PROTECTING THE NORTH SEA: NORWAY

Norway

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Credits

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Cover: Dead man's fingers (*Alcyonium digitatum*), red cushion star (*Porania pulvillus*), European edible sea urchin (*Echinus esculentus*), sponges and algae. © OCEANA/ Juan Cuetos

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Executive summary

The Norwegian waters of the North Sea represent an exceptional enclave of marine biodiversity in the region, with an array of ecological features that distinguish it from the rest of the North Sea. In particular, the Norwegian Trench (also known as the Norwegian Deep) – which reaches depths of roughly 700 m – represents the deepest part of the otherwise shallow North Sea. As a result, these waters are home to a variety of deep-sea habitats, such as ecologically valuable bamboo coral gardens and deep-sponge aggregations, which are not found elsewhere in the region. Other important and productive ecosystems are found in shallower waters along the coast, such as kelp forests and eelgrass meadows, which support a diversity of associated species.

While the biodiversity richness of Norwegian waters has been repeatedly recognised, research efforts to characterise and map marine life on the seabed have primarily focused on regions other than the North Sea and Skagerrak. At the same time, protection of North Sea waters also remains low in Norway – a mere 1.3% – and information is needed to inform conservation and management in the Norwegian North Sea, both within the Norwegian Trench and in surrounding areas. In order to help address this lack of information, Oceana conducted two at-sea research expeditions during the summer of 2016 and 2017, to gather data about benthic species and communities. Surveys were conducted mainly through visual (non-intrusive) methods (filming via a remotely operated vehicle and professional divers), and were complemented with seabed grab sampling of infauna, and seabed mapping with a multibeam echosounder.

In total, 18 habitats and 801 taxa were recorded, including reef-forming and engineer species (such as soft corals, sponges, and foraminifera) that increase habitat complexity and attract associated fauna, as well as a range of commercial species that have spawning and/or nursery areas in the Norwegian Trench. Among the valuable marine features documented were 39 species and nine habitat types that are considered priorities for conservation, because they are listed under national or international frameworks. These conservation priorities include habitats and species that by law must be protected. The most noteworthy habitat found was a forest of Endangered bamboo coral (*Isidella lofotensis*); Oceana's research provided the first-ever *in situ* footage of this threatened habitat in North Sea waters, where it should be urgently protected.

Considering these findings and the current low level of protection of Norwegian waters, it is clear that Norway must increase marine spatial protection in order to comply with international and national laws and commitments. Oceana recommends that new marine protected areas be designated in both shallow and deep-water areas, to safeguard threatened species and habitats, areas of essential fish habitat, and vulnerable marine ecosystems. Critically, given the high level of human pressure on Norwegian North Sea waters, these protected areas must be effectively managed to minimise ongoing threats to marine life. Oceana also urges Norway to dedicate resources to studying the habitats and species of the Norwegian Trench, in line with efforts that have been made in other regions of the country. Such research is likely to identify other key areas and features that deserve and require conservation action.

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THE NORWEGIAN WATERS OF THE NORTH SEA

Norway's coastline is one of the world's longest and most irregular, lined by fjords – which are only present in a handful of countries in the world – and dotted with thousands of islands.[1] Its territorial sea extends around 100 000 km², five times the surface of freshwater bodies in the country, while national marine waters (outside the baseline of the territorial sea) cover a surface of approximately 2 000 000 km², reaching offshore areas such as the Svalbard archipelago and the island of Jan Mayen.[1]

Norwegian coastal waters are very valuable as they host abundant and varied flora and fauna, such as sugar kelp (*Saccharina latissima*) and *Laminaria hyperborea* forests; eelgrass (*Zostera marina*) and dwarf eelgrass (*Z. noltei*) beds, which are crucial habitats for many species, including juvenile and adult fishes; and other important habitats such as areas with high densities of scallops, and spawning grounds for fish.[2] Nesting populations of seabirds such as gulls, terns, fulmars and auks have been documented along the Norwegian coast of the North Sea and the Skagerrak, as well as marine mammals including minke whale, grey seal and porpoises.[3] Moreover, inshore areas of the Norwegian Sea are home to the world's largest cold-water coral reef (with *Lophelia pertusa* as the main reef-building species),[4] known for supporting abundant fish populations and a wide diversity of benthic species.[5]

The deepest waters in Norway are concentrated in the north of the country (the Norwegian Sea), reaching depths down to approximately 4000 m. They host diverse and abundant marine life, including benthic species and habitats such as coral reefs, gorgonian forests, and sea pen and sponge communities, which contribute to the presence of large fish stocks, as well as seabirds and marine mammals.[6]

Marine habitats also play an important role in the economic sector of the country, as they support significant fisheries and aquaculture, and constitute a main recreational area for the Norwegian population — around 80% of whom live within ten kilometres of the sea.

Geographically and for administrative purposes, Norwegian waters are divided into three sea areas: the *Barents Sea - Lofoten*, the *Norwegian Sea*, and the *North Sea and Skagerrak*. The latter area is the main focus of this report, and in the context of the broader North Sea, is especially interesting from a biodiversity perspective. While most of the North Sea is shallow, with two-thirds of the area less than 100 m depth,[7] the Norwegian part is considerably deeper; the North Sea's deepest point (>700 m) occurs within the trough known as the Norwegian Trench.[7] Deep shelf trenches or channels are typically productive systems, where species from adjacent shallow areas cohabitate with species from the upper continental slope and the mesopelagic zone.[8] As a result, the Norwegian North Sea has high levels of species richness and hosts assemblages not found elsewhere in the North Sea. For these reasons, the Norwegian Trench is a major area of focus of this report.

Previous research in Norwegian waters has mainly focused on the Norwegian and Barents Seas, with large-scale programmes such as MAREANO,[9] a multi-disciplinary collaboration among different Norwegian research institutions. This programme has carried out extensive mapping of seabed terrain and depth, sediments, benthic habitats, species diversity, and pollutants, with the aim of informing management. Major Norwegian coastal habitats, such as kelp forests[10,11,12] and eelgrass meadows[13,14,15] have also been the subject of many studies. In contrast, comprehensive studies of benthic biodiversity in the Norwegian North Sea, particularly the Norwegian Trench, are relatively scarce.

To address gaps in knowledge about benthic biodiversity in the area, especially the Norwegian Trench, Oceana conducted research surveys in 2016 and 2017, to provide information about seabed species, communities, and habitats. The findings of those surveys are presented here, in the broader context of the biodiversity of the area and the threats it faces, and the implications for its protection.

Geomorphology of the Norwegian Trench

The Norwegian Trench (also known as the Norwegian Deep, and *Norskerenna* in Norwegian) is the largest depression in the North Sea.[16] This topographic feature starts in the inner Skagerrak (off Langesund), and extends for around 900 km along the Norwegian coast, until the shelf edge roughly west of Nordfjord (65°N)[6] (Figure 1). The deepest point of the trench (roughly 700 m depth) is 50 km from the coast, in the easternmost part of the Skagerrak, and rises to a sill depth of 275 m, off Jæren.[17] Its width varies from 35 to 80 km at the 250 m isobath.[17] The trench has an asymmetrical shape, with steeper and rougher slopes on the north side than the south. There are also exceptionally deep depressions (pockmarks) on the southern slope of the trench, due to a combination of leaking gases and strong currents, which prevent sediment deposition in the pockmarks.[18]

From a geological perspective, the Norwegian Trench was shaped by the paleo-ice stream

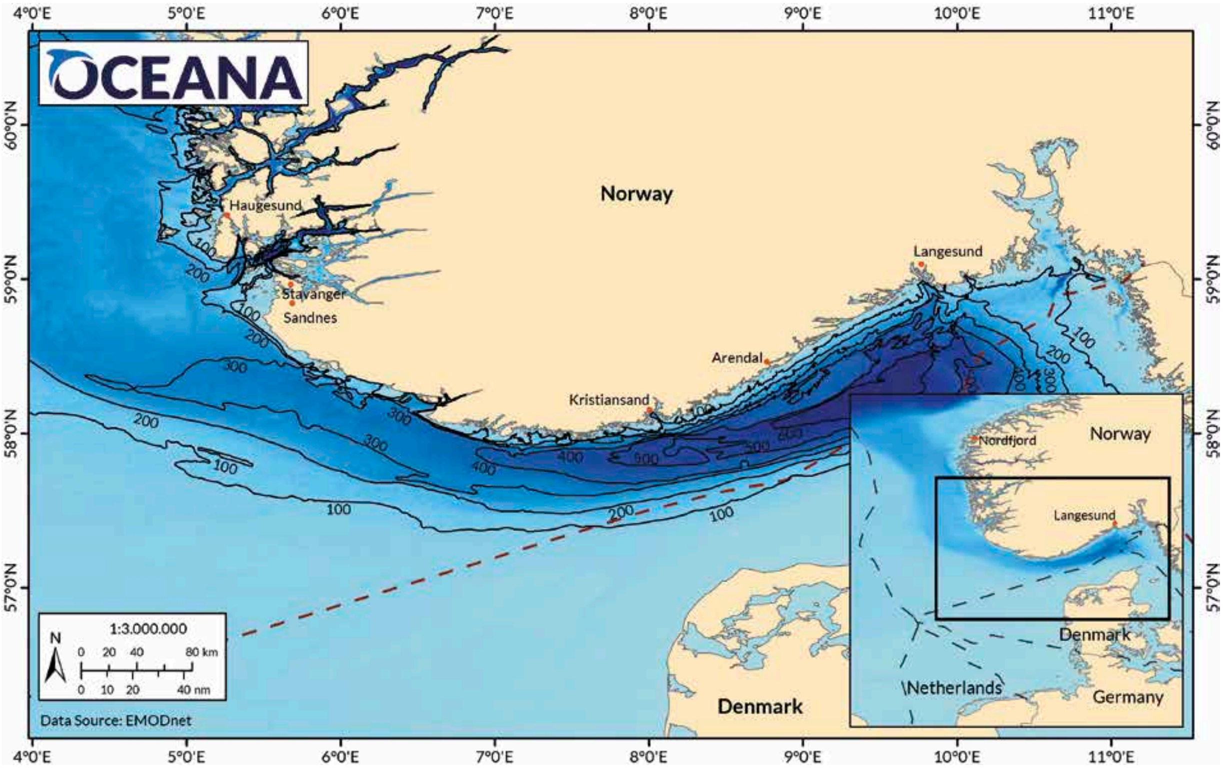
Coastal landscape, Norway.
© OCEANA/ Juan Cuetos

system known as the Norwegian Channel Ice Stream (NCIS).[19] This fast-flowing ice stream originated in the Quaternary period, and transported meltwater and sediments from the continent to the deep sea, following the coast of Norway from the Skagerrak.[19]

Since the Norwegian Trench is the deepest part of the North Sea, it has a strong influence on North Sea currents. A significant portion of the Atlantic water that enters the North Sea between the Faroe and Shetland Islands flows into the trench and along the Norwegian coast.[5,17] Mathematical models have also shown how the trench plays a significant role in the coupling of the inflow/outflow waters from the Baltic Sea through the Skagerrak.[17]

The coastline nearest to the Norwegian Trench, especially the southwestern area of the country where this study was focused, represents an anomalous part of Norway since there are few fjords. Instead, it is dotted with multiple islands along the coast.[19]

Figure 1. Location and bathymetry of the southern part of the Norwegian Trench. The inset map shows the broader extent of the Norwegian Trench along the Norwegian coast (from Nordfjord to Langesund).



The substrate of the Norwegian Trench is mostly composed of fine mud (Figure 2). Unlike most coastal trenches, it has an inverted hydrodynamic (and sedimentation) pattern, which influences the distribution of faunal communities.[20] The deepest parts of the trench are characterised by relatively strong currents with near-bottom horizontal sediment transport, which causes resuspension.[21] Therefore, high densities of suspension feeders inhabit the deeper parts, whereas subsurface deposit feeders dominate the shallow-slope zones, where higher sedimentation rates are observed. An upwelling which occurs in the central part of the Skagerrak and spreads horizontally at the surface brings large amounts of nutrients and enhances primary productivity in the area.[22]

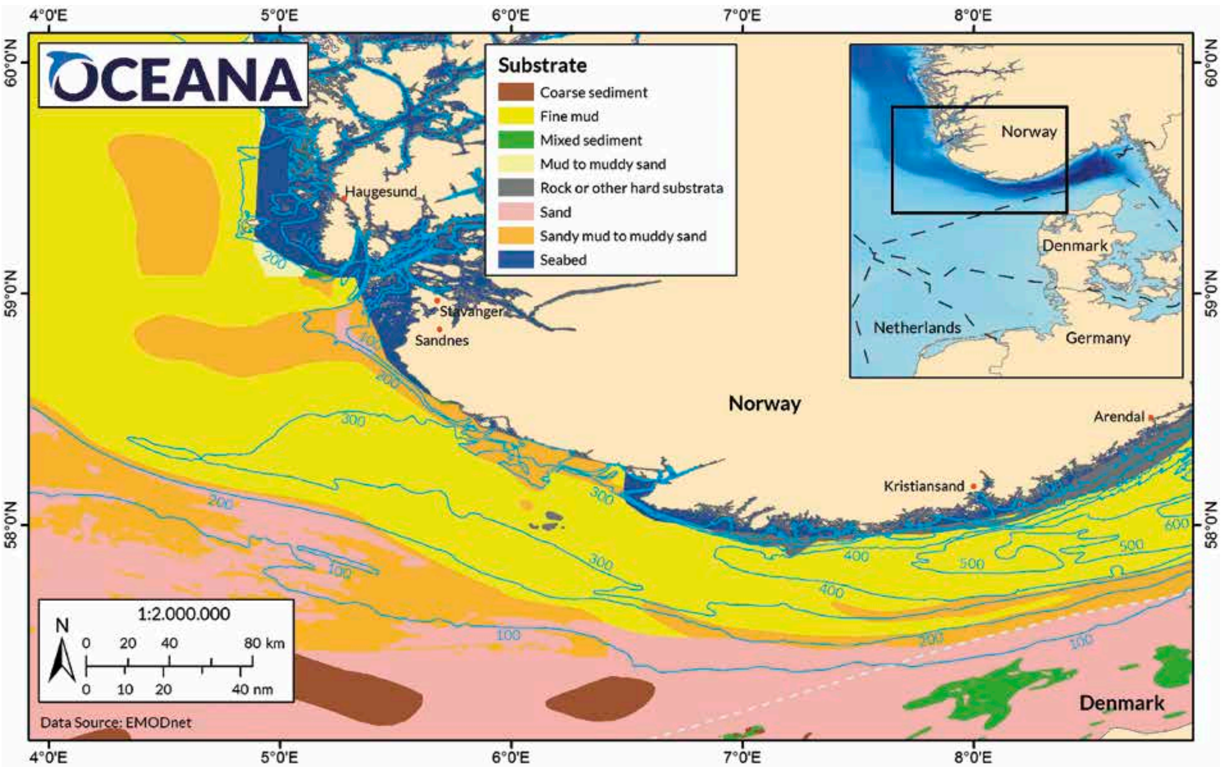


Figure 2. Sediment composition of the Norwegian Trench and adjacent areas.

Regarding benthic communities, in 1905, Petersen characterised for the first time the macrofauna inhabiting the Norwegian Trench, and described it as an *Amphilepsis norvegica - Pecten vitreus* community, although only three deep stations (275-670 m) were sampled at that time.[23] Later studies involving this area focused on the distribution of species such as: ostracods (Elofson, 1941), amphipods (Enequist, 1950), cumaceans (Forsman, 1940) and foraminifera (Höglund, 1947).[12] Rosenberg *et al.* (1996)[21] carried out the first study of benthic communities in relation to depth and sedimentation; overall, results showed a dominance of polychaetes (23-73%, according to sampling station) and molluscs (4-49%), followed by crustaceans (2-20%), echinoderms and sipunculids (1-6%).

Various studies[24] have revealed the presence of cold-water corals at the northernmost edge of the Norwegian Trench. The only North Sea record of the aforementioned cold-water coral *L. pertusa* comes from the area near the boundary of the North and Norwegian Seas (e.g., at Statfjord field, off the island of Fugløy), associated with concrete structures from the oil industry, such as rigs, platforms and pipes. Other coral gardens have been also documented,[24] such as the one found in Troll gas field (310 m deep, at the northern limit of the Norwegian Trench), associated with gas-leaking pockmarks. In this case, large colonies of gum coral (*Parogorgia arborea*) have been found, with clusters of up to 30 *Acesta excavata* bivalves, constituting the first record of large corals in the Norwegian Trench. This suggests the occurrence of seepage-induced nutrient enrichment.

Other research in the Norwegian North Sea, at the Snorre oil field (situated at the northern edge of the Norwegian Trench), has revealed highly diverse taxa (420 taxa recorded).[25] Polychaetes were the most abundant group (41% of all individuals and 31% of all taxa found), followed by molluscs (16% of individuals but 23% of taxa) and crustaceans (25% of taxa but only 11% of individuals).

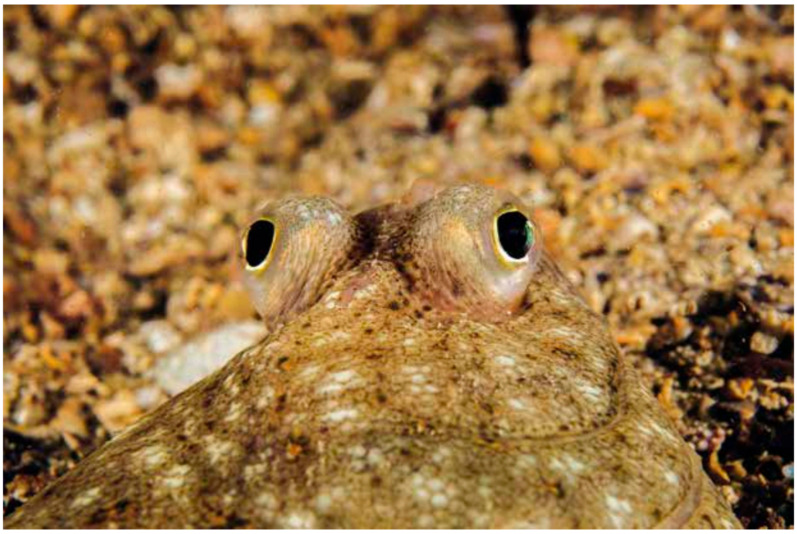
Lumpsucker (*Cyclopterus lumpus*).
© OCEANA/ Juan Cuetos

Regarding fishes, Norwegian waters host ecosystems dominated by boreal (cold-temperate) species such as the gadoids cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), and saithe (*Pollachius virens*), as well as clupeids such as herring (*Clupea harengus*).[26] Because the Norwegian Trench differs from other areas, it contains deep-water fish species not found elsewhere in the North Sea. Historical hydroacoustic and trawl surveys identified distinct pelagic and demersal species assemblages that varied according to depth, and which differed from those ones in the shallower areas outside the trench. Although species composition differs by season, in the upper layers (around 180-200 m depth) of the western and south-western areas of the Norwegian Trench, the main species found were Müller's pearlsides (*Maurolicus mulleri*) and blue whiting (*Micromesistius poutassou*), which formed a two-layered pelagic species association.[27] Other, less-abundant species were saithe (*Pollachius virens*), lumpsucker (*Cyclopterus lumpus*), and Norway pout (*Trisopterus esmarkii*).[27] In the central Skagerrak, scattered individuals of roundnose grenadier (*Coryphaenoides rupestris*), greater argentine (*Argentina silus*), and blue whiting (*Micromesistius poutassou*) were found between 200-250 m and 400 m depth. Below this, a characteristic deep-pelagic stratum was identified between 445-640 m, which was dominated by roundnose grenadier (*Coryphaenoides rupestris*) and greater argentine (*Argentina silus*).[27] This assemblage resembles that of outer shelf areas of the Northeast Atlantic, possibly as a result of the distinctive bathymetry of the Norwegian Trench and its aforementioned Atlantic current influence.[27] Moreover, the western and southern areas of the trench appear to be used as wintering areas and feeding grounds by fishes inhabiting nearby shallow slopes, particularly populations of saithe (*P. virens*) and Norway pout (*T. esmarkii*).[27]

Various fish species have areas of essential fish habitat (EFH) (i.e., spawning and nursery grounds) in the Norwegian North Sea. In comparison to other Norwegian regions (e.g., the Barents Sea), spawning periods in the North Sea are longer and more variable, as an adaptation to planktonic dynamics.[26] Norwegian waters, and the trench in particular, represent a suitable environment for many species to spawn.

Data about those fishes that spawn in the Norwegian North Sea have been compiled by Sundby *et al.* (2017)[26] and described as follows: the deep-water gadoids tusk (*Brosme brosme*), ling (*Molva molva*) and blue ling (*Molva dypterygia*) spawn in an area that overlaps with the trench, reaching the northernmost and deepest region in the Norwegian North Sea, except for blue ling, which is more restricted to the western part of the trench. A similar pattern to blue ling also applies to mackerel (*Scomber scombrus*), plaice (*Pleuronectes platessa*), and witch (*Glyptocephalus cynoglossus*), while pearlside (*Maurolicus muelleri*) and roundnose grenadier (*Coryphaenoides rupestris*) spawn further to the south Another group of fishes spawn on the shelf along the western edge of the trench, including cod (*Gadus morhua*), hake (*Merluccius merluccius*), lemon sole (*Microstomus kitt*), and long rough dab (*Hippoglossoides platessoides*). Other species use spawning grounds partially inside Norwegian waters, but remain on the shelf, far outside the deep areas of the trench. Such species include sandeels (Ammodytidae), sole (*Solea solea*), and dab (*Limanda limanda*) at the southwestern corner of the Norwegian EEZ, and greater argentine (*Argentina silus*) at the northern and southeastern limits.

European plaice
(*Pleuronectes platessa*).



Common dab (*Limanda limanda*).
© OCEANA/ Juan Cuetos

These spawning areas have been recognised as areas that should be treated with special caution by local authorities and are included within the management plan of the *North Sea and Skagerrak* area.[28] This is the case of the Norwegian Government-designated 'vulnerable and particularly valuable areas'. This designation does not imply any particular restrictive measures for commercial activities carried out inside them, but serves to identify areas where special caution should be considered.[29]

Twelve 'vulnerable and particularly valuable areas' lie in the *North Sea and Skagerrak*: eight along the coast and four in the open North Sea. These areas were selected according to the species and habitats present and are considered vulnerable because they are important for biodiversity, spawning grounds, or contain coral reefs. Four of the areas overlap with the study areas in this report (see *Oceana surveys*): Karmøyfeltet bank area, and Siragunnen bank area, both important spawning areas for Norwegian spring-spawning herring (*Clupea harengus*) and retention areas for drifting fish eggs and larvae; and *Listastrendene* protected landscape and *Outer Boknafjorden/Jærstrendene* protected landscape, both significant for migratory and wintering seabirds, and as whelping grounds for harbour and grey seal (in the case of *Outer Boknafjorden/Jærstrendene* protected landscape). Additionally, the entire coast has been recognised by the Norwegian authorities as a generally valuable area.[29]

Threats

Among the three Norwegian administrative divisions, *North Sea and Skagerrak* is the marine area most affected by anthropogenic activities.[3] This zone supports major fisheries, one of the most heavily developed oil and gas industries, and one of the busiest shipping routes in the world.[3] The concentration of marine litter in the area is higher than anywhere else in the North Atlantic.[28] Moreover, aquaculture activities, wastewater discharge, runoff from agriculture, and spills of hazardous and radioactive substances — of which the highest levels are in the Skagerrak and Norwegian Trench area — also have serious impacts on coastal and marine ecosystems.[3] Pollution, particularly plastic pollution, is becoming a growing issue on Norwegian coasts, as is happening at a global scale. Climate change is also affecting this region, increasing the vulnerability of its marine ecosystems, and putting marine life under added pressure.[3]

Oil and gas exploitation represents Norway's largest industry. While the country only supplies two percent of the global demand for oil, it is the third-largest exporter of natural gas and covers 25% of Europe's needs. Almost of all the oil and gas production is exported, representing half of the total national exports of goods.[30] Total petroleum production in 2018 was about 227 million standard cubic metres of oil equivalents (Sm^3 o.e.), yielding an export revenue of 45 billion euros.

The *Norwegian Petroleum Activities Act* requires impact assessments both before and after oil and gas activities, such as the opening of new areas, pipeline and cable laying, cessation of field production, and disposal of installations.[31] The production of petroleum and its derivatives, as well as their use, generates multiple impacts at local and global scales. In addition to directly exacerbating the greenhouse effect and ocean acidification due to the release of emissions during petroleum extraction and combustion, the industry severely threatens the marine environment in a number of other ways.[32] In the worst-case scenario, the discharge of oil and harmful chemicals to the marine environment during oil spills has devastating consequences for many marine organisms, including plankton, invertebrates, fishes, birds, and marine mammals. Resulting adverse effects range from reduced growth to disease, impaired reproduction, impaired physiological health, and mortality.[33] The most dramatic oil spill that has ever taken place in the North Sea occurred in Norway in 1977, at the Ekofisk Bravo platform.

Gas tankers in Haugesund.
© OCEANA/ Carlos Minguell

On a more localised scale, drilling and extraction of oil industry products, as well as the installation of infrastructure directly on the seafloor, has other consequences for marine life. For example, drilling increases sediment loads in the water column, with deleterious effects on surrounding marine biota.[34] Moreover, underwater noise from oil drilling can negatively affect the health and behaviour of marine mammals and fishes.[35]

Five active oil wells lie inside the study areas in this report (see Figure 3).

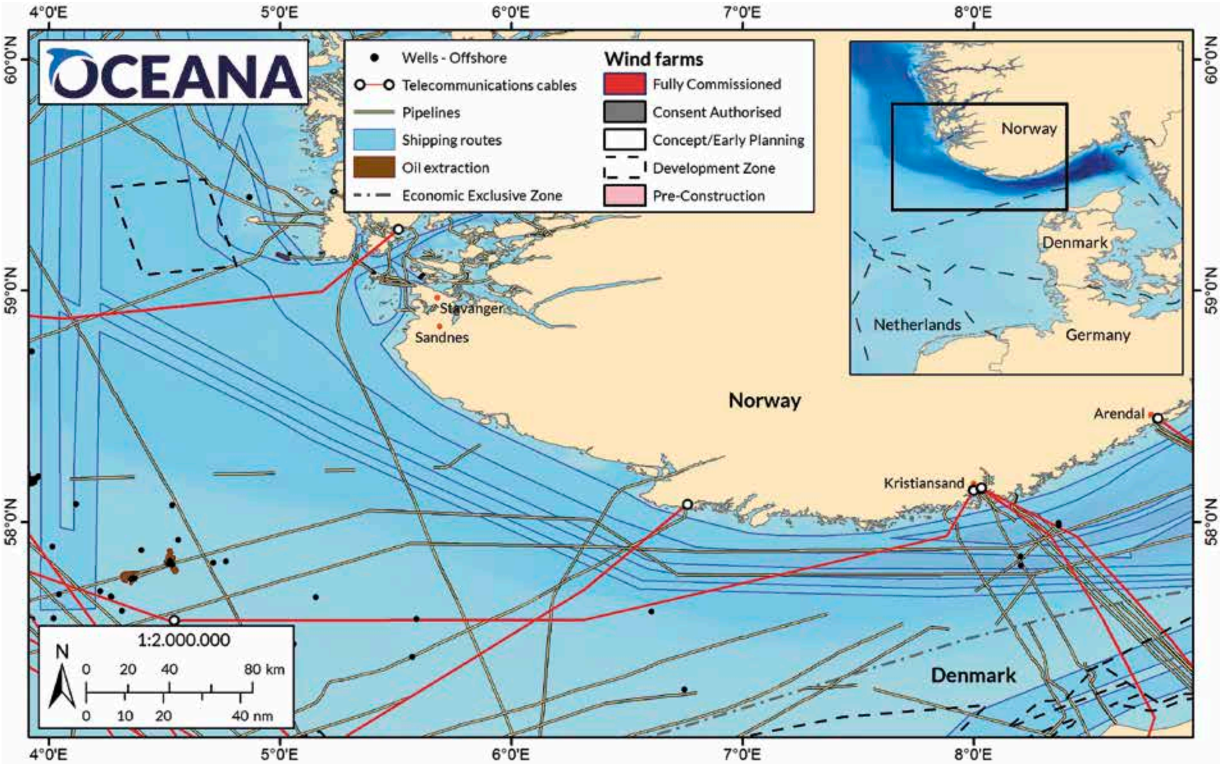


Figure 3. Shipping lanes and major offshore infrastructure in the Norwegian North Sea and Skagerrak, including cables, pipelines, oil wells and extraction areas, and wind farms (both authorised and potential projects). Data sources: Norwegian Petroleum Directorate,[36] University College London Energy Institute,[37] TeleGeography,[38] ChartWorld[39] and 4C Offshore.[40]

Fisheries

The waters of the North Sea and Skagerrak are intensively fished, and the Norwegian waters that are the focus of this report correspond to two of the most heavily fished areas, ICES Divisions 3.a.20 (Skagerrak) and 4.a (Northern North Sea).[41] Fishing in those waters is carried out by both Norwegian vessels and vessels from EU countries, which fish under bilateral and trilateral agreements with Norway. In the case of stocks shared between the EU and Norway (e.g., cod, haddock, whiting), respective catch limits are agreed on an annual basis.[41] Norwegian vessels also fish outside Norway's national waters and 90% of Norwegian catches occur in fishing grounds shared with other countries such as Russia, Iceland, the Faroe Islands, Greenland and the EU.[42]

Norway has a diverse fishing fleet composed of 6025 vessels,[43] with about 1585 operating in the North Sea.[41] Around 60% of this fleet belong to small-scale, coastal fisheries (<10 m length).[43]

These vessels typically target demersal fishes, crustaceans, and cephalopods, and fish using traps, pots, gillnets, hand-lines, long-lines and Danish seines.[41,44] Intermediate-sized vessels (10-24 m) target mostly shrimp and cod with trawls, as well as cod, saithe, ling, and monkfish using gillnets, and Norway lobster with pots and traps.[41,44] The industrial fleet is composed of thirty vessels of 24-40 m in size, and targets Norway pout and sandeel to produce fishmeal rather than for direct human consumption. The offshore fleet, with vessels greater than 40 m length, mainly fishes with otter trawls, as well as seines and longlines.[41]

Trawler sailing.
© OCEANA/ Juan Cuetos

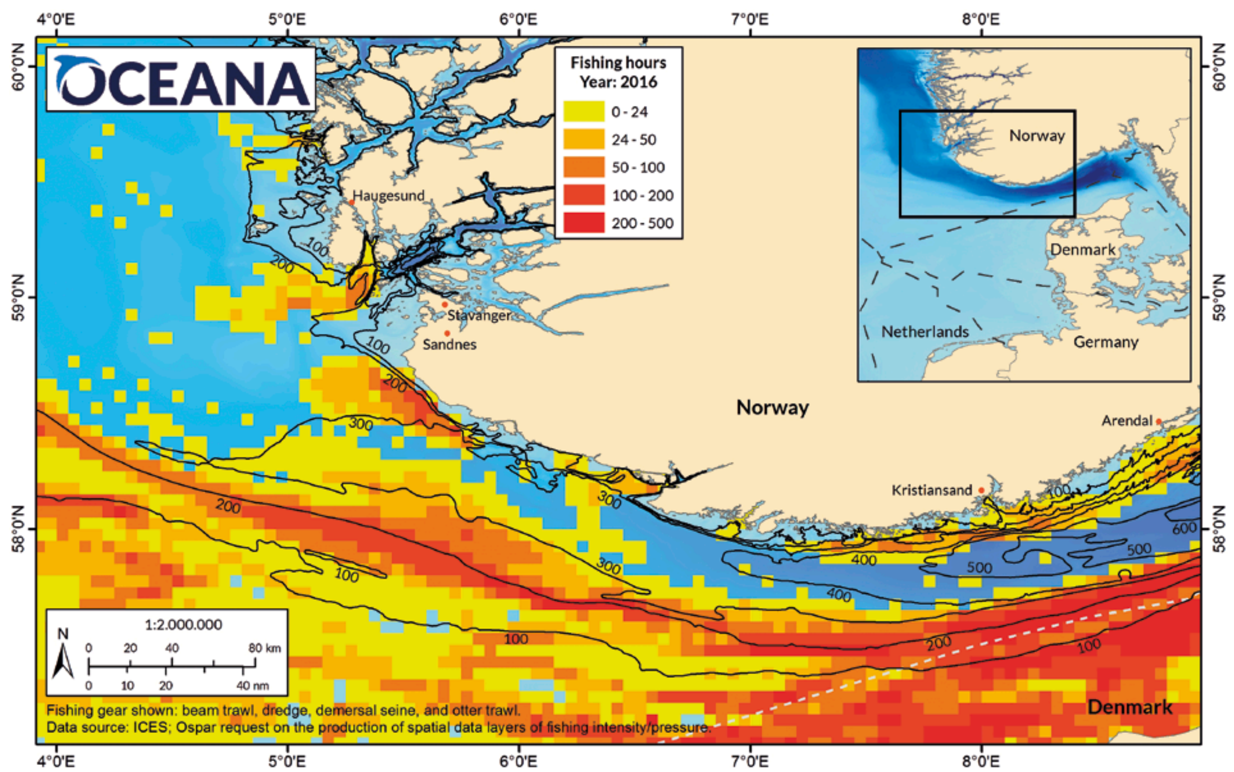
Oceana's study areas in Norway (see *Oceana surveys*) lie off the coastline of the counties of Vest-Agder and Rogaland. In those waters, local vessels account for less than 10% of all vessels fishing in the area,[43] while the majority of fishing is carried out by the EU fleet. According to Global Fishing Watch,[45] coastal areas are exploited by local vessels, whereas the external margin of the trench (with depths around 200 m) is subject to the most intensive fishing activity, mainly by Norwegian and Danish-flagged vessels. The deepest part of the trench remains unfished.

Bottom otter trawls are the most common type of fishing gear in Norwegian waters, especially in the outer edge of the trench and the central Skagerrak, where fishing effort averaged up to 100-200 mW (thousand kW days at sea) hours between 2014 and 2017.[41] Beam trawls, which are used extensively in the central and southern North Sea, are concentrated in Norwegian waters in the central Skagerrak.

Such types of trawling gears produce serious impacts on benthic species and are considered to represent the most extensive anthropogenic physical disturbance in the marine environment.[46] Figure 4 shows the fishing effort exerted by vessels using mobile bottom-contacting gears (e.g., otter trawl, beam trawls and demersal seines), the gear types that are most damaging to vulnerable seabed ecosystems. Among other effects, they cause direct mortality of non-targeted fauna and physical changes in sediment composition, complexity and biogeochemistry, which in turn can have effects on seabed communities.[47] If chronic bottom fishing persists in the long term, deleterious effects arise such as reductions in community productivity; changes in trophic structure and function due to decreases in faunal biomass, numbers and diversity; changes to the body size and age structures of benthic populations; and, ultimately, a shift towards communities dominated by faster life cycles.[47] When used over sandy or muddy bottoms, resuspension of sediments occurs, altering environmental conditions and affecting filter-feeding organisms. Moreover, these are non-selective gears, that capture a wide array of non-target species — both fish and non-fish species.[38]

In addition to mobile bottom-contacting gears, other fishing gear types used in Norwegian waters of the North Sea, but with lower fishing effort, include pelagic trawls and seines, and static gears. Some of these gears can also potentially have deleterious effects. For example, gillnets can trap seabirds such as razorbills while the birds dive for prey.

Figure 4. Fishing hours by bottom-contacting gears in 2016. Adapted from ICES (2017).[48]



Shipping

Major transport shipping routes cross the North Sea and Skagerrak, for example, for vessels going northwards along the Norwegian coast, heading to and from the Baltic Sea, and travelling between the main Norwegian ports and those in other North Sea countries. The area, particularly the southern part, represents the busiest shipping area in Norway and is used by many kinds of vessels transporting a wide variety of cargo.

In Norway, the added value of this industry was calculated in 2009 to be 5.5 billion euros, equivalent to 4.6% of total value added in the area. International shipping is the largest shipping-related industry, and generated value added of more than about 4.3 billion euros (including spin-off effects).[28]

The main impacts of the shipping industry are related to air pollution — accounting for 33% of all trade-related emissions derived from fossil fuel combustion, including 3.3% of global anthropogenic atmospheric CO_2. Moreover, it has been recognised as a significant source of greenhouse gases — namely nitrous oxides and sulphur dioxide — released into the atmosphere though fuel combustion.[49]

Maritime shipping is also associated with the release of garbage and pollutants to the sea, accounting for 20% of all ocean pollution.[50] Specifically, the main sources of pollution are antifoulants, oil and chemical spills, tank washings, dry bulk cargo releases, and sediment contamination of ports during transhipment and shipbreaking activities. Hazardous and noxious substances (HNS) (i.e., explosives, gases, flammable liquids, flammable solids, oxidisers, organic peroxides, toxic and infectious substances, radioactive material, corrosive substances, and miscellaneous dangerous substances) are regularly transported by sea, representing 10-15% of global marine cargo.[49] A marine accident can cause chemical fires, explosions or a spill of HNS, with resulting deleterious impacts on marine ecosystems.

Ballast water also represents a serious threat to the marine environment. At a global scale, around ten billion tonnes of ballast water are transported every year.[50] The greatest associated risk is that it serves as one of the main vectors for the introduction of aquatic invasive species in new areas. With estimations of 3000-7000 species being transported every day in ships,[51] the use of ballast water can pose a major threat to marine biodiversity, and can have significant economic and human health impacts.

Additionally, underwater noise from intensive shipping activity has risen by about 15 dB during the last 50 years, mostly due to transportation but also other underwater activities such as resource extraction and fishing.[49] It can severely impact marine life even over long distances, due to the spread of acoustic waves in water. The detrimental effects of underwater noise pollution have been acknowledged not only for mammals, but also for fish and other marine organisms, and vary according to the duration and intensity of the noise. Long-term, low-intensity noises, such as the ones generated by marine traffic, can have greater negative impacts on biota than the ones coming from underwater explosions, which are normally high-intensity but short-term noises.[52] Impacts also vary depending on the nature of the marine species, resulting in behavioural changes, such as altered swimming direction, speed, and respiration patterns, physical injury or harm, and even death.[53]

Container ship. Norwegian Trench.
© OCEANA/ Juan Cuetos

Norwegian marine waters extend over more than two million square kilometres, of which, according to official international sources on marine protected areas, only 4.4% is protected.[54] This protection encompasses a range of different types of designations, including national parks, nature reserves, wildlife conservation areas, botanical conservation areas, protected landscapes, and OSPAR MPAs. These designations have varying objectives and levels of protection as classified according to the criteria of the International Union for Conservation of Nature (IUCN),[55] and many designations also overlap spatially within the same areas, making it complicated to obtain a clear overview of the state of protection. Furthermore, it should be noted that internationally reported figures on Norwegian MPAs are not comprehensive with respect to areas protected under fisheries restrictions, and so actual levels of protection are likely to be higher than these figures suggest.

In total, there are 1124 internationally reported MPAs in Norway.[54] While over half of these areas (542) are in the *North Sea and Skagerrak*, many are relatively small, and in total only 1.3% of this area is protected.[54] Of these protected areas, 73 lie completely or practically inside the Oceana study areas from this report (Figure 5).

Marine areas in Norway are mainly protected within the framework of two major pieces of national legislation, which fall under the jurisdiction of two separate government ministries. The Ministry of Climate and Environment is responsible for protecting areas under the *Nature Diversity Act*, the key piece of Norwegian legislation aimed at protecting biological, geological and landscape diversity and ecological processes through conservation and sustainable use.[56] Under this law, types of MPAs that can be created are national parks, nature reserves, habitat management areas, and 'marine protected areas'.[a] Each of these has differing objectives. National parks aim to protect large portions of distinctive or representative ecosystems which are relatively unimpacted by human activity; nature reserves provide strict protection; habitat management areas protect ecologically important habitats of one of more species; and 'marine protected areas' are focused on safeguarding areas of conservation value (or those that are ecologically important for terrestrial species).[57]

Beyond individual sites, the process to establish an MPA network in Norway started back in 2001, when a cross-sectorial advisory committee composed of five government agencies, scientific institutions and stakeholders such as industry and environmental NGO representatives, evaluated and proposed 36 areas to become MPAs.[58] These areas are spread throughout

a For clarity, the Norwegian protected area category 'marine protected area' is written in inverted commas, to distinguish it from the more general term.

Norway's territorial waters, vary in size from 5 km^2 to more than 3000 km^2, and include a range of locations from inland fjords to wide corridors linking the coast and the continental shelf.

Although the 36 areas were supposed to have been formally established by 2009-2010,[64] the process has not yet been completed.[59] Eighteen of the areas that aim to protect coastal areas, fjords, and coral reefs have been designated, but the process to establish the remaining ones is either ongoing or has not yet begun. In the *North Sea and Skagerrak* marine area, nine potential MPAs were proposed, of which three have been approved: *Jærkysten*, *Framvaren*, and *Transekt Skagerrak*, the latter of which is included within Raet National Park. One of them, *Rogaland*, overlaps with Oceana's Southwestern Trench survey area (see *Oceana surveys*). The Norwegian Government, in its recently released *Updated Ocean Strategy*, committed to present a plan for MPAs, in order to strengthen efforts to preserve marine biodiversity, within the context of the post-2020 global biodiversity framework under the United Nations Convention on Biological Diversity (CBD).[60]

In addition to MPAs designated under the *Nature Diversity Act*, marine spatial protection can also be established by the Ministry of Fisheries and Coastal Affairs, through the *Marine Resources Act*, which regulates the exploitation of wild living marine resources.[61] Under this legislation, which is the main fisheries law in Norway, the use of bottom trawls is partially prohibited within 12 nm (trawling for kelp, shrimps, and Norway lobster (*Nephrops norvegicus*) is still permitted). The law also allows for the

Oksøy lighthouse.
© OCEANA/ Juan Cuetos

restriction of fishing activities within specific areas. For example, partial and total fishing closures are in place for certain key species such as sandeel and European lobster, and areas where only certain fishing gears may be used for particular species, such as cod, which can only be fished with rod and handline.[62] Four years after these restrictions entered into force, a BACI study[63] of European lobster and cod in the closed areas confirmed their effectiveness, as European lobster catches had increased by 245% inside the closed areas (and increased 87% in control areas), and mean size of individuals had increased by 13% inside the closed areas. Meanwhile, the average length of cod was 5 cm larger within the closed areas than in control areas.

In addition to the *Marine Resources Act*, another piece of fisheries legislation applies to the protection of benthic habitats. National regulation J-61-2019[64] (an amended version of J-128-2011[65]) restricts bottom fishing along the Norwegian continental slope, in order to safeguard vulnerable marine ecosystems (VMEs)[b] such as coral reefs, at depths greater than 1000 m and in other specified areas. Similar to regulations on fishing in international waters under the jurisdiction of the North-East Atlantic Fisheries Commission, vessels in Norwegian waters are required to record and report encounters with VMEs (defined on the basis of catches that exceed 30 kg of live coral and/or 400 kg of live sponges), and to move at least two nautical miles away from the most likely point of capture before resuming fishing. Exceptions may be granted for vessels with an experimental fishing permit from the Directorate of Fisheries.[66] Under these regulations, eighteen areas that had previously been restricted to bottom-contacting gears, with the purpose of preserving coral reefs, were turned into MPAs.

Proposals for additional MPAs in Norwegian waters have been made by the non-governmental organisation WWF, with the aim of making the network of North Sea MPAs more ecologically coherent and representative.[67] For the Norwegian North Sea and the Skagerrak, WWF proposed the designation of the aforementioned Troll Pockmark, due to the presence of multiple craters measuring up to 100 m in diameter and 8 m depth, as well as gum gorgonian (*Paragorgia arborea*). Other areas proposed included waters off the island of Fugløy, with the largest *L. pertusa* reef in the North Sea and three 'blue belts' (Shetland-Norway, Karmøy-Holene and Egersund). Blue belts are defined as management areas which do not necessarily have to be designated as MPAs, but are comparable with the IUCN categories IV (Habitats/Species Management Area) and VI (Protected area with sustainable use of natural resources).

b VMEs are groups of species, communities, or habitats (particularly in the deep-sea) that may be vulnerable to damage from fishing activities.

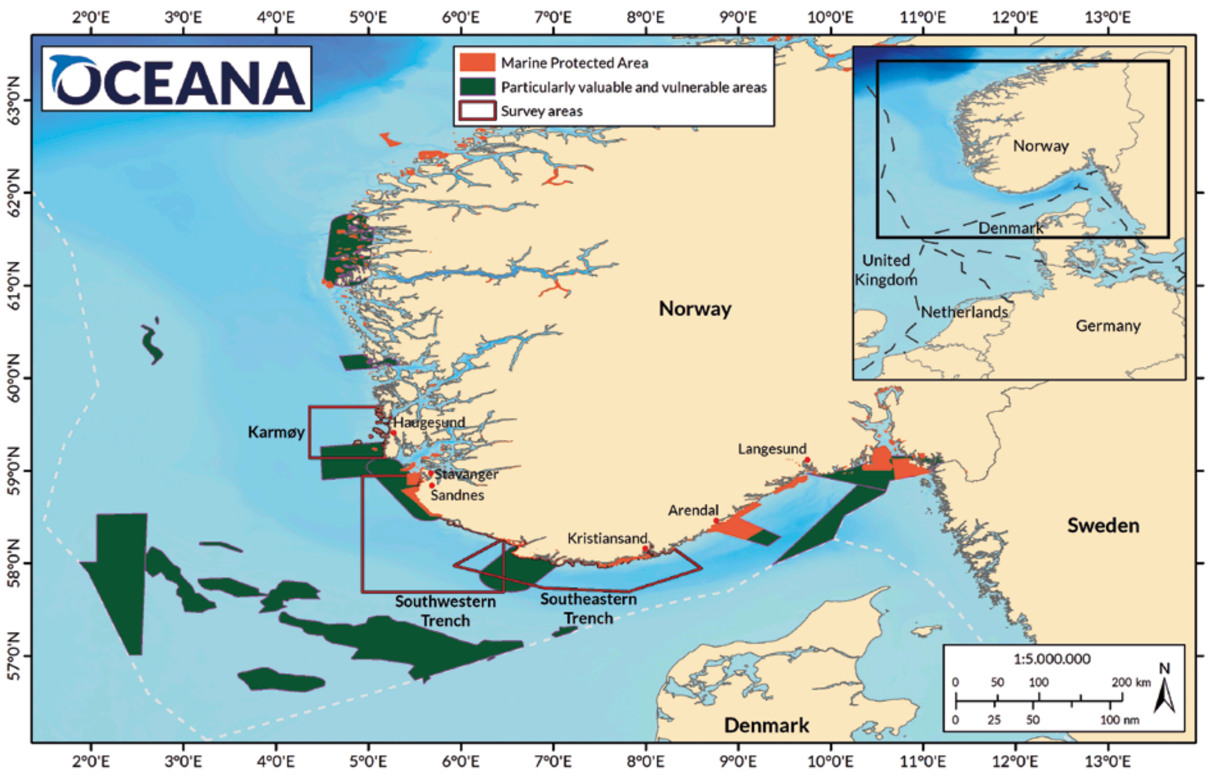
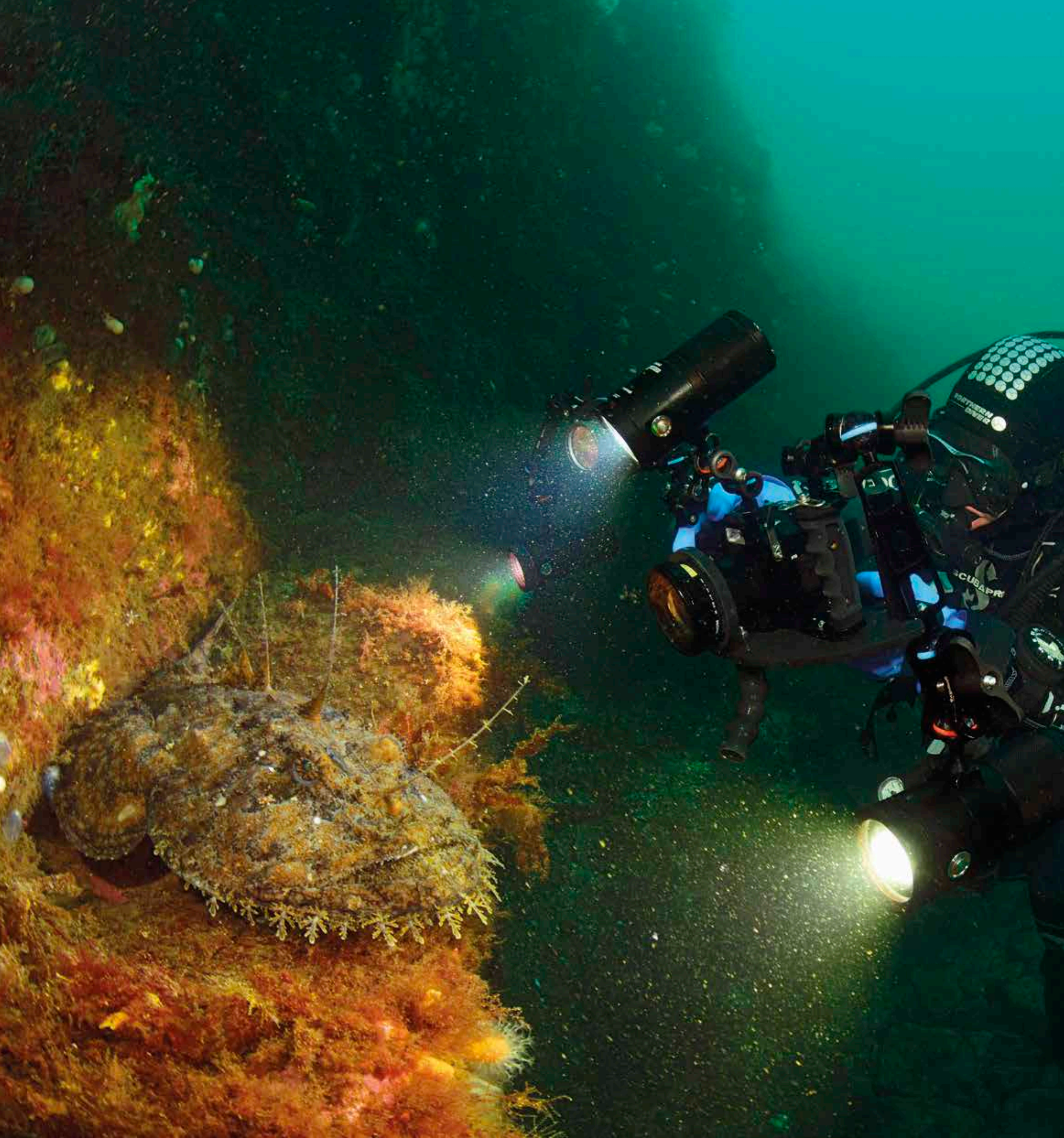


Figure 5. MPAs and Particularly Valuable and Vulnerable areas in the Norwegian North Sea and Skagerrak.

In addition to protection granted to marine areas, one marine species (dwarf eelgrass, *Zostera noltei*) is listed as a 'Priority Species' in Norway, under the *Nature Diversity Act*. As a result, its removal, damage and destruction are prohibited.[68]



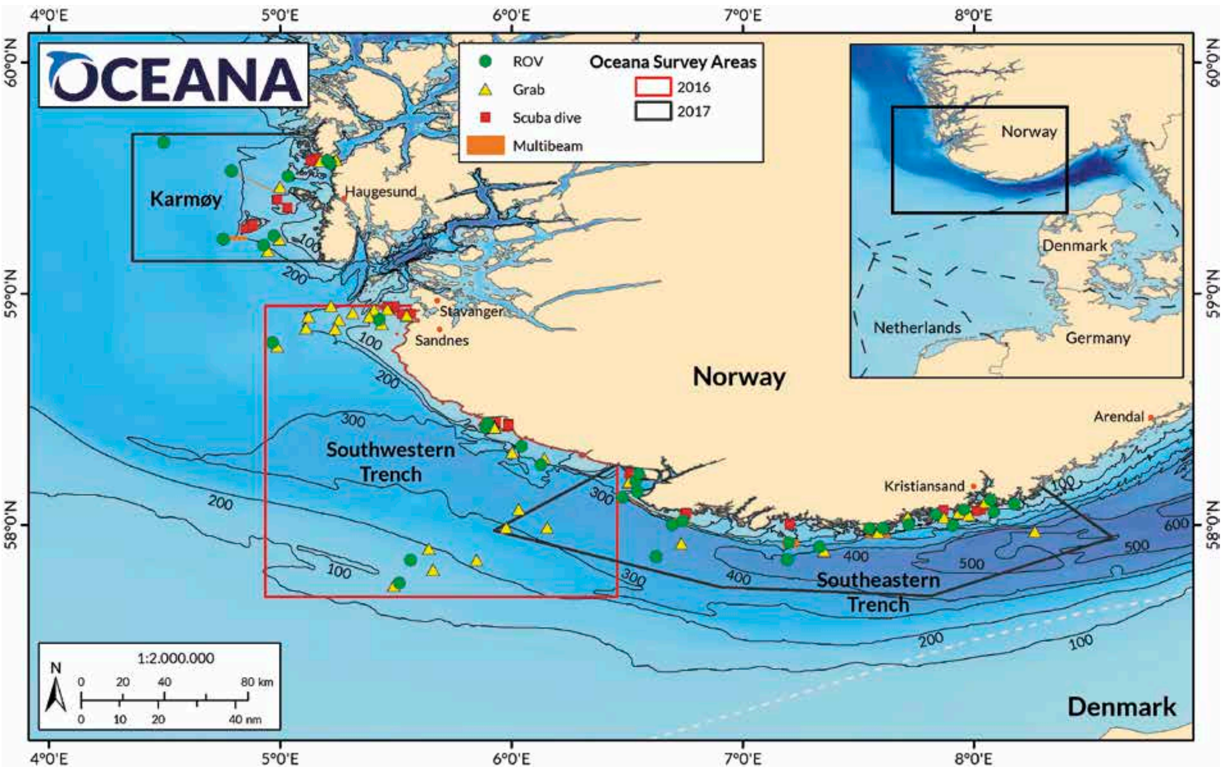
OCEANA SURVEYS

Oceana surveyed Norwegian waters during two eight-week, at-sea research expeditions carried out across the North Sea in 2016 and 2017. These expeditions aimed to gather first-hand information from areas of known or potential ecological importance, but from which benthic biological data were lacking. Surveys of these zones were carried out onboard the research survey vessel *MV Neptune*, a fully equipped vessel of 49.85 m overall length and 10 m extreme breadth.

During the Norwegian portion of the expeditions, research was primarily focused on the deepest zone — the Norwegian Trench — and took place in three survey areas ('Southwestern Trench' (henceforth SW Trench), 'Karmøy', and 'Southeastern Trench' (henceforth SE Trench)). Surveys were carried out from 28 July - 10 August 2016, and 10-18 July 2017, with a total of 18 days of work at sea. Most of the survey effort was concentrated in coastal areas, due to poor weather conditions in areas further offshore (Figure 6).

The seabed was explored mostly by low-impact, visual means: filming with a remotely operated vehicle (ROV) and by professional SCUBA divers. Infaunal grab sampling was also carried out, as well as seabed mapping with a multibeam echosounder, and sampling of oceanographic parameters using a conductivity, temperature, and depth (CTD) device. Each of the survey methods is described in more detail below.

Figure 6. Survey points in Norwegian waters during the 2016 and 2017 Oceana North Sea expeditions. Points are shown according to sampling type (i.e., ROV, SCUBA diving, grab samples, and multibeam).



Scuba surveys

Visual data were gathered by one group (in 2016) or two groups (in 2017) of professional SCUBA divers. Each group comprised a photographer, a videographer, and two safety divers. A total of 24 dives were done in Norway (nine in SW Trench, six in Karmøy and nine in SE Trench), producing high-definition video footage and high-resolution still images.

Rov surveys

For ROV image recording, a Saab Seaeye Falcon DR ROV was used, equipped with a high-definition video (HDV) camera of 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. Images were recorded both in high and low definition, and simultaneously documented position, depth, course and time. Lasers on the ROV were used to estimate sizes and abundances. Considering the average speed and the wide angle of the camera (i.e., it was able to film transects of approximately 1.5 m width), the ROV allowed the observation of around 550-650 m^2 of seabed per hour.

Eight ROV transects were carried out in Karmøy (depths 113-357 m), eight in the SW Trench (depths 47-208 m), and 19 in the SE Trench (depths 65-459 m). Surveyed sites were selected based on scientific literature, data provided by Norwegian institutions, bathymetric and substrate data, and acoustic backscatter data, which provided further information about the characteristics of the seafloor. Backscatter data were obtained using a Reson Seabat 7125 SV multibeam echosounder (Teledyne Marine), which was operated at a frequency of 200 kHz, with a maximum ping rate of 50 Hz, 256 equidistant beams, maximum swathe angle of 128°, and depth resolution of 6 mm. The data were recorded in QINSy and cleaned using Qimera (both from Quality Positioning Services BV).

During and following the expeditions, analysis of the footage recorded by the ROV was carried out by Oceana scientists. All of the visible species were identified to the finest taxonomic level possible.

Infaunal sampling

Benthic infaunal community composition was examined using a 12 L Van Veen grab sampler. A total of 40 grab surveys were taken in Norway: 25 in SW Trench, five in Karmøy and ten in SE Trench. During the expeditions, specimens retained on 0.5 mm and 1 mm mesh sieves were kept and identified to the finest taxonomic resolution possible. Those samples that could not be identified definitively while on board were preserved and identified following the expeditions.

In the three survey areas in Norway, Oceana identified a total of 801 taxa, 584 of which to the species level (see *Annex*, Table A). These organisms were documented in association with 18 main types of habitats and/or communities. The task of describing specific, clearly isolated habitats, communities and assemblages is complicated in the Norwegian context, which is characterised by a complexity of marine ecosystems, especially in shallow coastal habitats. In the heterogeneous context of Norwegian waters — one of the richest and most diverse areas of the North Sea — a 'mosaic' of benthic habitats and communities sometimes occurs, in which dominant species can differ even at a scale of several metres, depending on variation in factors such as substrate, physico-chemical conditions, productivity, light, depth, water temperature, and anthropogenic impact. Thus, the 18 habitat and community types presented below were described based on their main defining features, such as habitat-forming species, associated fauna, substrate, and depth.

Five of these habitat types were found in shallower coastal areas, mostly associated with photosynthetic species (e.g., kelp forests, eelgrass meadows, calcareous algae aggregations) while three were associated with deeper waters, mainly with deep-sea gorgonians and bamboo coral. The remaining ten habitat types were more broadly distributed, occurring both in shallow and deep waters. Each of these habitats is described in the following sections according to its substrate and roughly in order of increasing depth. The importance of each is explained, together with detailed descriptions of the primary associated species and main secondary associated species, substrate type, documented depth range and, if relevant, its occurrence in combination with other habitats. A full list of the documented habitats, by survey area, can be found in Table B of the Annex.

Toothed wrack (*Fucus serratus*).
© OCEANA/ Juan Cuetos

Most of the locations surveyed in Norwegian waters were characterised by soft bottoms. Mainly composed of mud, but also with some sandy and detritic areas, these habitats are home to some of the most noteworthy habitat-building species, such as bamboo coral and sea pens and, on a smaller scale, anemones and foraminifera. These species help to increase the heterogeneity of otherwise less complex bottoms, and thereby increase levels of associated biodiversity by, for example, providing structures in which other organisms may take refuge. These soft-bottom habitats and communities occurred throughout the Norwegian Trench (especially those habitats and communities associated with fine-grained sediment: fine mud, mud, and muddy sand), and in shallower, offshore areas with thicker granulometry (i.e., sand, sandy mud).

Hard-bottom areas were also documented, primarily along the coast, and consisted of rocky beds or isolated boulders surrounded by soft bottoms (such as in the centre of the Norwegian Trench). These substrates hosted important habitats formed by vulnerable engineer species (such as gorgonians and massive demosponges, hydrozoans, and algae); such habitats support the most highly biodiverse communities, and sometimes act as EFH.

Shallow bottoms with macroalgae

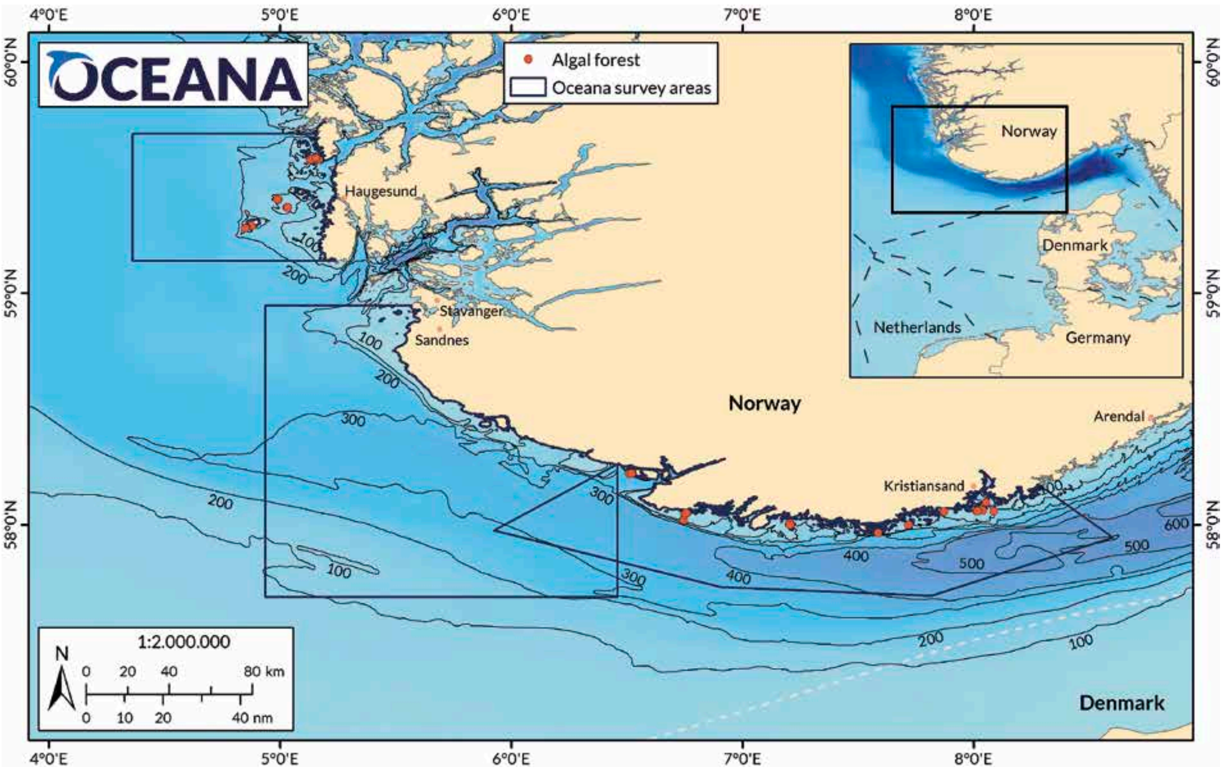


Figure 7. Locations of shallow-bottom habitats with macroalgae.

These habitats were found in the Karmøy and SE Trench areas, both along the coast and around the islands off Haugesund (15-32 m depth). They comprised several species of brown macroalgae, both forming monospecific and mixed forests, and sometimes with the presence of kelps. As photosynthesisers, these organisms play a major ecological role as primary producers, providing multiple ecosystem services such as supporting food webs and serving as nurseries.[69]

Sargassum (*Sargassum* sp.).
© OCEANA/ Carlos Minguell

The most commonly found macroalgae in Norwegian waters were brown macroalgal species, such as *Ascophyllum nodosum*, *Desmarestia aculeata*, *D. viridis*, *Dictyota dichotoma*, *Fucus serratus*, *F. vesiculosus*, *Halidrys siliquosa*, *Pelvetia canaliculata*, *Sargassum muticum*, *Sphacelaria cirrosa;* red macroalgae such as *Bonnemaisonia hamifera*, *Delesseria sanguinea*, *Heterosiphonia plumosa*, *Palmaria palmata;* and green macroalgae such as *Cladophora rupestris* and *Ulva intestinalis*.

The main species associated with this habitat type were the bryozoans *Electra pilosa* and *Membranipora membranacea*, breadcrumb sponge (*Halichondria panicea*), the mollusc *Calliostoma zizyphinum* and the hydrozoan *Obelia geniculata*. These forests were home to numerous fishes, some of them juveniles; ichthyofauna was mostly composed of cuckoo wrasse (*Labrus mixtus*), pollack (*Pollachius pollachius*) and poor cod (*Trisopterus minutus*).

Shallow bottoms with eelgrass (*Zostera marina*)

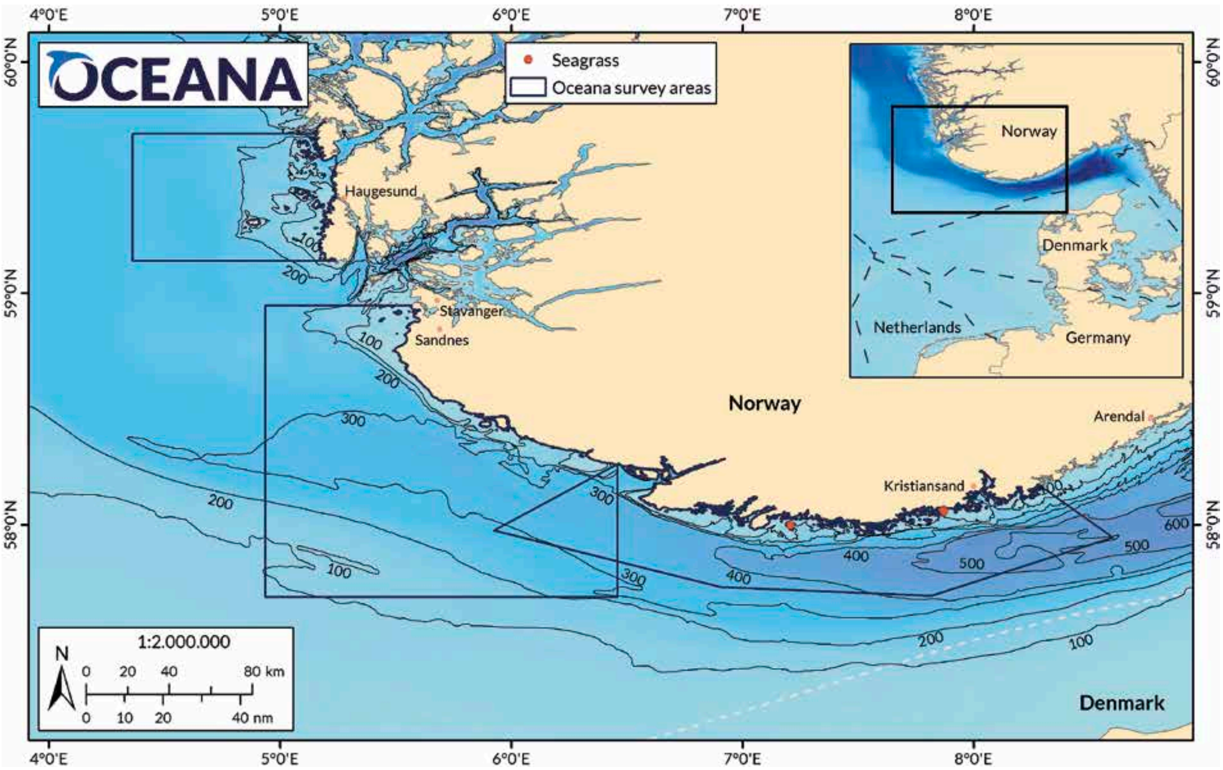


Figure 8. Locations of shallow-bottom habitats with eelgrass (*Zostera marina*).

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

Eelgrass (*Zostera marina*) meadows are vital structural and functional features in coastal areas. They are characterised by high primary production and associated faunal diversity, and play a critical role in providing other ecosystem services, such as nursery and feeding areas.[70] In fact, Norwegian eelgrass meadows have been shown to host twice as many macroinvertebrate individuals as surrounding sandy areas.[71] They are also important indicator species, as they are sensitive to eutrophication and water quality. In Norwegian waters of the Skagerrak region, over 3300 such meadows have been mapped, with a total cover of 50.3 km^2.[70]

The eelgrass meadows documented by Oceana were found only in the SE Trench survey area. They were composed of small patches of *Z. marina* in shallow bottoms (around 20 m) over gravel and coarse sand. In some cases, these gardens were mixed with brown macroalgae, principally the species *Chorda filum* and *Sargassum muticum*. Lion's mane jellyfish (*Cyanea capillata*) was also spotted in these habitats.

Kelp forests

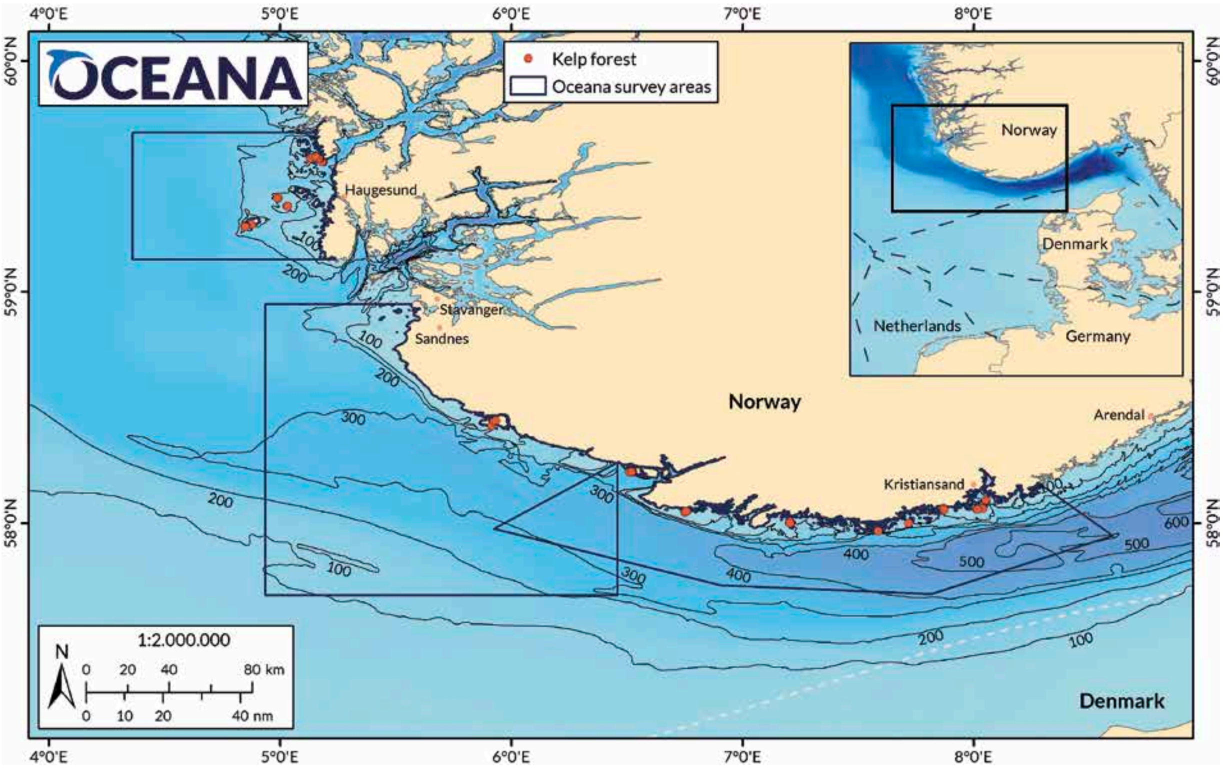


Figure 9. Locations of habitats with kelp forests.

Kelps are considered foundation species, forming highly productive, three-dimensional, forest-like habitats in coastal areas.[72] These habitats play a key role in ecosystem functioning, as well as in local economies, as they are important nurseries for juveniles of targeted fishery species. Moreover, kelps are cultivated and harvested in Norway, as there is a growing commercial interest in their alginates and high nutritional value.[72]

Kelp (*Laminaria* sp.) forest.
© OCEANA/ Juan Cuetos

In Norway, kelp forests cover over 8000 km^2, consisting mainly of tangle (*Laminaria hyperborea*) and sugar kelp (*Saccharina latissima*). Since the 1970s, these forests have experienced a general decline caused by overgrazing by sea urchins, potentially a consequence of altered eutrophic or climatic conditions, which was followed by a partial recovery.[73] A single *L. hyperborea* individual can support, on average, nearly 8000 individuals of roughly 40 macroinvertebrate species.[74] Off Norway, this species may also help to reduce wave height by as much as 60%.[75]

During the two Oceana expeditions, kelp forests were mostly documented during SCUBA surveys, in all three survey areas. These forests formed mono- or multi-specific forests on rocky bottoms at depths of 15-32 m. In some cases, an understory of brown and red algae grew below the canopy of these forests. The main forest-forming species observed were *Alaria esculenta*, *L. hyperborea*, *S. latissima* and *Saccorhiza polyschides*, although *Chorda filum* also formed dense aggregations. Other, unidentified species from the genus *Laminaria* were also documented.

Dabberlocks (*Alaria esculenta*).
© OCEANA/ Juan Cuetos

Kelp forests hosted a multitude of species, which both colonised them and sheltered in the canopy. The main benthic species were sponges such as *Halichondria panicea* and *Sycon ciliatum*, bryozoans like *Electra pilosa* and *Membranipora membranacea*, and hydrozoans such as *Obelia geniculata*. Crustaceans such as acorn barnacle (*Balanus crenatus*), edible crab (*Cancer pagurus*), and common lobster (*Homarus gammarus*), and fishes like Ballan wrasse (*Labrus bergylta*), cuckoo wrasse (*L. mixtus*), pollack (*Pollachius pollachius*), and poor cod (*Trisopterus minutus*) were also frequently documented.

Shallow bottoms with coralline algae (maërl)

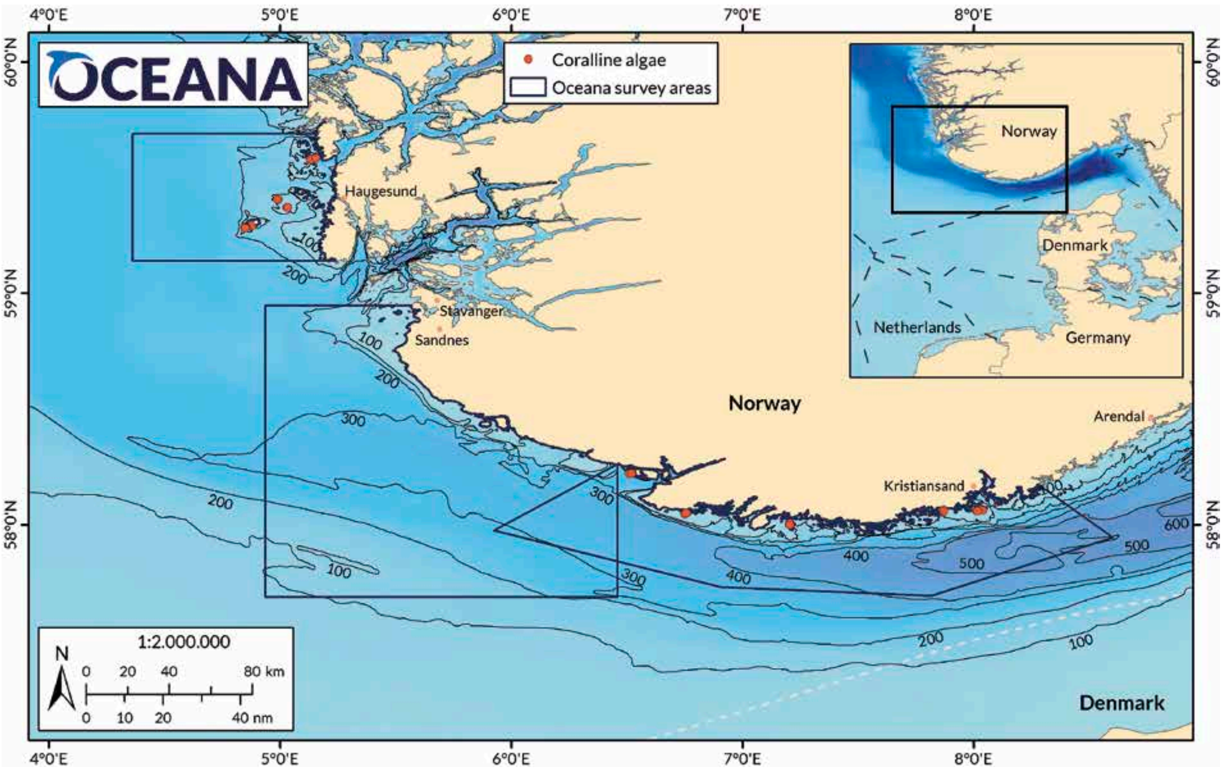


Figure 10. Locations of shallow bottoms with coralline algae.

Coralline algae (maërl) were present on shallow, rocky bottoms in the Karmøy and SE Trench areas. These red algae form calcareous structures, which in turn are colonised by other algae, invertebrates, and various associated species.[76] The thick crusts that they form host a high diversity of fauna – the thicker the crust, the higher the associated diversity.[77] Dead specimens continue to play a similar role to live ones as long as the structure is preserved, although they support less biodiverse assemblages.[78] Their skeletons are composed of calcium carbonate, and have an active role in the carbonate cycle of coastal areas as a key biogenic source. They are very susceptible to ocean acidification, and their fragile structures are vulnerable to mechanical destruction.

In the Norwegian waters surveyed, the main species of coralline algae were *Lithothamnion glaciale* and *Phymatolithon lenormandii*. They were documented living on boulders and hard substrate, at depths of 15-35 m. Sharing this habitat were sponge species such as breadcrumb spone (*Halichondria panicea*), *Leucosolenia* sp. and *Mycale lingua*; bryozoans such as *Crisia* sp., *Parasmittina trispinosa*, and narrow-leaved hornwrack (*Securiflustra securifrons*); ascidians such as light bulb tunicate (*Clavelina lepadiformis*); echinoderms such as common sea star (*Asterias rubens*), edible sea urchin (*Echinus esculentus*), and red cushion star (*Porania pulvillus*); soft corals such as dead man's fingers (*Alcyonium digitatum*); and fishes such as goldsinny wrasse (*Ctenolabrus rupestris*), cuckoo wrasse (*Labrus mixtus*), and lemon sole (*Microstomus kitt*).

Dead man's fingers (*Alcyonium digitatum*) and red calcareous algae.

Infralittoral boulders with anemones (*Metridium senile*, *Urticina eques*)

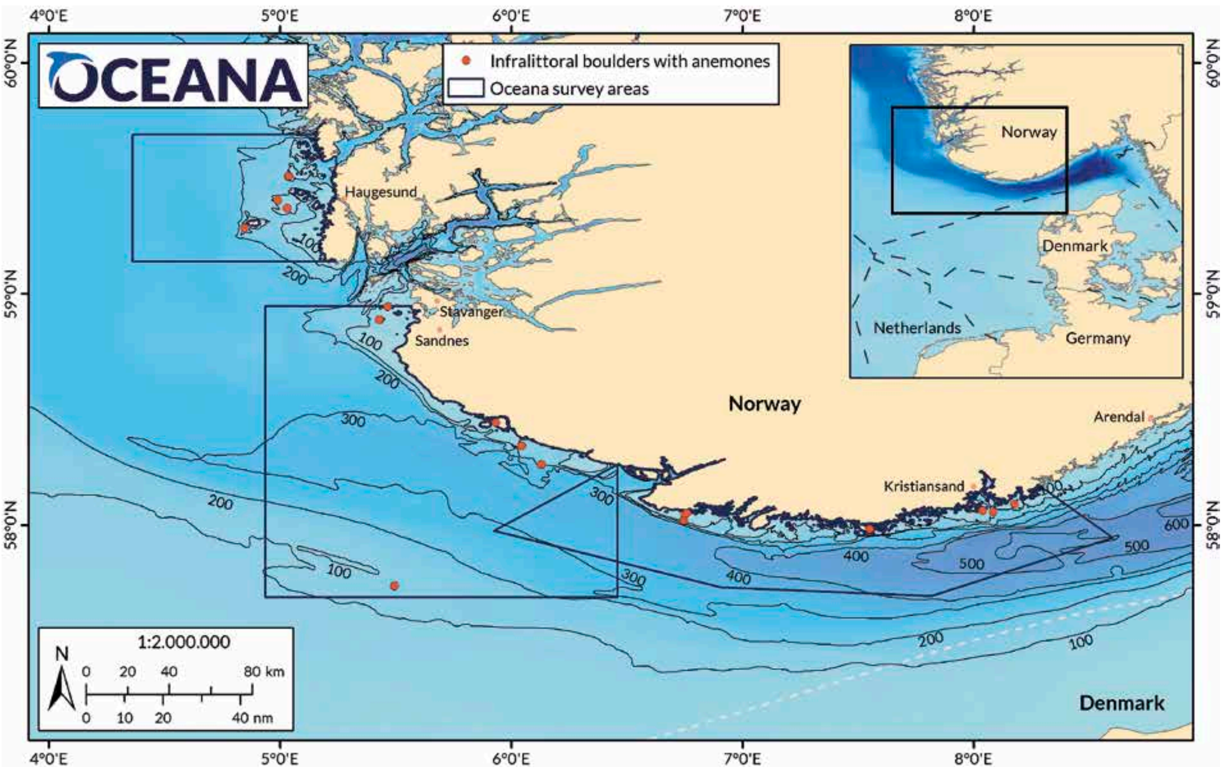


Figure 11. Locations of habitats formed by anemones (*Metridium senile*, *Urticina eques*) on infralittoral boulders.

Plumose anemones (*Metridium senile*).

The plumose anemone (*Metridium senile*) and horseman anemone (*Urticina eques*) were recorded from rocky bottoms over a wide variety of depths: *M. senile* from 22-72 m, and *U. eques* from 15-157 m. Both species formed habitats in which they were dominant, on boulders in shallower areas.

Both species of anemone shared the rocky bottoms with other anemones that were locally abundant (*Bolocera tuediae*, *Sagartia* spp.) forming a turf with species like coralline algae (e.g., *Phymatolithon lenormandii*), kelps, bryozoans (e.g., *Crisia* sp., *Parasmittina trispinosa*), sponges (e.g., *Halichondria panicea*, *Sycon ciliatum*), and many other epibionts. Observed associated species included crustaceans such as *Caprella* sp., edible crab (*Cancer pagurus*), and common lobster (*Homarus gammarus*); and fishes such as cod (*Gadus morhua*).

Shallow-infralittoral hard bottoms with gorgonians

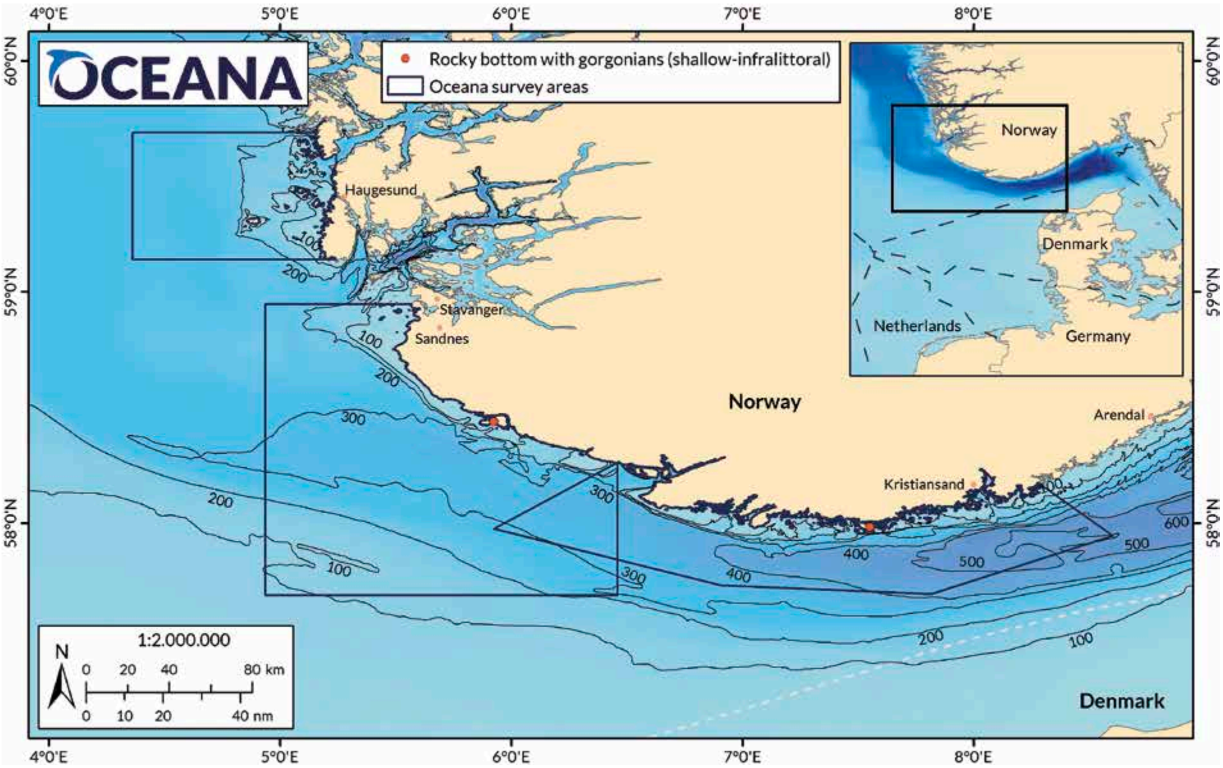


Figure 12. Locations of shallow-infralittoral hard bottoms with gorgonians.

Species of the genus *Swiftia* are among the most common gorgonians that form hard-bottom coral gardens in the North Atlantic Ocean; these gardens, in turn, support a diversity of species, some of which only occur in this habitat.[79] During the Oceana surveys, a garden formed by northern sea fan (*S. dubia*, previously known as *S. pallida*) and *S. rosea* was documented in one sampling spot (SW Trench), in which both gorgonian species grew on sedimented rocks at depths of 44-47 m. In some areas, the gorgonians were mixed with various demosponges (e.g., *Halichondria* sp., *Phakellia* spp., *Polymastia* sp.), as well as the cnidarian *Caryophyllia (Caryophyllia) smithii*. In this case, it was documented only during 2016. The echinoderm red cushion star (*Porania pulvillus*) was regularly documented, and the bryozoan *Porella compressa*, as well as a multitude of unidentified foraminifera. Juvenile cod (*Gadus morhua*) and one individual of ling (*Molva molva*) were also identified.

Mixed garden of gorgonians *Swiftia dubia* and *S. rosea*.

In addition to this coral garden, two isolated individuals of *S. rosea* were also found in SE Trench, at a similar depth (49-55 m).

S. dubia is considered a VME indicator species.[80] This categorisation means that its presence signals the occurrence of ecosystems (namely hard-bottom coral gardens), which are vulnerable to physical impacts, such as from fishing gears.

Deep-circalittoral hard bottoms with gorgonians

Although most of the North Sea does not provide suitable habitat for deep-sea gorgonian gardens, the physical and environmental factors of the deep waters of the Norwegian Trench allow some sea fan species to grow on hard substrate. Sea fans, with their three-dimensional structure, increase benthic habitat heterogeneity and provide ecosystem services such as habitat for commercial fish species. They also form symbiotic associations with a variety of invertebrates, such as crustaceans, ophiuroids, molluscs and polychaetes.[81]

As was the case for the sea fan genus *Swiftia*, the genus *Paramuricea* is widely distributed and an important element of deep-sea ecosystems. In the North-East Atlantic, gorgonians of the genus *Paramuricea* help to form hard-bottom coral gardens, and are considered VME indicator species.[81] These gorgonians are threatened by bottom trawling, oil extraction, and indirect threats such as climate change.

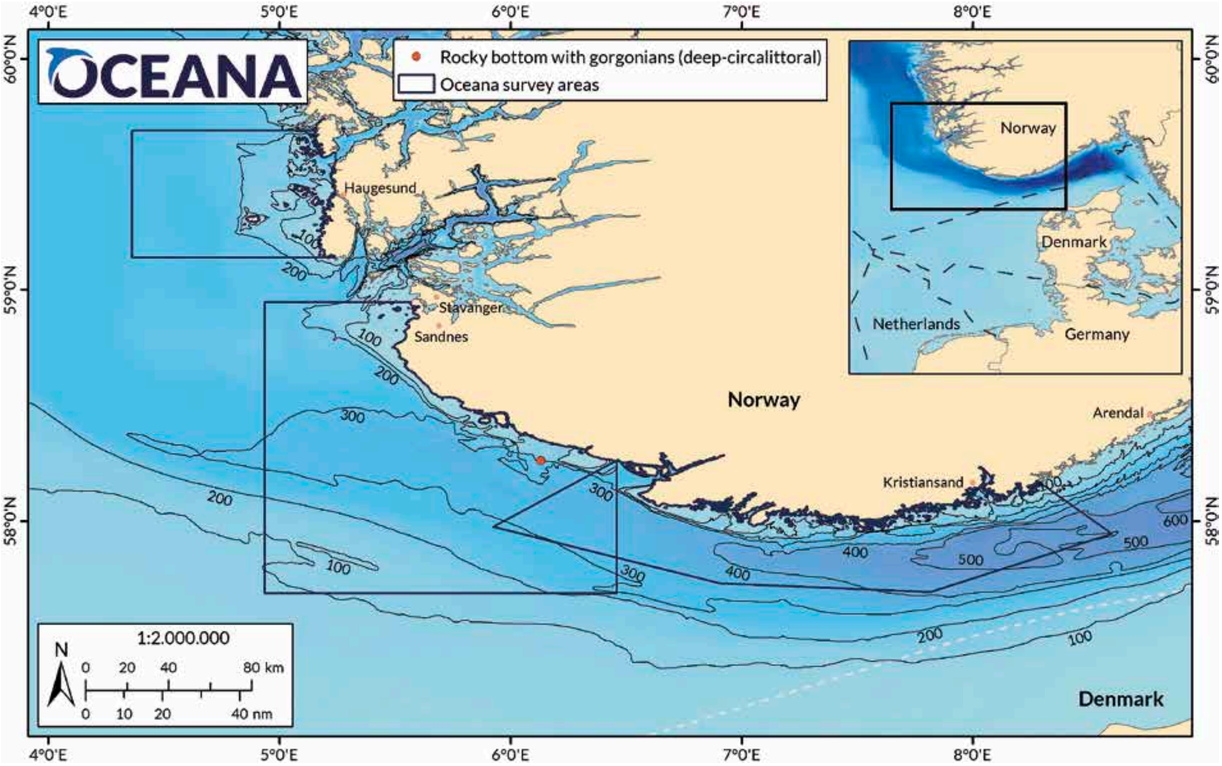


Figure 13. Location of deep-circalittoral hard bottom with gorgonians.

During the Oceana surveys, a garden formed by flattened sea fan coral (*Paramuricea placomus*) was found in the SW Trench area (149-156 m deep). The main associated species found were Gorgon's head basket stars (*Gorgonocephalus* sp.), and northern shrimp (*Pandalus borealis*), both of which were living on the sea fans. These findings were consistent with previous research identifying *Gorgonocephalus* basket stars, and shrimps (e.g., Caridea, Paguridae) as the main fauna associated with deep-sea gorgonians.[82] Other epibiont species observed within this community were the hydrozoan *Diphasia alata*, the annelid lacy tubeworm (*Filograna implexa*), and North Atlantic cup sponge (*Axinella infundibuliformis*).

Flattened sea fan coral (*Paramuricea placomus*).

In the surrounding habitat, aggregations of sea squirts of the order Stolidobranchia were present. Various arborescent sponges also formed part of this community, such as *Geodia* sp., *Mycale lingua*, *Phakellia ventilabrum*, and *Polymastia* sp. Other species observed in the area included crustaceans such as *Galathea* sp., squat lobster (*Munida sarsi*), and *Pandalina profunda*, and fishes such as lesser weaver (*Echiichthys vipera*), saithe (*Pollachius virens*), and thornback ray (*Raja clavata*).

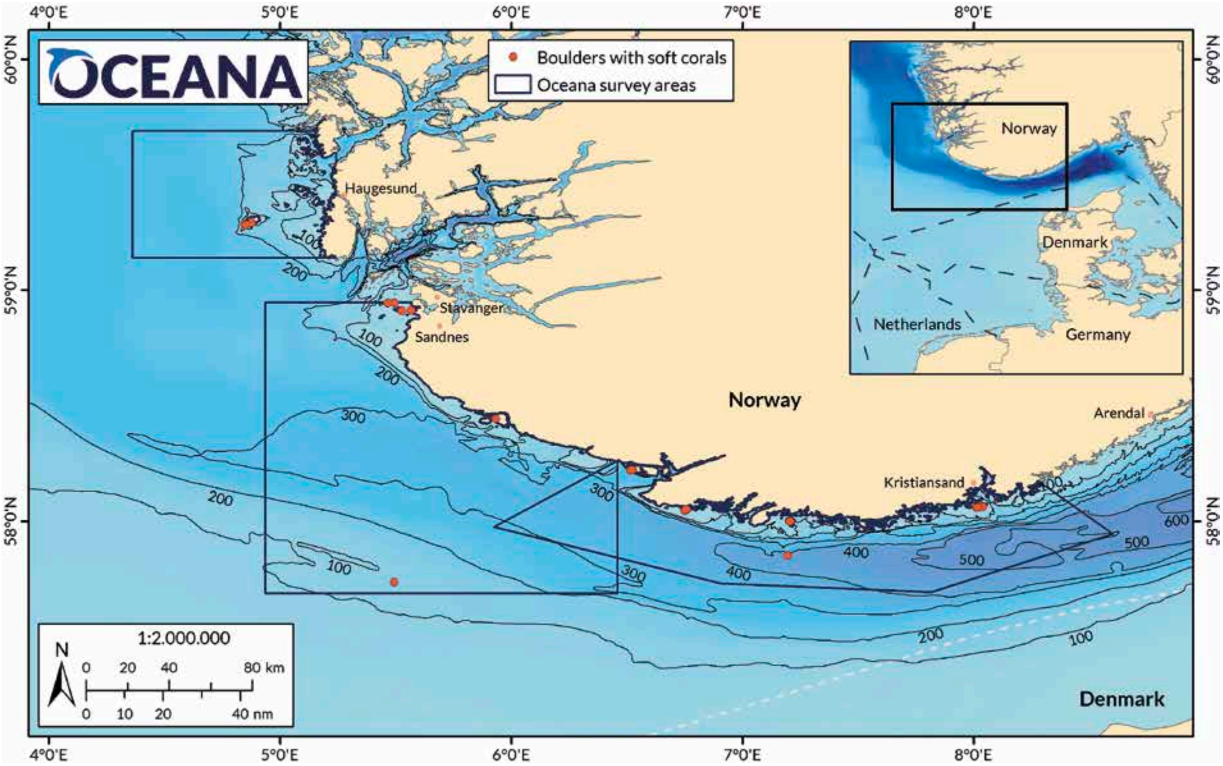


Figure 14. Locations of boulders with soft corals.

Species of the genus *Alcyonium* are the most common soft corals in the North Sea, occurring on both soft and hard bottoms. They can aggregate in high densities, forming assemblages both in shallow and deep waters, increasing bottom complexity and productivity like other benthic suspension feeders.[83]

Dead man's fingers (*Alcyonium digitatum*) and *A. palmatum* were identified in all three Norwegian survey areas, mostly settled on boulders. *A. digitatum* was more common in shallow waters (at depths of 15 m or greater); *A. palmatum* was less frequently documented, at depths of around 460 m. In addition, an unidentified species of *Alcyonium* was observed to form small aggregations on boulders and rocks at 460 m deep.

The largest aggregations of *A. digitatum* were documented in shallow depths, on rocky bottoms, together with the coralline algae *Phymatolithon lenormandii*, or growing within the understory of kelp forest. Many bryozoans comprised part of the community formed by the soft corals, such as *Crisia* sp., *Membranipora membranacea*, and *Parasmittina trispinosa*, as well as hydrozoans like *Amphilectus fucorum*, and sponges such as breadcrumb sponge (*Halichondria panicea*) and stalked tube sponge (*Haliclona urceolus*). Colonial light bulb tunicate (*Clavelina lepadiformis*) was also regularly observed.

Dead man's fingers (*Alcyonium digitatum*). © OCEANA/ Juan Cuetos

Boulders with hydrozoans (*Abietinaria abietina*)

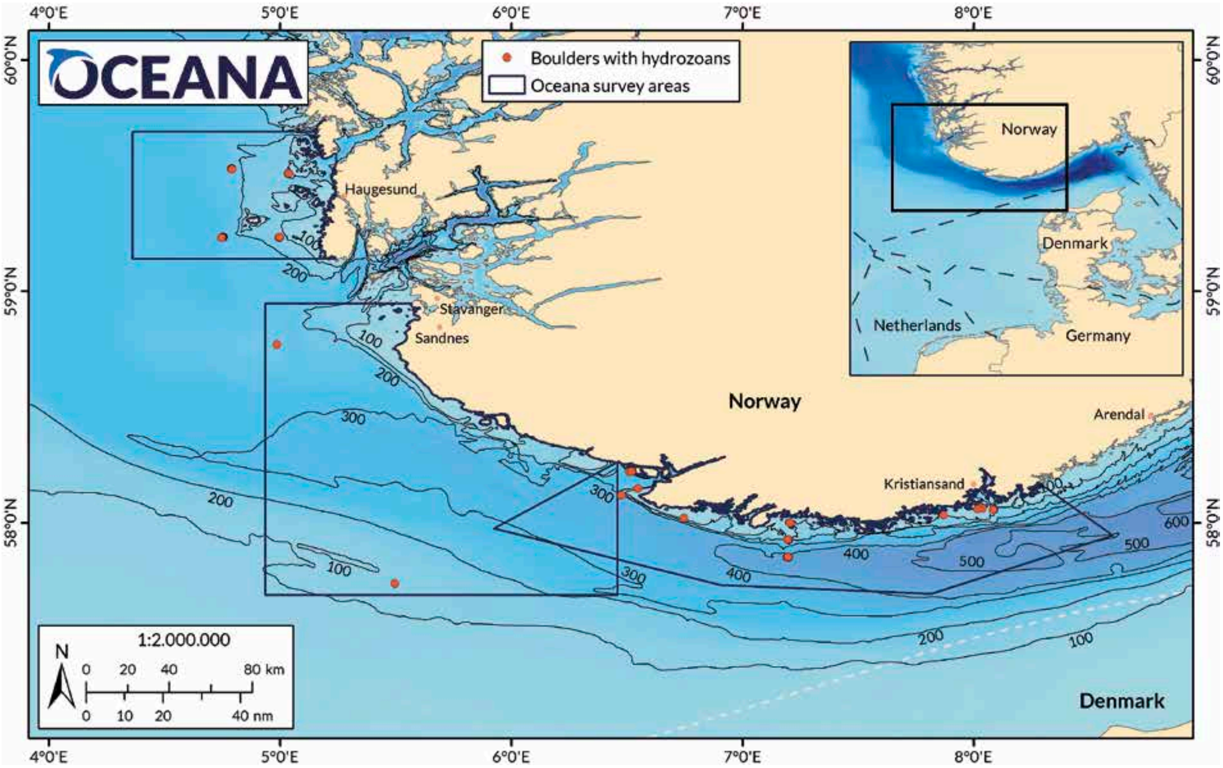


Figure 15. Locations of boulders with hydrozoans (*Abietinaria abietina*).

Hydrozoans can create three-dimensional structures and aggregate in gardens, such as the ones formed by gorgonians.[84] Thus, they also help to increase habitat complexity,[85] and serve as EFH, creating associations with fishes, allowing them to shelter or as spawning and nursery grounds.[86] Likewise, they are susceptible to severe damage through anthropogenic impacts, both direct and indirect ones (e.g., bottom trawling, climate change).[84]

Although various hydrozoans (e.g., *Halecium halecinum*, *Sertularella gayi*, *S. polyzonas*) were observed forming some type of aggregation, sea fir (*Abietinaria abietina*) was the most common hydrozoan that covered boulders in soft bottoms. Communities of *A. abietina* on boulders frequently occurred in soft-bottom areas characterised by aggregations of *Gracilechinus acutus* (see *Muddy bottoms with sea urchins* (Gracilechinus acutus)). Although the hydrozoans were documented throughout the three survey areas, the densest aggregations were identified in one sampling location in the SE Trench survey area, at 460 m deep. Also forming part of these gardens were sponges such as chalice sponge (*Phakellia ventilabrum*), and encrusting sponges such as *Hymedesmia paupertas*. The serpulid lacy tubeworm (*Filograna implexa*) was also found in these habitats, as well as various crustaceans, such as *Dichelopandalus bonnieri* and squat lobster (*Munida sarsi*).

Sea fir (Abietinaria abietina).

Boulders covered with brachiopods (*Novocrania anomala, Terebratulina retusa*)

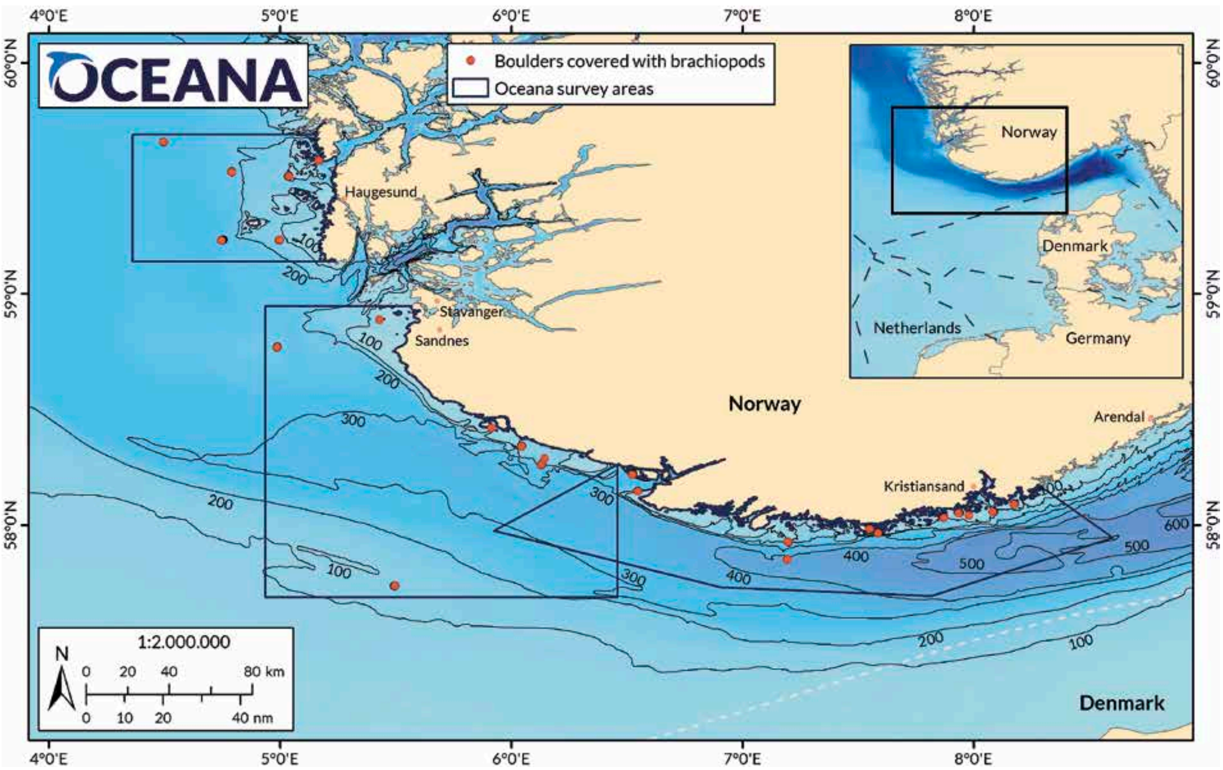


Figure 16. Locations of boulders covered with brachiopods (*Novocrania anomala*, *Terebratulina retusa*).

Surveys found that the brachiopod *Novocania anomala* was a common coloniser on boulders, in all three sampling areas. This species proliferated in high densities, completely covering extensive rocky areas, across a wide depth range (50-270 m). A second brachiopod species, *Terebratulina retusa*, was also abundant in some areas of hard substrate.

Boulders with brachiopods.

Faunal species associated with these brachiopods were those typical of hard substrate, including various arborescent sponge species (e.g., *Phakellia robusta*, *P. ventilabrum*) and, to a lesser extent, encrusting sponges (*Hymedesmia paupertas*); hydrozoans (e.g., *Abietinaria abietina* and *Halecium halecinum*); bryozoans (e.g., *Flustra foliacea* and *Reteporella beaniana*); anemones (e.g., *Bolocera tuediae* and *Urticina eques*); and an array of crustaceans (e.g., *Cancer pagurus*, *Lithodes maja* and squat lobster (*Munida sarsi*)). The echinoderms *Ceramaster granularis*, *Porania pulvillus* and *Stichastrella rosea*, and the tubeworm *Serpula vermicularis* were also regularly observed in this habitat.

Muddy bottoms with foraminifera

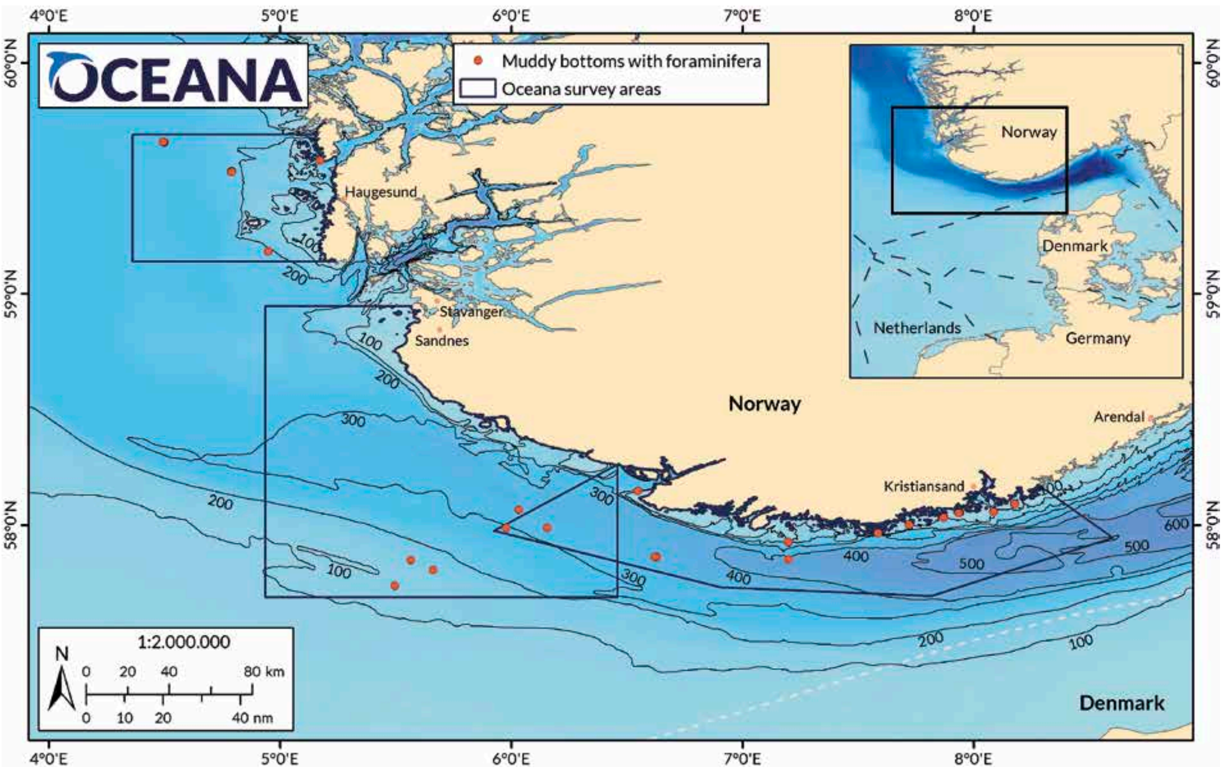


Figure 17. Locations of muddy bottoms with foraminifera.

Foraminifera can form tree-like, calcareous structures that add complexity to the soft bottoms they inhabit and provide substrates that are used by associated fauna. The presence of these structures is considered as an indicator of good environmental status, as they have a short life cycle and rapid turnover, a fast response to environmental changes, and are well preserved as fossil records.[87]

During Oceana's research, foraminifera-dominated habitats were found in highly sedimented bottoms, with little to no slope, at depths between 150-350 m. The species *Astrorhiza limicola* and *Pelosina arborescens* were documented, although the main foraminifer species that covered extensive areas of the seabed remains unidentified.

These habitats were present in all three sampling areas, and were strongly associated with benthopelagic ichthyofauna, such as Norway pout (*Trisopterus esmarkii*), and to a lower degree witch (*Glyptocephalus cynoglossus*), long rough dab (*Hippoglossoides platessoides*) and hake (*Merluccius merluccius*). The chondrichthyans *Chimaera monstrosa* and *Rajella fyllae* were also documented in association with this habitat.

Observed epibenthic macrofauna in these areas included crustaceans such as squat lobster (*Munida sarsi*), Norway lobster (*Nephrops norvegicus*), and *Spirontocaris liljeborgii*; echinoderms such as *Stichastrella rosacea* and *Parastichopus tremulus*; and cnidarians such as *Bolocera tuediae, Funiculina quadrangularis* and *Halecium halecinum*.

Juvenile of hake (*Merluccius merluccius*) on muddy bottom with foraminifera.

Muddy bottoms with burrowing megafauna (*Nephrops norvegicus*, *Galathea* sp. and *Munida sarsi*)

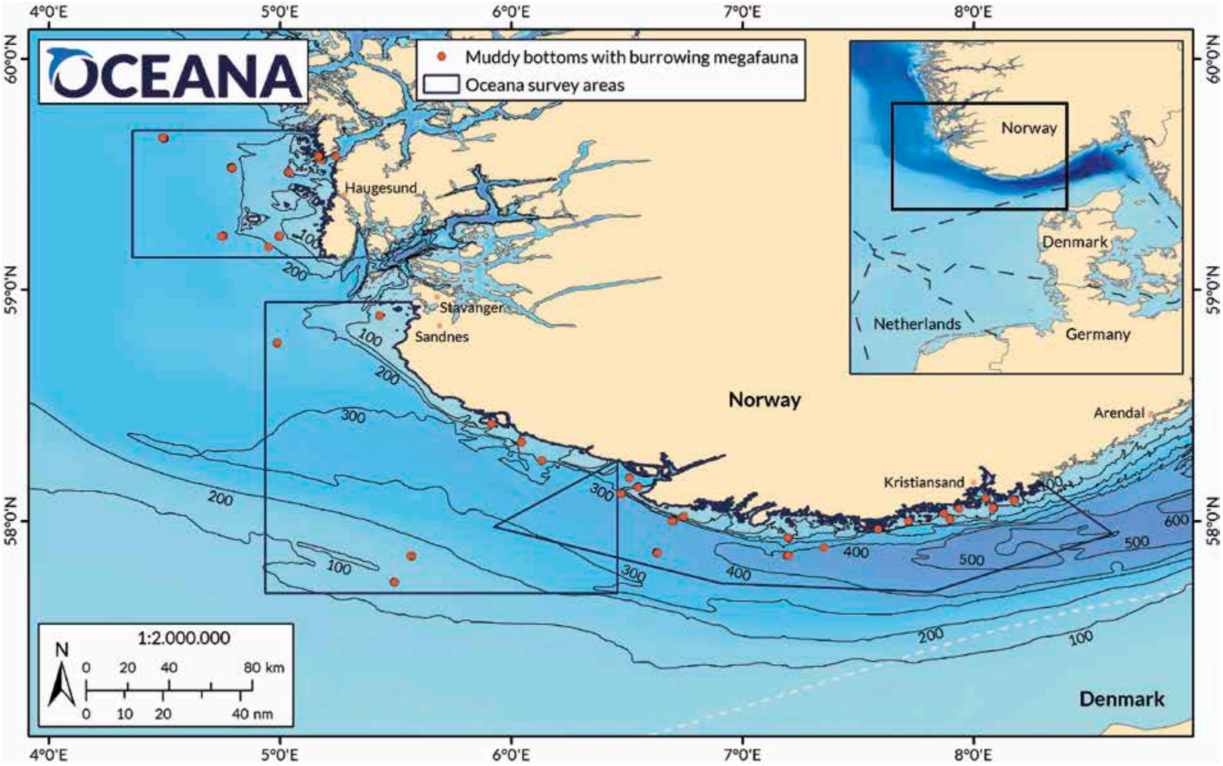


Figure 18. Locations of muddy bottoms with burrowing megafauna (*Nephrops norvegicus*, *Galathea* sp. and *Munida sarsi*)

Benthic macrofaunal organisms interact with and can strongly influence the seabed, especially in soft substrate environments. For example, some fishes and crustaceans excavate holes in the seabed, in order to create burrows to use for shelter, mating, or laying eggs. These bioturbations may greatly affect biochemical processes, ecosystem functioning, and microbial activities in such sediments, due to modifications in the exchange rates of oxygen, carbon dioxide, and nutrients between the sediment and the overlying water.[88]

This habitat was widely extended in all three sampling areas, at depths ranging from 60 m to 460 m. Some of the main species found in association with this habitat were decapod crustaceans, such as *Galathea* sp., squat lobster (*Munida sarsi*), and Norway lobster (*Nephrops norvegicus*), which use such holes to shelter when they are not feeding, as a sign of social hierarchy and for ambushing prey.[89,90] Hagfish (*Myxine glutinosa*) was also abundant in these areas. This habitat was also found mixed with various soft-bottom benthic habitats described in other sections, such as those formed by bamboo corals, sea pens, and foraminifera aggregations.

Norway lobster (*Nephrops norvegicus*) in its burrow.

Muddy bottoms with bamboo corals (*Isidella lofotensis*)

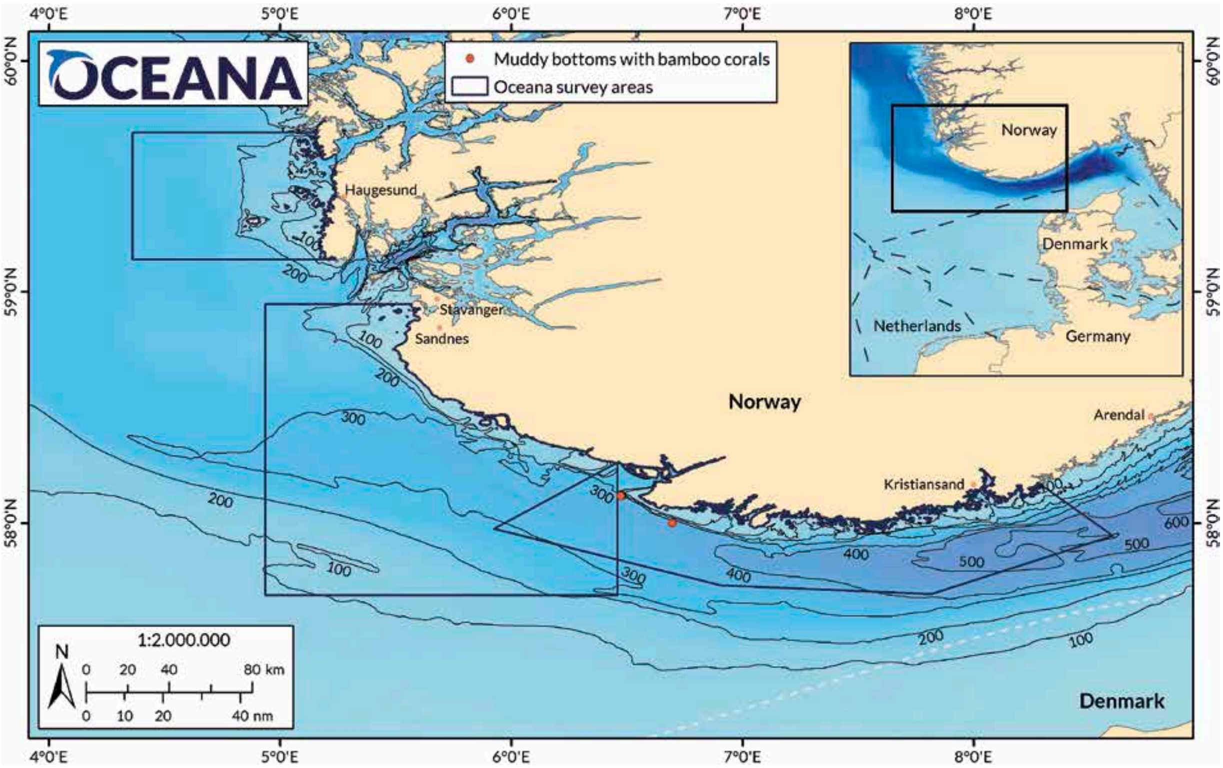


Figure 19. Locations of muddy bottoms with bamboo corals (*Isidella lofotensis*).

Bamboo coral (*Isidella lofotensis*) is considered nearly endemic to Norway, as there is only one record from outside of Norway, in the east of Greenland at 75°N.[91] In Norway, its distribution extends from the Skagerrak to Lofoten. Although there are a few records from the Norwegian continental shelf,[91] it occurs almost exclusively in fjords – where it reaches densities of up to 167 colonies/100 m^2.[92] This gorgonian is considered to be of high conservation value[92] and is categorised in the North-East Atlantic as a VME indicator species.[80] The gardens that it forms are listed as Endangered on the Norwegian Red List of Ecosystems and Habitat Types.[93] It also represents EFH for various commercial species, such as *Nephrops norvegicus*.[94]

I. lofotensis had previously been documented from the Skagerrak, with the most detailed recent information from records of bycatch during research trawl surveys by the Institute of Marine Research.[91,94] Oceana's surveys provided the first *in situ* images of *I. lofotensis* in the south-western Skagerrak (in the SW Trench survey area), where it formed a garden at a depth range of 317-387 m. This coral garden was home to a wide diversity of crustaceans and benthic fishes. The surrounding seabed was highly bioturbated, with crustaceans such as *Dichelopandalus bonnieri*, squat lobster (*Munida sarsi*) and northern shrimp (*Pandalus borealis*), and krill species such as *Meganyctiphanes norvegica* and *Pontophilus norvegica*. Sea pens such as *Funiculina quadrangularis*, *Halipteris finmarchica*, *Kophobelemnon stelliferum* and *Protoptilum carpenteri* were interspersed among the bamboo corals, and commercial fishes documented in this habitat included witch (*Glyptocephalus cynoglossus*), ling (*Molva molva*) and Norway pout (*Trisopterus esmarkii*). The echinoderms *Asteronyx loveni*, *Parastichopus tremulus* and rosy starfish (*Stichastrella rosea*) were frequently documented in this habitat.

I. lofotensis was also documented from a second location, in which there were a few sparse colonies.

Bamboo coral (*Isidella lofotensis*) and similar shrimp (*Atlantopandalus propinqvus*). SE Trench.

Muddy bottoms with anemones (*Bolocera tuediae*) and cerianthids (*Pachycerianthus multiplicatus*)

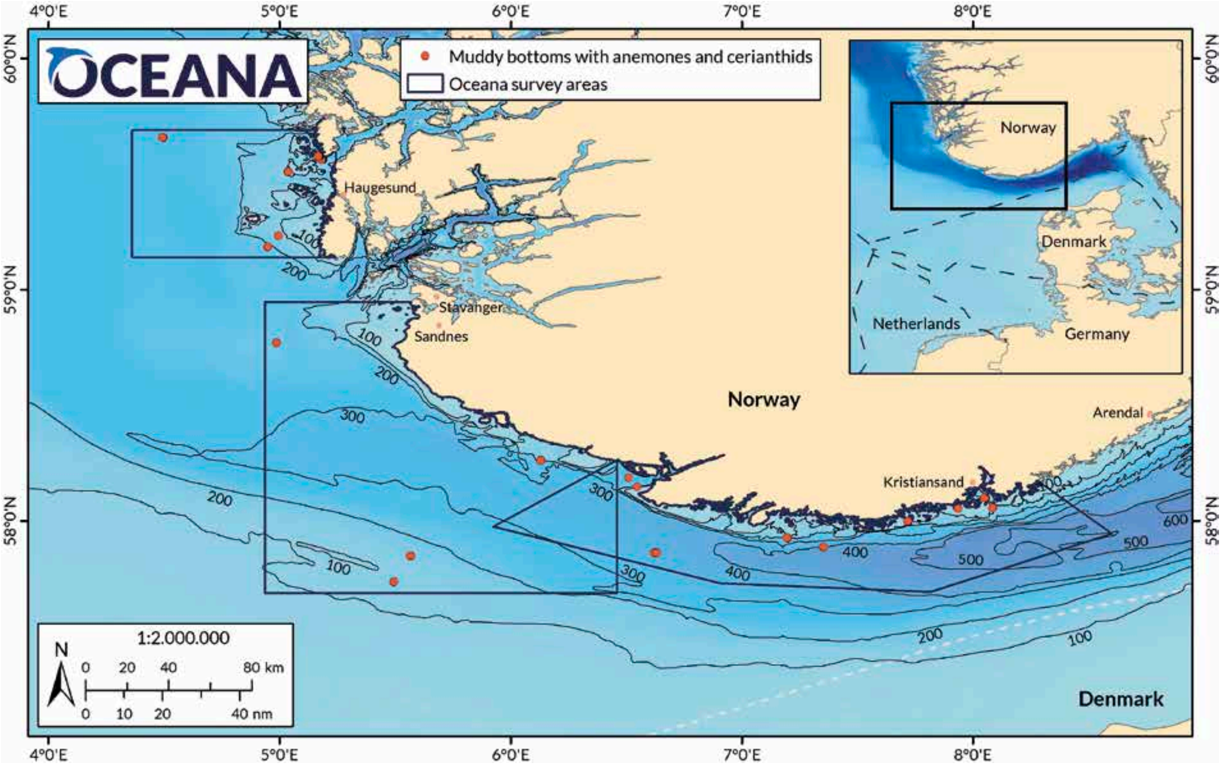


Figure 20. Locations of muddy bottoms with anemones (*Bolocera tuediae*) and cerianthids (*Pachycerianthus multiplicatus*).

Anemones and tube anemones play a similar role to bamboo coral (*I. lofotensis*) in soft bottoms, but on a smaller scale, enhancing habitat complexity with their structures. Species such as deeplet sea anemone (*Bolocera tuediae*) and Mediterranean tube anemone (*Pachyceranthus multiplicatus*) were commonly observed in the three survey areas, growing on mud and providing shelter to associated fauna. *B. tuediae* was also settled in some areas of hard substrate, together with other anemones such as *Urticina eques*.

Oceana identified habitats characterised by these two anemone species on muddy bottoms in all three survey areas, at depths of 150-410 m. Both *B. tudiae* and *P. multiplicatus* were consistently observed to host aggregations of decapod crustaceans below them. This observation was consistent with a previous study of the symbiotic association between these anemones and decapods, amphipods, and copepods, described in the eastern Skagerrak.[95] In this study, all observed individuals of *B. tuediae* and 93% of *P. multiplicatus* individuals had different shrimp species aggregated beneath them. This association is believed to be primarily beneficial for the crustaceans, in that the anemones provide protection against predators, and may also obtain leftover or regurgitated food from the anemone.

Deeplet sea anemone (*Bolocera tuediae*) and associated decapods.

During Oceana's research, the main associated decapods found in these habitats were *Dichelopandalus bonnieri*, polar shrimp (*Lebbeus polaris*), squat lobster (*Munida sarsi*), and friendly blade shrimp (*Spirontocaris liljeborgii*). Krill (such as *Meganyctiphanes norvegica*) and *Pandalus borealis* were also observed. Other organisms identified in these areas included cnidarians such as sea pens (e.g., *Virgularia mirabilis, Funiculina quadrangularis*), echinoderms such as the holothurian *Parastichopus tremulus*, and fishes such as Norway pout (*Trisopterus esmarkii*) and various chondrichthyans (*Chimaera mostrosa, Etmopterus spinax* and *Galeus melastomus*).

Muddy bottoms with ascidians (*Molgula manhattensis* and *Polycarpa pomaria*)

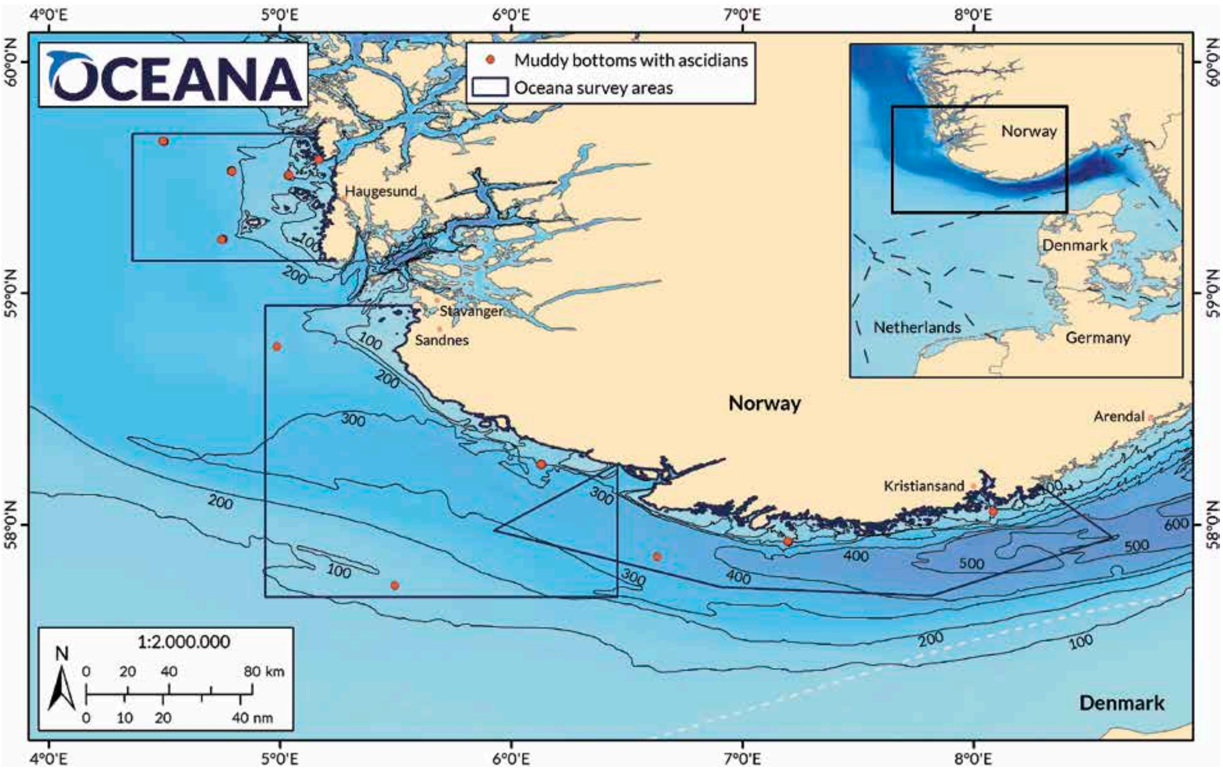
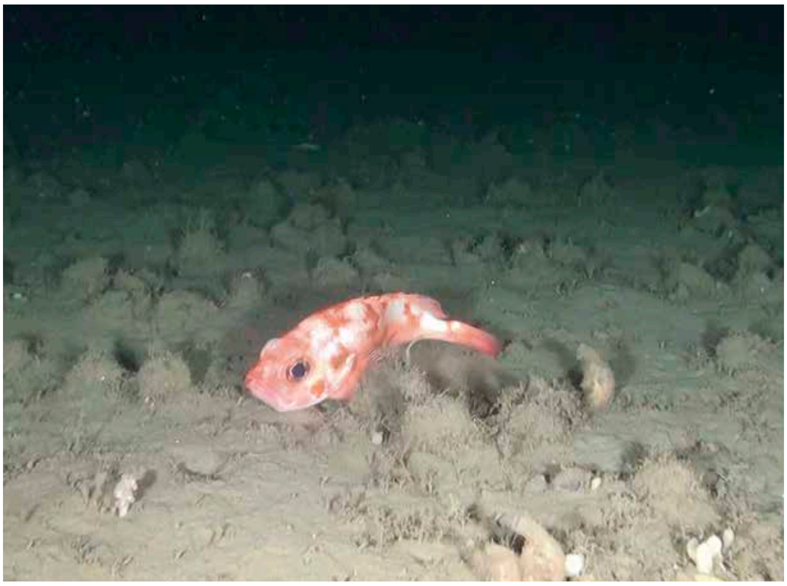


Figure 21. Locations of muddy bottoms with ascidians (*Molgula manhattensis* and *Polycarpa pomaria*).

The ascidian *Molgula manhattensis* originates from the east coast of North America and is considered invasive in Nordic waters.[96] It can settle on hard substrates such as shells and rocks, but also can be found in sand.[97] It is considered a coastal species, inhabiting waters down to about 90 m.[97] In Norwegian waters, it has been found in a few places along the central west coast (Hordaland county and around the Trondheimsfjord),[98] although later records situate the species along the southern coast of Norway, off Østfold and Oslofjorden (the Skagerrak).[99]

During the Oceana expeditions, high densities of *M. manhattensis* and *Polycarpa pomaria* (an ascidian that is native to the North-East Atlantic) were found on soft bottoms in all three survey areas. They covered extensive areas, at depths of 194-280 m. A variety of crustaceans (e.g., *Dichelopandalus bonnieri*, *Meganyctiphanes norvegica*, *Munida sarsi*) were found sheltering in the fields of these ascidians, as well as other organisms such as echinoderms (*Parastichopus tremulus*, *Stichastrella rosea*), sea pens (*Protoptilum carpenteri*) and foraminifera. The latter were abundant and formed part of this habitat. Barrett's horny sponge (*Geodia barretti*), an individual round skate (*Rajella fyllae*) and blue-eyed bob-tail squid (*Rossia glaucopis*) were also documented.

Norway redfish (*Sebastes viviparus*) in *Polycarpa pomaria* field.



Muddy bottoms with sea urchins (*Gracilechinus acutus*)

While habitat-forming species are generally sessile, various mobile fauna can also help to structure and add complexity to the sea bottom, thereby playing an important ecological role. This is the case of some echinoderms that concentrate in very high numbers to form feeding aggregations, such as certain species of crinoids, holothurians, and ophiuroids. Sea urchins are another example, as they can aggregate in large concentrations of individuals, creating mobile habitats and important feeding areas. Their three-dimensional shape allows them to host, on a small scale, other organisms such as hydroids, sponges, and barnacles.[100]

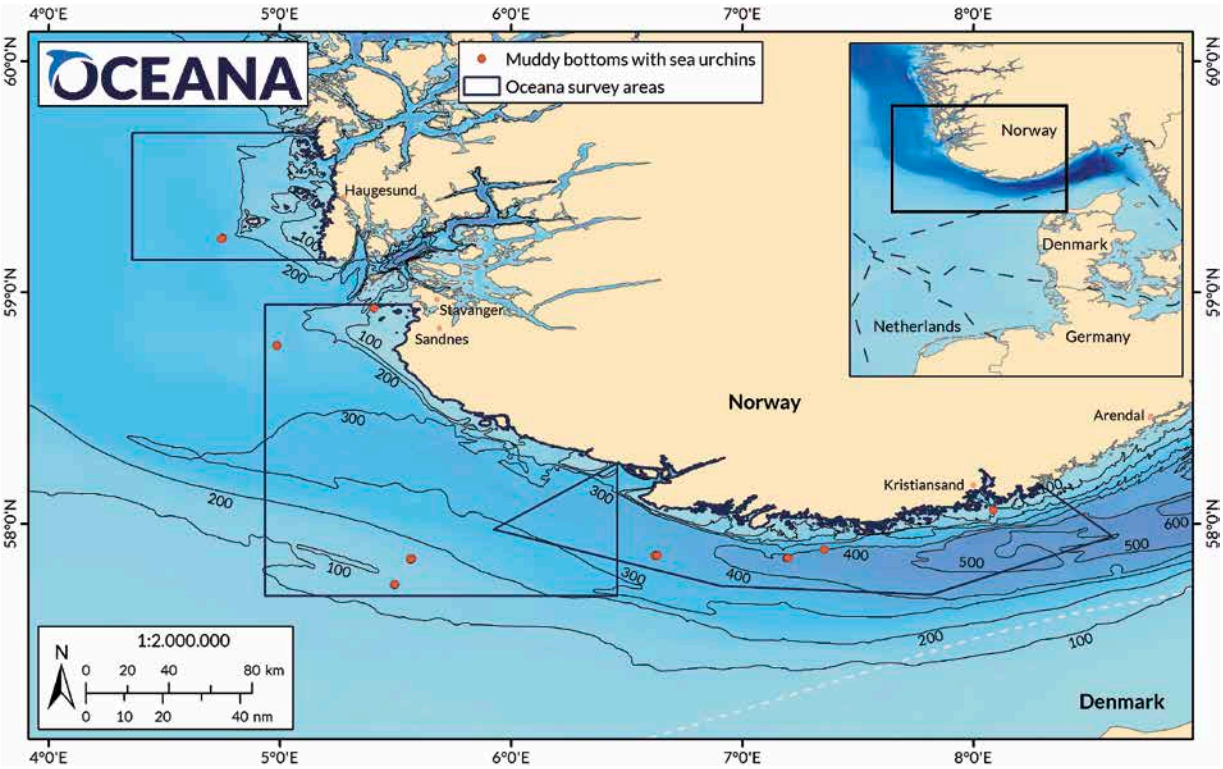


Figure 22. Locations of muddy bottoms with sea urchins (*Gracilechinus acutus*).

Although white sea urchin (*Gracilechinus acutus*) was documented in all three survey areas, in certain spots of the SE Trench survey area, it was highly concentrated on muddy bottoms, with aggregations of over 20 individuals. The two largest such aggregations were recorded from depths of 354 m and 460 m. The areas where *G. acutus* proliferated were associated with bioturbating crustaceans (i.e., *Dichelopandalus bonnieri*, *Munida sarsi*), foraminifera, and other echinoderms, such as *Astropecten irregularis*.

White sea urchin (*Gracilechinus acutus*) aggregation on soft bottom.

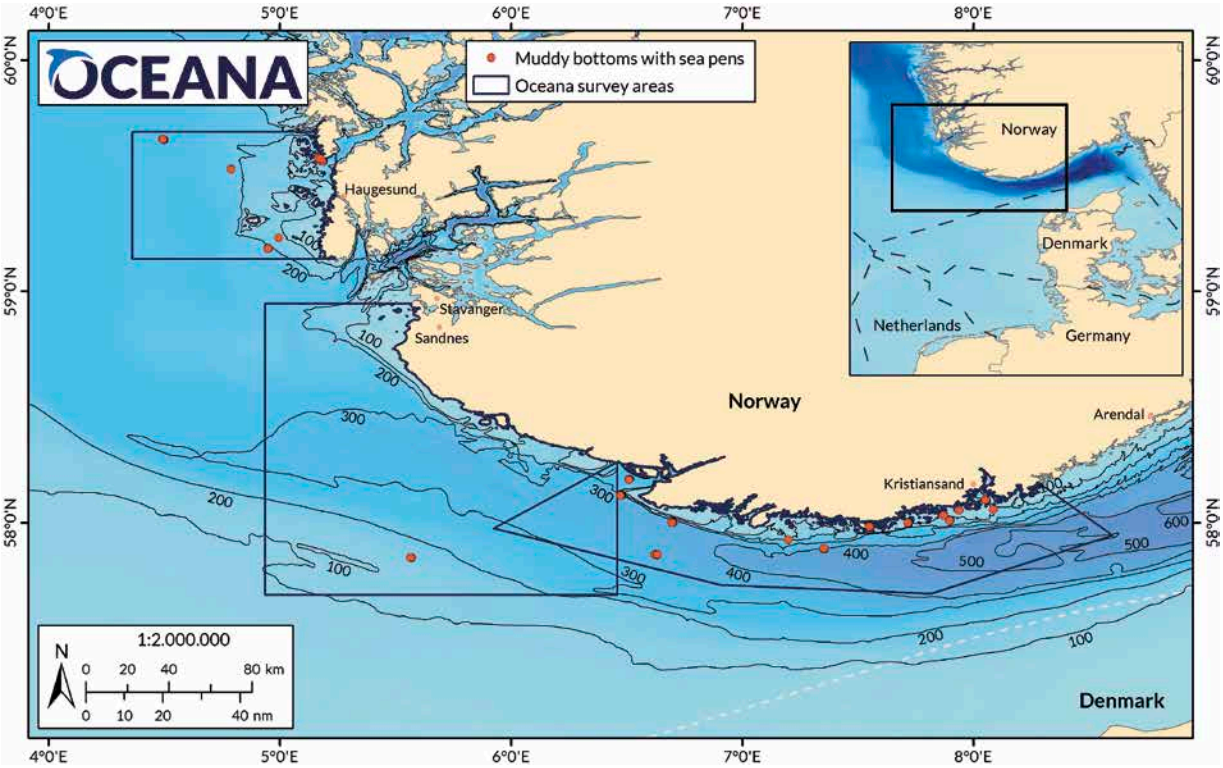


Figure 23. Locations of muddy bottoms with sea pens.

Sea pens are cold-water corals, belonging to the order Pennatulacea, which are generally found on soft bottoms.[101] They can form dense meadows, reaching 0.1-2 m above the surface of the sediment[101] and thus, they are considered to be amongst the largest organisms that generate complexity in biotic habitats.[102] Sea pens create biogenic habitats for many organisms, including various shrimps, ophiuroids, and commercial fishes, and serve as a nursery habitat.[101,103] These corals are extremely vulnerable to bottom-contact fishing gears, which can damage or completely sweep colonies from the seabed, and are considered VME indicator species.[80]

In the three areas studied in Norwegian waters, sea pens were documented in nearly all of the surveys in soft bottom areas, at depths of 49-412 m. Seven sea pen species were recorded (i.e., *Funiculina quadrangularis*, *Halipteris finmarchica*, *Kophobelemnon stelliferum*, *Pennatula phosphorea*, *Protoptilum carpenteri*, *Virgularia mirabilis* and *V. tuberculata*). Of these, the ones found in greatest abundance were *Funiculina quadrangularis*, *Kophobelemnon stelliferum*, and *Virgularia mirabilis*, both in monospecific gardens and mixed with other sea pen species.

Tall sea pen (*Funiculina quadrangularis*) with associated anemone *Ptychodactis patula*.

The substrate in this habitat type was generally bioturbated, indicating the presence of crustaceans such as *Dichelopandalus bonnieri* and squat lobster (*Munida sarsi*). Other species that were commonly observed to comprise part of this community included deeplet sea anemone (*Bolocera tuediae*) and Norwegian red sea cucumber (*Parastichopus tremulus*), and foraminifera. The bamboo coral *Isidella lofotensis* was also documented from sea pen gardens, as well as witch (*Glyptocephalus cynoglossus*). Associations were also observed between tall sea pen (*F. quadrangularis*) with the anemone *Ptychodactis patula*, and with the ophiuroid *Asteronyx loveni*.

Hard substrate with demosponges

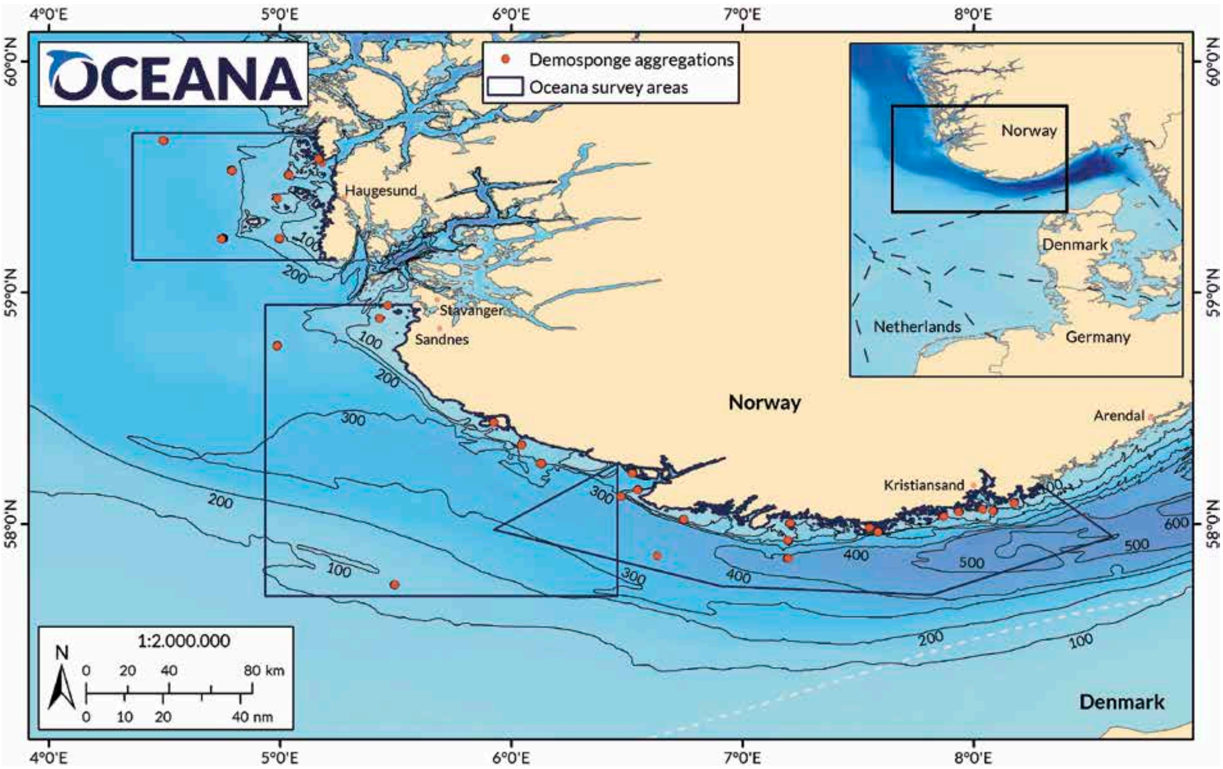


Figure 24. Locations of hard substrate with demosponges.

Demosponges (the group that includes most living sponge species) display a broad array of morphologies and are adaptable to a wide variety of substrates and depths.[104] They can proliferate and create dense monospecific or multispecific aggregations, and become the dominant species in habitats that host other biota, thereby increasing habitat complexity and biodiversity. They also participate in the cycling of nutrients such as carbon and nitrogen, as well as in the transfer of matter and energy from sediments to the water column.[105]

Many demosponges are vulnerable to mechanical damage, mainly in relation to bottom-contacting gears and anchoring,[105] but they are also very sensitive to pollution and habitat destruction. Some of the documented species have been listed as indicators of deep-sea sponge aggregations, either on hard or soft bottoms.

Oceana's surveys found areas of hard substrate covered by structuring sponges in all three sampling areas, particularly on sites where boulders were surrounded by soft bottoms. The main sponge species associated with boulders were *Antho dichotoma*, North Atlantic cup sponge (*Axinella infundibuliformis*), *A. rugosa*, *Craniella cranium*, *C. zetlandica*, Barrett's horny sponge (*Geodia barretti*), *G. macandrewii*, sheep's tongue sponge (*Mycale lingua*), *Phakellia robusta*, and chalice sponge (*P. ventilabrum*). Encrusting sponges were also documented in these communities, such as *Hymedesmia paupertas* and other unidentified species. Fan-shaped sponges such as *Phakellia* spp. developed the largest canopies (up to 40 cm width), which were associated with species such as crustaceans (*Dichelopandalus bonnieri*), crinoids (*Anthedon* sp.), hydrozoans (*Abietinaria abietina*) and bryozoans (*Reteporella beaniana*). Other demosponges (e.g., *Plakortis simplex* and *Quasillina brevis*) were more closely associated with sedimented rocky bottoms, which also hosted some of the species that grew on boulders (*M. lingua*, *Phakellia* spp., *C. cranium*).

Chalice sponge (*Phakellia ventilabrum*).

The two Oceana expeditions in Norwegian waters documented a variety of species and habitats that are considered conservation priorities. This is the case for features that are listed under national, European, or regional frameworks that recognise their threatened status and/or establish legal requirements for their protection. These frameworks include: Red Lists of threatened species, ecosystems, and habitat types; the OSPAR Convention; the Bern Convention; and the list of VME habitats and indicator taxa from the International Council for the Exploration of the Sea (ICES). As such, their occurrence in Norwegian waters of the North Sea deserves special consideration, with respect to the biodiversity value of the area and necessary management measures. These features are discussed in more detail below.

Threatened and protected habitats

Six broad habitat categories identified in Norway during the Oceana North Sea expeditions are recognised as priorities for conservation (Table 1; Figure 25). These habitats are all formed by organisms such as corals, sponges, or kelps, which enhance habitat complexity and provide important habitat (e.g., refuge, feeding, or nursery areas) for associated species.

At the international level, Norway is a Contracting Party to the Convention for the Protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention'). Under OSPAR, 16 habitat types have been identified as priorities for protection, through their inclusion on the OSPAR List of Threatened and/or Declining Species and Habitats. The list is meant to guide OSPAR in setting priorities for future work on protection and conservation of marine biodiversity, and lays the basis for the development of management measures, such as the designation of marine protected areas as part of the OSPAR network of MPAs.

Four of the habitat types documented by Oceana in Norwegian waters of the North Sea are listed as threatened and/or declining under OSPAR:

- 'Coral gardens' are formed by non-scleractinian corals that build their colonies by "burgeoning", hosting rich and complex ecosystems. Many coral species can form these aggregations, such as gorgonians, leather corals, and bamboo corals. In the Greater North Sea (OSPAR Region II), coral garden records in Norway have been described mostly in the channels around the Oslofjord, and in the open Skagerrak, with rich communities formed by the gorgonian species *Muriceides kuekenthali*, *Paramuricea placomus* and *Primnoa resedaeformis*.[106] The following habitat types documented by Oceana during the Norwegian North Sea surveys correspond to the OSPAR definition of coral gardens: 'Shallow-infralittoral hard bottom with gorgonians'; 'Deep-circalittoral hard bottoms with gorgonians'; 'Boulders with soft corals'; 'Muddy bottoms with bamboo corals'; and 'Muddy bottoms with sea pens'.

- 'Deep-sea sponge aggregations' are defined by OSPAR as comprising sponges of the classes Hexactinellida and Demospongiae, in high densities, on soft or hard substrata. These communities share habitat preferences with cold-water corals, inhabiting depths over 250 m, although in Norway, they have been recorded from waters as shallow as 30 m in fjords (Trondheim Fjord and the Koster) and Oslofjord). According to OSPAR, 'Deep-sea sponge aggregations' have only been documented in two areas in the North Sea: the Karmøy area (between Bergen and Kristiansand and possibly beyond) where the dominant sponges are *Geodia* spp. and *Stryphnus ponderosus*, and parts of the eastern Skagerrak, with species such as *Antho dichotoma*, *Axinella rugosa*, *Geodia baretti*, *Mycale lingua*, *Phakellia* spp., and *Stelletta normani*, among others. [107] In Oceana's research findings, deep-sea sponge aggregations correspond to the habitat type 'Hard substrate with demosponges'.

The OSPAR habitat 'Sea-pen & burrowing megafauna communities' refers to plains of fine mud in which bioturbation creates a complex habitat that enhances oxygen penetration.[108] This habitat is typically found from 15 m depth to more than 200 m depth. The main burrowing species include crustaceans (i.e., *Callianassa subterranea*, *Calocaris macandreae* and *Nephrops norvegicus*) that are typically associated with the sea pens *Pennatula phosphorea* and *Virgularia mirabilis*. In the North Sea, this habitat occurs in deeper offshore areas and in sheltered bottoms inside fjords, where the tall sea pen *Funiculina quadrangularis* normally occurs.[108] The two habitat types documented by Oceana in this study are 'Muddy bottoms with burrowing megafauna (*Nephrops norvegicus*, *Galathea* sp. and *Munida sarsi*)', and 'Muddy bottoms with sea pens'.

'*Zostera* beds' are formed by the species *Zostera marina* and *Zostera noltei*, creating dense beds in sheltered bays and lagoons in sand/sandy mud down to 5 m deep, and in and intertidal areas on mud/sand mixtures. In Norway, *Z. marina* can occasionally reach depths of 10 m in areas with very clear waters. These seagrasses help to stabilise the substratum, provide shelter to many organisms, and are highly productive.[109] This habitat coincides with 'Shallow bottoms with eelgrass (*Zostera marina*)' documented by Oceana in the SE Trench area.

OSPAR has recommended measures that countries should undertake to better protect these fragile habitats, including introducing national legislation to protect them, such as the designation of MPAs.[110,111,112,113] However, it should be noted that OSPAR has no jurisdiction over fisheries issues, and therefore cannot mandate any direct management measures to address fishing activities, which represent the main threats facing coral gardens, deep-sea sponge aggregations, and sea pen communities. Instead, for example, national environmental authorities are encouraged to request their fisheries counterparts to establish fisheries closures deemed necessary for habitat conservation.

Also at the international level, four of the habitat and community types listed in Table 1 are considered to be VME habitats, according to the classification developed by ICES.[80] Such habitats require specific conservation measures, as established under United Nations General Assembly Resolutions 61/105 and 64/72 on sustainable fisheries, and the UN Food and Agriculture Organization *International Guidelines for the Management of Deep-sea Fisheries in the High Seas.*[95,96] These VMEs are discussed below (see *Threatened and protected species*) because the habitats are described on the basis of representative taxa.

Table 1. Features of conservation interest documented in Norway during the 2016 and 2017 Oceana expeditions. EN: Endangered; VU: Vulnerable; VMEs: Vulnerable Marine Ecosystems.

FEATURES		INTERNATIONAL FRAMEWORKS				NATIONAL FRAMEWORKS	
		IUCN Red List[114]	OSPAR[115]	Bern[116]	VMEs[80]	Norwegian Species Red List[117]	Norwegian Habitats Red List
Habitats	Coral gardens		(a)		✓		
	Deep-sea sponge aggregations		(b)		✓		
	Sea-pen & burrowing megafauna communities		(c)		✓		
	Zostera beds		(d)				
	Bamboo coral (*Isidella lofotensis*) forest				✓		EN (North Sea)[93]
	Sugar kelp forest						EN (North Sea and Skagerrak)[118]
Species	CHORDATA						
	Alca torda					EN	
	Amblyraja radiata	VU					
	Gadus morhua		(c)				
	Halichoerus grypus			Annex III			
	Phoca vitulina			Annex III			
	Raja clavata		(e)				

CNIDARIA						
Caryophyllia inornata				(g)		
Caryophyllia (Caryophyllia) smithii				(g)		
Cerianthus lloydii				(h)		
Cerianthus membranaceus				(h)		
Epizoanthus incrustatus				(i)		
Funiculina quadrangularis				(j)		
Halipteris finmarchica				(j)		
Isidella lofotensis				(k)		
Kophobelemnon stelliferum				(j)		
Pachycerianthus multiplicatus				(h)		
Paramuricea placomus				(k)		
Pennatula phosphorea				(j)		
Protoptilum carpenteri				(j)		
Swiftia dubia				(k)		
Virgularia mirabilis				(j)		
ECHINODERMATA						
Antedon sp.				(l)		
MOLLUSCA						
Arctica islandica		(e)				
Nucella lapillus		(f)				
PORIFERA						
Axinella infundibuliformis				(m)		
Axinella rugosa				(m)		
Craniella zetlandica				(m)		
Geodia atlantica				(n)		
Geodia barretti				(n)		
Geodia macandrewii				(n)		
Mycale lingua				(m)		
Phakellia robusta				(m)		
Phakellia ventilabrum				(m)		
Polymastia boletiformis				(m)		
Polymastia mammillaris				(m)		
Polymastia penicillus				(m)		
Polymastia robusta				(m)		

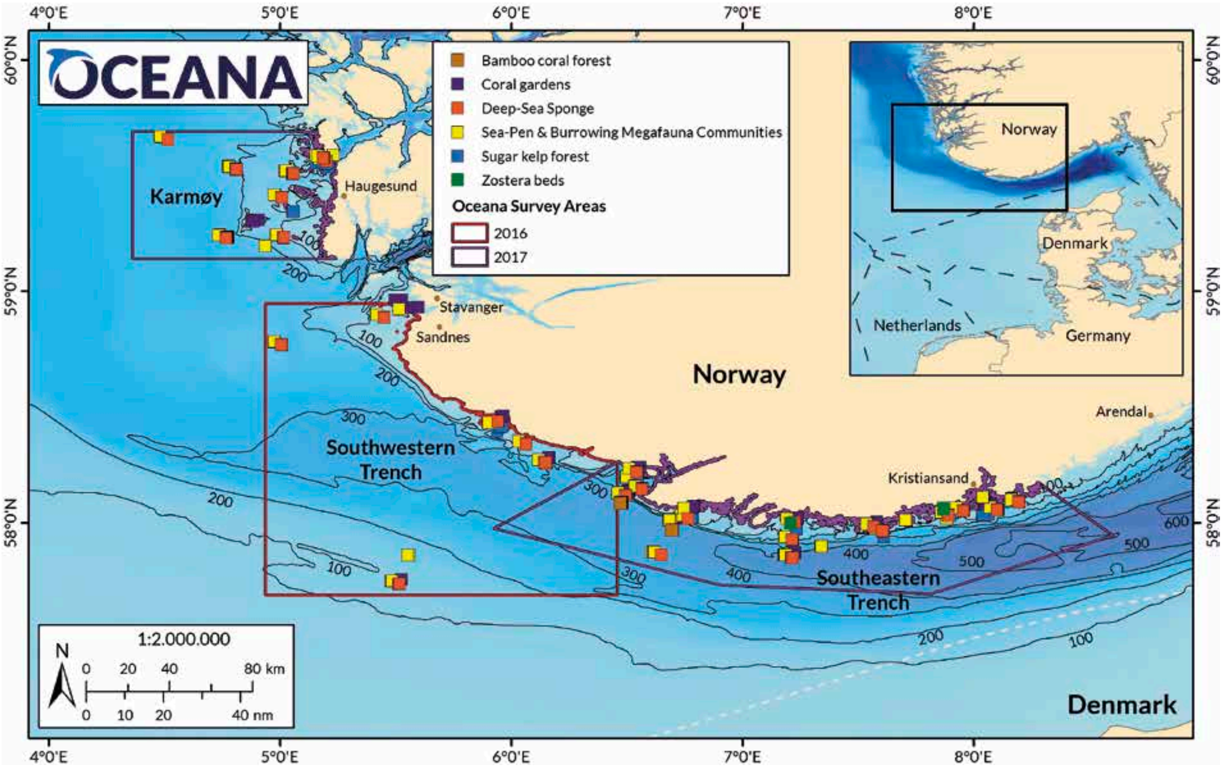
(a) OSPAR Habitats under threat and/or decline (Regions I, II, IV and V)
(b) OSPAR Habitats under threat and/or decline (Regions I, II, III, IV and V)
(c) OSPAR Habitats under threat and/or decline (Regions II and III)
(d) OSPAR Habitats under threat (Regions I, II, III and IV) and decline (Region II)
(e) OSPAR Habitats under threat and/or decline (Region II)
(f) OSPAR Habitats under threat and/or decline (Regions II, III and IV)
(g) VME habitat type: Coral garden; Habitat subtype: Soft bottom coral graden: Cup-coral fields
(h) VME habitat type: Anemone aggregations; Habitat subtype: Soft bottom anemone aggregations
(i) VME habitat type: Anemone aggregations; Habitat subtype: Hard bottom anemone aggregations
(j) VME habitat type: Seapen fields
(k) VME habitat type: Coral garden; Habitat subtype: Hard bottom coral garden: Hard bottom gorgonian and black coral gardens
(l) VME habitat type: Mud and sand emergent fauna
(m) VME habitat type: Deep-sea sponge aggregations; Habitat subtype: Hard bottom sponge aggregations
(n) VME habitat type: Deep-sea sponge aggregations; Habitat subtype: Soft bottom sponge aggregations

At the national level, the *Norwegian Red List for Ecosystems and Habitat Types* aims to give decision-makers better knowledge for biodiversity management, although it does not mandate legal protection. Two of the habitat types documented during Oceana's surveys are recognised as threatened on the Norwegian Red List:

- 'Bamboo coral forest' was added to the Red List in 2018, under the category of Endangered (i.e., it has a very high risk of becoming extinct in the wild).[93] Bamboo coral (*Isidella lofotensis*) has a limited known distribution, which comes from research trawl surveys by the Institute of Marine Research. It is highly vulnerable to bottom trawling, which is the main driver of its decline and affects 50-90% of the suitable area for this habitat.[93] It corresponds to the Oceana habitat type 'Muddy bottoms with *Isidella lofotensis*'.
- 'Southern sugar kelp forest' (i.e., forests formed by *Saccharina latissima* in the North Sea and the Skagerrak) is also listed as Endangered.[118] The Skagerrak sub-unit has seen a particularly pronounced decline, of up to an estimated 80%.[118] Sugar kelp in the Skagerrak faces an ongoing decline in distribution, as a consequence of habitat degradation due to worsening environmental conditions, specifically related to pollution and climate change. The threatened status of *S. latissima* forests in the Norwegian North Sea reflects broader declines in kelp forests. Globally, over the last 100 years, kelp forests have been degraded and threats to kelp ecosystems have severely increased in number and magnitude. The primary threats facing kelp forests are related to climate change, including ocean warming (temperature is the most decisive variable affecting kelp distribution) and the increasing of number and severity of storms. Other anthropogenic threats include direct overharvesting, fishing, pollution and eutrophication.[119] Kelp is also generally decreasing at the European scale.[120] The loss of kelp forests is particularly worrying given that they are one of the most productive ecosystems on Earth — comparable to tropical rainforests — and provide a wide range of ecosystem services with high social, economic and ecological value. The Red List habitat type corresponds to the Oceana habitat 'Kelp forest'.

Regarding kelp forests, this valuable habitat type has also been proposed for inclusion on the OSPAR List of Threatened and/or Declining Species and Habitats, and the listing process is ongoing.

Figure 25. Habitats of conservation interest found in Norwegian survey areas.



Threatened and protected species

Oceana surveys in Norwegian waters documented 39 species that are considered priorities for conservation, based on their inclusion in conservation frameworks (Table 1; Figure 26). These species were predominantly cnidarians (16 species, of mostly corals and sea pens) and sponges (13 species, all demosponges). The list also includes six species of chordates (razorbill, harbour seal, grey seal, starry ray, thornback ray, and cod). Finally, two molluscs, one bryozoan and one echinoderm documented by Oceana are also of recognised conservation interest.

Four of these species are included on the OSPAR List of Threatened and/or Declining Species, with respect to their populations in the Greater North Sea (OSPAR Region II):

- Ocean quahog (*Arctica islandica*) is considered to be the longest-lived non-colonial animal in the world, with a maximum age of more than 500 years,[121] and is one of the slowest growing marine bivalves. It has suffered a significant decline in abundance in the North Sea, especially in shallower waters (30-50 m) where fishing activity is high. These losses suggest that ocean quahog is very sensitive to mechanical damage and incidental catch from bottom gears such as beam trawls.[122]

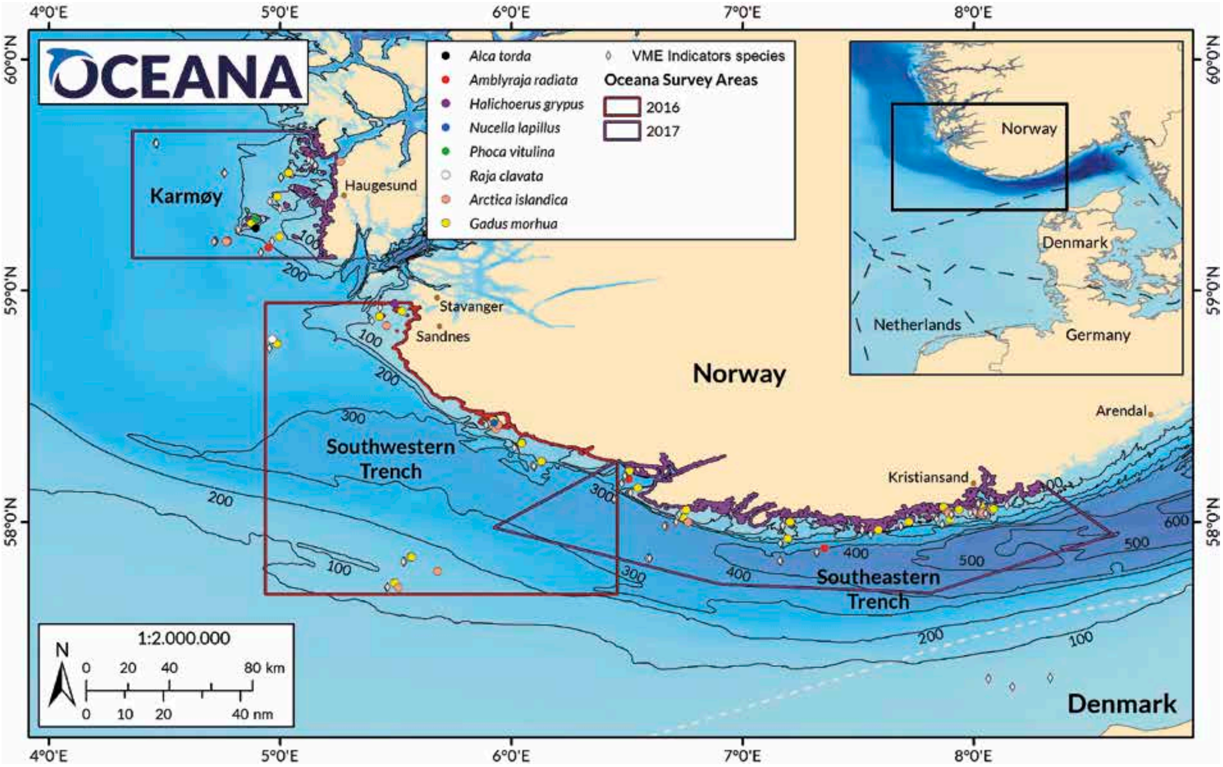
- The gastropod dogwhelk (*Nucella lapillus*) used to be widely distributed throughout the North Atlantic. Its population has severely declined in recent years due to its sensitivity to synthetic chemical pollutants.[123] The main threat to dogwhelk is the extended use of antifouling paints containing tributyltin – a compound that produces an irreversible condition in dogwhelk known as 'imposex,' in which female individuals develop male characteristics.[124]
- Thornback ray (*Raja clavata*) was listed due to a severe decline caused by fishing pressure across the OSPAR maritime area, mostly in the North Sea.[125] It is the principal commercial species among the skates and rays, accounting for 73-77% of the landings reported to species level within this group.[126] The population appears to have increased in the last eight years, but its status remains unknown.[126]
- Atlantic cod (*Gadus morhua*) is widely distributed in the North-East Atlantic, but was listed as threatened in 2008 in the North Sea and Celtic Seas, after stocks had declined by more than 50%, to below safe biological limits.[127] The most recent assessment of the population in the North Sea, eastern English Channel, and the Skagerrak indicates that despite a period of apparent increase, cod in these areas has once again been declining; it is below safe limits and remains subject to ongoing overfishing.[128]

The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) is a binding international agreement that aims to conserve wild flora and fauna and their natural habitats, and also to promote European co-operation in this area.[129] The Bern Convention mandates the protection of species listed on its appendices, although it also allows regulated exploitation of certain species. Among the species recorded by Oceana in Norwegian waters, two seal species are listed in Appendix III of this convention: harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*). They are therefore protected species, and Contracting Parties (including Norway) must ensure that their populations are kept out of danger, and that any exploitation is regulated.

Twenty-eight species documented during Oceana's research in Norway have been identified by ICES as indicators of vulnerable marine ecosystems (VMEs). These species are mostly cnidarians and sponges, as well as one crinoid. They are considered representative of five specific VME habitat types, and six VME habitat subtypes, according to the ICES classification.[80] Given that many of these species only occur in deeper waters, the Norwegian Trench is practically the only area in the North Sea where these VMEs can occur. The protection of VMEs from destructive fishing practices is a legal obligation for countries and regional fisheries management organisations,[130] and involves the adoption of management measures such as the closure of an area to bottom-contacting fishing gears if the presence of VMEs is documented.

Two species found by Oceana in Norway's marine waters are categorised as threatened on Red Lists of threatened species. Thorny skate (*Amblyraja radiata*), a deep, benthic, widely distributed species is categorised as Vulnerable (i.e., it has a high risk of extinction in the wild.) on the global IUCN Red List[131] while razorbill (*Alca torda*), is listed as Endangered on the Norwegian Red List of Species.[96] These listings do not imply any legal protection, and instead provide a comprehensive compilation of information on species' conservation status, range, population size, habitat and ecology, use and trade, and threats. Species Red Lists are used as key indicators of biodiversity health by government agencies, wildlife departments, and other organisations.

Figure 26. Species of conservation interest found during the 2016 and 2017 Oceana North Sea Expeditions.



Commercial species

During Oceana's surveys in Norway, 93 taxa were identified that are commercially exploited in the North Sea, including various algae, crustaceans, echinoderms, fishes, and molluscs (Table 2). These species included fishes for which Norwegian waters are known to represent EFH (see *Biodiversity of the Norwegian Trench*), including ling (*Molva molva*), plaice (*Pleuronectes platessa*), witch (*Glyptocephalus cynoglossus*), cod (*Gadus morhua*), lemon sole (*Microstomus kitt*), long rough dab (*Hippoglossoides platessoides*), dab (*Limanda limanda*) and greater argentine (*Argentina silus*).[26]

Table 2. Commercial species observed during Oceana surveys in the Norwegian North Sea. Species were identified as commercially exploited based on reported catches from the North Sea (FAO Division 27.4), according to Eurostat records from 2008-2017.[132]

Species	Common name	Species	Common name
ALGAE			
Ascophyllum nodosum	Rockweed	*Saccharina latissima*	Sugar kelp
Chondrus crispus	Irish moss	Laminariaceae	Kelps
Delesseria sanguinea	Red delesseria	*Palmaria palmata*	Dulse
Dilsea carnosa	Fleshy dilsea	Phaeophyceae	Brown macroalgae
Fucus serratus	Toothed wrack	Rhodophyceae	Red macroalgae
Laminaria digitata	Tangle	*Ulva lactuca*	Sea lettuce
Laminaria hyperborea	Tangle		
ARTHROPODA			
Anomura	Anomura decapods	*Lithodes maja*	Norway king crab
Cancer pagurus	Edible crab	*Meganyctiphanes norvegica*	Norwegian krill
Carcinus maenas	Green crab	*Nephrops norvegicus*	Norway lobster
Chaceon affinis	Deep-sea red crab	Pandalidae	Pandalid shrimps
Crangon crangon	Common shrimp	*Pandalus borealis*	Northern shrimp
Homarus gammarus	Common lobster	*Pandalus montagui*	Aesop shrimp
CHORDATA			
Acanthocardia echinata	Thorny cockle	*Labrus bergylta*	Ballan wrasse
Acantholabrus palloni	Scale-rayed wrasse	*Limanda limanda*	Dab
Anarhichas lupus	Atlantic wolf-fish	*Liocarcinus depurator*	Sandy swimming crab
Argentina silus	Greater argentine	*Lophius piscatorius*	Anglerfish
Arnoglossus laterna	Scaldfish	*Melanogrammus aeglefinus*	Haddock
Arnoglossus thori	Thor's scaldfish	*Merlangius merlangus*	Whiting
Ascidiacea	Sea squirts	*Merluccius merluccius*	Hake
Brosme brosme	Tusk	*Micromesistius poutassou*	Blue whiting
Callionymus lyra	Dragonet	*Microstomus kitt*	Lemon sole
Chimaera monstrosa	Rabbitfish	*Molva molva*	Ling
Clupea harengus	Atlantic herring	*Myxine glutinosa*	Hagfish
Ctenolabrus rupestris	Goldsinny wrasse	*Pleuronectes platessa*	Plaice
Cyclopterus lumpus	Lumpfish	Pleuronectidae	Righteye flounders
Enchelyopus cimbrius	Fourbeard rockling	*Pollachius pollachius*	Pollack
Etmopterus pusillus	Smooth lanternshark	*Pollachius virens*	Saithe
Etmopterus spinax	Velvet belly	*Raja clavata*	Thornback ray
Gadiculus argenteus	Silvery pout	Scorpaenidae	Scorpionfishes
Gadus morhua	Cod	*Sebastes viviparus*	Norway redfish
Glyptocephalus cynoglossus	Witch	*Symphodus melops*	Corkwing wrasse
Gobiidae	Gobies	*Trachinus draco*	Greater weever
Gobius niger	Black goby	*Trisopterus esmarkii*	Norway pout
Gobiusculus flavescens	Two-spotted goby	*Trisopterus luscus*	Pouting
Helicolenus dactylopterus	Blackbelly rosefish	*Trisopterus minutus*	Poor cod
Hippoglossoides platessoides	Long rough dab	*Zeugopterus punctatus*	Topknot
Malacocephalus laevis	Softhead grenadier		

ECHINODERMATA			
Asterias rubens	Common sea star	*Echinus esculentus*	Edible sea urchin
Asteroidea	Sea stars		
MOLLUSCA			
Arctica islandica	Ocean quahog	*Loligo vulgaris*	European squid
Buccinum undatum	Whelk	Mactridae	Mactra surf clams
Callista chione	Smooth venus	Mytilidae	Sea mussels
Cephalopoda	Cephalopods	*Mytilus edulis*	Blue mussel
Chamelea striatula	Striped venus	*Patella vulgata*	Common limpet
Chlamys islandica	Icelandic scallop	*Pecten maximus*	Scallop
Dosinia exoleta	Rayed dosinia	Pectinidae	Scallops
Gastropoda	Gastropods	Veneridae	Venus clams

Anthropogenic impacts

During both expeditions, several human threats to benthic ecosystems were documented. The scars of demersal fishing — one of the most extensive fishing activities in the study area — were recorded during six ROV dives, in which trawl marks were visible on the seabed. The impact generated by these fishing gears has been classified as geotechnical, as there is a mechanical interaction of the gear components with the seabed; and hydrodynamic, as it causes turbulence and mobilisation of the sediment.[133] Intensive use of these gears has deleterious biological impacts, such as significant declines in infaunal and meiofaunal diversity, which can affect ecosystem functioning[134] (see *Threats: Fisheries*).

Figure 27. Trawl mark on the seabed in the SE Trench survey area.

Figure 28. Ghost trap on the seabed of the SE Trench survey area, with *Cancer pagurus* trapped inside. © OCEANA/ Carlos Minguell

In addition to damage from fishing impacts, an array of discarded fishing gears was frequently found on the bottom. In most cases, these were fishing traps, but nets and lines were also documented. Such 'ghost' gears continue to entrap marine life, posing a permanent threat to the biota (Figure 28).

A variety of marine garbage was also documented in Norwegian waters. Records included tyres, electronic waste, plastics, and assorted domestic waste (Figure 29).

Figure 29. Domestic waste on the seabed in the Karmøy survey area.

RECOMMENDATIONS AND CONCLUSIONS

The waters of Norway undoubtedly host one of the richest and most atypical spots in the North Sea. The Norwegian Trench is exceptional in North Sea waters, because its depths support an array of deep sea habitats and species not found anywhere else in this otherwise shallow region.

The first protections for marine ecosystems in Norway date back to 1923[54] and, since then, over one thousand MPAs of multiple types have been created. However, this number is misleading. Because most of the MPAs are small, the total area protected is still just 4.4% of Norway's national waters, well below the international target of 10% by 2020, let alone the more ambitious target of 30% by 2030, as called for by IUCN and others.[135]

Nor is the distribution of MPAs equitable among the three areas into which national waters are divided. The Norwegian Trench lies within *North Sea and Skagerrak*, which is the area subject to the greatest intensity and variety of human pressures. This area contains over half of Norway's MPAs, yet the total level of protection is a mere 1.3%. These protections are skewed towards the Skagerrak (10.1% protected), while only 0.3% of North Sea waters are protected. Furthermore, all of these MPAs are located in coastal waters, thereby leaving most of the deepest waters unprotected. Considering the magnitude of human-related threats to marine life in this area, the lack of protection in the *North Sea and Skagerrak* is of grave concern.

The level of knowledge about life on the seabed in Norway's three sea areas is also unbalanced, as relatively less research effort has been allocated to the North Sea than to the Barents and Norwegian Seas. The MAREANO project, in particular, has compiled extensive data from detailed seafloor mapping (including mapping of biotopes and habitats) and disseminated its findings through an online platform.[9] The project's first phase was completed during 2006-2010 and provided useful information for the management of northern Norwegian waters (i.e., the updated version of the integrated management plan of the *Barents Sea – Lofoten* area) to be used by national authorities for cross-sectoral (e.g., fisheries and petroleum extraction) management in that area. A second phase is in process in the Barents Sea and in the shelf areas of the Norwegian Sea, and has contributed to the updated management plan of the latter area.

The findings obtained from Oceana's two research expeditions in Norway have significantly added to the knowledge of the *North Sea and Skagerrak* area. In contrast with previous studies in the area, which mostly relied on traditional sampling methods such as hydroacoustic and trawl surveys, Oceana's surveys have provided visual data collected *in situ* by remotely operated vehicle and professional divers, complemented with additional data from seabed grab samples. These surveys revealed the presence of diverse benthic ecosystems, in both shallow and deep waters, along the southern part of the Norwegian Trench. In total, Oceana documented the occurrence of 18 main habitat types, and 801 associated taxa, 584 of which were identified to the species level. These diverse ecosystems ranged from eelgrass meadows and ecologically rich kelp forests in shallow areas, to gardens of gorgonians (e.g., *Paramuricea macrospina*, *Swiftia dubia*, and *S. rosea*), soft corals (e.g., *Alcyonium digitatum* and *A. palmatum*), bamboo coral (*Isidella lofotensis*), sea pens (e.g., *Funiculina quadrangularis* and *Pennatula phosporea*), and sponge aggregations (e.g., *Geodia barretti*, *Phakellia robusta*) in deeper waters.

Among the valuable marine features documented during the two expeditions were 39 species and six broad habitat types (corresponding to nine habitat types documented by Oceana) that are listed under national and international conservation frameworks. These conservation priorities include specific habitats and species that must be protected by law. Their occurrence in Norwegian waters of the North Sea and Skagerrak further emphasises the fact that the designation of MPAs is not only desirable, but also mandatory, according to Norway's obligations under international and national law:

- As a signatory to the OSPAR Convention, Norway is required to implement measures for the protection and recovery of species and habitats that OSPAR has listed as threatened and/or declining: *Zostera* beds; coral gardens; deep-sea sponge aggregations; sea pens and burrowing megafauna; and the species *Arctica islandica; Gadus morhua*; *Nucella lapillus*; and *Raja clavata*. Such measures should include actions to minimise anthropogenic impacts, including the establishment of MPAs.
- As a Contracting Party to the Bern Convention, Norway must take measures to ensure the protection of two seal species (*Halichoerus grypus* and *Phoca vitulina*) that were documented during these expeditions.
- Under both international and national law, Norway is also required to protect vulnerable marine ecosystems (VMEs). Oceana's surveys identified 28 species that are VME indicators, including corals and sponges; many of these organisms are deep-sea benthic fauna which are not found elsewhere in the North Sea. The presence of VMEs, such as coral gardens and deep-sea sponge aggregations, requires management measures to be taken by Norway — including the closure of areas of VME habitats to bottom fishing.

Of the VME species, one in particular merits special attention: bamboo coral (*Isidella lofotensis*). The forests formed by this species are at high risk of extinction, due to extensive shrimp trawling within its restricted known area of distribution in the *North Sea and Skagerrak*.[93] Oceana's surveys represented the first time that an *I. lofotensis* forest had been filmed in that area. Given its Endangered status, Norway should adopt urgent measures to close this area – and other known areas of its occurrence – to bottom fishing and other human impacts. These conservation measures should be accompanied by detailed visual seabed surveys, in order to better determine the extent of fragile bamboo coral forests and safeguard them.

Overall, it is clear that Norway urgently needs to increase the spatial protection of its waters in order to comply with international and national laws and commitments for marine conservation. This increase must be substantial, because despite the ecological importance of Norway's seas, marine protection remains very low. If Norway is to achieve the Aichi biodiversity target under the United Nations Convention on Biological Diversity (i.e., protection of at least 10% of coastal and marine waters),[136] it needs to protect at least an additional 113 351 km^2 by 2020.[54] Such an advance would appear to be very unlikely, particularly given the slow rate at which Norway has attempted to develop its national network of MPAs; eighteen years after having initiated the process, only half of the proposed areas have been designated, despite repeated statements from the Norwegian Government about the development of this network.

Beyond simple considerations of total area to be protected, the designation of MPAs in Norwegian waters also needs to be targeted. New MPAs must be established, at a minimum, to encompass areas with species and habitats that are protected by law. Ideally, they should also be created to safeguard areas that host vulnerable marine ecosystems, serve as essential fish habitat, are home to threatened species, or represent biodiversity hotspots in general. In some cases, candidate areas for such protection are straightforward to identify. For example, while certain priority species and habitats were widely documented across the three Oceana surveys areas, others were very localised. This is the case for eelgrass (*Z. marina*), which was found in three locations very close to the coast, one of which is unprotected. Another example is sugar kelp forest, which was documented from eight locations that are either unprotected or only partially protected. In the case of bamboo coral (*I. lofotensis*), the species was found in two specific locations (although its distribution requires further study).

It should be emphasised that if Norwegian marine protected areas (whether new or existing) are to achieve their intended aims, they require effective management to limit threats to marine life. Currently, Norway's marine waters are protected through a variety of types of protected areas, many of which are spatially overlapping. These areas have been established under different kinds of legislation and have differing objectives and implications for management. For example, only nature reserves are intended to provide strict protection to the features within their boundaries; other types of areas are closed to some or all fishing (but not to other threats), while others do little to restrict human activities. In general, it is difficult to get a clear sense of how much of Norway's marine area is under real protection – and the intensity of human pressure in the *North Sea and Skagerrak* area points to a clear need for strong and effective measures.

Finally, Oceana's surveys highlight the need for greater emphasis to be placed on the study and protection of the Norwegian waters of the *North Sea and Skagerrak* area. These waters are recognised for their ecological importance, partly due to the fact that the Norwegian Trench represents a unique deep-water region of the North Sea. Oceana's research, though non-exhaustive, documented an array of diverse, valuable, and threatened seabed ecosystems, and identified key areas and features that should be prioritised for protection. Future research is therefore likely to reveal additional such areas, particularly in deeper waters, where relatively less research has been carried out. The Norwegian Government has dedicated considerable resources to the study and mapping of the seabed in the Barents and Norwegian Seas. The North Sea, due to its ecological importance and the high level of human activity in the area, also merits dedicated resources, research, and conservation action, to ensure the long-term persistence of its marine life.

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ANNEXES

Table A. Taxa documented in Norway during the 2016 and 2017 Oceana North Sea research expeditions. Taxa are listed by alphabetical order and according to sampling method.

Species	Grab	ROV	Scuba
ANNELIDA			
Annelida indet.		X	
Aphrodita aculeata		X	
Aphroditoidea indet.		X	
Bonellia viridis		X	
Chaetopterus sp.		X	
Chone infundibuliformis		X	
Ditrupa arietina	X	X	
Eunice norvegica			X
Filograna implexa		X	X
Harmothoe extenuata			X
Harmothoe imbricata	X		
Hirudinea sp.			X
Hyalinoecia tubicola	X		
Hydroides sp.		X	
Hydroides norvegica		X	
Lagis koreni	X	X	
Lanice conchilega		X	
Maxmuelleria faex		X	
Nereis pelagica			X
Owenia fusiformis	X		
Oxydromus flexuosus		X	
Pectinaria sp.	X	X	
Placostegus tridentatus	X	X	
Platynereis dumerilii		X	
Polychaeta indet.		X	
Protula tubularia		X	
Sabella sp.		X	
Sabella pavonina		X	
Sabellida indet.		X	
Sabellidae indet.		X	
Serpula sp.		X	
Serpula vermicularis		X	
cf. *Serpula vermicularis*		X	
Serpulidae indet.		X	
Spiochaetopterus sp.		X	
Spirobranchus sp.		X	X
Spirobranchus triqueter	X	X	X
Spirorbis sp.		X	X
Terebellida indet.		X	
Tomopteris sp.		X	

ARTHROPODA			
Achaeus cranchii		X	
Achelia echinata		X	
Acidostoma obesum	X		
Alpheus glaber		X	
Ampelisca sp.	X	X	
Amphipoda indet.	X	X	X
Anapagurus chiroacanthus		X	
Anomura indet.		X	
Astacilla longicornis		X	
Austrominius modestus		X	
Balanidae indet.		X	
Balanomorpha indet.	X	X	X
Balanus sp.		X	X
Balanus balanus	X	X	X
Balanus crenatus		X	
Bathynectes maravigna		X	
Calocarides coronatus	X		
Calocaris macandreae	X		
Cancer pagurus		X	X
Caprella sp.		X	X
Caprella linearis		X	
Carcinus maenas		X	X
Caridea sp.		X	X
Chaceon affinis		X	
Corophiidae indet.		X	
Crangon crangon		X	
Diastylis cornuta	X		
Dichelopandalus bonnieri		X	
Diogenes pugilator		X	
Ebalia granulosa	X		
Epimeria sp.		X	
Epimeria (Epimeria) cornigera		X	
Eualus sp.		X	
Eualus gaimardii		X	
Eualus pusiolus		X	
Eucarida indet.		X	
Euphausiacea indet.		X	
Eusergestes arcticus		X	
Galathea sp.		X	
Galathea dispersa		X	
Galathea intermedia		X	
Galathea squamifera			X
Galathea strigosa		X	X

Galatheidae indet.		X	
Gammarellus sp.		X	
Geryon sp.		X	
Haploops sp.	X		
Homarus gammarus			X
Hyas sp.		X	
Hyas araneus			X
Inachus sp.		X	
Iphimedia obesa		X	
Isopoda indet.		X	X
Lebbeus polaris		X	
Lepadomorpha indet.		X	
Liocarcinus depurator		X	
Liocarcinus holsatus		X	
Lithodes maja		X	X
Megabalanus tintinnabulum		X	
Meganyctiphanes norvegica		X	
Munida sp.		X	
Munida intermedia		X	
Munida rugosa	X	X	
Munida sarsi	X	X	
Mysida indet.		X	X
Nephrops norvegicus		X	
Nymphon hirtipes		X	
Pagurus sp.		X	X
Pagurus bernhardus		X	X
Pagurus cuanensis		X	
Pagurus prideaux		X	X
Pagurus pubescens		X	
Pandalidae indet.		X	
Pandalina sp.		X	
Pandalina brevirostris		X	
cf. *Pandalina brevirostris*		X	
Pandalina profunda		X	
Pandalus sp.		X	
Pandalus borealis		X	
Pandalus montagui		X	
Pontophilus norvegicus		X	
Scalpellum scalpellum		X	
Semibalanus balanoides			X
Sessilia indet.		X	
Spirontocaris liljeborgii		X	
Stenopleustes latipes		X	
Syscenus infelix		X	

Unciola sp.	X		
Verruca stroemia			X
BRACHIOPODA			
Brachiopoda indet.	X	X	
Hemithiris psittacea	X		
Macandrevia cranium	X		
Novocrania anomala	X	X	
Terebratulina sp.		X	
Terebratulina retusa	X	X	
BRYOZOA			
Bryozoa indet.	X	X	X
Bugula sp.		X	X
Caberea sp.		X	
Caberea boryi		X	
Caberea ellisii		X	X
Cellaria sp.		X	
Cellepora pumicosa		X	X
Celleporella hyalina			X
Cheilostomatida indet.		X	
Cradoscrupocellaria reptans			X
Crisia sp.		X	X
Crisia denticulata		X	
Crisia eburnea			X
Disporella hispida			X
Electra pilosa			X
Escharoides coccinea			X
Exidmonea atlantica	X	X	
Flustra foliacea		X	
Hornera sp.		X	
Hornera lichenoides		X	
Kinetoskias sp.		X	
Membranipora membranacea			X
Omalosecosa ramulosa		X	X
Palmiskenea sp.		X	
Palmiskenea skenei		X	
Parasmittina sp.		X	
Parasmittina trispinosa		X	X
Plagioecia patina		X	X
Porella compressa		X	X
Reteporella sp.		X	X
Reteporella beaniana		X	X
Schizomavella sp.		X	X
Schizomavella (Schizomavella) linearis		X	X
Schizomavella (Schizomavella) mamillata		X	

Schizoporella dunkeri			X
Securiflustra securifrons		X	X
CHAETOGNATHA			
Chaetognatha indet.		X	
CHLOROPHYTA			
Acrosiphonia sp.			X
Bryopsis plumosa			X
Chaetomorpha sp.			X
Cladophora rupestris		X	X
Ulva sp.			X
Ulva lactuca			X
Valonia sp.			X
CHORDATA			
Acantholabrus palloni		X	
Alca torda			X
Amblyraja radiata		X	
Anarhichas lupus		X	X
Aplidium sp.		X	X
Aplidium glabrum		X	
Aplidium turbinatum			X
Argentina sp.		X	
Argentina silus		X	
Argentina sphyraena		X	
Argentinidae indet.		X	
Arnoglossus laterna		X	
Arnoglossus thori		X	
Ascidia sp.		X	
Ascidia conchilega		X	X
Ascidia mentula		X	X
Ascidia virginea		X	X
Ascidiacea indet.		X	
Ascidiella sp.		X	
Ascidiella aspersa		X	
Ascidiella scabra		X	X
Botrylloides sp.			X
Botryllus schlosseri			X
Brosme brosme		X	
Buenia jeffreysii		X	
Callionymus lyra		X	X
Callionymus maculatus		X	
Callionymus reticulatus			X
Centrolabrus exoletus			X
Chimaera monstrosa		X	

Ciona intestinalis		X	
Clavelina lepadiformis			X
Clupea harengus			X
Corella parallelogramma	X	X	X
Cottidae indet.		X	
Ctenolabrus sp.			X
Ctenolabrus rupestris		X	X
Cyclopterus lumpus			X
Dendrodoa grossularia			X
Didemnum sp.		X	X
Diplosoma listerianum			X
Enchelyopus cimbrius		X	
Entelurus aequoreus			X
Etmopterus pusillus		X	
Etmopterus spinax		X	
Gadiculus sp.		X	
Gadiculus argenteus		X	
Gadidae indet.		X	X
Gadus morhua		X	X
Galeus melastomus		X	
Glyptocephalus cynoglossus		X	
Gobiidae indet.		X	
Gobius niger			X
Gobiusculus flavescens			X
Halichoerus grypus			X
Helicolenus dactylopterus		X	
Hippoglossoides platessoides		X	
Labridae indet.		X	X
Labrus sp.			X
Labrus bergylta		X	X
Labrus mixtus			X
Limanda limanda		X	
Lissoclinum perforatum		X	X
Lophius piscatorius		X	X
Lumpenus lampretaeformis		X	
Lycenchelys sarsii		X	
Lycodes sp.		X	
Lycodes gracilis		X	
Lycodes pallidus		X	
Lycodes vahlii		X	
Malacocephalus laevis		X	
Melanogrammus aeglefinus		X	
Merlangius merlangus		X	X

Merluccius merluccius		X	
Micromesistius poutassou		X	
Microstomus kitt		X	X
Molgula sp.		X	
Molgula citrina		X	
Molgula manhattensis		X	
cf. *Molgula manhattensis*		X	
Molva molva		X	X
Myxine glutinosa		X	
Phoca vitulina			X
Phrynorhombus norvegicus		X	
Pisces indet.		X	X
Pleuronectes platessa			X
Pleuronectidae indet.		X	
Pollachius sp.		X	X
Pollachius pollachius		X	X
Pollachius virens		X	
Polycarpa sp.		X	
Polycarpa pomaria		X	
cf. *Polyclinella azemai*		X	
Polyclinum aurantium		X	
Pomatoschistus sp.		X	X
Pomatoschistus norvegicus			X
Pycnoclavella aurilucens			X
Raja clavata		X	
Rajella fyllae		X	
Scorpaenidae indet.		X	
Sebastes viviparus		X	
Styela coriacea		X	
Symphodus melops			X
Syngnathus acus			X
Synoicum pulmonaria		X	
Taurulus bubalis			X
Thorogobius ephippiatus			X
Trachinus draco			X
Trididemnum cereum			X
Triglops murrayi		X	
Trisopterus sp.		X	
Trisopterus esmarkii		X	
Trisopterus luscus		X	
Trisopterus minutus		X	X
Tunicata indet.	X		X
Zeugopterus punctatus			X

CNIDARIA			
Abietinaria abietina		X	
Actinauge richardi		X	
Actinia equina			X
Actinaria indet.		X	
Actinostola callosa		X	
Actinothoe sphyrodeta			X
Adamsia palliata		X	X
Aglantha digitale		X	
Aglaophenia pluma			X
Alcyonium sp.		X	X
Alcyonium digitatum		X	X
Alcyonium palmatum		X	
Anemonia indet.		X	X
Anthoptillum carpenteri		X	
Anthozoa indet.		X	
Aurelia aurita			X
Bolocera tuediae		X	
Bougainvillia muscus		X	
Caryophyllia (Caryophyllia) inornata		X	
Caryophyllia (Caryophyllia) smithii		X	X
Cerianthus lloydii		X	X
Cerianthus membranaceus		X	
Clava multicornis			X
Corymorpha nutans		X	
Cyanea sp.		X	X
Cyanea capillata		X	X
Cyanea lamarckii		X	X
Diphasia sp.		X	
Diphasia alata		X	
Diphasia margareta		X	
Ectopleura larynx		X	X
Edwardsiella carnea			X
Eudendrium sp.		X	
Eudendrium rameum		X	
Funiculina quadrangularis		X	
Gonactinia prolifera			X
Halcampoides sp.		X	
Halecium sp.		X	X
Halecium beanii		X	
Halecium halecinum		X	X
Halecium muricatum		X	
Halecium plumosum			X
Halipteris finmarchica		X	

Halopteris catharina		X	
Hormathia digitata		X	
Hydractinia sp.		X	
Hydractinia echinata			X
Hydrozoa indet.	X	X	X
Isidella lofotensis		X	
Kirchenpaueria pinnata		X	
Kophobelemnon sp.		X	
Kophobelemnon stelliferum		X	
Lafoea dumosa		X	
Leptothecata indet.		X	
Lucernaria quadricornis			X
Lytocarpia myriophyllum		X	X
Metridium senile		X	X
Nanomia cara		X	X
Nematostella vectensis			X
Nemertesia antennina		X	
Nemertesia ramosa		X	
Obelia geniculata			X
Octocorallia indet.		X	
Pachycerianthus multiplicatus		X	
Paramuricea placomus		X	
Pennatula phosphorea		X	
Pennatulacea indet.	X		
Periphylla periphylla		X	
Plumulariidae indet.		X	
Polyplumaria flabellata		X	
Protanthea simplex		X	X
Protoptilum carpenteri		X	
Ptychodactis patula		X	
Rhizocaulus verticillatus		X	
Sagartia sp.			X
Sagartia elegans			X
Sagartia troglodytes			X
Sagartiogeton undatus		X	X
Sarcodictyon sp.		X	
Schizotricha frutescens		X	X
Scleractinia indet.	X	X	
Sertularella sp.		X	X
Sertularella gayi		X	
Sertularella polyzonias		X	X
Sertularella rugosa		X	
Sertulariidae indet.		X	
Siphonophorae indet.		X	

Stomphia coccinea		X	
Swiftia dubia		X	
Swiftia rosea		X	
Thuiaria articulata		X	
Tubularia indivisa		X	X
Urticina sp.			X
Urticina eques		X	X
Urticina felina		X	X
Virgularia sp.		X	
Virgularia mirabilis		X	
Virgularia tuberculata	X	X	
Zoantharia indet.		X	
CTENOPHORA			
Beroe cucumis		X	
Bolinopsis infundibulum		X	
Ctenophora indet.		X	
Euplokamis dunlapae		X	
ECHINODERMATA			
Amphilepis norvegica	X		
Amphiura chiajei	X		
Amphiura filiformis	X		
Antedon sp.		X	
Antedon bifida		X	
Antedon petasus		X	
Asterias rubens	X	X	X
Asteroidea indet.		X	
Asteronyx loveni		X	
Astropecten sp.		X	
Astropecten irregularis		X	X
cf. *Astropecten irregularis*	X		
Brissopsis lyrifera	X		
Brissus unicolor		X	
Ceramaster granularis		X	
Conocrinus lofotensis		X	
Crossaster papposus		X	X
Echinocardium sp.	X		
cf. *Echinocardium chrodatum*	X		
Echinocyamus pusillus	X		
Echinus esculentus		X	X
Gorgonocephalus sp.		X	
Gorgonocephalus medusae		X	
Gracilechinus sp.		X	
Gracilechinus acutus	X	X	

Gracilechinus esculentus		X	
Henricia sp.		X	X
Henricia sanguinolenta		X	
Hippasteria phrygiana		X	
Hyocrinidae indet.		X	
Leptasterias (Leptasterias) muelleri		X	
Luidia ciliaris			X
Luidia sarsii		X	
Marthasterias glacialis		X	X
Mesothuria intestinalis		X	
Oestergrenia digitata	X		
Ophiactis balli		X	
Ophiopholis aculeata			X
Ophiothrix fragilis		X	X
Ophiura sp.	X	X	
Ophiura albida		X	
Ophiura ophiura	X	X	
Ophiura robusta		X	
Ophiuroidea indet.	X	X	
Parastichopus tremulus		X	
Porania sp.		X	
Porania (Porania) pulvillus		X	X
Pseudarchaster parelii		X	
Psolus squamatus		X	
Pteraster militaris		X	
Spatangoida indet.		X	
Stichastrella rosea		X	
FORAMINIFERA			
Astrorhiza arenaria	X		
Astrorhiza limicola	X	X	
Astrorhizidae indet.	X		
Foraminifera indet.	X	X	
Pelosina sp.		X	
Pelosina arborescens		X	
Rhabdammina abyssorum	X		
cf. *Rhabdammina discreta*	X		
Saccammina sphaerica	X		
MOLLUSCA			
Abra sp.	X		
Abra alba	X		
Abra longicallus	X		
Abra nitida	X		
Abra prismatica	X		

Acanthocardia paucicostata	X		
Acanthodoris pilosa		X	
Acteon tornatilis	X		
Aequipecten sp.		X	
Aequipecten opercularis	X		X
Anomia ephippium	X	X	
Antalis sp.	X		
Antalis entalis	X		
Antalis vulgaris	X		
Aplysia punctata			X
Aporrhais pespelecani	X	X	X
Aporrhais serresianus	X		
cf. *Aporrhais serresianus*	X		
Arctica islandica	X	X	X
Asbjornsenia pygmaea	X		
Asperarca nodulosa	X		
Astarte sp.	X	X	
Astarte crebricostata	X		
Astarte elliptica	X		
Astarte montagui	X		
Astarte sulcata	X	X	
Bathyarca pectunculoides	X		
Bathypolypus sp.		X	
Bathypolypus bairdii		X	
Bela sp.	X		
Bivalvia indet.	X	X	
Bolma rugosa		X	
Buccinum undatum		X	X
Cadlina laevis		X	X
Caecum sp.	X		
Caenogastropoda sp.		X	
Calliostoma sp.	X		
Calliostoma zizyphinum		X	X
Cardiomya costellata	X		
Cardiomya striata	X		
Cephalopoda indet.		X	
Cerithiopsidae indet.	X		
Cerithiopsis metula	X		
Chamelea striatula	X		
Chiton sp.		X	
Chlamys sp.		X	
Chlamys islandica	X	X	
Colus gracilis		X	
Conidae indet.	X		

Corbula gibba	X		
Ctena decussata	X		
Delectopecten vitreus	X		
Dendronotus lacteus			X
Dentalium sp.	X		
Diaphorodoris luteocincta			X
Doris pseudoargus			X
Dosinia sp.			X
Dosinia exoleta	X		
Dosinia lupinus	X		
Edmundsella pedata			X
Emarginula sp.		X	
Emarginula fissura	X		
Ennucula tenuis	X		
Epitonium sp.	X		
Eulimella acicula	X		
Eulimella scillae	X		
Euspira sp.	X		
Euspira catena	X		
Euspira fusca	X		
Euspira montagui	X		
Euspira nitida		X	
Facelina bostoniensis		X	
Flabellina affinis			X
Gari fervensis	X		
Gari tellinella	X		
Gastropoda indet.	X	X	X
Gibbomodiola adriatica	X		
Gibbula sp.			X
Gouldia minima	X		
Hermania scabra	X		
Heteranomia squamula	X		
Hiatella arctica	X		
Iothia fulva	X		
Jorunna tomentosa		X	X
Karnekampia sulcata	X		
Lepeta caeca	X		
Lepidochitona cinerea			X
Limacia clavigera			X
Limatula gwyni	X		
Limatula subauriculata	X		
Limea crassa	X		
Limopsis minuta	X		
Liomesus ovum	X		

Loligo vulgaris		X	
Lucinoma borealis	X		
Mactra stultorum	X		
Mactridae indet.	X		
Mimachlamys varia	X		
Modiolula phaseolina	X		
Modiolus modiolus		X	
Mollusca indet.		X	
Mytilidae indet.	X		
Mytilus sp.	X		
Mytilus edulis	X		X
Nassariidae indet.		X	
Neptunea antiqua		X	
Neptunea despecta		X	
Nitidotellina lischkei	X		
Nucella lapillus	X		
Nucula sp.	X		
Nucula hanleyi	X		
Nucula nitidosa	X		
cf. *Nucula nitidosa*	X		
Nucula nucleus	X		
Nucula pusilla	X		
Nucula sulcata	X		
Nuculana minuta	X		
Nuculana pernula	X		
Nuculidae indet.	X		
Nudibranchia indet.		X	X
Oenopota sp.	X		
cf. *Oenopota* sp.	X		
Oenopota pyramidalis	X		
Oenopota tenuicostata	X		
Onoba sp.	X		
Palliolum sp.	X	X	
Palliolum incomparabile	X		
Palliolum striatum	X		
Panomya norvegica	X		
Papillicardium papillosum	X		
Parathyasira equalis	X		
Parvicardium sp.	X		
Parvicardium exiguum	X		
Parvicardium minimum	X		
Parvicardium pinnulatum	X		
Parvicardium scabrum	X		
Patella sp.			X

Patella pellucida	X		X
Patella vulgata			X
Patellogastropoda indet.	X		
Pecten sp.			X
Pecten maximus		X	X
Pectinidae indet.	X	X	
Phaxas pellucidus	X		
Pleurotomella sp.	X		
Pleurotomella packardii	X		
Pododesmus sp.	X		
Pododesmus patelliformis	X		
Polycera sp.			X
Polycera quadrilineata			X
Polyplacophora indet.		X	
cf. *Portlandia intermedia*	X		
Propebela assimilis	X		
Propebela exarata	X		
Propebela turricula	X		
Psammobiidae indet.	X		
Pseudamussium peslutrae	X	X	
Puncturella noachina	X		
Raphitoma aequalis	X		
Retusa sp.	X		
Retusa obtusa	X		
Retusa truncatula	X		
Rissoa sp.	X		X
Rossia sp.		X	
Rossia glaucopis		X	
Roxania utriculus	X		
Ruditapes philippinarum	X		
Scabrotrophon fabricii	X		
Scaphander lignarius		X	
Scaphopoda indet.	X		
Semelidae indet.	X		
Sepia sp.		X	
Sepiida indet.		X	
Sepiola sp.		X	
Sepiola atlantica		X	
Similipecten similis	X	X	
Simnia patula			X
Sphenia binghami	X		
Spisula elliptica	X		
Steromphala cineraria	X		X
Striarca lactea	X		

Tectura virginea	X		
Tellina sp.	X		
Thracia distorta	X		
Thyasira sp.	X		
Thyasira biplicata	X		
Thyasira flexuosa	X		
Thyasira gouldi	X		
Thyasira obsoleta	X		
Thyasira sarsii	X		
Timoclea ovata	X		
Tonicella marmorea			X
Trivia arctica			X
Trivia monacha			X
Trophonopsis muricata	X		
Turritellinella tricarinata	X		
Typhlomangelia nivalis	X		
Veneridae indet.	X		
Venus casina	X		
Volutomitra groenlandica	X		
Yoldiella sp.	X		
Yoldiella lenticula	X		
Yoldiella lucida	X		
Yoldiella philippiana	X		
NEMERTEA			
Nipponnemertes pulchra		X	
OCHROPHYTA			
Acinetospora crinita			X
Alaria esculenta			X
Ascophyllum nodosum		X	X
Asperococcus bullosus			X
Chorda filum			X
Desmarestia sp.		X	X
Desmarestia aculeata		X	X
Desmarestia ligulata			X
Desmarestia viridis		X	X
Dictyota dichotoma		X	X
Fucus sp.			X
Fucus serratus		X	X
Halidrys siliquosa		X	X
Laminaria sp.		X	X
Laminaria digitata		X	
Laminaria hyperborea			X
Laminariaceae indet.			X

Leathesia marina			X
Phaeophyceae indet.		X	
Pylaiella littoralis			X
Saccharina latissima		X	X
Saccorhiza polyschides			X
Sargassum muticum			X
Sphacelaria sp.		X	
Sphacelaria cirrosa			X
PLATYHELMINTHES			
Oligocladus sanguinolentus			X
Prostheceraeus vittatus			X
PORIFERA			
Amphilectus fucorum		X	X
Amphilectus lobatus		X	
Antho sp.		X	X
Antho (Antho) dichotoma		X	
Antho (Jia) brattegardi		X	
Aplysilla sp.		X	
Aplysilla rosea		X	
Aplysilla sulfurea		X	X
Axinella infundibuliformis		X	X
Axinella rugosa		X	
Biemna variantia		X	
Chelonaplysilla sp.		X	
Ciocalypta penicillus		X	
Clathria sp.		X	
Clathria (Clathria) barleei		X	
Clathria (Microciona) laevis		X	
Clathrina sp.		X	
Clathrina clathrus			X
Clathrina coriacea			X
Clathrina lacunosa		X	
Cliona sp.		X	
Cliona celata		X	X
Craniella sp.		X	
Craniella zetlandica		X	
Crella (Grayella) pulvinar		X	
Demospongiae indet.	X	X	
Dysidea fragilis		X	
cf. *Endectyon delaubenfelsi*		X	
Geodia sp.		X	
Geodia atlantica		X	
Geodia barretti		X	

Geodia macandrewii		X	
Grantia compressa			X
Halichondria sp.		X	X
Halichondria (Halichondria) bowerbanki		X	X
cf. *Halichondria (Halichondria) bowerbanki*		X	
Halichondria (Halichondria) urceolus		X	
Halichondria (Halichondria) panicea		X	X
cf. *Halichondria (Halichondria) panicea*		X	
Haliclona sp.		X	
Haliclona (Haliclona) oculata		X	
Haliclona (Haliclona) urceolus		X	X
Haliclona (Reniera) cinerea			X
Haliclona (Reniera) cratera		X	
Halisarca dujardinii			X
Hemimycale sp.		X	
Hemimycale columella		X	
Hexadella dedritifera		X	
Hymedesmia sp.		X	
Hymedesmia (Hymedesmia) paupertas		X	X
Hymedesmia (Stylopus) coriacea		X	
Iophon sp.			X
Iophon nigricans		X	
Isodictya palmata		X	
Leucosolenia sp.			X
Leucosolenia variabilis		X	
Lissodendoryx (Ectyodoryx) atlantica		X	
cf. *Macandrevia cranium*		X	
Mycale sp.		X	
Mycale (Mycale) lingua		X	X
Myxilla (Myxilla) incrustans			X
Oceanapia robusta		X	
Pachymatisma johnstonia		X	
Phakellia sp.		X	
Phakellia robusta		X	
Phakellia ventilabrum		X	
Polymastia sp.		X	X
Polymastia boletiformis		X	X
Polymastia mamillaris		X	X
Polymastia penicillus		X	X
Porifera indet.		X	X
Quasillina brevis		X	
cf. *Quasillina brevis*		X	
Spongosorites sp.		X	
Stryphnus sp.		X	

Stryphnus fortis		X	
Suberites carnosus		X	X
Suberites ficus		X	
Sycon ciliatum			X
Sycon quadrangulatum		X	
Sycon raphanus			X
Terpios gelatinosus	X	X	
RHODOPHYTA			
Ahnfeltia plicata			X
Bonnemaisonia sp.			X
Bonnemaisonia asparagoides		X	X
Bonnemaisonia hamifera			X
Ceramium virgatum			X
Chondrus crispus			X
Corallina sp.			X
Corallina officinalis			X
Corallineae indet.		X	
Cystoclonium purpureum			X
Delesseria sanguinea			X
Dilsea carnosa			X
Drachiella spectabilis			X
Hapalidiaceae indet.			X
Heterosiphonia plumosa			X
Hildenbrandia rubra			X
Jania rubens		X	
Lithothamniaceae sp.		X	
Lithothamnion glaciale			X
Palmaria palmata			X
Phycodrys rubens		X	X
Phymatolithon lenormandii			X
Rhodophyta indet.		X	
Vertebrata lanosa			X
SIPUNCULA			
Golfingia (Golfingia) vulgaris vulgaris	X		
Phascolosoma (Phascolosoma) stephensoni	X		
Sipuncula indet.	X		
TRACHEOPHYTA			
Zostera (Zostera) marina			X

Table B. Habitats and communities documented in Norway during the 2016 and 2017 Oceana North Sea research expeditions, according to study area.

Habitats and Communities	Karmøy	SW Trench	SE Trench
Shallow bottoms with macroalgae	X		X
Shallow bottoms with eelgrass (*Zostera marina*)			X
Kelp forests and other Laminariales	X	X	X
Coralline algae	X		X
Infralittoral boulders with anemones (*Metridium senile*, *Urticina eques*)	X	X	X
Shallow-infralittoral hard bottom with gorgonians		X	X
Deep-circalittoral hard bottom with gorgonians		X	
Boulders with soft corals	X	X	X
Boulders with hydrozoans (*Abietinaria abietina*)	X	X	X
Boulders covered with brachiopods (*Novocrania anomala*)	X	X	X
Muddy bottoms with foraminifera	X	X	X
Muddy bottoms with burrowing megafauna (*Nephrops norvegicus*, *Galathea* sp. and *Munida sarsi*)	X	X	X
Muddy bottoms with bamboo corals (*Isidella lofotensis*)			X
Muddy bottoms with anemones (*Bolocera tuediae*) and cerianthids (*Pachycerianthus multiplicatus*)	X	X	X
Muddy bottoms with ascidians (*Molgula manhattensis* and *Polycarpa pomaria*)	X	X	X
Muddy bottoms with sea urchins (*Gracilechinus acutus*)	X	X	X
Muddy bottoms with sea pens	X	X	X
Hard substrate with demosponges	X	X	X

Norway

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