MARINE FAUNA OF HARD SUBSTRATA OF THE CLEAVER BANK AND DOGGER BANK

Niels Schrieken, Adriaan Gittenberger, Joop Coolen & Wouter Lengkeek

As most of the sea bottom in the Dutch part of the North Sea consists of sand, marine fauna that live in association with hard substrates are rarely monitored. We report here on the results of a species inventory in June 2011 done by scuba-diving while focusing on a wreck on the Dogger Bank and on rocky bottoms on the Cleaver Bank. This resulted in various new records of species for the Dutch part of the North Sea. This result appeared for a large part linked to the added value of monitoring with scuba-divers. It is therefore concluded that scuba-divers should be used in addition to the more traditional monitoring methods in which dredges and grabs are used, if one aims at getting an accurate view of the biodiversity present in marine regions like the North Sea.

INTRODUCTION

As most of the sea bottom in the Dutch part of the North Sea consists of sand, marine fauna of hard substrate are rarely monitored. We report here on the results of a species inventory in June 2011 done by scuba-diving, focusing on hard substrata on the Dogger Bank and the Cleaver Bank in the Dutch part of the North Sea. Scuba-divers have previously searched a selection of locations on the Cleaver Bank, but this is the first scuba-diving expedition conducted on the Dutch Dogger Bank. The assessment from sponges to bryozoans and fishes included two dives on several wrecks on the Dogger Bank and two dives on the natural rocky bottoms of the Cleaver bank at depths between 30 and 48 meters. In total 61 species were scored on the Dogger Bank and 44 species were scored on the Cleaver bank. A large number of these species are new records for the Dutch parts of the Dogger Bank and Cleaver Bank regions. For several species like the nudibranches *Polycera faeroensis* and *Doto dunnei* and the snail *Simnia patula* these are first records of their autochthonous occurrence in the Netherlands, i.e. that they have settled with breeding populations on the Dutch part of the North Sea. The added value of monitoring with scuba-divers in areas like the Dogger Bank and Cleaver Bank is discussed.

RESEARCH AREA

The total surface of the Dutch part of the continental shelf is 57000 km² (Reith et al. 2005). Within this area the Dutch Government has designated several areas with special ecological value (Lindeboom et al. 2008). This varies from sandbanks which are slightly covered by water, to open-sea reefs consisting of rocks, boulders, oyster banks, mussel banks and peat beds. The Cleaver Bank and Dogger Bank are the focus of the present study. The Dogger Bank is a sandbank with a depth of 18 to 30 meters (Lindeboom et al. 2008). This shallow part of the continental shelf is influenced heavily by waves and light can penetrate down to the bottom, resulting in a unique fauna (Lindeboom et al. 2008). Ship wrecks are the only hard substrates on the Dogger Bank. The Dutch part of the Cleaver Bank is 900 km², 1.5% of the total Dutch Continental Shelf, between 30 and 50 meters deep. It is the largest area within the Dutch North Sea with coarse sediment, in which about 30% of the gravel is not covered with sand (Lindeboom et al. 2008). The combination of being relatively deep and the presence of gravel makes that the bottom is less influenced by waves than on the Dogger Bank. Plants and animals that live in and on soft substrates are relatively well studied in the North Sea

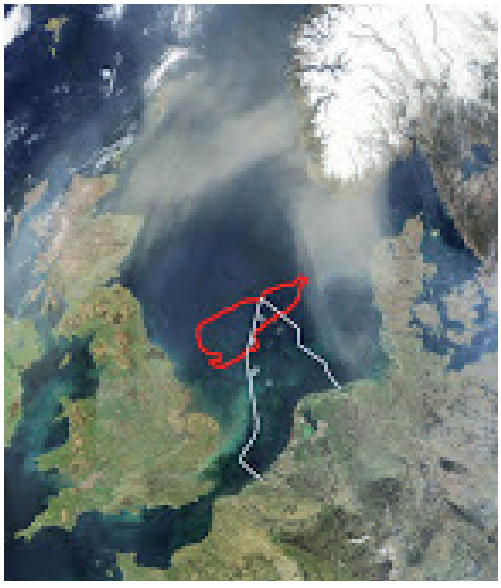

Figure 1. Dive locations of Expedition Doggersbank 2011 on the Cleaver Bank and Dogger Bank. The red line indicates the borders on the Dogger Bank. The white line indicates the borders of the Dutch part of the continental shelf. The upper two white circles show the dive locations in the Dogger Bank. The lower two white circles show the dive locations on the Cleaver Bank.
Figuur 1. Duiklocaties van de Expeditie Doggersbank 2011 op de Klaverbank en Doggersbank. De rode lijn begrenst de internationale grens van de Doggersbank. De witte lijn begrenst het Nederlandse continentale plat van de Noordzee. De bovenste twee witte cirkels betreffen de duiklocaties op de Doggersbank. De onderste twee cirkels betreffen de duiklocaties op de Klaverbank.

(Diesing et al. 2009, Callaway et al. 2002). However relatively is known about the fauna of hard substrata on the Dutch part of the continental shelf and in the Dutch Wadden Sea (Gittenberger et al. 2010).

One shipwreck site on the Dogger Bank and two sites with gravel and rocks on the Cleaver Bank where investigated (fig. 1, table 1).

MATERIAL AND METHODS

During an expedition in June 2011 to the central North Sea we focused on recording hard-substrate related macrofauna, i.e. species of which the individuals or colonies live on, in, or underneath hard substrata like gravel, rocks and shipwrecks. When species typical of soft substrates were encountered, they were also scored.

The monitoring method that was used included scuba-diving and resembled the monitoring as is described in Holt & Sanderson (2001). The dives were made at depths between 30 and 34 meters with diving times between 36 and 49 minutes. During each dive we searched an area of about five meters along both sides of a 50 meter long rope for as far as the dive time allowed it. This provides an indication of the area searched, as the exact area searched during each dive was not standardized because of variables like depth, visibility and current strengths. During the dives four scuba-divers scored the species that they came across on the standardized North Sea monitoring forms of the ANEMOON Foundation (www.anemoon.org). Voucher specimens (including egg-capsules) were preserved on 96% ethanol and stored at GiMaris and Naturalis Biodiversity Center.

To study which of the species were new to the Dutch Dogger Bank and Cleaver Bank, comparisons were made with the lists of Van Moorsel (2003) for the Cleaver Bank and Van Moorsel (2011) for the Dogger Bank. Van Moorsel (2003) includes the results of the monitoring of benthos species on the Cleaver Bank between 1983-2002 with five sampling methods, i.e. scuba-diving, underwater video, beam trawl, Hamon grab and bottom scraper. Van Moorsel (2011) provides an overview of the species for the whole international Dogger Bank based on monitoring programs using beam-trawls, bottom grabs and underwater video.

Table 1. Dives made on the Dogger Bank and Cleaver Bank.
Tabel 1. Duiken gemaakt op de Doggersbank en Klaverbank.

Description	Date and time	Position	Depth	Substrate type
Jeanette Kristina	14.VI.2011 17:01	055 17.116'N 003 26.972'E	30 m	Wreck
Jeanette Kristina	14.VI.2011 19:14	055 17.116'N 003 26.972'E	31 m	Wreck
Cleaver Bank II	16.VI.2011 14:01	054 00.219'N 003 10.486'E	33 m	Gravel
Cleaver Bank III	16.VI.2011 19:45	054 02.475'N 003 16.979'E	34 m	Gravel

RESULTS

During the two dives on the Dutch Dogger Bank 61 species were recorded (table 2), of which 29 are not included in the list of the 218 species known for the whole Dogger Bank (Van Moorsel 2011). Three species were recorded for first time in the Dutch North Sea: the snail *Simnia patula* and the nudibranchs *Doto dunnei* and *Polycera faeroensis* (Gittenberger et al. 2011, Schrieken et al. 2011).

During the two dives on the Dutch part of the Cleaver Bank 44 species were recorded (table 2). Of these, 13 are not on the list of 148 species of the Cleaver Bank presented by van Moorsel (2003). The snail *Simnia patula* and the nudibranch *Doto dunnei*, both also found in the Dogger Bank,are new to the Dutch North Sea (Gittenberger et al. 2011, Schrieken et al. 2011).

DISCUSSION

New records for the Cleaver Bank and Dogger Bank

The new investigations yielded many new species for the Dogger Bank and Cleaver Bank, compared to the lists in Van Moorsel (2003, 2011). Some of these new species are pelagic, like jellyfish, ctenophores and fish, which may explain why they are missing from the lists of Van Moorsel, who have a focus on benthic species. However, most of the new species are benthic, like nudibranches and hydroids. Some of these may concern new introductions and settlers in the North Sea because of global warming or human aided introductions. However, the main reason appears to be that most of the traditional monitoring has been focused on soft substrata, usingwith methods like beam-trawls, Hamon grabs and video recording. Only in one case scuba-divers were used to search some parts of the Dutch Cleaver Bank (Van Moorsel 2003). For the Dutch Dogger Bank, the 2011 expedition that is presented here, is the first expedition with scuba-divers.

Added value of monitoring with scuba-divers

Scuba-divers can find species that may be abundantly present, but are missed if only methods focused on soft substratum are used. Reasons for this are that scuba-divers can search habitats that are inaccessible with other monitoring methods, like the inside of a wreck or the underside of a rock. Furthermore scuba-divers can specifically search for atypical specimens and can study the live specimens, with all their patterns and colours. Some sea-anemones like *Sagartia troglodytes* tend to retract their tentacles and discolor when they are preserved.

Rare and small organisms

Scuba-divers can search for both small species like the nudibranch *Doto dunnei* (fig. 2) and large species of more than a meter in size like the common ling *Molva molva* (fig. 3). Most other monitoring methods, like dredges and grabs, are not suitable to score such a large size range of organisms.

Table 2. Species that were recorded during the dives on the Dutch part of the Dogger Bank and the Cleaver Bank. In the columns Dogger Bank and Cleaver Bank it is indicated before the '/' whether the species was observed during the expedition, and behind the '/' it is indicated whether the species was already known for the Dogger Bank and Cleaver Bank according to respectively Van Moorsel (2011) and Van Moorsel (2003). * The species was recorded as new for the Netherlands.
Tabel 2. Soorten die tijdens de duiken op het Nederlandse gedeelte van de Doggersbank en Klaverbank zijn waargenomen. In de kolommen Dogger Bank en Cleaver Bank wordt voor de '/' met een 1 aangegeven of de soort is waargenomen tijdens de expeditie. Na de '/' wordt met een 1 aangegeven of deze soort al bekend was voor de Doggersbank en Klaverbank volgens respectievelijk Van Moorsel (2011) en Van Moorsel (2003). * Dit betreft een nieuwe soort voor Nederland.

Accepted name	**Author**	**Dogger Bank**	**Cleaver Bank**	**Group**
Ascophyllum nodosum	(Linnaeus) Le Jolis, 1863	1/0	-	Algae
Halichondria panicea	(Pallas, 1766)	1/1	-	Porifera
Leucosolenia variabilis	(Haeckel, 1870)	1/0	-	Porifera
Sycon ciliatum	(Fabricius, 1780)	1/1	-	Porifera
cf. *Aglaopheniidae* sp.		1/0	-	Hydrozoa
Cyanea capillata	(Linnaeus, 1758)	-	1/0	Hydrozoa
Ectopleura larynx	Ellis & Solander, 1786	1/0	-	Hydrozoa
Cyanea lamarckii	Péron & Lesueur, 1810	-	1/0	Hydrozoa
Halecium halecinum	(Linnaeus, 1758)	-	1/1	Hydrozoa
Hydractinia echinata	(Fleming, 1828)	1/1	1/1	Hydrozoa
Kirchenpaueria pinnata	(Linnaeus, 1758)	1/1	1/1	Hydrozoa
Obelia dichotoma	(Linnaeus, 1758)	1/0	-	Hydrozoa
Sertularella cf. *gayi*	(Lamouroux, 1821)	-	1/0	Hydrozoa
Tubularia indivisa	Linnaeus, 1758	-	1/1	Hydrozoa
Alcyonium digitatum	Linnaeus, 1758	1/1	1/1	Alcyonaca
Diadumene cincta	Stephenson, 1925	-	1/0	Actiniaria
Metridium senile	(Linnaeus, 1761)	1/1	-	Actiniaria
Sagartia elegans	(Dalyell, 1848)	1/0	-	Actiniaria
Sagartia troglodytes	(Price in Johnston, 1847)	1/0	-	Actiniaria
Urticina felina	(Linnaeus, 1761)	-	1/0	Actiniaria
Beroe gracilis	Künne, 1939	1/0	1/0	Ctenophora
Pleurobrachia pileus	(O. F. Müller, 1776)	1/0	-	Ctenophora
Aphrodita aculeata	Linnaeus, 1758	-	1/1	Polychaeta
Lagis koreni	Malmgren, 1866	1/1	-	Polychaeta
Lepidonotus squamatus	(Linnaeus, 1758)	1/0	-	Polychaeta
Sabella pavonina	Savigny, 1822	-	1/1	Polychaeta
Spirobranchus triqueter	(Linnaeus, 1758)	1/1	1/1	Polychaeta
Aporrhais pespelecani	(Linnaeus, 1758)	1/1	-	Caenogastropoda
Buccinum undatum	Linnaeus, 1758	1/1	1/1	Caenogastropoda
Colus gracilis	(da Costa, 1778)	-	1/1	Caenogastropoda
Euspira catena	(da Costa, 1778)	1/1	-	Caenogastropoda
Gibbula cineraria	(Linnaeus, 1758)	-	1/0	Caenogastropoda

Table 2. Continued

Accepted name	Author	Dogger Bank	Cleaver Bank	Group
*Simnia patula**	(Pennant, 1777)	1/0	1/0	Caenogastropoda
Cuthona nana	(Alder & Hancock, 1842)	-	1/0	Opisthobranchia
*Doto dunnei**	Lemche, 1976	1/0	1/0	Opisthobranchia
Eubranchus exiguus	(Alder & Hancock, 1848)	1/0	-	Opisthobranchia
Facelina bostoniensis	(Couthouy, 1838)	-	1/1	Opisthobranchia
Flabellina gracilis	(Alder & Hancock, 1844)	-	1/0	Opisthobranchia
Flabellina lineata	(Lovén, 1846)	1/0	-	Opisthobranchia
Geitodoris planata	(Alder & Hancock, 1846)	1/0	-	Opisthobranchia
*Polycera faeroensis**	Lemche, 1929	1/0	-	Opisthobranchia
Tergipes tergipes	(Forsskål in Niebuhr, 1775)	1/0	-	Opisthobranchia
Aequipecten opercularis	(Linnaeus, 1758)	-	1/1	Bivalvia
Angulus fabula	Gmelin, 1791	1/1	-	Bivalvia
Hiatella arctica	(Linnaeus, 1767)	1/1	-	Bivalvia
Mytilus edulis	Linnaeus, 1758	1/1	-	Bivalvia
Alloteuthis subulata	(Lamarck, 1798)	1/1	-	Cephalopoda
Balanus balanus	(Linnaeus, 1758)	1/1	-	Cirripedia
Balanus crenatus	Bruguière, 1789	1/1	1/1	Cirripedia
Jassa sp.	Leach, 1814	1/0	-	Amphipoda
Homarus gammarus	(Linnaeus, 1758)	1/0	-	Decapoda - Macrura
*Galathea intermedia**	Liljeborg, 1851	1/1	-	Decapoda - Anomura
Galathea strigosa	(Linnaeus, 1761)	-	1/1	Decapoda - Anomura
Pagurus bernhardus	(Linnaeus, 1758)	1/1	1/1	Decapoda - Anomura
Pagurus cuanensis	Bell, 1846	-	1/1	Decapoda - Anomura
Pisidia longicornis	(Linnaeus, 1767)	1/1	1/1	Decapoda - Anomura
Cancer pagurus	Linnaeus, 1758	1/1	1/1	Decapoda - Brachyura
Hyas coarctatus	Leach, 1816	1/1	1/1	Decapoda - Brachyura
Macropodia rostrata	(Linnaeus, 1761)	-	1/1	Decapoda - Brachyura
Liocarcinus holsatus	(Fabricius, 1798)	1/1	-	Decapoda - Brachyura
Alcyonidium cf *condylocinereum*	Porter, 2004	1/0	-	Bryozoa
Bugula simplex	Hincks, 1886	1/0	-	Bryozoa
Cellepora pumicosa	(Lamouroux, 1816)	1/0	-	Bryozoa
Electra pilosa	(Linnaeus, 1767)	1/1	1/1	Bryozoa
Schizomavella linearis	(Hassall, 1841)	1/0	-	Bryozoa
Caprella linearis	(Linnaeus, 1767)	1/0	-	Caprellidae
Asterias rubens	Olivi, 1792	1/1	1/1	Asteroidea
Astropecten irregularis	(Pennant, 1777)	-	1/1	Asteroidea
Ophiura albida	Forbes, 1839	-	1/1	Ophiuriodea
Ophiothrix fragilis	(Abildgaard, in O.F. Müller, 1789)	1/1	1/1	Ophiuriodea
Psammechinus miliaris	(P.L.S. Müller, 1771)	1/1	1/1	Echinoidea
Ascidia cf *mentula*	Müller, 1776	-	1/0	Tunicata

Table 2. Continued

Accepted name	Author	Dogger Bank	Cleaver Bank	Group
Ascidiella aspersa	(Müller, 1776)	-	1/1	Tunicata
Dendrodoa grossularia	(Van Beneden, 1846)	-	1/1	Tunicata
Diplosoma listerianum	(Milne-Edwards, 1841)	1/0	-	Tunicata
Callionymus lyra	Linnaeus, 1758	-	1/1	Actinopterigii
Ctenolabrus rupestris	(Linnaeus, 1758)	1/0	-	Actinopterigii
Gadus morhua	Linnaeus, 1758	1/1	-	Actinopterigii
Buglossidium luteum	(Risso, 1810)	1/1	-	Actinopterigii
Liparis liparis liparis	(Linnaeus, 1766)	-	1/0	Actinopterigii
Microstomus kitt	(Walbaum, 1792)	1/1	-	Actinopterigii
Molva molva	(Linnaeus, 1758)	1/0	-	Actinopterigii
Myoxocephalus scorpius	(Linnaeus, 1758)	1/1	-	Actinopterigii
Pleuronectes platessa	Linnaeus, 1758	-	1/1	Actinopterigii
Pollachius virens	(Linnaeus, 1758)	1/0	-	Actinopterigii
Pomatoschistus sp.	Gill, 1863	1/1	1/1	Actinopterigii
Trisopterus luscus	(Linnaeus, 1758)	1/0	-	Actinopterigii

Figure 2. Diver holding a hydroid inhabited by several nudibranches that are only a few millimeters in size (*Doto dunnei*). The white coils concern the egg-capsules of this nudibranch species. All photos Adriaan Gittenberger.
Figuur 2. Duiker die een hydropoliep vasthoudt waarop verschillende enkele millimeters grote zeenaaktslakken (*Doto dunnei*) zitten samen met hun witte eierkapsels. Alle foto's Adriaan Gittenberger.

Figure 3. The common ling *Molva molva*, one of the large species found on the Dogger Bank, that likes to live in the wrecks.
Figuur 3. De leng *Molva molva*, een van de grotere diersoorten op de Doggersbank die zich graag terugtrekt in de wrakken.

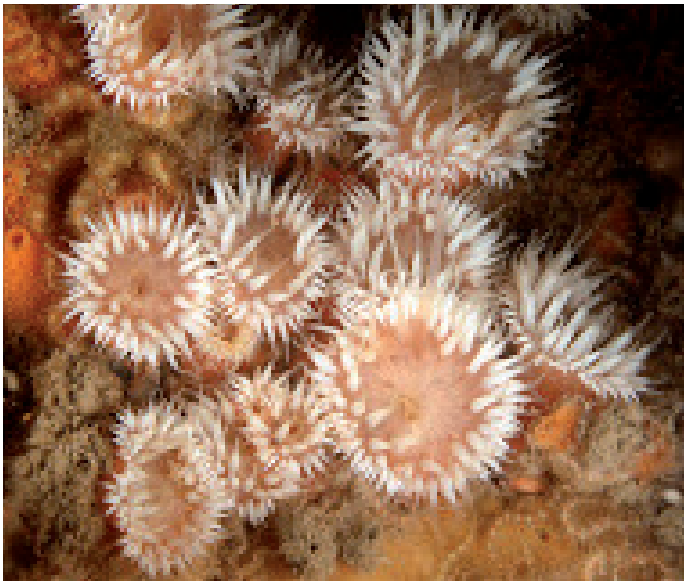

Figure 4. The sea anemone *Sagartia elegans*, which typically lives on hard substrates. It is therefore abundantly found on the wrecks on de Dogger Bank, and is probably missed in monitoring focusing on the sandy bottom in the region.
Figuur 4. De zee-anemoon *Sagartia elegans*, die voorkomt op harde substraten. Deze soort is daarom ook zeer algemeen te vinden op de wrakken op de Doggersbank, terwijl hij waarschijnlijk in de monitoring gericht op de zandbodem in deze regio gemist wordt.

Harsh environments
Traditional monitoring methods including dredges and grabs cannot be used to take samples on sea bottoms with gravel and rocks like are present on the Cleaver Bank, as this may damage the equipment (Van Moorsel 2011). Such areas are therefore often skipped in monitoring programs. Divers can easily monitor those areas and find and record species typical for hard substrata, like the common sea anemone *Sagartia elegans* (fig. 4, table 2).

Hidden environments
Scuba-divers can search in hidden environments that are more or less inaccessible with other monitoring methods. They can look underneath rocks and in holes and on the inside of wrecks. In this way species can be recorded that may be common and widespread, but are missed in other monitoring programs. This includes small crustaceans like the linear skeleton shrimp *Caprella linearis*, but also large adult cods *Gadus morhua* and less commonly known fishes like the goldsinny wrasse *Ctenolabrus rupestris* and the leopard spotted goby *Thorogobius ephippiatus*. These species usewrecks as refugia, as is discussed in more detail by Lengkeek et al. (2013).

Fragile species
Most of the traditional monitoring methods are not suitable to monitor fragile species like ctenophores, jellyfish and nudibranchs. They are usually badly damaged when caught in a dredge, grab or fishnet, while scuba-divers can observe, photograph, and carefully collect them.

Added value of traditional sampling
As is indicated above, monitoring by scuba-diving appears to have many benefits above the more traditional monitoring methods focusing mostly on soft substrata. However, there are also several disadvantages. Scuba-divers are expensive and there is relatively little time to search for species. Scuba-divers are less capable of finding organisms that live hidden in the sand. Furthermore dives are less suited for also quantitative assessments. This is easier when taking a large number of standardized samples with a grab or dredge. Finally it takes considerably more time to sample over a wide range of localities with scuba-diving. In a week's expedition in a large region many more samples can be taken with grabs and dredges.

CONCLUSION

The more traditional survey methods focusing on soft substrates are best suitable to find a relatively large number of species, spread over a large region, with relatively low costs in comparison to using a monitoring method with scuba-divers. However, the present study illustrates that including only a few dives in the standard monitoring programs, would probably increase the number of recorded species with at least 10%. Most of these species are related to hard substratum It is therefore concluded that if one aims at having an accurate view of the dynamics of the biodiversity present in marine regions like the Cleaver Bank and Dogger Bank, even a relatively small extra monitoring effort with scuba-divers focusing on hard substrata can provide significant added value.

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SAMENVATTING

Aan hard substraat gerelateerde soorten van de Klaverbank en Doggersbank in de Nederlandse Noordzee

Aangezien het grootste gedeelte van de bodem in de Nederlandse Noordzee uit zand bestaat, worden soorten die aan hard substraat zijn gerelateerd vaak gemist bij monitoringsprojecten. De hier gepresenteerde studie beschrijft een inventarisatie van sponzen tot mosdiertjes tot aan vissen met behulp van duikers in juni 2011, specifiek gericht op hard substraat van de Klaverbank en Doggersbank. Hoewel duikers al eens eerder voor monitoring waren ingezet op de Klaverbank, betreft dit de eerste inventarisatie met duikers op de Doggersbank. Hierbij werd één wrak op de Doggersbank doorzocht tijdens twee duiken. Op de Klaverbank, met een bodem bestaande uit kiezels en stenen, werden twee duiken gemaakt. De duikdieptes varieerden tussen 30 en 48 meter. In totaal werden 61 soorten op de Doggersbank gevonden en 44 soorten op de Klaverbank. Een groot aantal van deze soorten betrof voor de Nederlandse Doggersbank en Klaverbank nieuwe soorten. Enkele soorten, waaronder de zeenaaktslakken *Polycera faeroensis* en *Doto dunnei* en de slak *Simnia patula,* waren zelfs nieuw voor Nederland. Het relatief hoge aantal soorten dat als nieuw voor deze gebieden werd ontdekt tijdens slechts vier duiken, is in ieder geval gedeeltelijk te verklaren vanuit het feit dat de meeste monitoring in de Noordzee zich op zachte substraten concentreert. Daarnaast worden duikers relatief weinig voor monitoring ingezet, terwijl met deze methode een duidelijke meerwaarde heeft. Zo kunnen duikers bijvoorbeeld diep in wrakken doordringen waar zandhappers en sleepnetten nooit kunnen komen en kunnen duikers actief op zoek gaan naar organismen van een paar millimeter groot of juist heel grote dieren, zoals vissen van meer dan een meter. Anderzijds missen duikers ook soorten, vooral degenen die zich in zacht substraat bevinden. We concluderen dat met een relatief kleine monitoringsinzet van duikers een grote meerwaarde bereikt kan worden voor onderzoek naar de soortendiversiteit van gebieden zoals de Klaverbank en Doggersbank.

N. Schrieken
ANEMOON Foundation
BIOrganized
Grenadiersweg 8
NL-3902 JC Veenendaal, The Netherlands
nielsschrieken@biorganized.com
[Corresponding author]

A. Gittenberger
Naturalis Biodiversity Center
Institute of Biology Leiden (IBL) & Institute of Environmental Sciences (CML), Leiden University
ANEMOON Foundation
GiMaRIS
J.H. Oortweg 21
NL-2333 CH Leiden, The Netherlands
Gittenberger@ GiMaRIS.com

J.W.P. Coolen
Duik de Noordzee schoon
IMARES Wageningen UR
P.O. box 167
1790 AD Den Burg – Texel, The Netherlands
Joop.Coolen@wur.nl

W. Lengkeek
Duik de Noordzee schoon
Bureau Waardenburg
Varkensmarkt 9
NL-4101 CK Culemborg, The Netherlands
W.Lengkeek@BuWa.nl