of the Sound, and facilitate sustainable blue growth in the region.



References

Common periwinke (*Littorina littorea*) on laminarian. Sjollen, Sweden. © OCEANA/ Carlos Minguell

Addington, L. 2016. Danish policy on marine extraction and the developments in extraction practice in Denmark. Nature Agency, Ministry of Environment and Food of Denmark. European Marine Sand and Gravel Group Seminar, 25 April 2016, Gdansk, Poland. Available from: www.ciria.org/EMSAGG/EMSAGG_conferences.aspxa

Almada, V.C., Henriques, M. and Gonçalves, E.J. 1999. Ecology and Behaviour of Reef Fishes in the Temperate North-Eastern Atlantic and Adjacent Waters. In: Almada, V.C., Oliveira, R.F. and Gonçalves, E.J., (Eds.). Behaviour and Conservation of Littoral Fishes. Lisbon: ISPA, pp. 33-68.

Angantyr, L.A. and Nordell, O. 2007. Fysiske forstyrrelser/Fysisk störning i Øresund. Copenhagen: Øresundsvandsamarbejdet.

Anonymous. 1932. Kommissionen med Danmark angående fiskeriförhållandena i det till Sverige och Danmark gränsande farvattnen. Stockholm, 31 December 1932.

Azour, F., van Deurs, M., Behrens, J., Carl, H., Hüssy, K., Greisen, K., Ebert, R., and Møller, P.R. 2015. Invasion rate and population characteristics of the round goby *Neogobius melanostomus*: Effects of density and invasion history. Aquatic Biology 24: 41-52.

Bergström, U., Ask, L., Degerman, E., Svedäng, H., Svenson, A., and Ulmestrand, M. 2007. Effekter av Fredningsområden på fisk och kräftdjur i svenska vatten. Finfo 2007:2.

Boström, C., Baden, S. and Krause-Jensen, D. 2003. The seagrasses of Scandinavia and the Baltic Sea. In: Green E.P., Short F.P., Spalding M.D., (Eds.). World Atlas of Seagrasses: Present Status and Future Conservation. Berkeley: UNEP, University of California Press, pp. 27-37.

Boström, C., Baden, S., Bockelmann, A.C., Dromph, K., Fredriksen, S., Gustafsson, C., Krause-Jensen, D., Möller, T., Nielsen, S.L., Olesen, B., Olsen, J., Pihl, L. and Rindek, E. 2014. Distribution, structure and function of Nordic eelgrass (*Zostera marina*) ecosystems: implications for coastal management and conservation. Aquatic Conservation 24: 410-434.

Carneiro, G. and Nilsson, H. 2013. The Sound water – Humans and nature in perspective. Books. Book 2. Available from: http://commons.wmu.se/mer_book/2

Council Regulation (EU) 2016/1903 of 28 October 2016 fixing for 2017 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Baltic Sea and amending Regulation (EU) 2016/72. Official Journal of the European Union L 295, 29.10.2016, pp. 1-10.

Cruise Copenhagen. 2017. Ports of Copenhagen. Available from: http://www.visitcopenhagen.com/cruisecopenhagen/copenhagen/ports-copenhagen

Dahl, K., Lundsteen, S. and Asger Helmig, S. 2003. Stenrev – havbundens oaser. (MiljøBiblioteket, Vol. 2). Copenhagen: Gads Forlag. Available from: http://www2.dmu.dk/1_viden/2_publikationer/3_miljobib/rapporter/mb02.pdf

Dahl, K., Støttrup, J.G., Stenberg, C., Berggreen, U.C. and Jensen, J.H. 2016. Best practice for restoration of stone reefs in Denmark (codes of conduct). Aarhus University, DCE – Danish Centre for Environment and Energy. Technical Report from DCE – Danish Centre for Environment and Energy No. 91. Available from: http://dce2.au.dk/pub/TR91.pdf

Danish Maritime Authority (DMA). 2017. Navigation through Danish waters. Version 12.0. Available from: http://www.dma.dk/Documents/Publikationer/Navigation Through Danish Waters FEB 2017.pdf

Diekmann, R., and Möllmann, C. (Eds.). 2010. Integrated ecosystem assessments of seven Baltic Sea areas covering the last three decades. ICES Cooperative Research Report No. 302.

Dinesen, G. and Morton, B. 2014. Review of the functional morphology, biology and perturbation impacts on the boreal, habitat-forming horse mussel *Modiolus modiolus* (Bivalvia: Mytilidae: Modiolinae). Marine Biology Research 10: 845-870.

Directive 94/25/EC of the European Parliament and of the Council of 16 June 1994 on the approximation of the laws, regulations, and administrative provisions of the Member States relating to recreational craft. Official Journal of the European Union L 164, 30.6.94, pp. 15-38.

Duarte, C.M. 2002. The future of seagrass meadows. Environmental Conservation 29: 192-206.

Fishing Zealand. 2016. Sandsugning bliver ikke fra Øresund. 13 December 2016. Available from: http://fishingzealand.dk/nyheder/sandsugning-bliver-ikke-fra-oresund/

Göransson, P. 2002. Petersen's benthic macrofauna stations revisited in the Öresund area (southern Sweden) and species composition in the 1990s - signs of decreased biological variation. Sarsia 87: 263-280.

Göransson, P., Bertilsson Vuksan, S., Karlfelt, J. and Börjesson, L. 2010. *Haploops* -samhället och *Modiolus* -smahället utanför Helsingborg 2000-2009. Miljönämnden i Helsingborg.

Gundersen, H., Bryan, T., Chen, W., Moy, F.E., Sandman, A.N., Sundblad, G., Schneider, S., Andersen, J.H., Langaas, S. and Walday, M.G. 2017. Ecosystem Services in the Coastal Zone of the Nordic Countries. TemaNord 2016: 552. Nordic Council of Ministers.

HELCOM. 1998. Red List of Marine and Coastal Biotopes and Biotope Complexes of the Baltic Sea, Belt Sea and Kattegat - Including a comprehensive description and classification system for all Baltic Marine and Coastal Biotopes. Baltic Sea Environment Proceedings No. 75. Helsinki Commission, Helsinki.

HELCOM. 1999. Marine Sediment Extraction in the Baltic Sea: Status report. Baltic Sea Environment Proceedings No. 76. Helsinki Commission, Helsinki.

HELCOM. 2007. HELCOM lists of threatened and/or declining species and biotopes/habitats in the Baltic Sea area. Baltic Sea Environment Proceedings No. 113. Helsinki Commission, Helsinki.

HELCOM. 2009. Biodiversity in the Baltic Sea – An integrated thematic assessment on biodiversity and nature conservation in the Baltic Sea. Baltic Sea Environment Proceedings No. 116B. Helsinki Commission, Helsinki.

HELCOM. 2010. Maritime Activities in the Baltic Sea – An integrated thematic assessment on maritime activities and response to pollution at sea in the Baltic Sea Region. Baltic Sea Environment Proceedings No. 123. Helsinki Commission, Helsinki.

HELCOM. 2012. Checklist of Baltic Sea Macro-species. Baltic Sea Environment Proceedings No. 130. Helsinki Commission, Helsinki.

HELCOM. 2013a. Red List of Baltic Sea underwater biotopes, habitats and biotope complexes. Baltic Sea Environment Proceedings No. 138. Helsinki Commission, Helsinki.

HELCOM. 2013b. Red List of Baltic Sea species in danger of becoming extinct. Baltic Sea Environment Proceedings No. 140. Helsinki Commission, Helsinki.

HELCOM. 2013c. Species Information Sheet, *Haploops tenuis*. Available from: http://www.helcom.fi/Red List Species Information Sheet/HELCOM Red List Haploops tenuis.pdf

HELCOM. 2013d. Biotope Information Sheet, Baltic aphotic muddy sediment characterized by sea-pens. Available from: http://www.helcom.fi/Red List of biotopes habitats and biotope complexe/HELCOM Red List AB.H2T1.pdf

HELCOM. 2013e. Species Information Sheet, *Modiolus modiolus*. Available from: http://www.helcom.fi/Redist Species Information Sheet/HELCOM Red List Modiolus modiolus.pdf

HELCOM. 2016. Baltic Sea Clean Shipping Guide 2016 - Information for mariners on environmental and safety of navigation measures in the Baltic Sea. Available from: http://www.helcom.fi/Lists/Publications/Baltic Sea Clean Shipping Guide 2016.pdf

HH Ferries. 2016. Helsingborg-Helsingör summer traffic off to a good start. [Press release]. 22 August 2016. Available from: http://hhferriesgroup.com/wp-content/uploads/2016/08/Sommertrafik-Nyhed-22-aug-2016-UK.pdf

ICES. 1991. Report of the Working Group on the Effects of Extraction of Marine Sediments on Fisheries, 14-17 May 1991, Stromness, UK. ICES CM 1991/E:13.

ICES. 1995. Report of the Working Group on the Effects of Extraction of Marine Sediments on Fisheries, 25-28 April 1995, Dublin. ICES CM 1995/E:5.

ICES. 1996. Report of the Working Group on the Effects of Extraction of Marine Sediments on Fisheries, 23-26 April 1996, Stromness, UK. ICES CM 1996/E:7.

ICES. 2014a. Manual for the Baltic International Trawl Surveys (BITS). Series of ICES Survey Protocols SISP 7 - BITS. Available from: http://www.ices.dk/sites/pub/Publication Reports/ICES Survey Protocols (SISP)/SISP 7 - Manual for the Baltic International Trawl Surveys (BITS).pdf

ICES. 2014b. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 3-10 April 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:10.

ICES. 2016a. Effects of extraction of marine sediments on the marine environment 2005-2011. ICES Cooperative Research Report No. 330.

ICES. 2016b. Latest advice – Advice 2016. Available from: http://www.ices.dk/community/advisory-process/Pages/Latest-Advice.aspx

ICES. 2016c. Report of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT), 18-21 April 2016, Gdansk, Poland. ICES CM 2016/SSGEPI:06.

ICES. 2016d. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 12-19 April 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:11.

ICES. 2017. Report of the Working Group on Recreational Fisheries Surveys (WGRFS), 6-10 June 2016, Nea Peramos, Greece. ICES CM 2016/SSGIEOM:10.

Jensen, P., Aagaard, I., Burke, R.A., Jr., Dando, P.R., Jørgensen, N.O., Kuijpers, A., Laier, T., O'Hara, S.C.M., and Schmaljohan, R. 1992. 'Bubbling reefs' in the Kattegat: submarine landscapes of carbonate-cemented rocks support a diverse ecosystem at methane seeps. Marine Ecology Progress Series 83: 103-112.

Jonsson, P.R., Cornell, H., André, C., Svedäng, H., and Moksnes, P.O. 2016. Recent decline in cod stocks in the North Sea-Skaggerak-Kattegat shifts the sources of larval supply. Fisheries Oceanography 25: 210-228.

Kaae, B. C., Olafsson, A.S., Draux, H. and Skov-Petersen, H. 2016. Værdien af havfriluftsliv: Den rekreative anvendelse af Øresund. Fremtidens Øresund, Copenhagen, 3 February 2016.

Kautsky, L. and Kautsky, N. 2000. Baltic Sea, including Bothnian Sea and Bothnian Bay. In: Sheppard, C.R.C (Ed.). Seas at the millennium: an environmental evaluation: 1. Regional chapters: Europe, The Americas and West Africa. Amsterdam: Pergamon. pp. 121-133.

Kjellerup, S., Nicolaisen, J.F., and Jensen, F.P. 2014. Naturstyrelsen - Fællesområdet 554-CA Disken: Miljøvurdering. Orbicon Project No. 362-1400168. Available from: http://svana.dk/media/179104/miljoevurdering-disken.pdf

Køie, M. and Kristiansen, A. 2000. Havets dyr og planter. Copenhagen: Gads Forlag.

Krause, J.C., Diesing, M., and Arlt, G. 2010. The physical and biological impact of sand extraction: A case study of the Baltic Sea. Journal of Coastal Research SI 51: 215-226.

Krause-Jensen, D., Sagert, S., Schubert, H. and Boström, C. 2008. Empirical relationships linking distribution and abundance of marine vegetation to eutrophication. Ecological Indicators 8: 515-529.

Kristensen, L.D., Støttrup, J.G., Andersen, S.K. and Degel, H. 2015. Registrering af fangster i de danske kystområder med standardredskaber: Nøglefiskerrapport 2011-2013. DTU Aqua Report No. 286-2014. Charlottenlund: National Institute of Aquatic Resources, Technical University of Denmark.

Lindegren, M., Diekmann, R., and Möllmann, C. 2010. Regime shifts, resilience, and recovery of a cod stock. Marine Ecology Progress Series 402: 239-253.

Linde-Lauresen, A. 2010. Bordering: Identity processes between the national and personal. London and New York: Routledge.

Lomholt, S., Riemann, B., Dahl, K., Pedersen, N.N., Leth, J.O., Göke, C., Rasmussen, M.B., Skar, S., and Andersen, O.N. 2015. Marin råstofkortlægning og miljøundersøgelseri Øresund 2014: Undersøgelse af 3 udvalgte områder i Øresund og 3 indvindingsområder: Lappegrund, Nivå Flak og Skovshoved. Geological Survey of Denmark and Greenland Report 2015/20. Available from: http://svana.dk/media/179106/nst-2014-raastof-og-miljoerapport.pdf

Mackenzie, B.R., Alheit, J., Conley, D.J., Holm, P., and Kinze, C.C. 2002. Ecological hypotheses for a historical reconstruction of upper trophic level biomass in the Baltic Sea and Skagerrak. Canadian Journal of Fisheries and Aquatic Sciences 59: 173-190.

Miljø- og Fødevareministeriet. 2016. Nyt stenrev ved Gilleleje nærmer sig. [Press release]. 8 September 2016. Available from: http://mfvm.dk/nyheder/nyhed/nyhed/nyt-stenrev-ved-gilleleje-naermer-sig/

Naturstyrelsen. 2013a. Blue Reef – restoration of stone reefs in Kattegat/ Restaurering af stenrev I Kattegat. Available from: http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=LIFE06_NAT_DK_000159_LAYMAN.pdf

Naturstyrelsen. 2013b. Marin kortlægning - Kortlægning af sandbanker og rev i 38 kystnære marine Natura 2000-områder 2012. Available from: http://www2.nst.dk/download/Udgivelser/Marin_kortlaegning.pdf

Naturstyrelsen. 2016. NOVANA – Det nationale program for overvågning af vandmiljø og natur 2016: Programbeskrivelse. Available from: http://naturstyrelsen.dk/media/194550/novana2016-programbeskrivelse.pdf

Nauwalaers, C., Maguire, K., and Ajmone Marsan, G. 2013. The case of Oresund (Denmark-Sweden) – Regions and Innovation: Collaborating Across Borders. OECD Regional Development Working Papers, 2013/21, OECD Publishing.

Newell, R.C., Seiderer, L.J., and Hitchcock, D.R. 1998. The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. Oceanography and Marine Biology: An Annual Review 36: 127-178.

Newell, R.I.E. 2004. Ecosystem influences of natural and cultivated populations of suspension-feeding bivalve molluscs: A review. Journal of Shellfish Research 23: 51-61.

NIRAS. 2015. Naturstyrelsen - Erhvervsøkonomisk analyse af råstofindvinding i Øresund. NIRAS Project No. 221426. Available from: http://svana.dk/media/179103/erhvervsoekonomisk_analyse_raastofindvinding_oeresund.pdf

Norden Andersen, O.G., Nielsen, P.E. and Leth, J. 1992. Effects on sea bed, benthic fauna and hydrography of sand dredging in Køge Bay, Denmark. Proceedings of the 12th Baltic Marine Biologists Symposium, Fredensborg, pp. 1-6.

Norkko, A., and Bonsdorf, E. 1996. Rapid zoobenthic community responses to accumulations of drifting algae. Marine Ecology Progress Series 131: 143-157.

Oceana. 2014. Oceana proposal for a marine protected area: The Sound. Oceana, Copenhagen. 12 p. Available from: http://oceana.org/sites/default/files/euo/OCEANA_The_Sound_3.pdf

Olesen, H.J., and Storr-Paulsen, M. 2015. Eel, cod, and seatrout harvest in Danish recreational fisheries during 2012. DTU Aqua Report no. 293-2015. Charlottenlund: National Institute of Aquatic Resources, Technical University of Denmark.

Olesen, M. 2011. The Sound as a common Swedish-Danish protected sea. European Maritime Day, 20 May 2011, Gdansk, Poland. Available from: https://ec.europa.eu/maritimeaffairs/maritimeday/sites/mare-emd/files/olesen_en.pdf

Olesen M., Johansen, S.B., Göransson, P. 2011. Øresunds unikke dyreliv er truet. Aktuel Naturvidenskab, 2, pp. 32-36.

Orth, R.J., Carruthers, T.J.B., Dennison, W.C., Duarte, C.M. 2006. A global crisis for seagrass ecosystems. BioScience 56: 987-996.

OSPAR Commission. 2008. OSPAR List of Threatened and/or Declining Species and Habitats. Available from: http://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats

OSPAR Commission. 2009. Background Document for *Modiolus modiolus* beds. Available from: http://qsr2010.ospar.org/media/assessments/Species/P00425_Modiolus.pdf

Örestat. 2012. Øresund Trends 2012. Örestat. Available from: http://www.orestat.se/sites/all/files/tendensoresund_english.pdf

Popescu, I. 2010. Fisheries in Sweden. Directorate General for Internal Policies, Policy Department B: Structural and Cohesion Policies. Fisheries. IP/B/PECH/NT/2010-03. Available from: http://www.europarl.europa.eu/RegData/etudes/note/join/2010/438579/IPOL-PECH_NT(2010)438579_EN.pdf

Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. Official Journal of the European Union L 354, 28.12.2013, pp. 22-61.

Skóra K.E. and Stolarski, J. 1993. New fish species in the Gulf of Gdańsk. *Neogobius* sp [cf. *Neogobius melanostomus* (Pallas, 1811)]. Bulletin of the Sea Fisheries Institute 1: 83-84.

Sørensen, T.K., Egekvist, J., Brown, E.J., Hansen, F.I., Carl, H., Møller, P.R., Dinesen, G., Vinther, M. and Støttrup, J. 2016. Kortlægning af fiskenes levesteder i den danske del af Øresund. Rapport til Miljø- og Fødevareministeriet. Available from: http://orbit.dtu.dk/files/120898229/Publishers_version.pdf

Spalding, M., Taylor, M., Ravilious, C., Short, F.T. and Green, F. 2003. Global overview: the distribution and status of seagrasses. In: Green, E.P. and Short, F.T. (Eds.). World Atlas of Seagrasses. Berkeley: UNEP World Conservation Monitoring Centre, University of California Press, pp. 5-26.

Sparrevohn, C.R., and Storr-Paulsen, M. 2012. Eel, cod, and seatrout harvest in Danish recreational fisheries during 2011. DTU Aqua Report no. 253-2012. Charlottenlund: National Institute of Aquatic Resources, Technical University of Denmark.

Støttrup, J.G., Stenberg, C., Dahl, K., Kristensen, L.D. and Richardson, K. 2014. Restoration of a Temperate Reef: Effects on the Fish Community. Open Journal of Ecology 4: 1045-1059.

Sundqvist, F., and Tärnlund, S. 2015 Faktablad – Resultat från övervakningen av kustfisk 2015:5-Barsebäck (Öresund) 1999-2015. Väröbacka: Department of Aquatic Resources, Swedish University of Agricultural Sciences.

Svärd, M., Johansen Lilja, T., Lewander, M., Karlsson, M., and Backteman, K. (Eds.). 2016. Havet – om miljötillståndet i Svenska Havsområden 2015/2016. Swedish Institute for the Marine Environment, SwAM, and SEPA. Available from: http://www.havsmiljoinstitutet.se/digitalAssets/1575/1575894_havet_2015_16.pdf

Svedäng, H. 2010. Long-term impact of different fishing methods on the ecosystem in the Kattegat and Öresund. Directorate General for Internal Policies, Policy Department B: Structural and Cohesion Policies. Fisheries. IP/B/PECH/IC/2010-24. Available from: http://www.europarl.europa.eu/RegData/etudes/note/join/2010/438585/IPOL-PECH_NT(2010)438585_EN.pdf

Swedish Agency for Marine and Water Management (SwAM). 2012. Marine tourism and recreation in Sweden: A study for the economic and social analysis of the initial assessment of the Marine Strategy Framework Directive. SwAM Report 2012: 2.

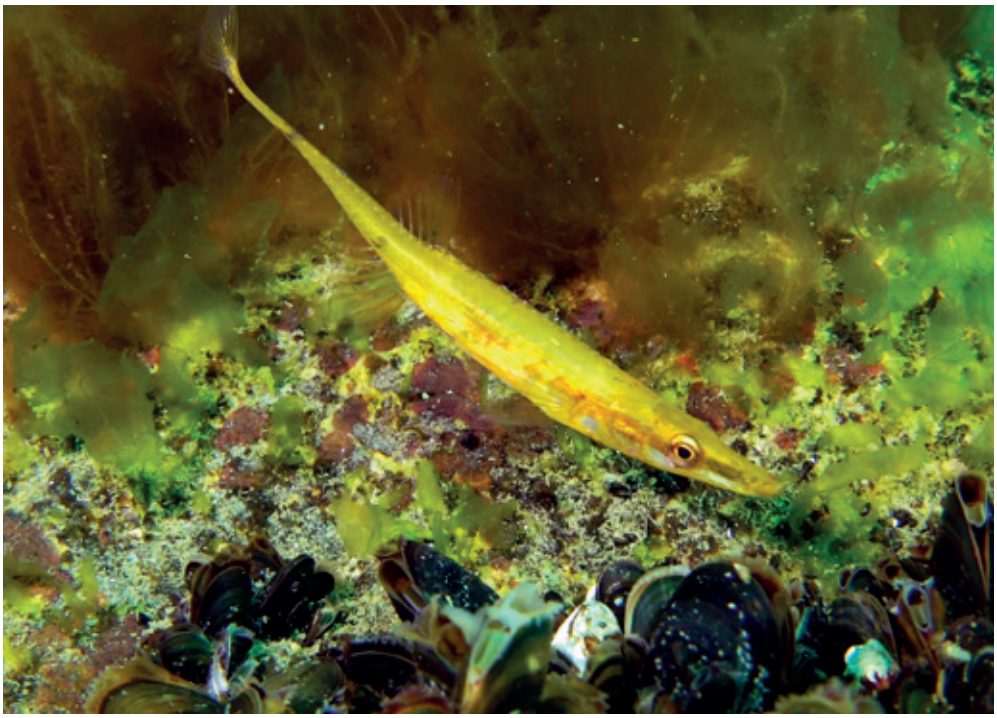
Swedish Environmental Protection Agency (SEPA). 2009. Sweden's commitment under the Baltic Sea Action Plan: Socio-economic impact assessment. Report 5989. Available from: https://www.naturvardsverket.se/Documents/publikationer/978-91-620-5989-7.pdf

Swedish Environmental Protection Agency (SEPA). 2013. Hunting and Fishing. Available from: http://www.swedishepa.se/enjoying-nature/the-right-of-public-access/this-is-allowed/hunting-and-fishing

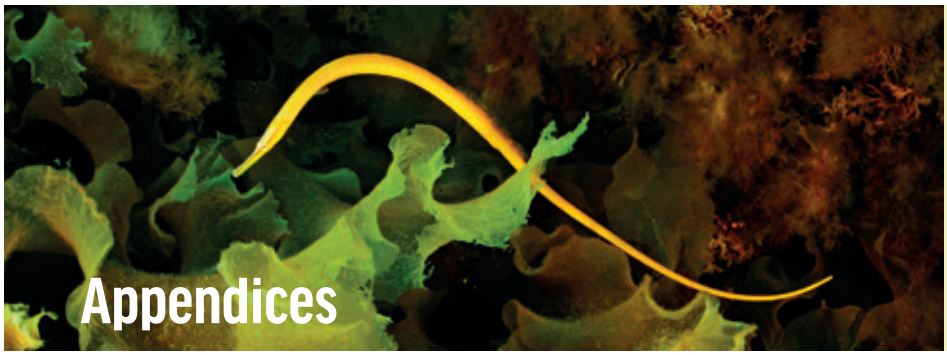
Swedish Maritime Administration (SMA). 2015. Sound VTS: Statistics. Available from: http://www.sjofartsverket.se/en/Sound-VTS/Statistics/

Waycott, M., Duarte, C.M., Carruthers, T.J.B., Orth, R.J., Dennison, W.C., Olyarnik, S., Calladine, A., Fourqurean, J.W., Heck, K.L. Jr and Hughes, R.A. 2009 Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proceedings of the National Academy of Sciences 106: 12377-12381.

Uścinowicz, S., Jegliński, W., Miotk-Szpiganowicz, G., Nowak, J., Pączek, U., Przezdziecki, P., Szefler, K., and Poręba, G. 2014. Impact of sand extraction from the bottom of the southern Baltic Sea on the relief and sediments of the seabed. Oceanologia 56: 857-880.



Sea stickleback (*Spinachia spinachia*).
Øresund Bridge, Sweden.
© OCEANA/ Enrique Talledo



Appendices

Snake pipefish (*Entelurus aequoreus*).
Kullaberg, Sweden.
© OCEANA/ Carlos Minguell

Appendix 1. Marine protected areas in Danish and Swedish waters of the Sound.

MPA Name	Protection	Reason for protection	Management plan and other relevant details	Total area (km²)	Marine area (km²)
Sweden					
Bunkeflo strandängar	Nature reserve, Habitat/Species Management Area	Coastal and terrestrial nature Eelgrass Migrating birds Important nursery areas for fish and other marine organisms.	Yes. Covers coastal landscapes. Specifically mentioned that no further management actions are needed at sea.	6.9	4.9
Falsterbo-Foteviken Falsterbo-Skujtfält	N2000 (SAC, SPA)	Reefs (1170) Sandbanks (1110) Lagoon (1150) Mudflats and sandflats (1140) Grey seal (1364) Harbour seal (1365) Birds Coastal and terrestrial nature	Yes. Includes requirements like: - Numbers and habitat of each bird species to be maintained or increased - Diversity and abundance of species that serve as food for birds to be preserved or increased - Sandbanks and lagoons to be guaranteed good water quality: little or no sedimentation, no plumes from boats, no disturbance from fishing gear or dredging, no wind turbines to be established, and no discharge of oil or other chemicals.	440.5	425.3
Grollegrund	Nature Reserve	High biodiversity High macroalgal diversity Spawning, nursery and feeding area for number of fish (e.g., cod and lesser spotted dogfish)	Yes. The main purpose of the nature reserve is the protection of the valuable sea bed environment and biodiversity within the area. It is not permitted to: moor or anchor boats; collect animals or plants (with the exception of fishing using a rod or net); use jet-skis; or arrange any form of competition or training using motorised vessels	15.8	15.8

MPA Name	Protection	Reason for protection	Management plan and other relevant details	Total area (km^2)	Marine area (km^2)
Knähaken	Nature Reserve	Rich animal life. The combination of Modiolus and *Haploops* found here is very rare.	Yes. The purpose is to protect and develop the long-term natural and cultural values of the area. It is not permitted to: moor or anchor boats; damage mussel banks or other marine fauna communities by harvesting or digging; collect animals and plants, (with the exception of standard fishing using a rod or net); or arrange any form of competition or training using motorised boats/ vessels.	13.6	13.6
Kullaberg	N2000 (SAC, SPA, Nature Reserves)	Reefs (1170) Harbour porpoise (1351) Birds Coastal and terrestrial nature	Yes. Focus on terrestrial nature. New measures to protect harbour porpoise proposed 2016 including, for example, measures for fisheries and traffic.	13.6	4.1
Lommabukten	N2000 (SCI, SPA)	Sandbanks (1110) Estuaries (1130) Mudflats and sandflats (1140) Birds Important spawning and breeding area for fish Coastal and terrestrial nature	Yes.	2.2	1.9
Löddeåns mynning	N2000 (SPA)	Reefs (1170) Sandbanks (1110) Lagoon (1150) Mudflats and sandflats (1140) Birds	Yes. Covers N2000 features.	4.8	3.5
Möllehässle-Kullens havsbad	N2000 (SCI)	Reefs (1170) Sandbanks (1110) Lagoon (1150) Coastal and terrestrial nature	Yes. Covers mainly coastal and terrestrial features.	2.5	1.6
Saxåns mynning-Järavallen	N2000 (SAC)	Reefs (1170) Sandbanks (1110) Estuaries (1130) Mudflats and sandflats (1140) Birds Important feeding and nursery area for fish	Yes. Covers N2000 features. Includes requirements like: - Selective fishing methods which do not damage seabed - No over-fertilisation - Securing the ecosystem structure of fish spawning and bird nesting areas - Populations of the typical species in each habitat should not be significantly reduced	19.6	19.5
Ven	N2000 (SAC)	Birds Coastal, terrestrial and cultural landscapes	Yes. Covers coastal and cultural landscape and birds.	0.6	0.3

MPA Name	Protection	Reason for protection	Management plan and other relevant details	Total area (km^2)	Marine area (km^2)
Denmark					
Gilleleje	N2000 (SCI)	Reefs (1170) Sandbanks (1110) Harbour porpoise (1351)	Yes.	151.1	151.1
Saltholm og omliggende hav	N2000 (SCI)	Reefs (1170) Sandbanks (1110) Bay (1160) Lagoon (1150) Grey seal (1364) Harbour seal (1365)	Yes.	72.5	54.6
Stevns rev	N2000 (SAC)	Reefs (1170) Sandbanks (1110) Rich macroalgal diversity Dense blue mussel beds	Yes.	46.7	46.6
Vestamager og havet syd for	N2000 (SAC, SPA)	Sandbanks (1110) Bay (1160) Lagoon (1150) Birds Coastal and terrestrial nature	Yes. N2000 features. Fishing is not considered a problem and is allowed. Traffic and access are prohibited during (bird) breeding season and areas.	62.1	40.3
Ølsemagle strand og Staunings Ø	N2000 (SAC)	Mudflats and sandflats (1140) Lagoon (1150) Bay (1160) Birds Coastal and terrestrial nature	Yes.	5.4	3.4

Nudibranch (*Palio dubia*). Rungsted, Sweden.
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Appendix 2. List of all species recorded during the 2016 Oceana Sound expedition.

ANIMALIA		
PORIFERA		
Chalinula limbata	*Haliclona oculata*	*Halichondria panicea*
Suberites ficus		
CNIDARIA		
Abietinaria abietina	*Alcyonium digitatum*	*Aurelia aurita*
Campanulariidae sp.	Cerianthidae sp.	*Cerianthus lloydii*
Clava multicornis	*Cyanea capillata*	*Cyanea lamarckii*
Dynamena pumila	*Halecium halecinum*	Hexacorallia cf. *Gonactinia prolifera*
Hexacorallia cf. *Protanthea simplex*	Hexacorallia cf. *Urticina felina*	*Hydractinia echinata*
Hydroidae cf. *Tubularia indivisa*	*Obelia longissima*	*Pennatula phosphorea*
Sagartiogeton undatus	*Tubularia indivisa*	*Virgularia mirabilis*
CTENOPHORA		
Beroe cucumis	*Bolinopsis infundibulum*	
BRYOZOA		
Alcyonidium gelatinosum	*Scrupocellaria scruposa*	Ctenostomatida sp.
Electra pilosa	Membraniporidae cf. *Einhornia crustulenta*	Membraniporidae cf. *Membranipora membranacea*
Scrupocellaria scruposa		
MOLLUSCA		
Acanthocardia echinata	*Aequipecten opercularis*	*Aporrhais pespelecani*
Arctica islandica	*Armina loveni*	*Buccinum undatum*
Cardiidae sp.	*Cerastoderma glaucum*	*Cuthona nana*
Dendronotus frondosus	*Doris pseudoargus*	*Eubranchus tricolor*
Flabellina lineata	*Flabellina verrucosa/Facelina bostoniensis*	*Littorina littorea*
Littorina saxatilis	*Modiolus modiolus*	*Mya arenaria*
Mytilus edulis	*Neptunea antiqua*	*Nucella lapillus*
Rissoa membranacea	*Tritea incrassata*	*Tritea reticulata*
Turritella communis		
ARTHROPODA - CRUSTACEA		
Amphibalanus improvisus	*Astacilla longicornis*	*Balanus balanus*
Balanus crenatus	*Caprella linearis*	*Carcinus maenas*
Crangon crangon	*Hyas araneus*	*Hyas coarctatus*
Hyperiidae cf. *Hyperia galba*	*Idotea balthica*	*Lekanesphaera rugicauda*
Mysidae sp.	*Nephrops norvegicus*	*Pagurus bernhardus*
Palaemon adspersus	*Palaemon elegans*	*Pandalus montagui*

PLATYHELMINTHES		
Procerodes littoralis		
ANNELIDA		
Arenicola marina	*Aphrodita aculeata*	*Oxydromus flexuosus*
Serpulidae sp.	*Spirorbis spirorbis*	*Spirorbis tridentatus*
ECHINODERMATA		
Amphiura chiajei	*Amphiura filiformis*	*Asterias rubens*
Astropecten irregularis	*Crossaster papposus*	*Echinus esculentus*
Gracilechinus acutus	*Henricia sanguinolenta*	*Luidia atlantidea*
Marthasterias glacialis	*Ophiocomina nigra*	*Ophiocten affinis*
Ophiopholis aculeata	*Ophiothrix fragilis*	*Ophiura albida*
Ophiura ophiura	*Psolus phantapus*	*Strongylocentrotus droebachiensis*
CHORDATA - TUNICATA		
Ciona intestinalis	*Dendrodoa grossularia*	*Styela coriacea*
CHORDATA - VERTEBRADA - PISCES		
Agonus cataphractus	*Ammodytes tobianus*	*Anguilla anguilla*
Callionymus lyra	*Callionymus maculatus*	*Callionymus reticulatus*
Ctenolabrus rupestris	*Cyclopterus lumpus*	*Gadus morhua*
Gasterosteus aculeatus	*Gobius niger*	*Gobiusculus flavescens*
Hippoglossoides platessoides	*Limanda limanda*	*Lumpenus lampretaeformis*
Microstomus kitt	*Neogobius melanostomus*	*Nerophis ophidion*
Pholis gunnellus	*Platichthys flesus*	*Pleuronectes platessa*
Pomatoschistus microps	*Pomatoschistus minutus*	*Pomatoschistus pictus*
Pungitius pungitius	*Scophthalmus maximus*	*Spinachia spinachia*
Symphodus melops	*Syngnathus acus*	*Syngnathus rostellatus*
Syngnathus typhle	*Taurulus bubalis*	*Trisopterus esmarkii*
Trisopterus minutus	*Zoarces viviparus*	
CHORDATA - VERTEBRADA - MAMMALIA		
Phocoena phocoena		

PLANTAE		
CHLOROPHYTA		
Ulva lactuca		
RHODOPHYTA		
Ahnfeltia plicata	*Callithamnion corymbosum*	*Callithamnion* sp.
Ceramium cf. *virgatum*	*Ceramium tenuicorne*	*Ceramium virgatum*
Chondrus crispus	*Coccotylus brodiei*	*Cystoclonium purpureum*
Delesseria sanguinea	*Dilsea carnosa*	*Furcellaria lumbricalis*
Hildenbrandia rubra	*Lithothamnion glaciale*	*Membranoptera alata*
Palmaria palmata	*Phycodrys rubens*	*Phyllophora crispa*
Phyllophora pseudoceranoides	*Phymatolithon laevigatum*	*Phymatolithon lenormandii*
Polyides rotundus	*Polysiphonia* sp.	
TRACHEOPHYTA		
Zostera marina		
CHROMISTA		
OCHROPHYTA		
cf. *Dictyosiphon chordaria*	cf. *Sphaerotrichia divaricata*	*Chorda filum*
Desmarestia aculeata	*Desmarestia viridis*	*Dictyosiphon* sp.
Fucus vesiculosus	*Halidrys siliquosa*	*Halosiphon tomentosus*
Fucus serratus	*Laminaria digitata*	*Litosiphon laminariae*
Pylaiella littoralis	*Saccharina latissima*	

Sugar kelp (*Laminaria saccharina*). Ven, Sweden.
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