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PROTECTING THE NORTH SEA: BORKUM STONES

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Credits

Citation: Álvarez, H., García, S., Perry, A.L., Blanco J., Maaholm, D.J., Aguilar, R. 2019. Protecting the North Sea: Borkum Stones. Oceana, Madrid. 56 p.

Cover: Plumose anemones (*Metridium senile*) and edible crab (*Cancer pagurus*) on *Tjalk* wreck in Borkum Stones. © OCEANA/ Juan Cuetos

Acknowledgements: Oceana is grateful for the collaboration of the North Sea Foundation, particularly Jip Vrooman, who generously shared her knowledge of Dutch marine policy and provided helpful comments on earlier versions of this report. The final draft was kindly reviewed by Oscar Bos, whose valuable input helped to improve the final report. We also thank the DISCLOSE project, particularly Leo Koop (Delft University of Technology), Sarah O'Flynn (Royal Netherlands Institute for Sea Research), and Karin van der Reijden (University of Groningen), who participated in the Dutch leg of the 2017 expedition and contributed to its success. We are grateful as well to Ben Stiefelhagen, Harold Batteram, Floor Driessen, Udo van Dongen, and Peter van Rodijnen from Dive the North Sea Clean Foundation (*Stichting Duik de Noordzee Schoon*) for joining the expedition during the Dutch Borkum Stones surveys. Oceana warmly acknowledges the crew of MV Neptune for their hard work and assistance during the 2017 expedition.

This project was made possible thanks to the generous support of the Dutch Postcode Lottery.

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Borkum Stones (*Borkumse Stenen* in Dutch, and *Borkum Riffgrund* in German) is a shallow, transboundary area shared between the Netherlands and Germany, and is one of the few remaining areas of natural geogenic reef in the southern North Sea. The seabed of Borkum Stones is heterogeneous, comprising a mix of hard substrates (ranging from cobbles and pebbles to large stones) surrounded by sand and gravel. This mosaic of substrates, in turn, supports a diverse benthic community with higher biodiversity levels than in neighbouring areas. Moreover, Borkum Stones is home to biogenic reefs formed by sand mason worm (*Lanice conchilega*), fragile structures that serve as important habitat for associated marine fauna.

In 2007, the German side of the area was designated as a Natura 2000 site (*Borkum-Riffgrund*), based on the presence of reefs and sandbanks, as well marine mammals, birds, and benthic invertebrates and fishes. Research surveys on the Dutch side of Borkum Stones have also revealed the presence of reefs and sandbanks, thus making the area eligible for similar protection. However, the Dutch side of the area remains unprotected, despite its recognised biodiversity value and ecological similarity to the German side.

In 2017, Oceana carried out a research expedition in the Dutch waters of Borkum Stones, to gather further information about the area's benthic species and communities. This research represented the first time that a remotely operated vehicle was used in the area, with further surveys carried out via filming by SCUBA divers, infaunal grab sampling, and seafloor imaging with a multibeam echosounder. In total, 148 taxa were identified, including 21 species that are priorities for conservation and 20 commercial species, some of which have nursery and/or spawning areas within Borkum Stones. Three habitat types were also documented that are priorities for conservation: sandbanks, and geogenic and biogenic reefs (i.e., stone fields and sand mason worm reefs, respectively). Both sandbanks and reefs are declining in the Netherlands due to human impacts.

Oceana recommends that the Dutch waters of Borkum Stones be protected, in order to safeguard their valuable benthic biodiversity. By protecting the area's sandbanks and reefs, and the species associated with them, the Netherlands would also enhance the ecological coherence of its network of marine protected areas and advance towards the fulfilment of its legal commitments at both the national and EU level. In particular, the protection and restoration of biogenic reefs is a target of the Dutch government under the EU Marine Strategy Framework Directive, and the presence of such reefs in Borkum Stones makes the area a strong candidate for protection.

To effectively conserve this transboundary area, Germany and the Netherlands must ensure the greatest possible consistency in terms of designated features and the development and implementation of management measures to protect them from human impacts. In parallel with these efforts, Oceana urges the Dutch and German governments to carry out comprehensive benthic habitat mapping of Borkum Stones, particularly to determine the full extent and condition of the fragile reefs formed by sand mason worm (*L. conchilega*).

Grab samples of sand mason worm (*Lanice conchilega*).
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Introduction

Borkum Stones (also known as Borkum Reef Grounds, and as *Borkumse Stenen* in Dutch and *Borkum Riffgrund* in German) is located in the southern North Sea, and encompasses waters of both the Netherlands and Germany. The Dutch part of Borkum Stones lies seven nautical miles north of Schiermonnikoog (one of the Wadden Islands) and covers an area of approximately 600 km^2 (Figure 1).[1] To the east, the German part of Borkum Stones is roughly 14 nautical miles north of Borkum Island, and encompasses an area of 625 km^2.[2]

The seabed in Borkum Stones is characterised by a mixture of sandy and hard bottoms. These bottoms, with rocks surrounded by gravels and sandy areas, are home to a wide

variety of benthic communities, and qualify for protection under the framework of the European Habitats Directive[3] on the basis of the occurrence of sandbanks and reefs. For that reason, in 2007 the German side of Borkum Stones was declared a Natura 2000 protected area (*Borkum-Riffgrund*).

The area is one of only two natural hard-bottom areas that remain in Dutch waters after decades of damaging anthropogenic activities that involve substrate removal, such as bottom-trawl fisheries.[4] The other such area, Cleaver Bank (*Klaverbank* in Dutch), is already protected under the EU Habitats Directive, on the basis of its reef habitat.

Oceana conducted research surveys in Borkum Stones in 2017, to provide information about the benthic species, communities, and habitats of the area. These surveys were part of a research expedition carried out across the waters of five North Sea countries, which aimed to gather critical data for improving the existing network of North Sea marine protected areas. The surveys in Borkum Stones focused mainly on the Dutch side of the area, due to the fact that those waters lack protection. The findings of Oceana's surveys are presented here, in the broader context of the biodiversity of Borkum Stones, the threats it faces, and the implications for the protection of the Dutch part of the area.

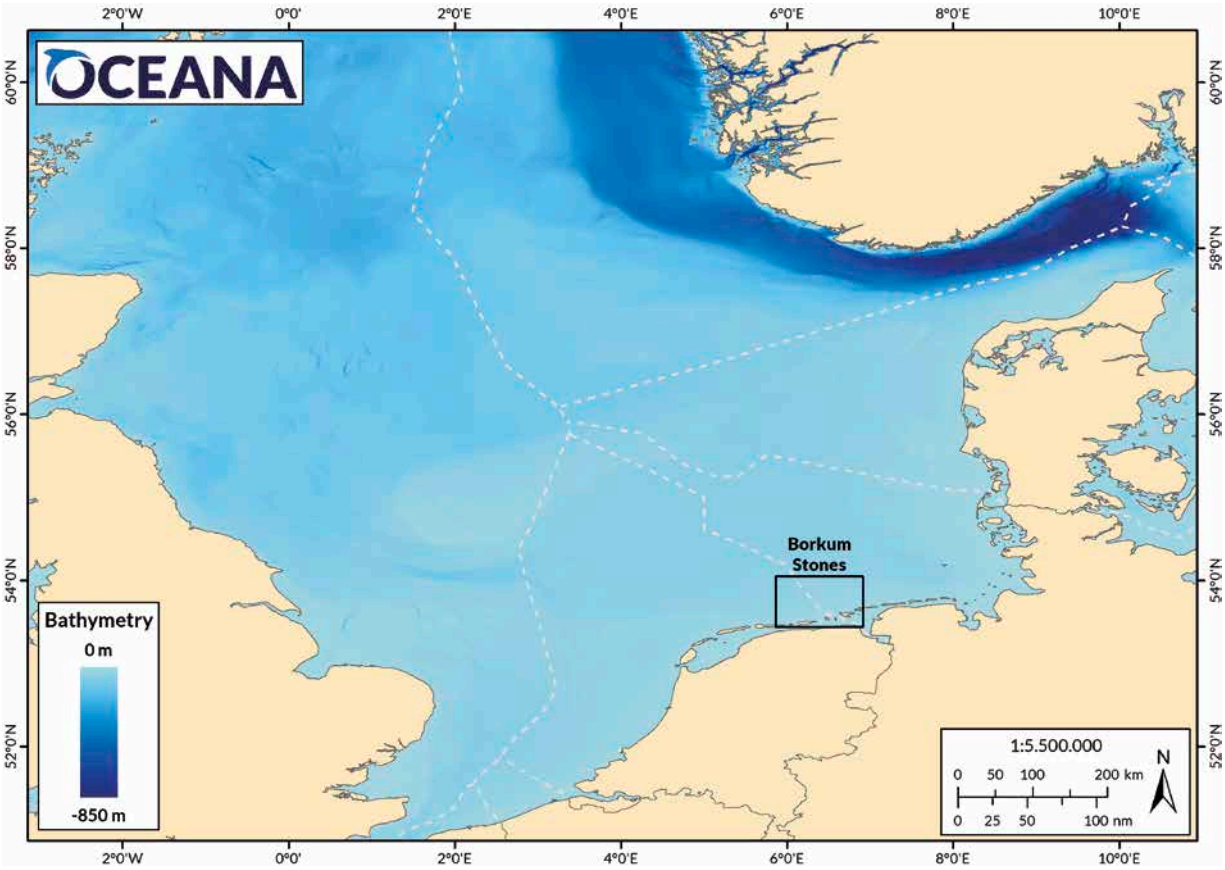


Figure 1. Location of the Borkum Stones study area. Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute.[7]

DESCRIPTION OF THE AREA

Lying to the north of the Wadden Sea islands, Borkum Stones is a shallow marine area. According to the area limits described in Lindeboom *et al.* (2005),[8] the Dutch side ranges in depth from a minimum of 8 m to a maximum of 33 m further offshore [a], while the German side spans depths from 18 to 33 m (Figure 2). As the Dutch part of Borkum Stones is not protected, it has no official boundaries, but a triangular-shaped area of circa 600 km^2 is most commonly used to refer to it (Figure 2).[9]

Borkum Stones is an area of mixed substrates, resulting from glacial relict sediments.[10,11] The presence of hard bottoms in the area is of ecological importance in both Dutch and German waters, because the bed of the North Sea is mainly formed by sand and mud.[12] The area's hard substrates, varying in size from cobbles and pebbles to large stones, are surrounded by sand and gravels; this combination forms a mosaic of habitat types that harbours a rich diversity of species.

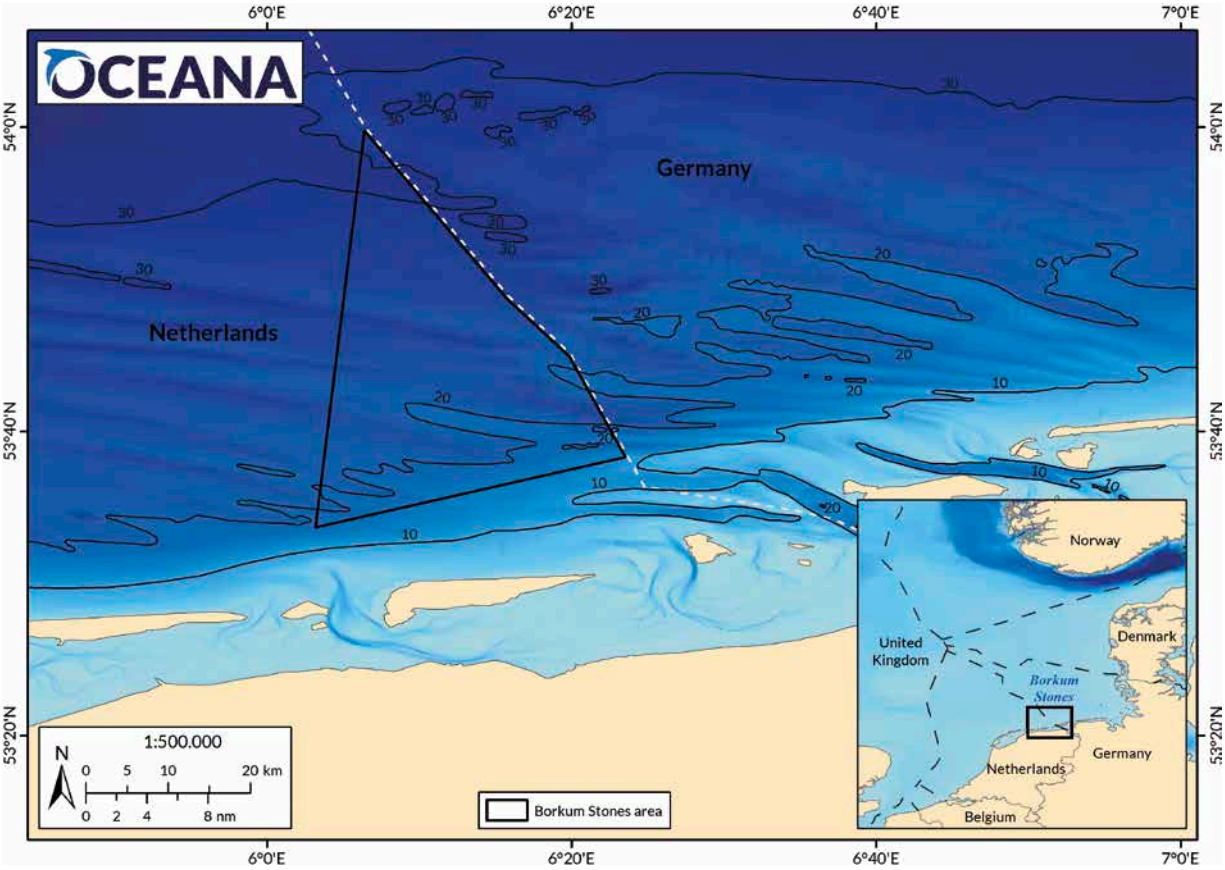


Figure 2. Detailed bathymetry of the Borkum Stones area. The triangular area shown corresponds to the Dutch area of Borkum Stones. The inset map shows the location of Borkum Stones in the North Sea. Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] Lindeboom *et al.* (2005).[8]

a Calculated based on EMODnet bathymetry[4] and the delimitation of the area proposed by Lindeboom *et al.* (2005).[7]

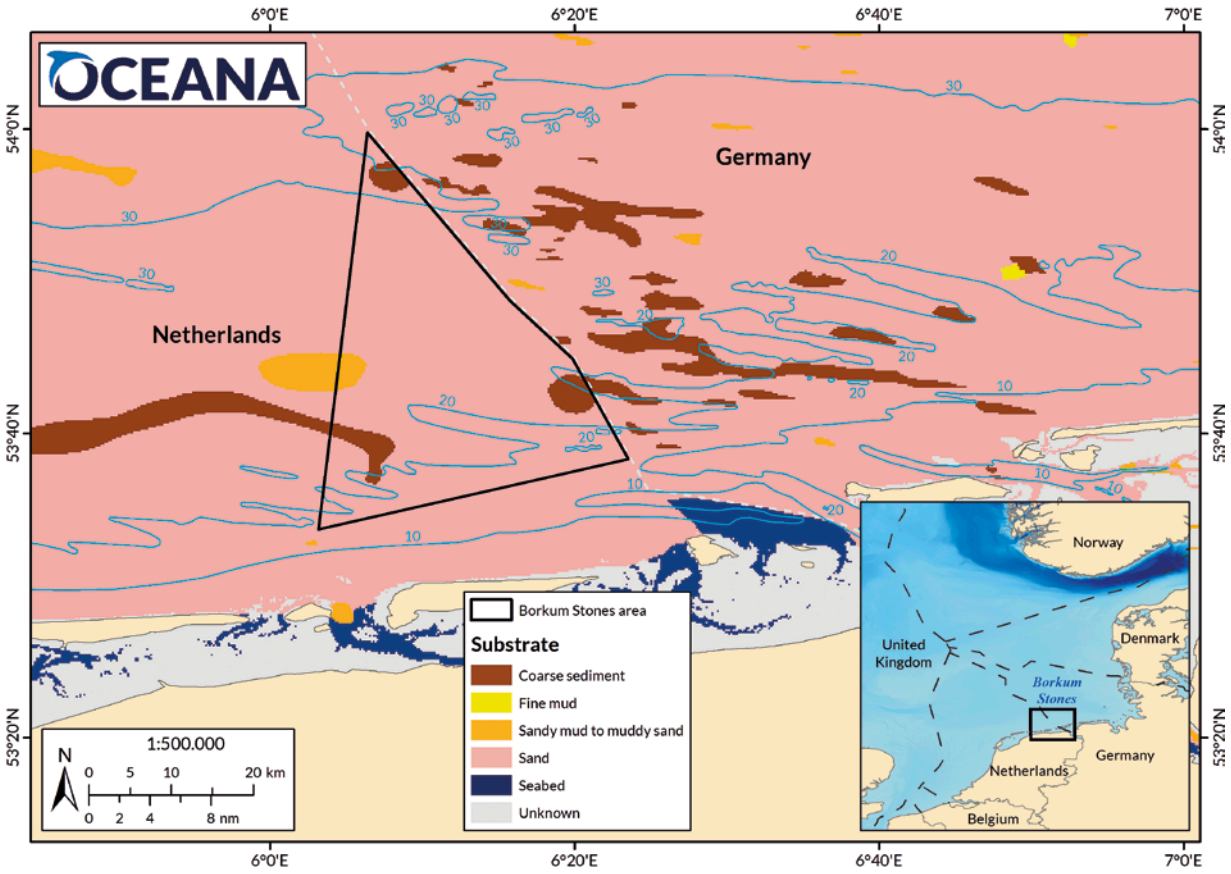


Figure 3. Substrate types and bathymetry of Borkum Stones. Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] Lindeboom *et al.* (2005).[8]

In Dutch waters, Borkum Stones is one of just two remaining natural hard bottom areas, together with Cleaver Bank, because other geogenic hard bottoms (e.g., boulders) and biogenic hard bottoms (including shellfish beds) have been removed by decades of human impacts, such as trawling, the introduction of pathogens, and climate change.[13] Other areas of hard substrate in Dutch waters are not natural, but instead are the result of human activities, such as windfarms, wrecks, and gas and oil extraction platforms. In total, geogenic hard bottoms are estimated to cover 9.8 km^2 [15] (see *Previous conservation proposals* for further details) on the Dutch side of Borkum Stones.

Based on the EMODnet classification of sediments, Borkum Stones comprises three main types of sediment: sand, sandy mud to muddy sand, and coarse sediment (Figure 3). The types of sediments in Borkum Stones have also been classified in various documents that consider biological components, particularly aggregations of sand mason worm (*Lanice conchilega*). These classifications have resulted in either three main habitat types (i.e., moderately fine to moderately coarse sand; *L. conchilega* fields on sand; and coarse sediment formed by gravels, pebbles and stones)[14] or four habitat types (i.e., rocky reefs; individual rocks in a sandy environment; sand with dense *L conchilega* beds; and sand bottom habitat).[15]

The ecological value of the Borkum Stones area was first brought to international attention in 2004, when Germany nominated *Borkum-Riffgrund* as a Site of Community Importance under the Habitats Directive.[2] This proposal (and the eventual designation of the area) reflected the mosaic of habitats and rich biodiversity present, including areas of reef and sandbank; sand mason worm (*Lanice conchilega*) fields, and plumose sea anemone (*Metridium senile*) aggregations; and protected pelagic species, such as harbour porpoise (*Phocoena phocoena*), common seal (*Phoca vitulina*), grey seal (*Halichoerus grypus*) and twait shad (*Alosa fallax*).[16,17] In addition, species listed under the Birds Directive are present in the area.[2,18] Lesser black-backed gull (*Larus fuscus*), which is listed in Annex I of the Birds Directive, and wintering great black-backed gull (*Larus marinus*) and common guillemot (*Uria aalge*), both listed in the Annex II, concentrate in the thousands in the *Borkum-Riffgrund* area.

Plumose anemones
(Metridium senile) on *Tjlak* wreck
© OCEANA Juan Cuetos

Following the proposed protection of *Borkum-Riffgrund*, the ecological importance of the Dutch part of Borkum Stones was recognised in 2005, when a government-commissioned study highlighted Borkum Stones as an area of high benthic biodiversity that was therefore likely to qualify for protected status.[8] Since that time, studies carried out to assess whether the Dutch side of Borkum Stones is indeed eligible for protection have confirmed its value as a rich and heterogeneous area, which is comparable to the German side.[19]

Borkum Stones has been described as "an atypical habitat in the Dutch sandy coastal area," which is distinctive from the surrounding sandy bottoms due to the presence of large boulders and coarse sediment.[20] Specifically, hard bottoms on the Dutch seabed of Borkum Stones comprise both reefs and fields of dense aggregations (>1500 individuals/m^2) of sand mason worm (*L. conchilega*).[15] The coverage of these two habitat types has been estimated at 9.8 km^2 and 74 km^2, respectively.[15]

The Dutch waters of Borkum Stones are also characterised by sandbanks that extend below 20 m depth and reach heights of 2.5-3 m above the seabed. These sandbanks are relatively lower than in other areas of the Dutch North Sea, such as Brown Bank, where sandbanks can reach heights of nearly 30 m.[8,21] Side-scan sonar studies on the Dutch side of Borkum Stones have indicated that sand covers an area of approximately 48 km^2, while an additional 58 km^2 comprises silt and clay.[1] These soft bottoms could potentially meet the criteria for being designated as sandbank under the EU Habitats Directive, similar to those bottoms protected within *Borkum-Riffgrund*, on the German side.[1]

In addition to these habitats, Borkum Stones is also known for the presence of long-lived species (i.e., those that live to more than ten years of age) such as rayed dosinia (*Dosinia exoleta*), ocean quahog (*Arctica islandica*),[16] and plumose sea anemone *(Metridium senile*), which forms aggregations covering large rocks in the area.[14,15] Flat oyster (*Ostrea edulis*) beds also historically occurred in the area, and a project has been underway in Borkum Stones since 2018 that aims to assess the potential for restoring such shellfish beds in deeper parts of the North Sea.[22] Pelagic protected species also live in the area, such as harbour porpoise (*Phocoena phocoena*), grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*).[1,16] The highest year-round densities of harbour porpoise in Dutch waters (0.5-3 individuals/km^2) have been found in the area that extends from Brown Bank to Borkum Stones.[23]

Borkum Stones is also a valuable area for seabirds, based on an analysis of seabird distributions across the Dutch continental shelf.[16] In particular, the Dutch side of Borkum Stones may be important for migrating red-throated diver (*Gavia stellata*), as significant numbers are seen in the area in spring. This species is listed as threatened under the Birds Directive. Based on its proximity to the coastal zone, which is

one of the key Dutch areas for seabirds year-round, Borkum Stones may also be important for other species of divers, ducks, and terns.

Finally, Borkum Stones is known to be an area that provides essential fish habitat (EFH) for a variety of commercial fish species. EFH are areas with certain ecological and/or physical characteristics that play a crucial role for the survival or replenishment of a fish stock at a specific life stage, such as spawning, nursery, or feeding grounds. In the case of Borkum Stones, spawning grounds and/or nursery areas have been documented for species that include cod (*Gadus morhua*), common sole (*Solea vulgaris*), sprat (*Sprattus sprattus*), and shrimps.[24,25]

Previous seabed research in the area

Historically, research to explore benthic life in Borkum Stones relied on methods such as box-corers and grabs, which are used to collect samples of sediment and the infaunal organisms that live within it (Table 1). In recent years, visual methods that provide data on habitats and megafauna have been carried out with towed and drop cameras, and by SCUBA divers. Prior to Oceana's research (see *Oceana surveys*), no surveys had been carried out in the area using a remotely operated vehicle (ROV).

Table 1. Overview of the main previous research survey programmes focused on benthic biodiversity that have been carried out in Dutch waters of Borkum Stones.

Institute or Programme	Year	Description/Aims
Delft University of Technology (TUDelft), University of Groningen (RUG), Netherlands Institute for Sea Research (NIOZ), and the North Sea Foundation, under the *DISCLOSE* project	2017-present	Study of vulnerable habitats in the Dutch North Sea, using a combination of methods, including acoustic mapping, towed camera, box-corer and Sediment Profile Imagery.[26]
Dutch NGOs (Dive the North Sea Clean Foundation, North Sea Foundation and WWF Netherlands)	2013, 2015, 2016	SCUBA surveys in Borkum Stones, documenting areas of gravel, boulders, and *Lanice conchilega*.[27]
IMARES[b] Wageningen UR, Department of Aquatic Ecology and Water Quality Management (AEW) of Wageningen University & Research Centre, Bureau Waardenburg	2009, 2013	Inventories of benthic biodiversity and habitats of the Dutch waters of Borkum Stones, with the aim of evaluating the need for protection under the Habitats Directive. Surveys were carried out with side-scan sonar, multibeam, Van Veen grab, box-corer, SCUBA airlift sampler and visual transects, and drop camera.[1,14,15]
ICES North Sea Benthos Project (multiple research institutes from France, Germany, Netherlands, UK)	1986, 2000	Study of macrobenthic fauna in the North Sea, including points immediately adjacent to Borkum Stones, through grabs and box-cores. Fourteen years later, some stations were revisited to compare outcomes and conduct a descriptive evaluation of the macrozoobenthos communities, assessing bottom-trawling effects.[28,29]
Rijkswaterstaat, Ministry of Infrastructure and Water Management and Wageningen Marine Research. National Surface Water Monitoring Programme (MWTL) -Monitoring of Marine Waters	1991-present	Long-term annual monitoring programme across a range of Dutch sites, which was later combined with the Marine Strategy Framework Directive (MSFD) monitoring programme. Surveys include benthic sampling using box-corers and dredges.[30]

b IMARES is now WMR (Wageningen Marine Research).

In the Dutch waters of the North Sea, resource exploitation and competition for space are both intense – and demand for space has been increasing.[31] This situation is exemplified in Borkum Stones, where multiple human activities converge in a small area and put heavy pressure on marine ecosystems. The main such activities in the area include fishing, maritime shipping, sand extraction, wind farms, and military training; the seabed is also crisscrossed by pipelines and telecommunications cables that run in various directions. Overall, fishing is considered to represent the greatest threat to benthic fauna in the area, while other activities are considered to have moderate impacts.[8]

Borkum Stones lies at the southern edge of the ICES 'Central North Sea' Division (IVb), an area of intensive fishing activity. In 2018, vessels from five EU Member States (i.e., Belgium, Denmark, Germany, the Netherlands, and the United Kingdom) were recorded to have fished within the triangular boundaries of the Dutch waters of Borkum Stones.[32]

These fisheries are primarily benthic in nature, although set gillnets are also used along the coast and on the shelf edge in shallow waters.[33] Based on the number of fishing hours recorded, the main gear types used in the area are beam trawls (mainly Dutch, as well as German and Belgian vessels targeting brown shrimp (*Crangon crangon*) and demersal fishes), followed by pots (UK vessels) and, to a lesser extent, bottom otter trawls and bottom seines (Dutch, Danish, and German vessels).[32,34] Figure 4 shows the intensity of fishing activities using bottom-contacting gears in the southern North Sea. While most of the Dutch waters of Borkum Stones are relatively less intensively fished, the southernmost part of the area coincides with one of the most heavily bottom-fished areas in the region.[34]

Bottom-contacting gears are known to have serious impacts on benthic ecosystems, including invertebrate mortality, resuspension of sediments, and direct physical destruction of biogenic habitats, which in turn reduces habitat complexity and ultimately can result in broad ecosystem changes.[35] Moreover, in the case of Borkum Stones, this practice is believed to have removed a portion of the boulders that were once in the area.[20]

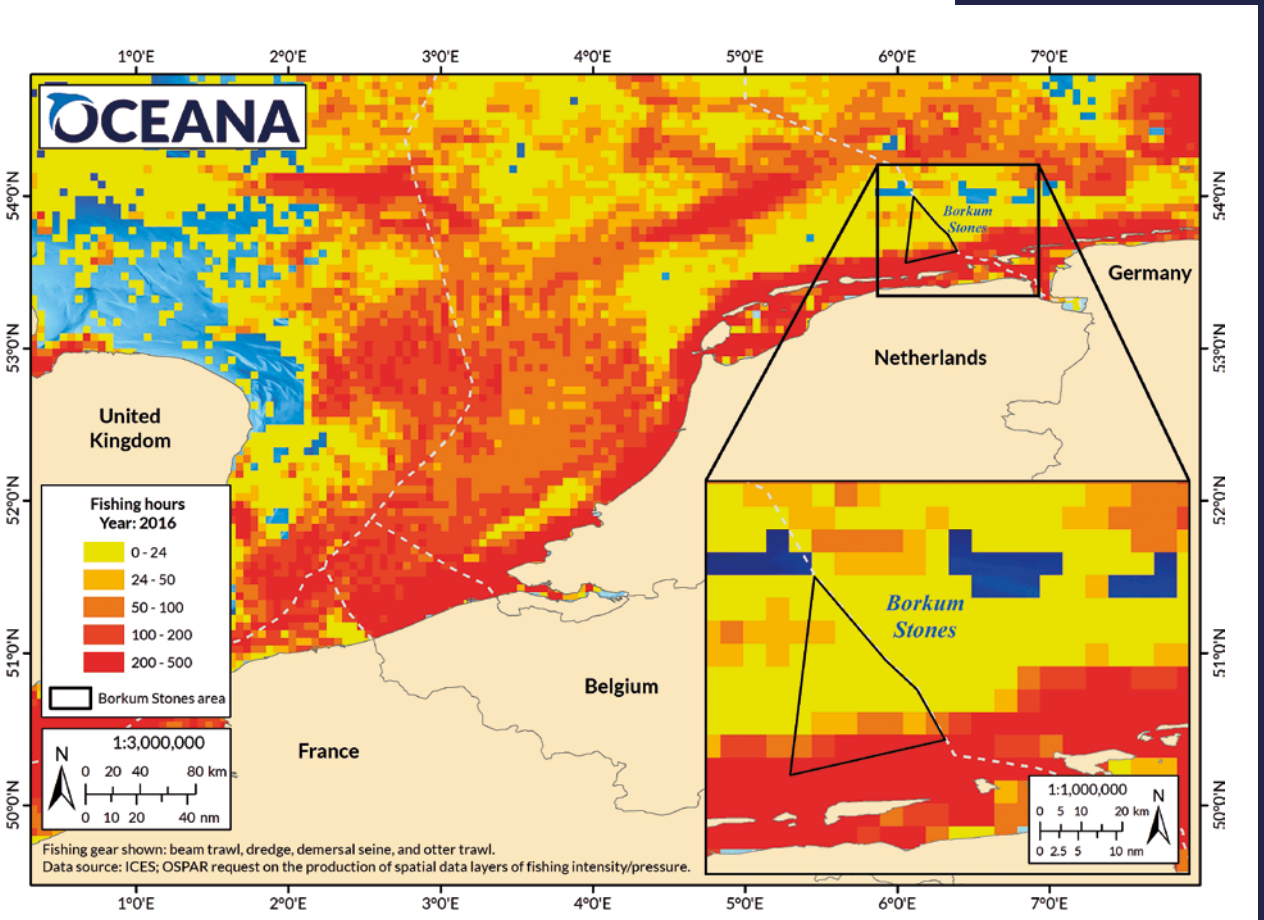


Figure 4. Fishing hours by bottom-contact gears in 2016, adapted from ICES (2017).[36] The triangle represents the Dutch area of Borkum Stones. Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] Lindeboom *et al.* (2005).[8]

In terms of maritime shipping, the North Sea is the busiest sea in the world, after the South China Sea. The six largest seaports are situated in the southern North Sea, and two of these (Rotterdam and Amsterdam) are in the Netherlands. Up to 260 000 ship movements are registered per year in Dutch waters[31] along more than 18 shipping lanes.[52] This intensity of shipping poses serious threats to the marine environment in the region, such as collisions and behavioural changes in cetaceans,[37] and the bioaccumulation of pollutants in the food web, which particularly affects top predators (i.e., large pelagic fishes, marine mammals), causes endocrine disruptions, and threatens human and environmental health.[38] Further environmental problems can result from the fact that the majority of vessels sailing in the area are non-European flagged.[39,40] Resulting impacts include the introduction of invasive species through ballast water[41] and fouling organisms, and a high concentration of pollutants due to the discharge of water and disposal of hazardous substances.[31]

The Dutch side of Borkum Stones is directly impacted by maritime shipping; it is trisected by a major east-west shipping route, the *Terschelling-German Bight* Traffic Separation Scheme (Figure 5). In total, these lanes cover 30% of the Dutch marine area of Borkum Stones. Beyond the direct impacts of shipping

vessels passing through the area, local effects documented in the region of Borkum Stones include non-indigenous species found in the ballast water of ships in the closest port, Eemshaven.[42]

Wind farms represent another potential threat to biodiversity in the Borkum Stones area, where more than ten new facilities were installed close to or inside the Oceana survey area between 2007 and 2015 (Figure 5). The construction and operation of wind farms produces a range of negative effects on benthic and pelagic fauna, resulting from driving piles into the sediment, broadband noise, pressure waves, and increased shipping traffic, among others.[43] In addition to these multiple direct threats to marine ecosystems, it should also be noted that under certain circumstances, an established wind farm may have some benefits for conservation.[44] For example, in some cases, the prohibition of bottom-contact fisheries within the area of a wind farm may allow for the recovery of certain benthic species.

No wind farms are permitted inside the Dutch part of Borkum Stones, due to the presence of the shipping lane, and a military training zone that involves the presence of navy vessels and low-flying F16 aircraft carrying out artillery practice.[8] However, two twin wind farms (*Windpark ZeeEnergie* and *Windpark Buitengaats*) lie outside the northwestern limit of the Dutch side; they comprise 150 turbines operating under the *Gemini Project*. [31,45] An additional wind farm (*Riffgat*) lies on the German side, about 8 nm northwest of the East Frisian island of Borkum. More than 18 wind farms are either present or planned in the vicinity of the German side of the Oceana survey area (Figure 5).[46]

Cargo ship
© OCEANA/ Juan Cuetos

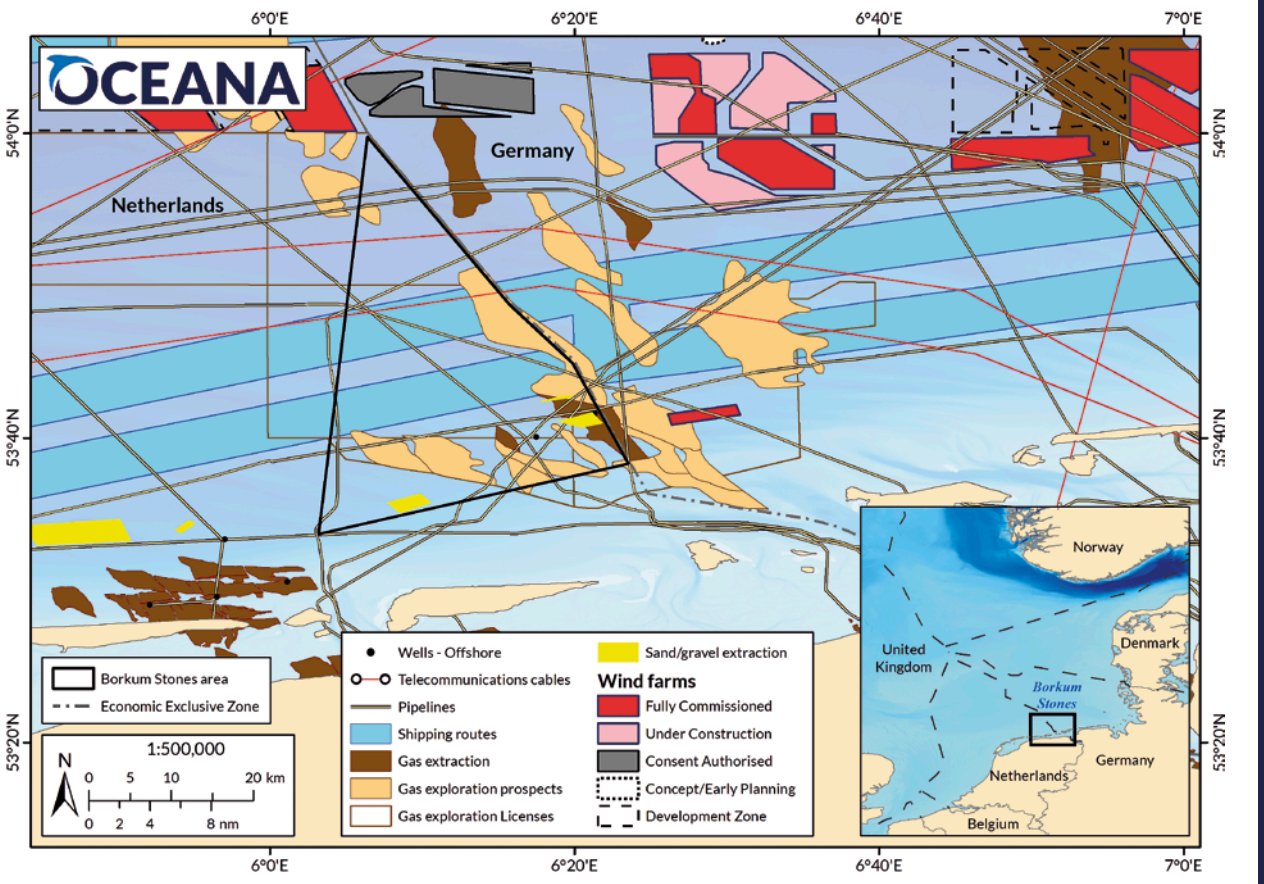


Figure 5. Shipping lanes and major offshore infrastructure in the Borkum Stones area, including cables, pipelines, gas extraction areas, sand/gravel extraction areas, and wind farms (both authorised and fully commissioned projects). Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] Lindeboom *et al.* (2005),[8] NLOG,[49] TeleGeography,[50] ChartWorld,[51] University College London Energy Institute,[52] 4c Offshore,[46] and the Marine Information and Data Centre.[53]

Finally, the Dutch waters of Borkum Stones are subject to other types of industrial activities that directly impact benthic systems. The area encompasses three licensed areas for sand and/or gravel extraction, two gas extraction areas, and two offshore exploration gas wells which were drilled in 2017 and 2018 (Figure 5). The company responsible for the wells (ONE-Dyas) holds further permits inside the area, and new exploratory wells are expected to be drilled.[47] Moreover, two offshore gas extraction platforms are in operation outside the Dutch Borkum Stones area, 8 nm and 7.5 nm to the southwest. A recent study[48] highlighted the potential risks that gas drilling in Borkum Stones poses to benthic fauna in general, and specifically to the flat oyster (*Ostrea edulis*) reef restoration project that has been running in the area since 2018.[22]

Previous conservation proposals

The protection of the Dutch waters of Borkum Stones was identified as a potential conservation priority more than a decade ago, on the basis of its diverse benthic fauna (see *Known ecological features of interest*). Following the 2005 publication of a government-commissioned study indicating that Borkum Stones was likely to qualify for protection,[8] the area began to figure in official government plans as a potential candidate for inclusion in the Natura 2000 network. The Dutch *National Water Plan (2009-2015)*[54] included Borkum Stones as a "potentially ecologically valuable area" on a map of North Sea spatial policy options and stated that detailed research would be carried out into the area's "nature values", in the context of Natura 2000 and the Marine Strategy Framework Directive (MSFD). The *Marine Strategy for the Dutch part of the North Sea 2012-2020*[4] (the programme of measures under the MSFD) established an aim of protecting 10-15% of the Dutch seabed against 'noteworthy' impacts. Under this plan, Borkum Stones was one potential area to be protected, based on the available scientific evidence indicating its ecological value.

However, its protection did not advance, following a statement made to the Dutch House of Representatives in 2015 by Sharon Dijksma, the then State Secretary of Economic Affairs. Her statement advised against the protection of Borkum Stones, on the basis that a sufficient area of reefs had already been protected with the Natura 2000 designation of *Klaverbank*.[55] This argument directly contradicted the advice of researchers from IMARES and Bureau Waardenburg, who had studied the area in 2012 and concluded that – like the German *Borkum-Riffgrund* – the Dutch side of Borkum Stones met the Habitats Directive criteria for reefs.[1] They asserted that despite the fact that almost 90% of known reefs in Dutch waters were within *Klaverbank*, Borkum Stones should nevertheless be protected, to obtain a spatially balanced distribution of protected habitats and to improve the ecological coherence of the Natura 2000 network, both of which are required under the Habitats Directive.[1] In a later publication, the authors similarly emphasised that rocky reefs on the Dutch side of Borkum Stones are unique, and qualify for protection under the Habitats Directive.[15] Furthermore, they confirmed, in line with research from Belgian waters,[56] that dense aggregations of sand mason worm (*Lanice conchilega*) should also be defined as reefs under the Habitats Directive.

Proposals for the protection of Borkum Stones have also been put forward by non-governmental organisations (NGOs). The North Sea NGO Coalition[c] proposed the area as part of a group of sites in the North Sea that they recommended for designation under Natura 2000 and OSPAR.[10,57] Their proposal

c WWF (Denmark, Germany, Netherlands, UK, Norway and Sweden), the North Sea Foundation (NSF) and a Belgian NGO coalition led by Natuurpunt.

was based on the recognised ecological value of Borkum Stones,[8] highlighting its importance for benthic fauna, fishes, seals, and other marine mammals. This coalition has continued to lobby the Dutch government to grant protection to the area.[58]

In 2017, the Dutch government, the (shrimp) fishing sector, and environmental NGOs reached an agreement (the *Noordzeekustvisserijakkoord*, also known as the *VIBEG-akkoord*) to protect a 108 km^2 area in Borkum Stones (Figure 6) that encompasses sandbanks, reefs, and *L. conchilega* fields.[59] The area is intended to be protected as a compensation measure to reduce the impact of opening a similar-sized area inside the *Noordzeekustzone* Natura 2000 MPA to shrimp fisheries. The agreement, which is still in a very preliminary process of implementation (J. Vrooman, pers. comm.), also establishes certain management measures, such as the prohibition of any bottom-contact fishing inside the new protected area, together with other management measures aimed at improving the sustainability and reducing the impacts of the fishery in the entire Natura 2000 site. The area to be closed (Figure 6) covers just 14.5% of the Dutch part of Borkum Stones[60] but would nevertheless be a step forward for the protection of the area.

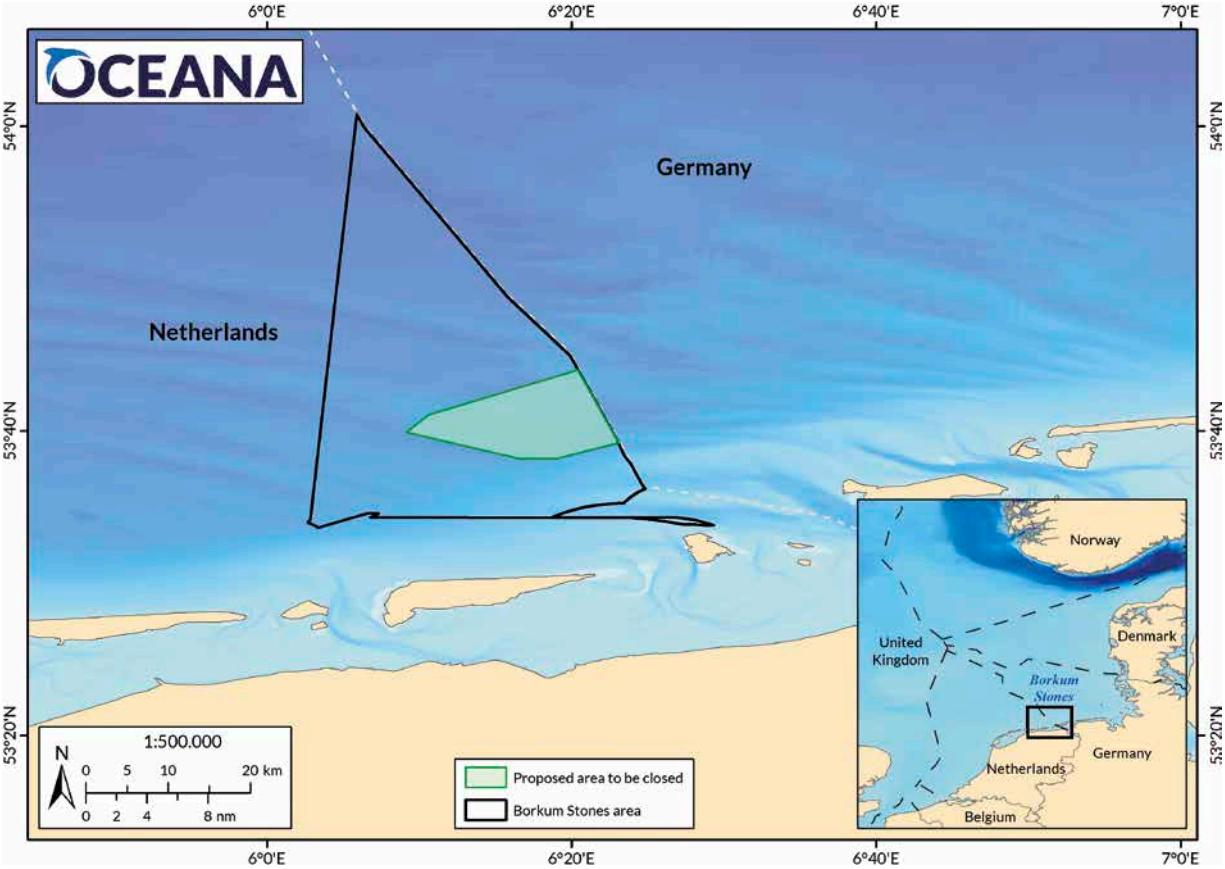


Figure 6. Proposed area to be closed to bottom fisheries (shaded in green) as part of the *Noordzeekustvisserijakkoord*. Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] and van Stralen (2017).[61]

Current conservation and management measures

Measures to ensure the protection of biodiversity in Borkum Stones are limited to German waters, where *Borkum-Riffgrund* was designated as a Special Area of Conservation (SAC) in September 2017 (Figure 7). Some activities have been prohibited within the site, such as the dumping of dredged material, introduction of alien species, recreational fisheries and aquaculture, while some other activities are permitted following an evaluation process.[62] Despite these restrictions, measures to limit the impacts of benthic fisheries in the area are still pending. In February 2019, the German government presented its recommendation to the European Commission for management measures inside four Natura 2000 MPAs (including *Borkum-Riffgrund*), jointly with Belgium, Denmark, France, the Netherlands, Sweden, and the UK (the other Member States with fishing interests in the sites). This process has been lengthy; the proposal was first subject to a national consultation process in Germany in 2016, and at the time of writing had not yet been adopted. Under the proposed measures, all mobile bottom-contacting gears would be prohibited within *Borkum-Riffgrund* to protect sandbanks, reefs, and other hard-bottom areas, while fishing effort with gillnets and entangling nets would be capped, to limit impacts on harbour porpoise (*Phocoena phocoena*).[63] In its review of the proposed measures, the Scientific, Technical and Economic Committee for Fisheries (STECF) of the European

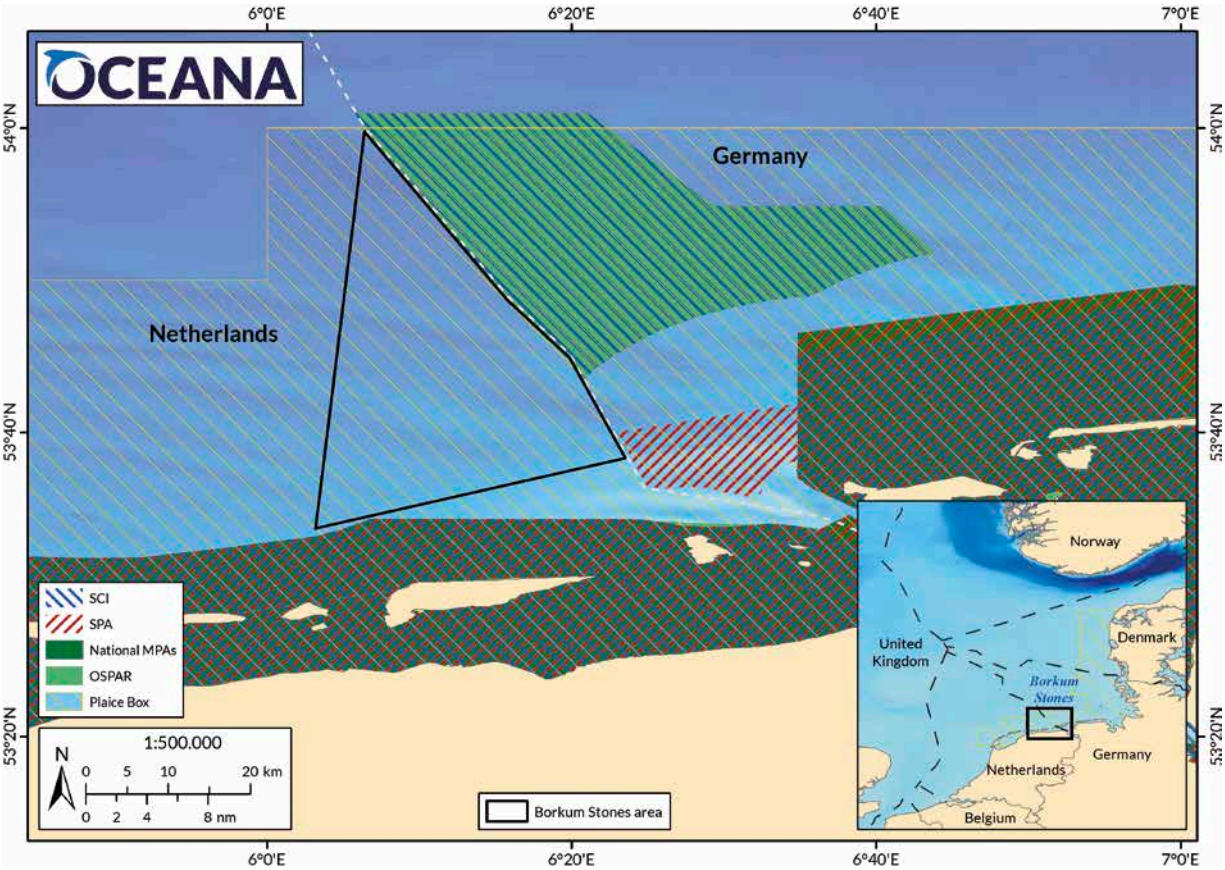
School of bib (*Trisopterus luscus*).
© OCEANA/ Carlos Minguell

Commission's Joint Research Centre noted that they would represent a first step towards the protection of reef and sandbank habitats, so long as there was full compliance.[64]

On the Dutch side, no specific measures are in place for the area. In 1990, the Netherlands Ministry of Agriculture, Nature and Food Quality included all Dutch waters in the North Sea ecological network, which implies that the precautionary principle applies to any human activity developed in the area.[65] Beyond this general framework, however, there are no specific management requirements for Borkum Stones.

On a wider scale, the entire Borkum Stones area – both Dutch and German waters – lies within the fisheries management area known as the 'Plaice Box'.[66] This area, which encompasses 38 000 km^2 of Danish, Dutch, and German coastal waters, has been subject to fisheries restrictions since 1989. Specifically, it excludes beam trawlers and otter trawlers with engine power in excess of 300 hp, with the aim of helping to recover plaice by reducing discarding of undersized individuals and increasing the abundance of mature individuals.[67] Its effectiveness has been questioned, as the spawning stock biomass of plaice did not increase as expected following its establishment, possibly due to the combination of other types of fisheries still permitted in the area and environmental changes (e.g., eutrophication and temperature).[57,67,68,69]

Figure 7. Marine protected areas within the Borkum Stones area. Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] OSPAR,[70] Pastoors *et al.* (2000),[67] Lindeboom *et al.* (2005).[8]



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OCEANA SURVEYS

Oceana surveyed Borkum Stones as part of an eight-week, at-sea research expedition carried out across the North Sea in 2017. This expedition aimed to gather first-hand information from areas of known or potential ecological importance, but from which data on benthos 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.

Research was conducted in Borkum Stones between 29 July and 7 August 2017, with a total of seven days of work at sea in the area. Most of the survey effort was concentrated on the Dutch side (Figure 8), because it remains unprotected. In addition, Oceana carried out its surveys in Borkum Stones in collaboration with the DISCLOSE project and the Dive the North Sea Clean Foundation (*Stichting Duik de Noordzee Schoon*; DDNZS) (see below), both of which focus on Dutch waters.

The seabed was investigated 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.

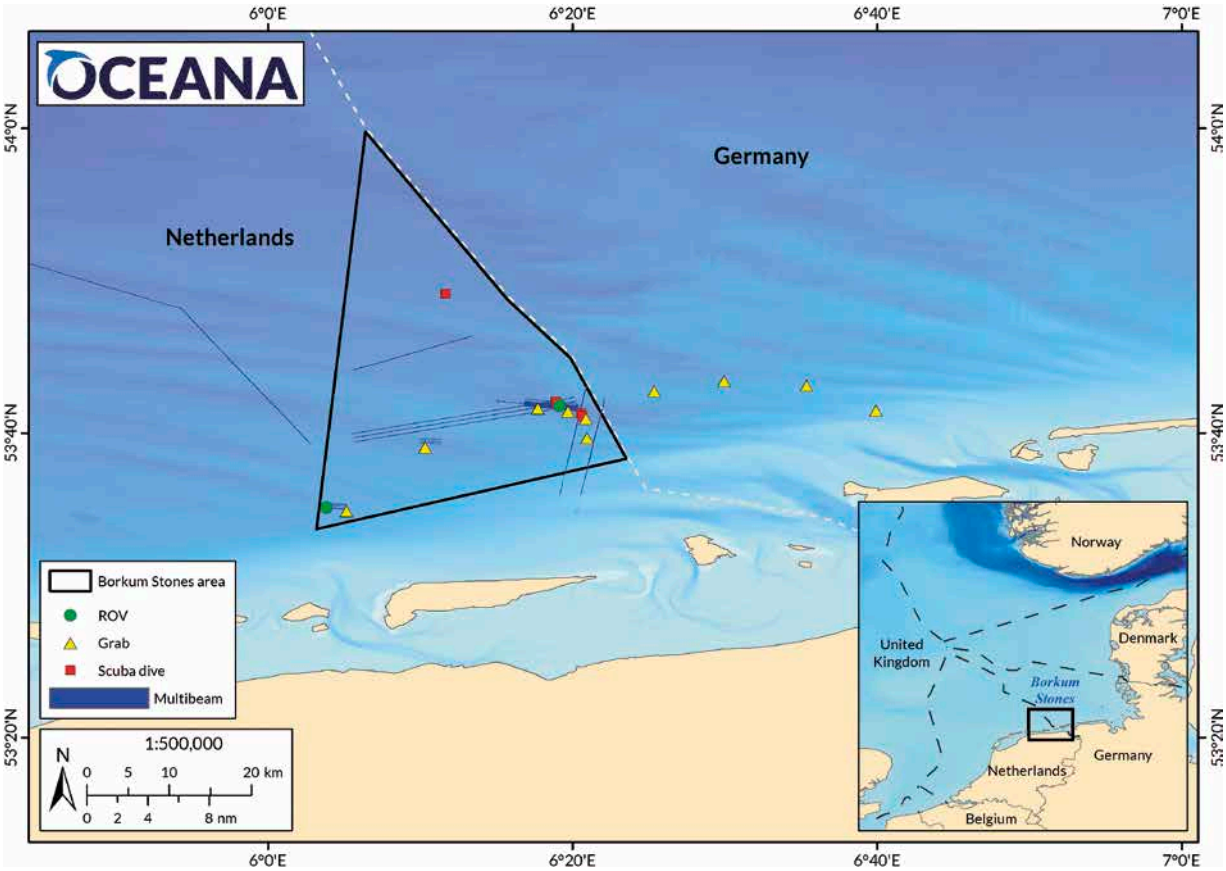


Figure 8. Survey points in Borkum Stones during the 2017 Oceana North Sea Expedition. Points are shown according to sampling type (i.e., ROV, SCUBA, grab samples, and multibeam echosounder). Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] Lindeboom *et al*. (2005).

SCUBA surveys

Oceana surveys

Visual data were gathered by eight professional SCUBA divers, divided into two teams; each team comprised a photographer, a videographer, and two safety divers. Two dives were done by Oceana divers in the Dutch waters of Borkum Stones, producing high-definition video footage and high-resolution still images.

Dive the North Sea Clean surveys

Further SCUBA surveys were carried out in collaboration with a team of five volunteer divers from DDNZS. This Dutch organisation specialises in wreck diving; removing waste, ghost nets and other abandoned fishing gears; and collecting biological and archaeological data while documenting the sea bottom. The DDNZS divers conducted five dives in the Borkum Stones area, two of which were done together with Oceana divers. The data from all five dives have been included in the results presented in this report.

Analysis

Following the expedition, all of the videos and still images filmed by the Oceana and DDNZS divers were analysed by Oceana scientists, who identified all of the visible species identified to the finest taxonomic level possible.

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 lx, and a 4.48 mm, f/1.8-3.4 zoom lens. Images were recorded both in high definition (to film specific features of interest) and low definition (for the total duration of surveys), along with position, depth, course and time. Lasers on the ROV were used in order 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 ca. 1.5 m width), the ROV allowed the observation of around 550-650 m^2 per hour of seabed.

Two ROV transects were carried out in Borkum Stones, both of which were in Dutch waters. Surveyed sites ranged in depth from 19.7 to 27.6 m and were selected based on 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 swath 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 expedition, analysis of the 65 minutes of 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 ten grab samples were taken in the Borkum Stone area: four in German waters, and six in Dutch waters. Surveyed sites ranged from 12 m depth in the eastern part of the German side, to 25 m depth in the Netherlands, close to the German border.

During the expedition, specimens retained on 0.5 mm and 1 mm mesh sieves were kept and identified. Of all the samples collected in Borkum Stones, those from German waters were kept by Oceana for further analysis after the expedition, together with part of the samples collected in Dutch waters. The remainder were sent to DISCLOSE collaborators at the Royal Netherlands Institute for Sea Research (NIOZ), for their own research. The results of those analyses were not yet available at the time of writing this report and are therefore not included here.

DISCLOSE project

Oceana worked in collaboration with the DISCLOSE project to carry out surveys in Dutch waters.[26] This project, a partnership between Delft University of Technology, the University of Groningen, NIOZ, and the North Sea Foundation, aims to reveal the distribution, structure and functioning of benthic communities and habitats in the Dutch North Sea. Borkum Stones is one of the areas of interest for DISCLOSE. During the Oceana expedition, three DISCLOSE scientists were present on board *MV Neptune*, and used additional technologies for carrying out benthic surveys: side-scan sonar, a towed camera and a sediment profile imagery device. The results of those surveys will be analysed and published under the framework of the DISCLOSE project.

In total, Oceana documented 148 taxa in Borkum Stones, of which 101 were identified to the species level, and 47 to higher levels (see *Annex*). Of the documented species, molluscs represented the most diverse group (n=51 taxa), followed by cnidarians (n=24 taxa), and fishes (n=24 taxa). Other less diverse taxa observed included arthropods, echinoderms, sponges, bryozoans, and, to a lesser extent, tunicates, annelids and ctenophores – with the latter represented by just one species.

Community types

Based on our observations, four types of habitats were documented in the area: i) sandy bottoms mixed with shell remains; ii) sandy bottoms mixed with shell remains and supporting dense facies of sand mason worms (*Lanice conchilega*); iii) coarse bottoms formed by sand mixed with shell remains and stones of varying sizes; and iv) a wreck covered by dense aggregations of cnidarians and sponges, which sheltering many fishes and crustaceans of different species (Figure 9). Details of the benthic communities associated with each of those four habitat types are provided below.

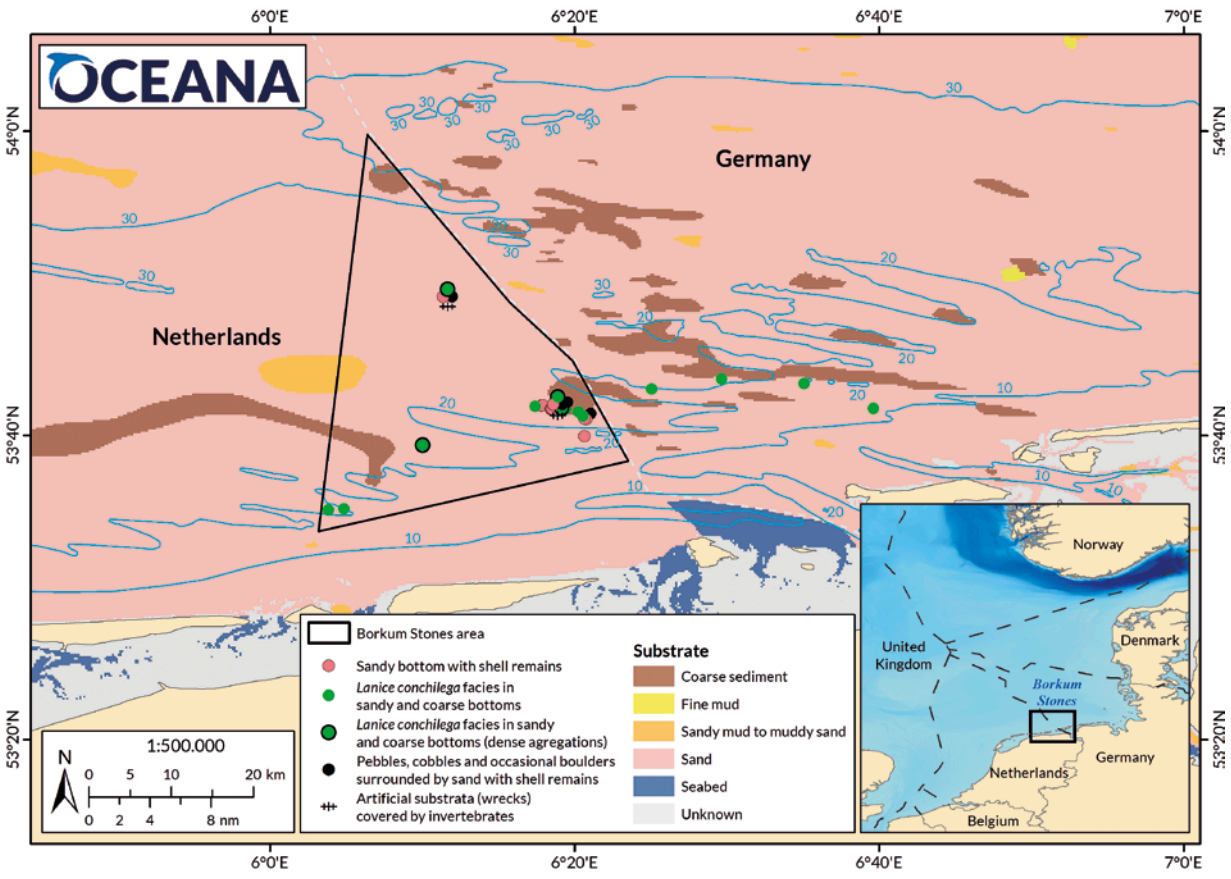


Figure 9. Benthic community types documented in Borkum Stones during the 2017 Oceana expedition, shown in relation to seabed substrate types. Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] and Lindeboom *et al.* (2005).[8]

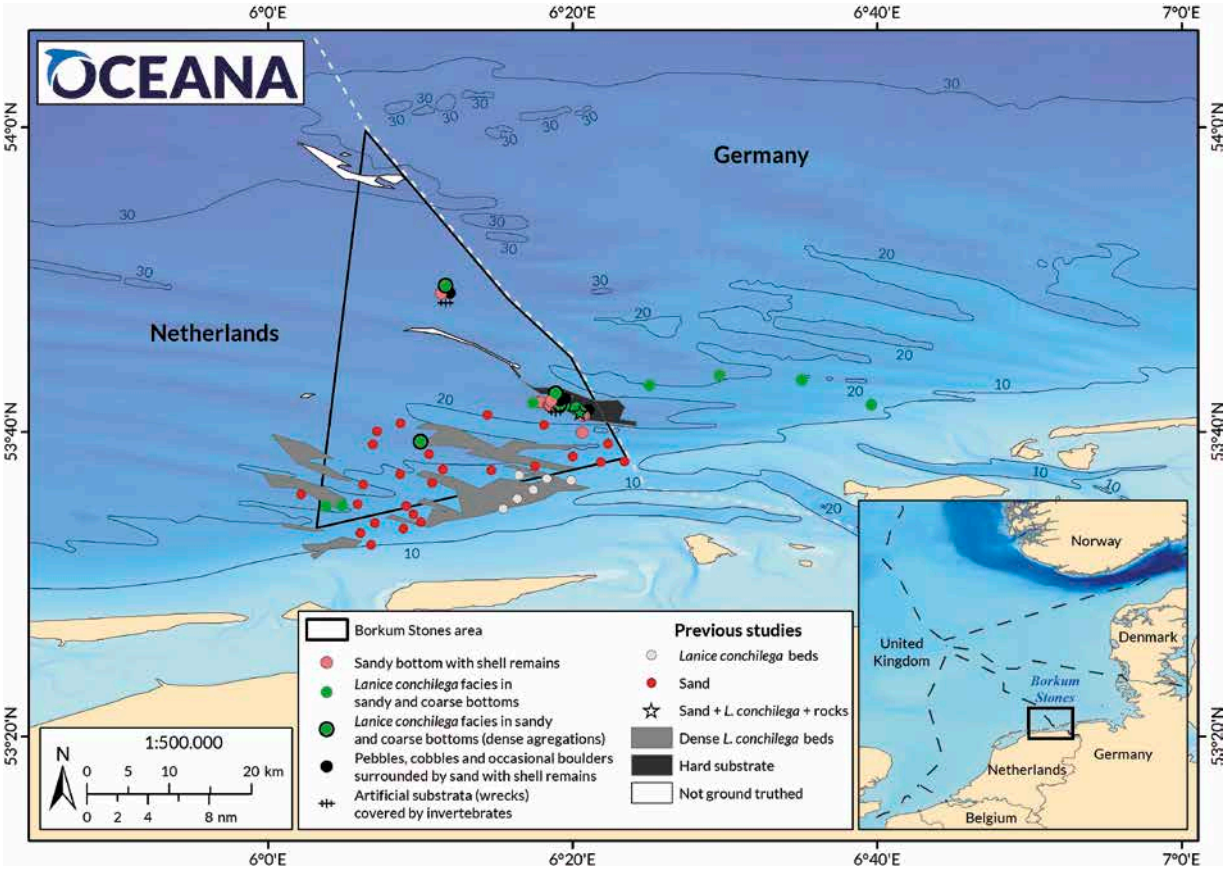


Figure 10. Benthic community types documented in Borkum Stones during the 2017 Oceana expedition, shown in relation to benthic observations from previous research by Coolen *et al.* (2015).[15] Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] Lindeboom *et al.* (2005).[8]

Sandy bottom with shell remains

[EUNIS code: A5.25: Circalittoral fine sand; A5.26: Circalittoral muddy sand]

Most of the seven SCUBA dives were carried out in locations with areas of sandy bottom. Crustaceans were the most documented taxa in such areas, and included species such as brown shrimp (*Crangon crangon*) and common hermit crab (*Pagurus bernhardus*). Molluscs were also commonly observed in this habitat, including bivalve species such as razor clam (*Ensis* sp.) and northern lucine (*Lucinoma borealis*), and the only record of common wentletrap (*Epitonium clathrus*) found during all of Oceana's North Sea surveys. Echinoderms were also abundant, and mainly comprised sea stars such as common sea star (*Asterias rubens*) and sand sea star (*Astropecten irregularis*); both species also occurred on other types of bottom. Fishes such as reticulated dragonet (*Callionymus* cf. *reticulatus)*, sand goby (*Pomatoschistus minutus*), and pogge (*Agonus cataphractus*) were also identified in sandy areas.

Lanice conchilega facies in sandy and coarse bottoms

[EUNIS codes: A5.14: Circalittoral coarse sediment; A5.25: Circalittoral fine sand; A5.26: Circalittoral muddy sand]

Very high densities of the tube-dwelling sand mason worm (*Lanice conchilega*) (Figure 11) were recorded during Oceana's

surveys in the Dutch waters of Borkum Stones, via all three biological sampling methods used (i.e., ROV, SCUBA, and grab samples). The bottom was found to be completely covered by sand mason worms in extensive parts of the ROV transects and some of the SCUBA transects. Similarly, grab samples contained high abundances of sand mason worms (up to approximately 100 individuals/0.2 m^2 of seabed area sampled) (Figure 12), further indicating the significant coverage of this species. Dense aggregations of sand mason worm are known to modify their habitat to a sufficient degree that they can be considered reef-forming and are associated with elevated levels of associated biodiversity.[56,71] In Borkum Stones, aggregations of *L. conchilega* have previously been documented to reach densities of more than 1500 individuals/m^2.[15,72] Oceana's observations indicate several new locations across Borkum Stones with dense *L. conchilega* aggregations (Figure 10), where further studies should be carried out to determine the extent and condition of those communities.

The sea bottom in areas characterised by *L. conchilega* aggregations was also home to bivalves, mainly edible cockle (*Cerastoderma edule*), Baltic tellin (*Limecola balthica*), elliptical surfclam (*Spisula elliptica*) and thick surfclam (*S. solida*). A dead ocean quahog (*Arctica islandica*) was also documented in one of these areas. Sea urchins, especially juveniles of heart-urchin (*Echinocardium cordatum*), were also present among the collected samples, as well as common sea star (*Asterias rubens*).

Figure 11. Sand mason worm (*Lanice conchilega*) fields on sandy bottom. © udovandongen.com

Figure 12. Sand mason worm (*Lanice conchilega*) collected in a grab sample. © OCEANA/ Juan Cuetos

Pebbles, cobbles and occasional boulders surrounded by sand with shell remains

[EUNIS code: A5.14: Circalittoral coarse sediment]

Mixed substrate of sand, abundant shell remains, and rocks of varying sizes (from pebbles to cobbles and boulders) was present in three of the SCUBA dives, one ROV transect, and one grab sample (Figure 13). In these areas, species associated with both hard and soft substrates were documented. Various anemones (e.g., *Metridium senile*, *Sagartia* spp.) were identified, together with leather corals (e.g., *Alcyonium digitatum*), hydozoans (e.g., *Sertularia argentea*), sponges (e.g., breadcrumb sponge (*Halichondria (Halichondria) panicea*)), and barnacles (e.g., *Balanus* sp., *Scalpellum scalpellum*), all of which are characteristic of hard bottoms and were found covering the surfaces of rocks. The observation of velvet goose barnacle (*S. scalpellum*,) appears to be the first record of this species in the Netherlands.[73,74]

Meanwhile, the main species associated with soft, sandy bottoms were tube anemones (e.g., *Cerianthus lloydii*) and small snakelocks anemone (*Sagartiogeton undatus*), echinoderms (e.g., *Asterias rubens* and *Astropecten irregularis*), and a wide variety of bivalves (e.g., sword razor shell (*Ensis siliqua*), solid surfclam (*Spisula solida*), rayed trough-shell (*Mactra stultorum*) and the remains of an ocean quahog (*Arctica islandica*)).

The only grab sample carried out in Borkum Stones that contained cobbles and pebbles was carried out close to the German border (Figure 14). These rocks served as substrate for some sessile species, such as plumose sea anemone (*Metridium senile*), bryozoans (*Einhornia crustulenta*), hydrozoans (*Sertularella gayi*), and slipper limpet (*Crepidula fornicata*). Also collected with the rocks and sediment were a juvenile *Ophiura* sp., and dozens of mollusc shells (e.g., *Abra alba*, *Cerastoderma edulis*, *Ensis ensis*, *Fabulina fabula*, and *Spisula elliptica*).

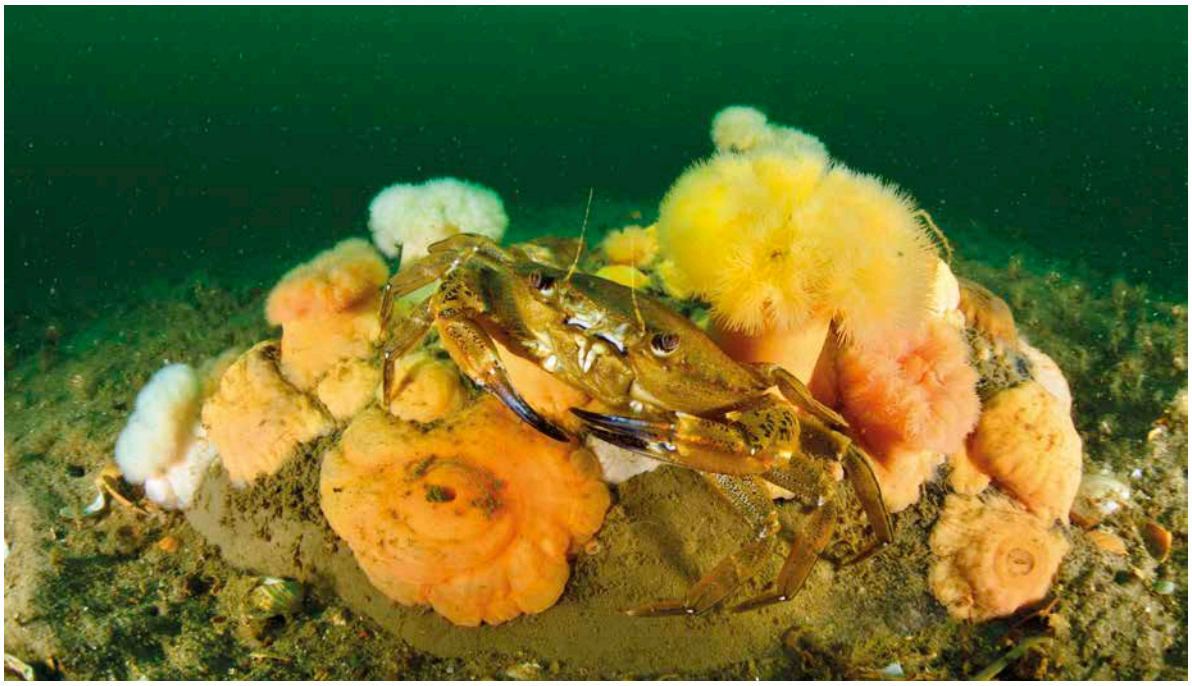


Figure 13. Plumose sea anemone (*Metridium senile*) and a velvet swimming crab (*Necora puber*) on a rock. © OCEANA/ Carlos Minguell

Figure 14. Sediment sample of muddy sand with cobbles and pebbles. © OCEANA/ Juan Cuetos

Artificial substrata (wrecks) covered by invertebrates

[EUNIS code: A4: Circalittoral rock and other hard substrata]

Three SCUBA dives were partially carried out in a wreck, the *Tjalk*, lying at 22 m on sandy bottom (Figure 15). The wreck served as substrate for various sessile species that almost completely covered the hull. The most common of these species were cnidarians such as plumose sea anemone (*Metridium senile*), elegant anemone (*Sagartia elegans*) and small snakelocks anemone (*Sagartiogeton undatus*); sponges such as breadcrumb sponge (*Halichondria (Halichondria) panicea*) and sea orange (*Suberites ficus*); and bryozoans such as *Conopeum seurati*.

The wreck also provided refuge for other benthic and pelagic fauna. Among the mobile species documented were crustaceans such as edible crab (*Cancer pagurus*), harbour crab (*Liocarcinus depurator*), and to a lesser extent, European lobster (*Homarus gammarus*) and velvet swimming crab (*Necora puber*). An empty ocean quahog (*Arctica islandica*) shell was spotted close to the wreck. Fishes observed in association with this habitat included large schools of bib (*Trisopterus luscus*) and, in smaller numbers, goldsinny wrasse (*Ctenolabrus rupestris*), cod *(Gadus morhua*), rock gunnel (*Pholis gunnellus*), and spotted dragonet (*Callionymus maculatus*). A ghost fishing net was also documented in the wreck, in which crustaceans, soft corals, and sponges were entangled (Figure 16).

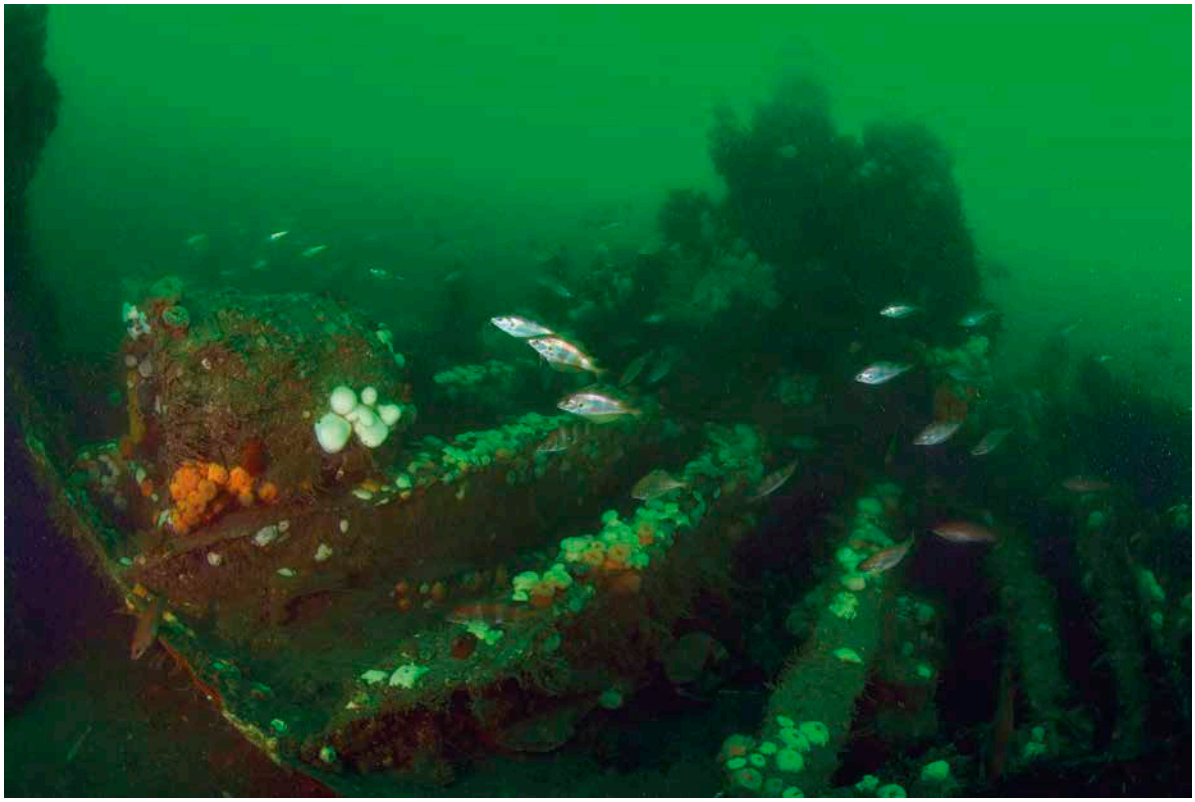


Figure 15. *Tjalk* wreck in Borkum Stones, covered in anemones and surrounded by bib (*Trisopterus luscus*) © OCEANA/ Carlos Minguell

Figure 16. Edible crab (*Cancer pagurus*) trapped in a ghost fishing net. © OCEANA/ Carlos Minguell

Features of conservation interest

During the Oceana expedition, 21 species and three habitats were documented in Borkum Stones that are considered priorities for conservation because these features are included within national, European, or regional frameworks that recognise their threatened status and/or establish requirements for their legal protection (Table 2). These frameworks include: EU Directives (i.e., the Habitats Directive and the MSFD), the OSPAR Convention, and Red Lists of threatened habitats and species. As such, their occurrence in Borkum Stones area deserves special consideration, with respect to the biodiversity value of the area and required management measures. The locations where these habitats and species were observed are shown in Figure 17 and Figure 18, respectively.

Table 2. Features of conservation interest documented in Borkum Stones. NL: Netherlands; DE: Germany; HD: EU Habitats Directive; MSFD: EU Marine Strategy Framework Directive. *Denotes species found by Oceana in Dutch waters of Borkum Stones but which are Red Listed in Germany.

Features		INTERNATIONAL FRAMEWORKS				NATIONAL FRAMEWORKS	
		HD[3]	MSFD[75]	European Red List of Habitats [76]	OSPAR[77]	NL Red List of Fishes [78]	DE Red List[79]
Habitats	Biogenic reefs	1170 Reefs	(d)				
	Geogenic reefs	1170 Reefs		Vulnerable[e]			
	Sandbanks	1110 Sandbank		Endangered[f]			
Species	Cod *(Gadus morhua)*				(g)		
	Banded wedge shell *(Donax vittatus)*						Threatened to unknown degree
	*Breadcrumb sponge *(Halichondria (Halichondria) panicea)*						Threatened to unknown degree
	*Common lobster *(Homarus gammarus)*						Endangered
	*Common pipefish *(Syngnathus acus)*						Threatened to unknown degree
	Common razor shell *(Ensis ensis)*						Endangered
	*Dead man's fingers *(Alcyonium digitatum)*						Vulnerable
	Dwarf swimming crab *(Liocarcinus pusillus)*						Vulnerable
	Elliptical astarte *(Astarte elliptica)*						Threatened to unknown degree
	Elliptical surfclam *(Spisula elliptica)*						Endangered
	*Plumose sea anemone *(Metridium senile)*						Threatened to unknown degree
	*Mud lobster *(Upogebia deltaura)*						Threatened to unknown degree
	*Ocean quahog *(Arctica islandica)*				(h)		Vulnerable
	Pea urchin *(Echinocyamus pusillus)*						Threatened to unknown degree
	Rayed trough-shell *(Mactra stultorum)*						Threatened to unknown degree
	Rock gunnel *(Pholis gunnellus)*					Vulnerable	
	*Sand sea star *(Astropecten irregularis)*						Threatened to unknown degree
	*Small snakelocks anemone *(Sagartiogeton undatus)*						Vulnerable
	*Solid surfclam *(Spisula solida)*						Threatened to unknown degree
	Subtruncate surfclam *(Spisula subtruncata)*						Threatened to unknown degree

d Environmental target under Dutch MSFD on return and recovery of biogenic reefs.

e Vulnerable: A5.14 Atlantic upper circalittoral coarse sediment; A5.44 Atlantic upper circalittoral mixed sediment.

f Endangered: A5.26 Atlantic upper circalittoral muddy sand. Further research would be required to definitively confirm the presence of this habitat type.

g OSPAR Species under threat and/or decline (Regions II & III).

h OSPAR Species under threat and/or decline (Regions I, II, III & IV).

Threatened and protected habitats

Biogenic reefs

Reefs formed by sand mason worm (*L. conchilega*) represent the features documented in Borkum Stones that hold the greatest conservation interest. Sand mason worm structures that rise a few centimetres above the seabed can serve as important habitat for marine fauna, providing refuge, nursery, or spawning habitat, or simply acting as hard substrate for epifauna and infauna.[71] During Oceana's research in the Dutch waters of Borkum Stones, large extensions of this habitat were recorded. The presence of these reefs is noteworthy because biogenic reefs are scarce in the southern North Sea in general, and in Dutch waters have almost disappeared.

In 2009, it was concluded that dense aggregations of *L. conchilega* are suitable to be defined as '*reefs*' under the framework of the Habitats Directive, according to the 'reefiness' criteria that had previously been applied to reef-like structures formed by other annelids (e.g., *Sabellaria spinulosa*).[71] *L. conchilega* has been shown to influence surrounding benthic biodiversity, increasing species richness in low-structured sandy bottoms to levels higher than rocky reefs,[15] and therefore qualifying as a type of biogenic reef.

Under the MSFD, *L. conchilega* reefs qualify for inclusion under the two qualitative descriptors that are relevant for benthic habitats (D1: Biodiversity and D6: Sea-floor integrity). In the case of the Netherlands specifically, one environmental target under the MSFD relates specifically to the "return and recovery of biogenic reefs."[75]

To date, the protection of reefs in Dutch waters has been limited to the designation of geogenic reefs as a protected feature in just one location: the offshore MPA *Klaverbank*. In recent years, however, increased attention has been paid to Dutch areas where biogenic reefs occur, namely Borkum Stones and Brown Bank (*Bruine Bank* in Dutch), where Oceana discovered reefs formed by ross worm (*Sabellaria spinulosa*) during the same 2017 expedition in which Borkum Stones was surveyed.[80,81] Such reefs had previously been thought to be extinct in Dutch waters. Similarly, the discovery of a shellfish reef comprised partly by flat oyster (*Ostrea edulis*) in the Voordelta area raises questions about the potential for the return of ecologically extinct *O. edulis* reefs to Dutch waters.[82] Further research is necessary to determine the total coverage of reefs on the Dutch sea bed – including biogenic reefs – to therefore be able to assess the extent to which reef protection should be expanded in Dutch waters.

In contrast to Dutch waters, no *L. conchilega* reefs were documented during Oceana surveys in German waters of Borkum Stones; however, sampling effort on the German side of Borkum Stones was more limited than on the Dutch side.

Geogenic reefs

Geogenic (i.e., stone) reefs are more common in the northern North Sea than in the southern North Sea, where they are relative rare and only occur in a few areas (such as Cleaver Bank and Borkum Stones).[15] Their scarcity is partly due to the long-term and ongoing removal of rocks in bottom-contact fishing gears[20] (see *Threats*), which are the main gear-types used in the southern North Sea.

The Borkum Stones area is primarily known for its hard substrate. As documented by Oceana, while the seabed in Borkum Stones is predominantly composed of medium-grained sands, it also comprises coarse sand mixed with pebbles, cobbles, and scattered boulders. Hard substrates such as these are of particular value for biodiversity, playing an important role in attracting relatively large numbers of associated benthic species.[15] This habitat is encompassed within the Habitats Directive definition of '*reefs*', and thus qualifies for protection within the Natura 2000 network of protected areas – in the same way that the geogenic reefs in German waters are a designated feature of the *Borkum-Riffgrund* SAC.[83]

The coarse and mixed sediments documented by Oceana in Borkum Stones (i.e., EUNIS categories A5.14: Atlantic upper circalittoral coarse sediment; and A5.44: Atlantic upper circalittoral mixed sediment) are also listed as Vulnerable in the North-East Atlantic region, on the European Red List of Marine Habitats.[76]

Sandy bottoms

Sandbanks

The conservation of sandbanks such as those in Borkum Stones is a priority because of the range of ecosystem goods and services that these systems provide. They support diverse communities of epifauna and infauna (particularly in areas between banks), they serve as feeding and nursery grounds for some commercial fishes, and they act to dissipate wave energy, thereby reducing coastal erosion.[20,21,84]

Sandbanks fall under the Habitats Directive category '*Sandbanks which are slightly covered by water all the time*'. This habitat type is relatively broad, comprising systems with a variety of substrate characteristics and depths. In the Netherlands, this category is interpreted as encompassing the entire complex of sandbanks, troughs and channels between them; any hard structures; and the water column that lies above all of these features. Depending on the region of Dutch waters, sandbanks are further categorised according to three subtypes, each with differing definitions;[85] sandbanks in Borkum Stones officially correspond to the North Sea coastal zone (i.e., subtype B).[86]

Harbour crab (*Liocarcinus depurator*) on sandy bottom
© OCEANA/ Juan Cuetos

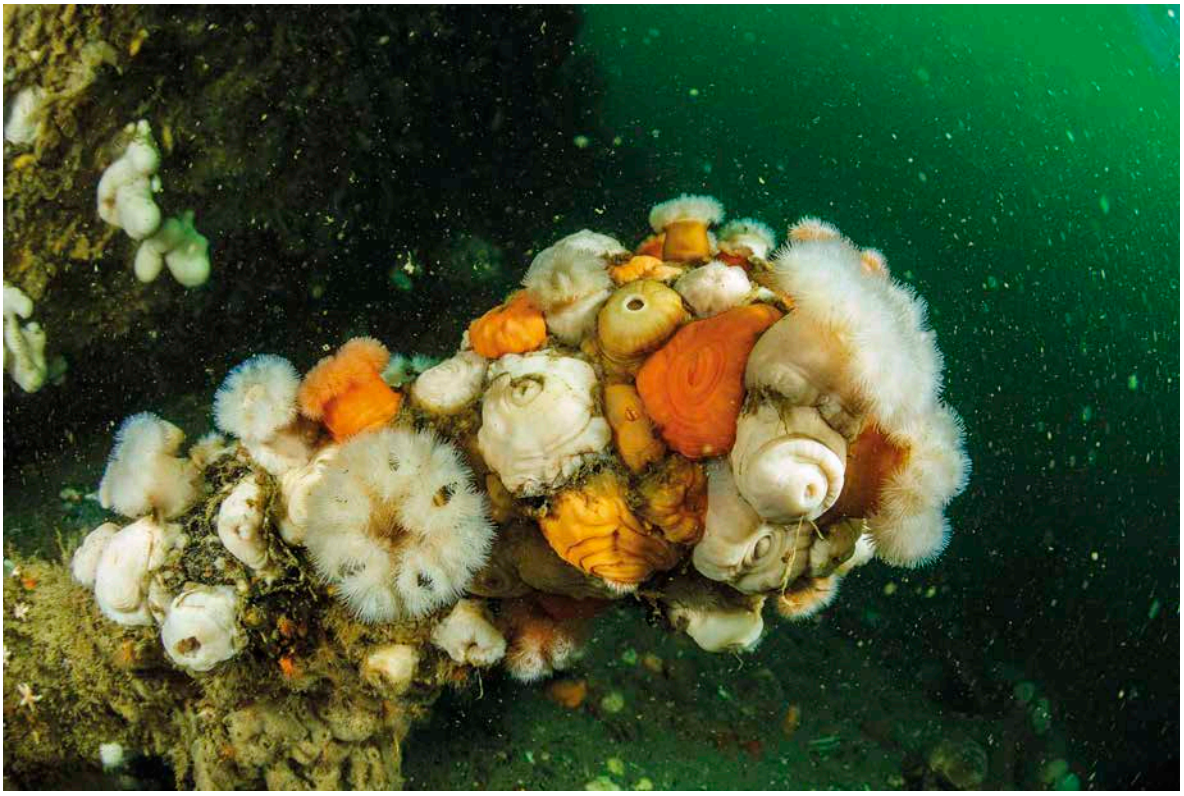
According to reports on the conservation status of habitats and species listed under the Habitats Directive, the quality of sandbank habitats in the Netherlands is deteriorating, suggesting that current protection measures are insufficient.[87] In the Netherlands, more than 60% of this habitat type falls within Natura 2000 areas, in line with EU recommendations.[88] However, for many of these areas, no management measures have been implemented yet. Beyond the Habitats Directive, sandbanks in Dutch waters are also included broadly under various targets associated with the two MSFD descriptors related to benthic habitats (D1 and D6), which include measures related to the reduction of human impacts on the seabed.

Oceana documented sandy bottoms at depths of 19.7-27.6 m in Borkum Stones; in some cases, these bottoms were covered with sand mason worm aggregations. Most of this depth range lies below the maximum depth stated in the official Dutch definition of sandbanks for the North Sea coastal zone subtype (i.e., 20 m), indicating that they would not technically be considered sandbanks under the Dutch interpretation of the Habitats Directive.[85] However, this strict limit is not entirely consistent with guidance at the EU level. Although under the Habitats Directive definition of '*sandbanks*' the water depth is not typically more than 20 m,[89] the Interpretation Manual of European Union Habitats states that sandbanks extending below 20 m depth may also be designated for protection within Natura 2000 sites[83] – as the Dutch authorities have done in the *Doggersbank* Natura 2000 area, where a deeper limit is applied.[85] Moreover, the German waters of Borkum Stones have been protected, in part, due to the presence of sandbanks[i], further emphasising the natural extension of this habitat to the Dutch waters of Borkum Stones.

i The German definition of sandbanks under the Habitats Directive is based on different criteria than are used by the Netherlands.

Muddy sands

Muddy sands corresponding to EUNIS habitat type A5.26 (Atlantic upper circalittoral muddy sand) are listed as Endangered in the North-East Atlantic region, on the European Red List of Marine Habitats.[76] These bottoms are characterised by a content of 5-20% silt in the substratum, and are vulnerable to bottom-contacting fishing gears. Muddy sands documented by Oceana could potentially correspond to this threatened habitat type, but further analysis of the substrate would be needed to definitively confirm its presence in the Borkum Stones area.



Tjalk wreck covered with plumose anemones *(Metridium senile)*
© OCEANA/ Juan Cuetos

Threatened and protected species

The Oceana expedition in Borkum Stones recorded a total of 21 species that are considered priorities for conservation, based on their inclusion in relevant conservation frameworks (Table 2). These species include eight molluscs, four cnidarians, three crustaceans, and three fishes, among others. Two of the species (i.e., cod and ocean quahog, of which only empty shells were found) are listed on the OSPAR List of Threatened and/or Declining Species and Habitats,[77] and as such are recognised priorities for protection. The associated OSPAR Recommendations for these species require Contracting Parties to implement measures to recover and conserve their North Sea populations.[90,91] A recent study to assess the implementation of these Recommendations in Dutch waters concluded that the Recommendation for cod had been fully implemented, while that for ocean quahog had only been partially implemented.[92] The remainder of the species in Table 2

are listed under national (either German or Dutch) Red Lists, with the status of Endangered, Vulnerable, or Threatened but to an unknown degree.

Five of the threatened and/or protected species documented by Oceana (Table 2) are also of commercial interest: cod, common razor shell, European lobster, subtruncate surfclam and solid surfclam (see *Commercial species*). Of these species, cod (*Gadus morhua*) deserves particular mention. Cod is one of the most economically and historically important species in the North Sea, with records of cod fisheries in the region that go back for centuries.[93] Intensive overfishing of cod drove a steep decline in biomass from the 1970s until the mid-2000s,[94] which was later followed by a period of apparent increase, as a result of the application of stricter management measures. However, the most recent assessment of the cod stock 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 currently below safe biological limits and remains subject to ongoing overfishing.[94] Cod is also known to spawn in Borkum Stones.[25] One of the critical aspects highlighted in the stock assessment is the fact that cod recruitment has been poor since 1998, which points even more strongly to the need to protect spawning and nursery grounds – such as Borkum Stones – to facilitate stock recovery.

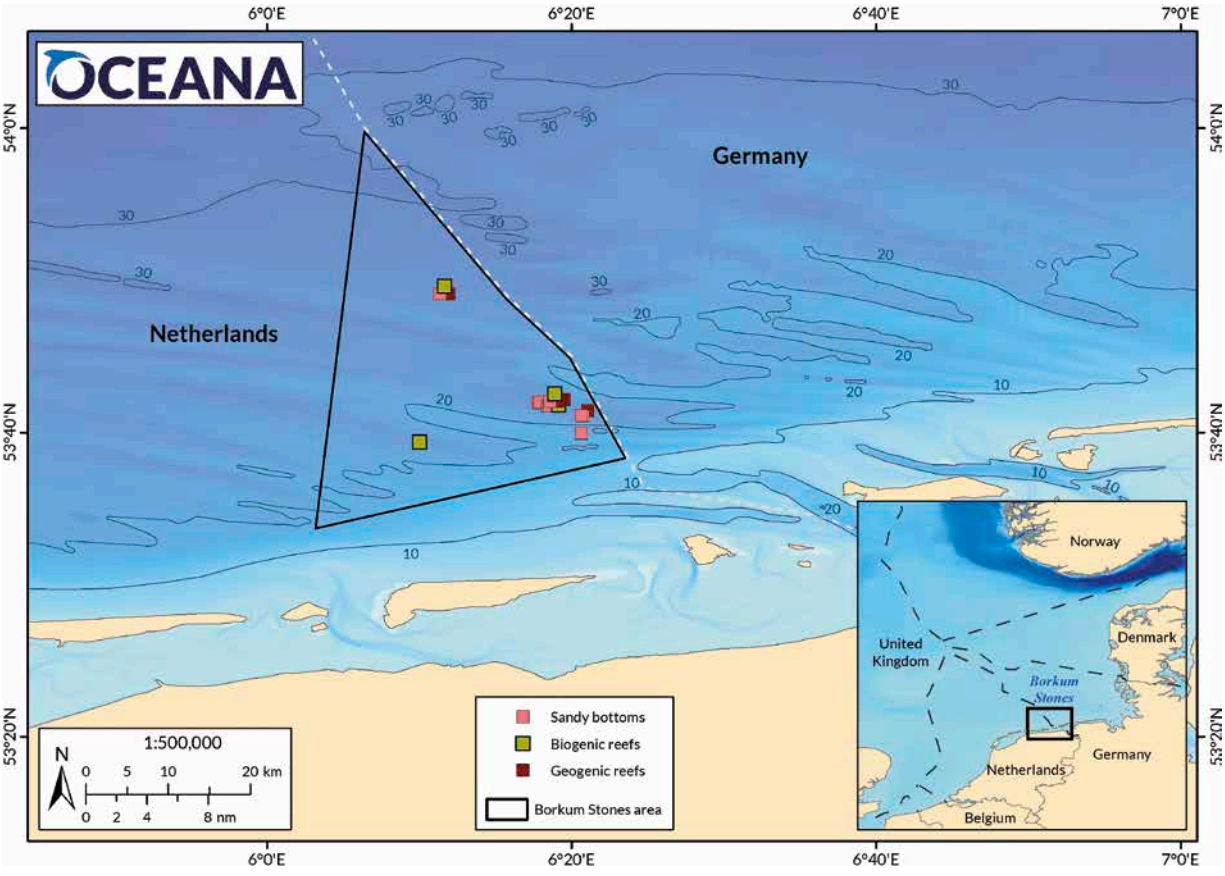
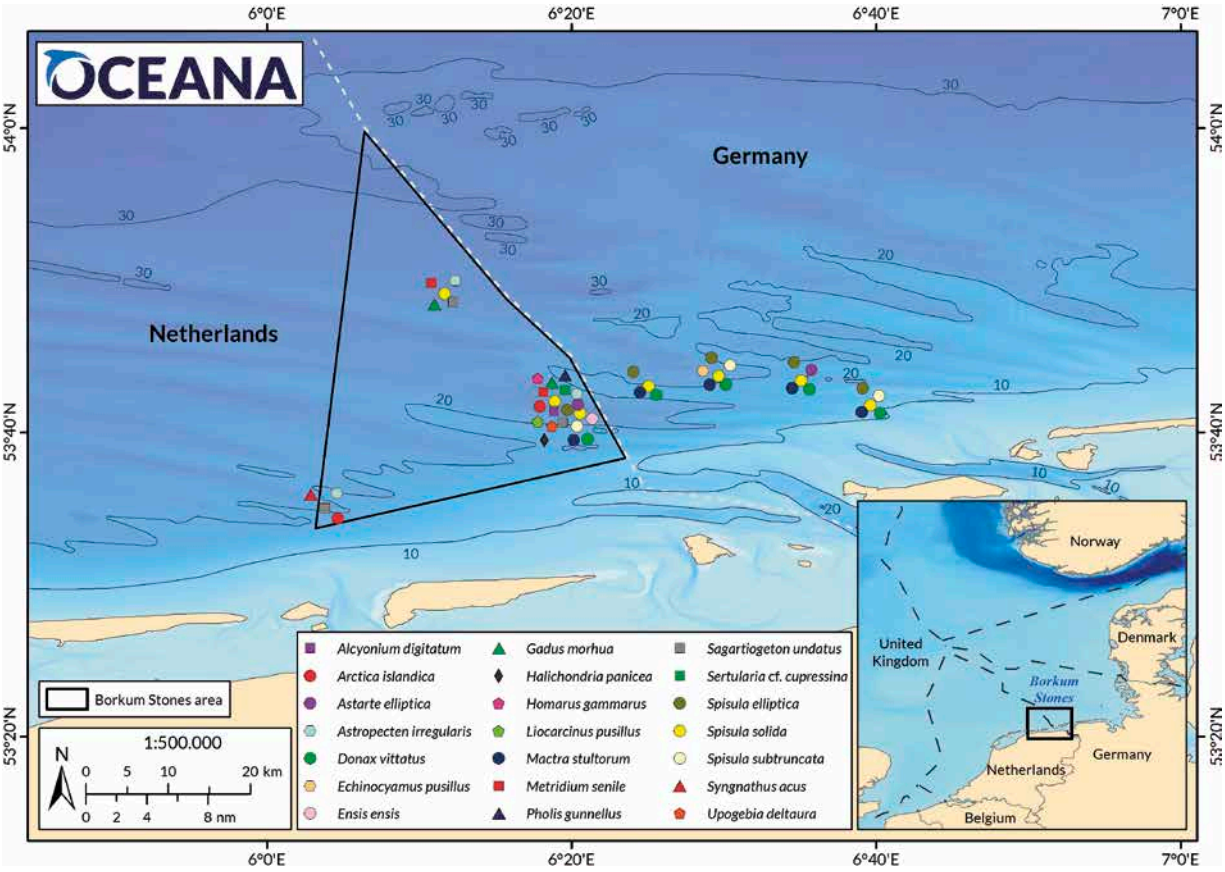


Figure 17. Habitats of conservation interest found in the Borkum Stones survey area. Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] and Lindeboom *et al.* (2005).[8]

Figure 18. Species of conservation interest found in the Borkum Stones survey area. Sources: EMODnet,[5] EEA,[6] Flanders Marine Institute,[7] and Lindeboom *et al*. (2005).[8]



Commercial species

Among the organisms recorded by Oceana were a range of species that are commercially fished in the fisheries division that corresponds to Borkum Stones (i.e., 'Central North Sea'; Table 3). These species include mainly fishes, as well as molluscs, crustaceans, and one echinoderm. For some of these species, Borkum Stones is also known to represent essential fish habitats (EFH), such as spawning or nursery areas (see *Known ecological features of interest*).[25] Examples of such species are cod (*Gadus morhua*) and sprat (*Sprattus sprattus*).

Table 3. Commercial species observed during Oceana surveys of Borkum Stones. Species were identified as commercially fished based on reported catches from the Central North Sea (FAO Division 27.4b), according to Eurostat records from 2009-2018.[95]

Species	Common name
ARTHROPODA	
Cancer pagurus	Edible crab
Carcinus maenas	Shore crab
Crangon crangon	Brown shrimp
Homarus gammarus	Common lobster
Necora puber	Velvet crab
CHORDATA	
Agonus cataphractus	Pogge
Callionymus lyra	Dragonet
Gadus morhua	Cod
Hippoglossoides platessoides	Long rough dab
Limanda limanda	Dab
Pleuronectes platessa	Plaice
Sprattus sprattus	Sprat
Trachurus trachurus	Horse mackerel
Trisopterus luscus	Bib
ECHINODERMATA	
Asterias rubens	Common sea star
MOLLUSCA	
Cerastoderma edule	Edible cockle
Ensis ensis	Common razor shell
Spisula solida	Solid surfclam
Spisula spp.	Surf clams
Spisula subtruncata	Subtruncate surfclam

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PROPOSAL FOR PROTECTION

The protection of Borkum Stones has been highlighted as a priority for more than 15 years (see *Previous conservation proposals*), on the basis of the threatened and protected habitats and species that occur within the area.[1,8] On the German side of Borkum Stones, the importance of these features was officially recognised through the designation of *Borkum-Riffgrund* as a Natura 2000 area in 2007 (although it should also be noted that measures to limit fishing impacts on protected features in that area are still pending). However, the Dutch side of the area remains unprotected, despite its recognised biodiversity value and ecological similarity to the German side. Below are presented the specific reasons, supported by Oceana's research, that underscore the need to protect the Dutch waters of the area.

Borkum Stones has several key characteristics that determine its uniqueness and fragility. Specifically, the Dutch part of Borkum Stones is characterised by: a rich mosaic of ecosystems, which provide high habitat complexity and support high associated levels of biodiversity;[96] its location near to the coast (although it waters reach depths of more than 30 m); and the presence of threatened and protected habitats, in particular:

- sandbanks, which in Dutch waters are currently only protected in shallow coastal zones and in one offshore Natura 2000 area.

- geogenic reefs, which are scarce in Dutch waters in general, and particularly in areas nearer to the coast.

- biogenic reefs (i.e., *Lanice conchilega* aggregations), which are not represented among reefs currently protected in the Netherlands.

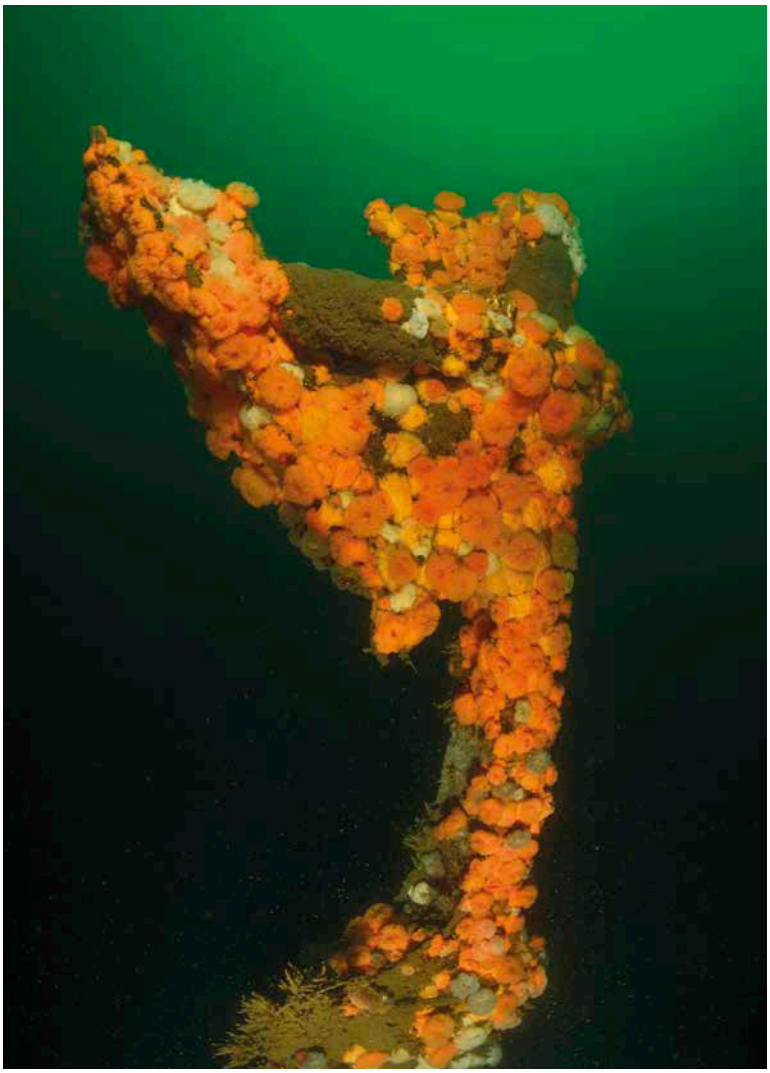
Sandbanks and reefs (including those built by reef-forming species) are important habitats upon which many characteristic North Sea species depend. However, these habitats are among those that are declining in the North Sea due to intensive human activity – and Dutch waters are no exception.[97] Reports on the conservation status of habitats and species listed under the Habitats Directive indicate that the quality of both sandbanks and reefs in the Netherlands is deteriorating.[87] Sandbanks are sensitive to impacts generated by human activities, such as mechanical disruption, habitat fragmentation, and pollution.[98] Biogenic reefs have also suffered from intensive anthropogenic impacts, disappearing entirely from many places where they once occurred in the North Sea, including the Netherlands (where other types of hard bottoms are also scarce).[97,99]

Despite their declining conservation status, sandbanks and reefs have been assessed as 'sufficiently protected' in relation to their spatial coverage in Dutch waters, under the assessment processes and criteria related to the Habitats Directive.[100,101] However, even though 70% of the official total area of Dutch sandbanks are protected inside Natura 2000 sites,[102] half of this area is concentrated in *Doggersbank*, an offshore site located nearly 100 nautical miles away from the nearest protected sandbank. This distance is too great to allow for connectivity among protected areas, and therefore limits the ecological coherence of the current Dutch MPA network.[96] Moreover, the actual extent of sandbanks in the Netherlands is likely to be greater than has been identified under the current Dutch definitions used to categorise sandbanks under the Habitats Directive. The strictness of these definitions precludes the inclusion – and therefore also protection within Natura 2000 – of sandbanks in areas such as Borkum Stones, where sandbanks appear to extend below the definitional depth limit of 20 m. Oceana urges the Dutch authorities to review the appropriateness of these definitions. In the case of Borkum Stones, this issue is particularly apparent, given that differences in the criteria used by Germany and the Netherlands have led to Germany protecting the area's sandbanks while the Netherlands has not officially recognised their occurrence.

In the case of reefs, almost 90% of their distribution is concentrated in the Natura 2000 site *Klaverbank*,[88] an offshore area that harbours only geogenic – not biogenic – reefs. The remaining 10% of known reef area occurs mostly in Borkum Stones,[15] where both geogenic and biogenic reefs (formed by *L. conchilega*) are present; and in Brown Bank, where biogenic reefs built by ross worm (*Sabellaria spinulosa*) were discovered during Oceana's research expedition there in 2017.[80,81] All of these biogenic reefs (of both *L. conchilega* and *S. spinulosa*) remain unprotected and thus are not represented within the Dutch Natura 2000 network, which is contrary to the requirement that Member States should consider the representativity of habitat sub-types within sites.[100] A portion of *L. conchilega* reef does lie within the *Noordzeekustzone* Natura 2000 area.[103] However, because this MPA is officially designated for sandbanks and other coastal habitats,[104] it offers no legal protection and therefore no specific management measures to safeguard *L. conchilega* reefs. More broadly, the protection of these and other types of biogenic reefs within the Dutch Natura 2000 network faces an additional hurdle, as the current Dutch definition of reefs under the Habitats Directive does not encompass biogenic reefs, which were not known to occur in Dutch waters at the time that the definition was established. This omission should be redressed as soon as possible, so that Natura 2000 sites can serve to protect the full range of reef types found in Dutch waters.

Under the frameworks of both the MSFD and the OSPAR Convention, specific environmental targets for benthic habitats have been established with the aim of achieving Good Environmental Status (GES) of EU marine waters and biodiversity. In the case of the Netherlands, one environmental target under the MSFD relates explicitly to the "return and recovery of biogenic reefs",[97] highlighting the fact that the issue is a priority for the Dutch government. Given the limited extent of biogenic reefs in Dutch waters, the protection of Borkum Stones would clearly be in line with this aim.

Likewise, the protection of the area would help to achieve another established MSFD target for the Netherlands: the protection of 10-15% of the Dutch North Sea against significant anthropogenic impacts.[97] Currently, only 0.3% of the Dutch marine environment is fully protected, while 4% is protected from 'noteworthy' disturbances to the seabed.[9] Considering this relatively low level of protection, it is unsurprising that the latest update of the Dutch Marine Strategy concluded that GES has not yet been achieved in the country's waters.[75]



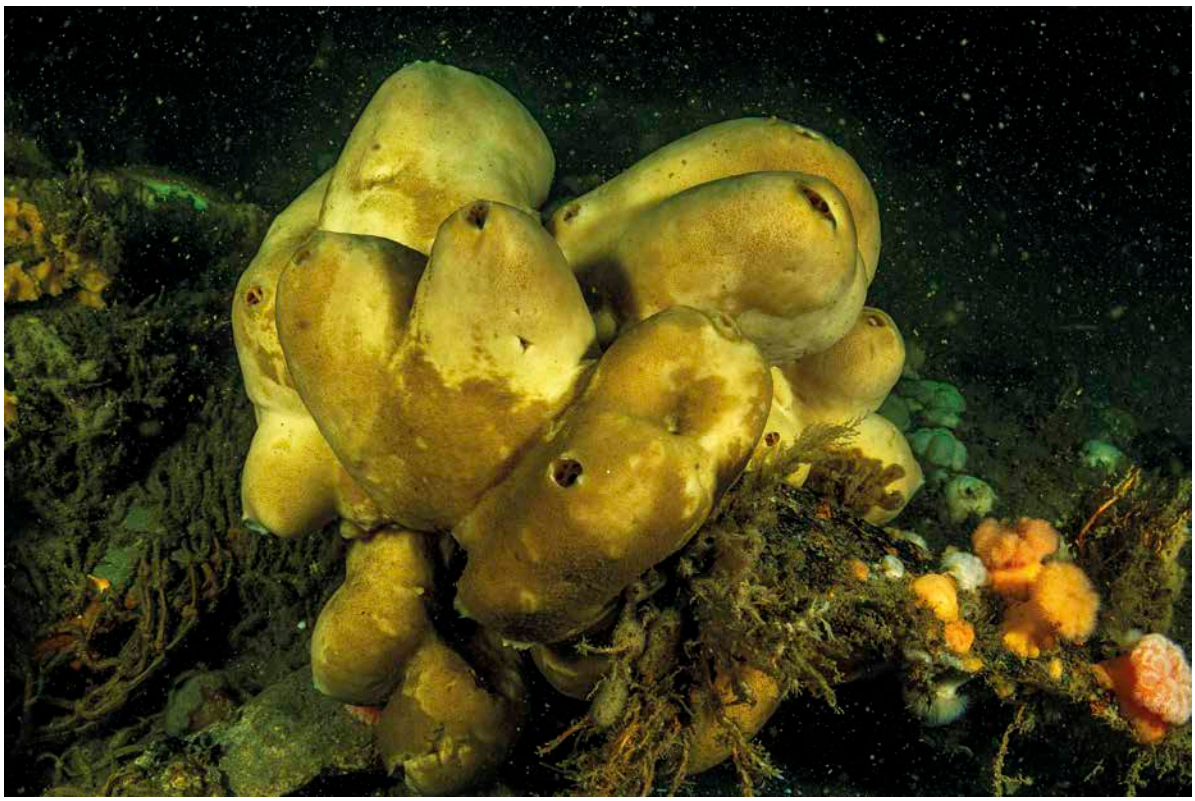
Tjalk wreck covered with plumose anemones (*Metridium senile*)
© OCEANA/ Carlos Minguell

The protection of the Dutch waters of Borkum Stones would therefore not only safeguard the valuable benthic ecosystems found within the area, but would also allow the Netherlands to fulfil its legal commitments for marine conservation at both the national and EU level. The inclusion of Borkum Stones' reefs and sandbanks within the Dutch network of MPAs would improve the ecological coherence of the network, making it more representative through the protection of biogenic reefs, and more strongly connected and balanced in terms of the spatial distribution of protected habitats.

At the international level, extending the protection of Borkum Stones to encompass Dutch waters will help to enhance the efficacy of spatial protection across the entire area. The Dutch and German waters of Borkum Stones are very similar; the key habitats and species that characterise the area extend across both sides of the maritime border,

and the threats they face are shared. For such transboundary protection to be effective, it is essential that both countries be as consistent and coordinated as possible in their approach, in terms of the features designated[8] and the measures developed for their conservation and management. Critically, both the Netherlands and Germany must ensure that such measures effectively address all of the main threats facing Borkum Stones – including fishing activity – in order to safeguard the ecological integrity of the area.

In parallel with developing measures of protection based on existing knowledge, Oceana urges the governments of both the Netherlands and Germany to conduct comprehensive habitat mapping of Borkum Stones, to characterise as precisely as possible the mosaic of benthic habitats found there. For example, further research is needed on the Dutch side, particularly in the centre and north of the area, to determine the extent and condition of sand mason worm (*L. conchilega*) reefs. The results of Oceana's surveys, in combination with those of earlier studies,[1,15] have indicated specific locations where such reefs occur or are likely to occur and where further research should be prioritised. Such data are vital for helping to inform the design of management measures to conserve the area's benthic biodiversity, and to establish an ecological baseline for future monitoring.



Sea orange (*Suberites ficus*) and plumose anemones (*Metridium senile*) © OCEANA/ Juan Cuetos

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ANNEX: RECORDED TAXA

Table A. Taxa documented in Borkum Stones during the Oceana North Sea expedition in 2017. Taxa are listed according to sampling method (SCUBA, ROV, and grab samples), and to whether they occurred in the waters of the Netherlands (NL) and/or Germany (DE).[j]

Species	SCUBA	ROV	GRAB	NL	DE
ANNELIDA					
Annelida indet	X		X	X	X
Lanice conchilega		X		X	
Polychaeta indet	X	X	X	X	
Polydora ciliata	X			X	
ARTHROPODA					
Balanidae indet	X			X	
Balanus crenatus	X			X	
Balanus sp.		X		X	
Bathyporeia guilliamsoniana			X	X	X
Brachyura indet		X		X	
Cancer pagurus	X			X	
Carcinus maenas		X		X	
Crangon crangon	X	X		X	
Eualus cranchii	X			X	
Homarus gammarus	X			X	
Liocarcinus depurator	X	X	X	X	
Liocarcinus holsatus	X			X	
Liocarcinus pusillus		X		X	
Liocarcinus sp.	X	X		X	
Macropodia rostrata	X	X		X	
Necora puber	X			X	
Pagurus bernhardus	X	X		X	
Pagurus sp.	X			X	
Scalpellum scalpellum		X		X	
Semibalanus balanoides	X			X	
Upogebia deltaura		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
CNIDARIA					
Alcyonium digitatum	X	X		X	

j The German side of Borkum Stones was only surveyed via grab sampling.

Actiniidae indet.	X			X	
Cerianthus lloydii	X	X		X	
Chrysaora hysoscella		X		X	X
Diadumene cincta	X			X	
cf. *Gonactinia prolifera*	X			X	
Halecium halecinum	X			X	
Halecium muricatum	X			X	
Halecium plumosum	X			X	
Hexacorallia indet.		X		X	
Hydractinia echinata		X		X	
Hydroidolina indet.	X			X	
Metridium senile	X	X	X	X	
Nemertesia ramosa	X			X	
Obelia longissima	X			X	
Sagartia elegans	X			X	
Sagartia sp.	X	X		X	
Sagartia troglodytes	X	X		X	
Sagartiogeton sp.	X			X	
Sagartiogeton undatus	X	X		X	
Sertularella gayi			X	X	
Sertularia argentea	X	X		X	
Sertularia cf. *cupressina*	X			X	
Thuiaria articulata	X	X		X	
CTENOPHORA					
Mnemiopsis leidyi	X			X	
ECHINODERMATA					
Asterias rubens	X	X	X	X	X
Astropecten irregularis	X	X		X	
Echinocardium cordatum		X	X	X	
Echinocyamus pusillus			X		X
Ophiura sp.			X	X	
Ophiura ophiura		X		X	
MOLLUSCA					
Abra alba	X		X	X	X
Abra prismatica			X		X
Abra sp.	X		X	X	X
Acanthocardia sp.		X		X	
Anomalodesmata indet.		X		X	
Arctica islandica[k]	X	X		X	
Asbjornsenia pygmaea			X		X
Astarte elliptica	X		X	X	X

k The two records of this species only consisted of empty shells; no live individuals were observed.

Astarte sp.			X		X
Astarte sulcata			X		X
Bivalvia indet.	X	X	X	X	
Cardiidae indet.	X			X	
Cerastoderma glaucum		X		X	
Cerastoderma edule	X		X	X	X
Cerastoderma sp.	X			X	
Chamelea striatula			X	X	
Corbula gibba			X	X	
Crepidula fornicata			X	X	
Donax vittatus			X		X
Dosinia sp.		X		X	
Pharidae indet.	X	X		X	
Ensis ensis			X		X
Ensis leei			X		X
Ensis sp.	X	X		X	
Ensis siliqua	X		X	X	X
Epitonium clathrus	X			X	
Euspira cf. *catena*			X	X	
Euspira sp.			X		X
Fabulina fabula			X		X
Gari depressa		X		X	
Laevicardium crassum	X			X	
Limecola balthica			X		X
Lucinoma borealis	X	X		X	
Lucinoma sp.	X			X	
Macomangulus tenuis			X		X
Mactra sp.	X	X		X	
Calliostoma sp.					
Calliostoma zizyphinum					
Cardiomya costellata					
Cardiomya striata					
Cephalopoda indet.					
Mactra stultorum	X		X	X	X
Mactridae indet.	X		X	X	X
Moerella donacina			X		X
Neptunea sp.	X			X	
Parvicardium pinnulatum		X		X	
Propebela turricula			X		X
Spisula elliptica	X		X	X	X
Spisula solida	X		X	X	
Spisula sp.	X			X	
Spisula subtruncata		X	X	X	

Tellina sp.	X		X	X	
Tellininae indet.			X		X
Thracia cf. *distorta*			X		X
Thracia villosiuscula			X		X
Veneridae indet.			X	X	
PISCES					
Agonus cataphractus	X	X		X	
Buglossidium luteum		X		X	
Callionymus lyra		X		X	
Callionymus maculatus	X	X		X	
Callionymus cf. *reticulatus*	X			X	
Ctenolabrus rupestris	X			X	
Gadidae indet.		X		X	
Gadus morhua	X			X	
Gobiidae indet.		X		X	
Hippoglossoides platessoides	X			X	
Limanda limanda		X		X	
Myoxocephalus scorpius	X			X	
Pholis gunnellus	X			X	
Pleuronectes platessa		X		X	
Pleuronectiformes indet.	X	X		X	
Pomatoschistus microps	X			X	
Pomatoschistus minutus	X			X	
Pomatoschistus pictus	X			X	
Pomatoschistus sp.	X	X		X	
Sprattus sprattus	X			X	
Syngnathus acus		X		X	
Taurulus bubalis	X			X	
Trachurus trachurus		X		X	
Trisopterus luscus	X			X	
PORIFERA					
Amphilectus fucorum	X			X	
cf. *Halichondria (Halichondria) panicea*	X			X	
Halichondria (Halichondria) bowerbanki	X			X	
Halichondria (Halichondria) panicea	X			X	
Halichondria sp.	X			X	
Haliclona sp.	X			X	
Suberites ficus	X			X	
TUNICATA					
Tunicata indet.	X			X	
Diplosoma sp.	X			X	
Diplosoma listerianum	X			X	

PROTECTING THE NORTH SEA: BORKUM STONES

European Headquarters - Madrid

Email: europe@oceana.org

European Union Office - Brussels

Email: brussels@oceana.org

Baltic and North Sea Office - Copenhagen

Email: copenhagen@oceana.org

UK Office - London

Email: oceanauk@oceana.org

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