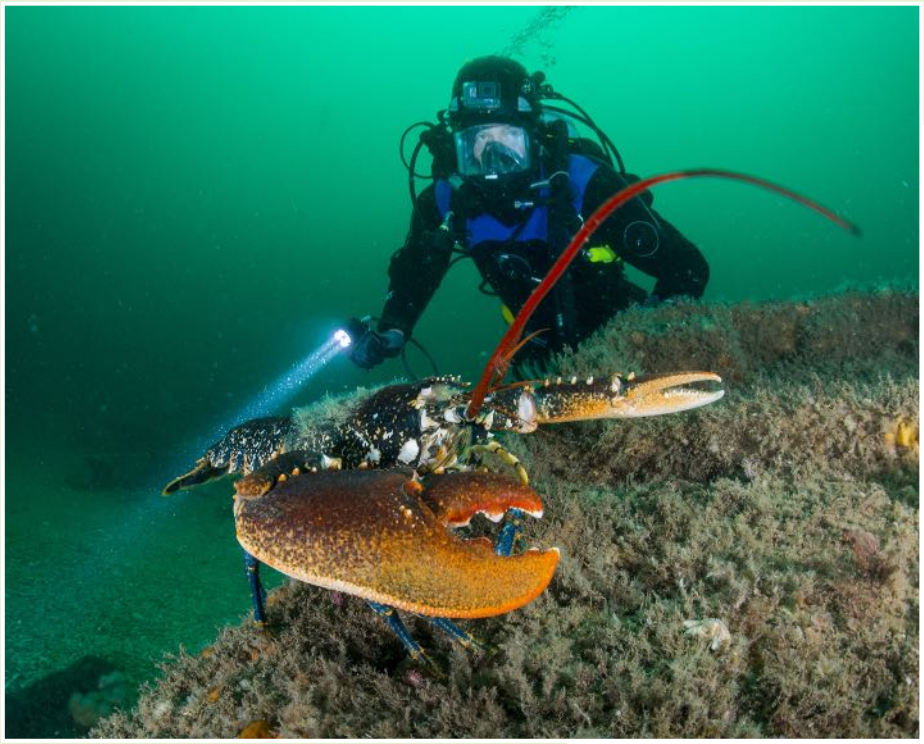
Dogger Bank Expedition 2021

Cruise report

Biodiversity - Nature restoration – Marine science – Film



Joint report by:
Waardenburg Ecology
WWF
ARK
Wageningen University
Dutch Maritime Productions

Dogger Bank Expedition 2021

Cruise report
Biodiversity - Nature restoration – Marine science – Film

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Preface

Located in the North Sea, the Dogger Bank (also known as Doggersbank in Dutch, Doggerbanke in Danish and Doggerbank in German) is a shallow area on a sandbank in the Dutch North Sea, German, Danish and UK waters. For many years there has been a desire among marine biologists, conservationists and filmmakers to undertake a joint expedition to the Dogger Bank. By working together and pooling objectives, resources and experiences, Waardenburg Ecology was able to lead such a joint expedition, in close cooperation with participating organisations. Waardenburg Ecology, WWF, and Wageningen Marine Research co-funded the Expedition. Dutch Maritime Productions, ARK Natuurontwikkeling and Wageningen University provided in-kind contributions. Dutch Maritime Productions was offered shiptime free of charge to contribute to their “Wild North Sea” film production, as an increase in awareness of North Sea nature was considered to be in the interest of all participating parties. There was fieldwork to fulfill project BENSO objectives by Waardenburg Ecology and to fulfill Flotilla Foundation funded project “Rewilding the North Sea: restoring habitats for sharks and rays” by WWF. To optimize outcomes for all parties a core group was formed by Captain Frank Loonstra, Edwin Kardinaal (Waardenburg Ecology), Emilie Reuchlin (WWF), Oscar Bos (WMR/WUR), Peter van Rodijnen (DMP). All of us are thankful for the good cooperation on board, the funding parties, the volunteers and professionals and particularly the crew Captain Frank Loonstra on his vessel MS Tender. Normally a report covers one particular project and its objectives. This report is more elaborate, in the sense that it covers a multitude of objectives and results. The expedition could only succeed through this cooperation and pooling of resources and knowledge. This report documents all objectives and results of all parties on board, so as to do justice to the richness of such a pooled effort and the first ever North Sea Dogger Bank expedition organized solely for the purpose of nature restoration, marine science, and film making. Joost Bergsma, Udo van Dongen, Daniel Beuker, Floor Driessen (Waardenburg Ecology), Ben Stiefelhagen, Melchior Stiefelhagen (Get Wet), Peter van Rodijnen (DMP) Tammo Bult (WUR), Brenda van Doorn-Deden, Peter van Ling, Karel van de Wijngaard (WWF/ ARK) contributed tot his report.

The authors thank everyone who has contributed to this cruise and to this report.

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Summary

Dogger bank expedition

Located in the North Sea, the Dogger Bank (also known as Doggersbank in Dutch, Doggerbanke in Danish and Doggerbank in German) is a shallow area on a sandbank in the Dutch North Sea, German, Danish and UK waters. It is a recognised area of ecological interest, due mainly to the high production and abundance of fish, cetaceans and seabirds in the area. The Dogger Bank has been designated as a protected nature area by the UK, the Netherlands and Germany. For many years there has been a desire among marine biologists, conservationists and filmmakers to undertake a joint expedition to the Dogger Bank in order to get more data from this important offshore area. This cruise report describes the joint expedition that took place 19-23 September 2021 and was led by Waardenburg Ecology, in collaboration with the World Wildlife Fund, Wageningen University and Research (WUR), Dutch Maritime Productions and ARK Natuurontwikkeling.

This report

This report describes activities, locations and methods used during the expedition.
The expedition was a joint effort of various parties, combining various projects with subsequent objectives. The overall goal is to record field observations and learn more about the biodiversity values and potential for nature restoration of the Dogger bank area.
Three main objectives are:

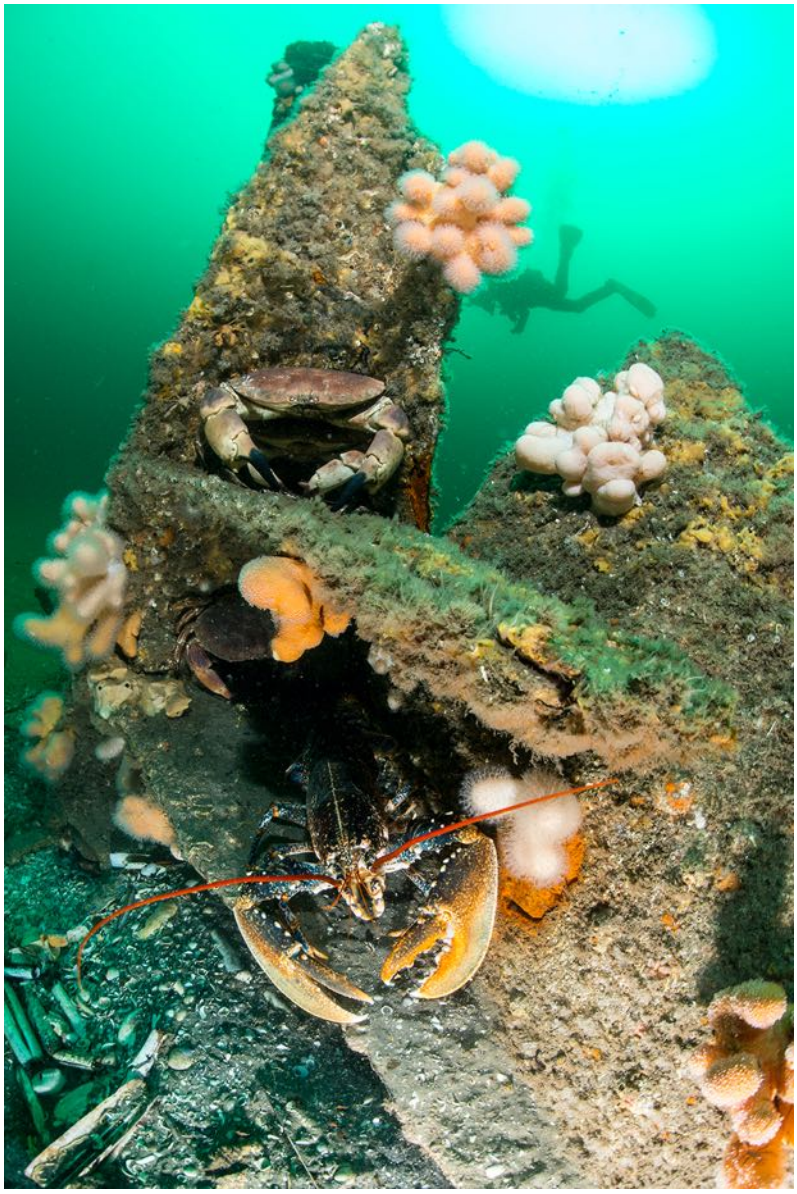
1. Nature Restoration - focusing on biodiversity & opportunities for nature restoration and enhancement (Chapter 3).
2. Marine Science - focusing on new research techniques and ecological monitoring (Chapter 4).
3. Film Making - focusing on shooting footage for the upcoming series and film “Wild North Sea” (Chapter 5).

A key principle of the expedition is that data and images are shared as much as possible, so both raw data and analysis are added to this cruise report.

Main results

Although the expedition was shorter than expected due to stormy weather, all three objectives were met. The collaborative approach - and performing different tasks at the same time - helped to achieve this. During the expedition, the expedition members dived at three wrecks, explored the seabed on the slope of the Dogger Bank, took samples, and collected images and data with a remotely operated vehicle (ROV), camera with bait, a drop-cam and eDNA as well as Marine Mammal and Bird observations.
Horse mussel (*Modiolus modiolus*) was found at wreck Ernst 38. Translocation experiments showed that it is possible to find and translocate mussels near shipwrecks on the Dogger bank. However, establishing the difference between juvenile horse mussels and blue mussels on board turned out to be difficult. The MMO and bird observations resulted in the finding of twelve different (sea)bird species and one mammal specimen. Two dropcam transects showed no reef building species. On the other hand, shipwrecks

were rich in marine life on the Dogger Bank, with horse mussel, shark eggs, European lobsters, edible crabs and of dead man's finger (corals) amongst many other taxa. The researchers also placed bags of rock near a wreck. The stones provide a hard surface and a structure for animals to attach themselves to, which is not possible on a bare sandy bottom. In offshore wind farms, such stones are deposited around the wind turbines as erosion protection. The researchers want to test whether the use of a mix of different sizes of stones has a beneficial effect on biodiversity. The experiments will be followed in the coming years and the results will benefit the technical design of future wind farms.
Innovative census techniques – small ROV, baited camera, eDNA - were tested and evaluated. The film crew documented the unusual find of two shark eggs and an octopus. 'De Wilde Noordzee' will be shown on television in 2024 as a four-part series by the EO and as a film in the cinema.



Biodiversity near wrecks: dead man's finger, European lobster, Edible crab (Udo van Dongen, Waardenburg Ecology).

Biodiversity near wrecks : common octopus (Udo van Dongen, Waardenburg Ecology).

Biodiversity near wrecks : dogfish egg (Udo van Dongen, Waardenburg Ecology).

1 Introduction

1.1 Background

Located in the North Sea, the Dogger Bank (also known as Doggersbank in Dutch, Doggerbanke in Danish and Doggerbank in German) is a shallow area on a sandbank in the Dutch North Sea, German, Danish and UK waters. It is a recognised area of ecological interest, due mainly to the high production and abundance of fish, cetaceans and seabirds in the area. The Dogger Bank has been designated as a protected nature area by the UK, the Netherlands and Germany. For many years there has been a desire among marine biologists, conservationists and filmmakers to undertake a joint expedition to the Dogger Bank in order to get more data from this important offshore area. This cruise report describes the joint expedition that took place 19-23 September 2021.

Objectives

The expedition was a joint effort of various parties, combining various projects with subsequent objectives. The overall goal is to record field observations and learn more about the biodiversity values and potential for nature restoration of the Dogger bank area. Three main objectives are:

1. Nature Restoration - focusing on biodiversity and opportunities for nature restoration and enhancement
2. Marine Science - focusing on new research methods and ecological monitoring techniques;
3. Film Making - focusing on shooting footage for the upcoming series and film “Wild North Sea”.

This report

A key principle of the expedition is that data and images are shared as much as possible, so both raw data and analysis are added to this cruise report. To structure the report, we will make a division between each of the specific objectives and relevant information in chapter 3, 4 and 5.

The Annexes (I-III) contain background documents that are relevant to the individual projects, and future expeditions.

2 Activities and equipment

2.1 Expedition plan and HSE

An elaborate cruise plan (Vaarplan) included the planning and safety procedures for the expedition Dogger Bank 2021. This plan included the Expedition's objectives, organization, planning, management of diving gasses, diving procedures, crew including their roles and responsibilities, materials, communication, research procedures, locations of interest and a statement about safety on board signed by all participants.

2.2 Participants

A full list of research crew members is listed in Table 1.

Table 1. Participants list

Name	Task
Wouter Lengkeek	Professional diver + stone reef experiment
Joost Bergsma	Professional diver + stone reef experiment
Udo van Dongen	Professional diver + underwater photography
Edwin Kardinaal	Projectmanagement
Ben Stiefelhagen	Professional Diver + support
Melchior Stiefelhagen	Professional Diver + support
Emilie Reuchlin-Hugenholtz	Projectmanagement WWF
Brenda van Doorn-Deden	Support
Peter van Ling	Support (Could not join)
Karel vd Wijngaard	Support
Oscar Bos	Projectmanagement WMR
Tammo Bult	Support
Reindert Nijland	PI eDNA research
Klaudie Bartelink	Professional diver + filmer
Peter van Roodijnen	Professional diver + filmer
Daniel Beuker	boat driver + MMO observations

2.3 Route and weather conditions

The planned route was followed as scheduled until bad weather on September 22, 2021 forced us to return earlier than planned. The weather conditions turned out to be more severe at the time when we had already started the work on the Dogger Bank. Where conditions were predicted good at departure, with a chance of running into some weather after a few days (however not considered so problematic and still able to do work at those predicted conditions), the reality after a few days into our expedition became more severe.

The weather reports also quickly progressed in their severity, going from 4-5 BFT to gale force 8, 9 and then 10 within 12 hours few hours.

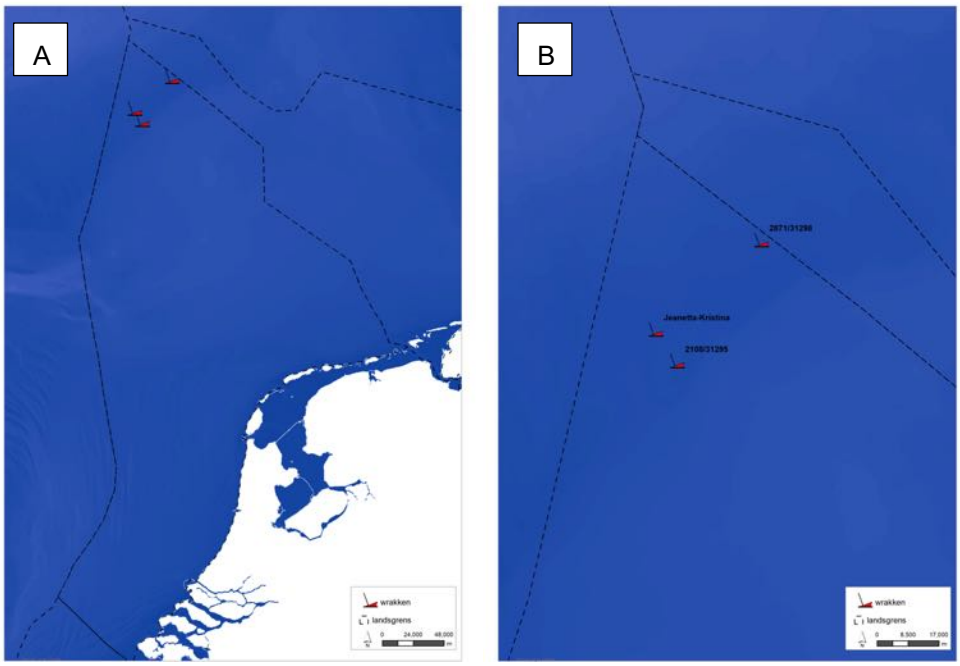


Figure 1. Wreck locations a. Wrecks on DCS. 1 b. Detailed map with 3 potential wrecks to visit.

Table 2. Locations and activities per day from arrival to early departure.

Date	Location	Activities
19-9-2021	Arrival of crew in Lauwersoog in the afternoon Departure from Lauwershaven in the evening	Loading equipment, materials, checking everything (incl decompression tank) etc.
20-09-2021	Continuing route to Dogger Bank, arrival Dutch section, northern part of Dogger in late afternoon Wreck Jeanette Kristina N 55 17.120 – E 3 26.969 N 55 17'14" – E 3 20'07"	Daytime: Spotting marine life (birds, mammals) above the surface 17:30 Dive on wreck Jeanette Kristina: - Seabed, eDNA and core samples, - Location inspection for BENSO rock placement, visual observations of marine life and surroundings - Film and video footage (i.e. octopus) Evening: Placement of 6000 kg stones in 6 batches at 15 meter distance from wreck Jeanette Kristina - On board: Processing carbon samples, seabed samples, visual observations - ROV setup inspection

21-09-2021	Morning Wreck Jeanette Kristina Afternoon 5.6 nm south or 45 min sailing south to wreck 2803 N 55.12.483 – E 3 32.469 Evening Northern transect 22:15 to 00:18 N 55 35.711 - E 3 34.412	Daytime: Spotting marine life (birds, mammals) above the surface 08:00 dive on wreck Jeanette Kristina: - Observations of goose barnacles, knotted wrackweed with 6 juvenile mussels 14:30 dive on Wreck 2803 - Shark eggs at bow of wreck. - Knotted wrackweed with (suspected) horse mussels on starboard; - Translocated mussels ; attached translocated mussels to anchor of wreck on bow side; took carbon samples, seabed samples, visual observations, - eDNA samples - Carbon samples - baited camera placement with chum of 2 mackerels and 2 crabs - ROV - FILM - Dropcam northern transect in late evening, depth ranging from 32 m - 40.5 m.
22-09-2021	8:00 Wreck 2803 N 55 12.483 – E 3 32.469 14:00 Wreck Ernst 38 N 55 26.090 - E 3 51.170 Southern transect Start 16:49 at N 55,351270 – O 3,954140. Finish 18:31 at N 55 17.650 – O 4 02.498 18:45 exit	8:30 uur dive on wreck 2803: checked status of translocated crate pinned down to seabed . Located close to shark eggs at approximately 2 m from wreck. Picking up baited camera - DMP shots of shark eggs on macro - eDNA samples 14:00 Dive 1wreck Ernst 38: found large (suspected) horse mussel, translocated large (suspected) horse mussel to iron basket number 1, inside wreck - Passing by is A12-CPP gasplatform 55° 23' 56.0" N, 003° 48' 36.0" E (PETROGAS) - Dropcam and ROV Southern transect - Exit because of gale force BFT10 on our tails so quick exit from area. Heavy storms
23-09-2021	Arrival Lauwersoog	Offloading gears and materials Part of the crew goes home
24-09-2021	Departure Borkum Reef Arrival Lauwersoog	WMR, BUWA crew carry on and depart for Borkum Reef Ground to place of coloured oysters with winch and dropcam (no diving activities) Offloading crew and materials/equipment

2.4 Locations

2.4.1 Location description – wreck Jeanette Kristina

- Date and time: 20-09-2021 17:30 and 21-09-2021 8:00
- Name of location / type: Wreck Jeanette Kristina
- Coordinates: N 55 17.120 – E 3 26.969 or N 55 17'14" – E 3 20'07"
- Depth: 30.5 m
- Describe location: Dogger Bank (Dutch section, middle/center part
- Information about wreck: Small wooden Danish fishing boat built in 1957, approximately 25 meters in length, snurrevad vessel judging from the lines still present although most netting has been removed by DDNS. Sank because of collision with other fishing vessel in 2004.
- Route to mussels: mid wreck, 1 meter distance from wreck
- Number of mussels: 7 juvenile blue mussels. nb found on second dive. Largest lost on seabed, so 6 were brought up to MStender.
- Number of clumps: 1 clump attached to knotted wrackweed, goose barnacles
- Dimensions of clump: max 8 cm x 8 cm x 8 cm
- Smallest mussel: 4.5 mm
- Largest mussel: 14 mm
- Presence spat / juveniles: 7 juveniles: x mm (lost) 14 mm, 10 mm, 10 mm, 7 mm, 6 mm (not present in translocated mussels because preserved for eDNA analysis), 4.5 mm
- Number large vs smaller: No adults
- Description of placement: Not attached to wreck, loose on seabed, right next to wreck on seabed
- Sediment description / size within 2-3 meters: Lots of big, empty shells, many fragmented pieces
- Type of substrate that (suspected) horse mussel is attached to: No substrate, but (suspected) horse mussels on goose barnacles and knotted wrackweed, potentially came in rolling across seabed.
- Approximare density: N/A; only found one clump
- Elevation from seabed: 0 meters; on seabed
- Species attached to (suspected) horse mussels: goose barnacles and knotted wrackweed
- Species nearby (suspected) horse mussels (unattached) None very close
- Predator species present: starfish, crabs, lobsters, cod
- Size of predators (starfish, crab, peacrab, boring sponge etc): large, adult individuals
- Approximate number of predators: Very low density, only 5 individual crabs and lobsters combined, very few starfish compared to other wrecks on

the North Sea. Possibly pea crab (see picture below), no boring sponge observed in vicinity.

- Description human activities/signs of activity etc
  Fisheries, plastics, balloon and fishline
- Source, sink ideas? Where might source be?
  Cannot be said, as clump was loose on seabed, source of juvenile blue mussels could have been from the wreck itself or elsewhere. fisheries
  - Other information: At location of found clump of blue mussels there was lots of empty shell, arctica islandica, ostrea edulis fossils Wreck completely covered with marine life, high biodiversity, lots of deadman's finger, sponges, anemones, loads of empty shells directly surrounding the wreck, coarse sand close to wreck, finer sand further away from wreck,

- Attach marker for translocation experiment:
  The mussel clump was brought up in net and kept on board until translocation later in the day in cocoswrap 35 placed on wreck 2803
- Take picture zoomed out to see location/surroundings (to be able to find location again)
  No need, we brought up the mussels
- Sediment sample(s)
  We took two samples of sediment:
  [Jeanette Kristina]/SED/20-09-2021/HM-CLOSE]
  [Jeanette Kristina]/SED/20-09-2021/HM-FAR]
  CLOSE was representative of close proximity to wreck (within 1 to 2 meters from wreck)
  FAR was taken 5-8 meters out, but visibility was ok and sediment sample FAR was representative for at least up until 10 meters out from wreck.

- Horse mussels like horse mussels around; look around to see if there are more:
  None other found, surroundings appear sandy, we looked around for horse mussels further out from wreck
- Take reel out to 25 meter distance from wreck / horse mussels and describe area:
  took it out 5-8 meters
- Temperature: 17 degrees Celsius
- Depth: 28 meter
- Depth profile from HM location to 25 meters out:
  N/A, probably 2 meter slope from seabed directly around wreck (30 meters depth) to outer area (28 meters depth)
- Seabed description: Sand, fine but heavy
- Sediment description: very few sanddune type movement in seabed
- Sediment sizes measure: very fine
- Large sandwaves/ripples: no
- Idea of seabed movement: flat, very little movement
- Shell fragments: only close to wreck not so far out
- Presence shellfish: (suspected) horse mussels, prickly cockle
- Elasmobranch eggcase: none found, however squid eggs were found
-

Photo 1. Historical photo of Jeanette Kristina Source: fiskerforum.com


Photo 2. Detail of rope on vessel (Udo van Dongen).

Photo 3. Collected materials, shell material and sediment, near wreck Jeanette Kristina (WWF).

Photo 4. Collected specimen near wreck Jeanette Kristina (WWF).

Photo 5. Wreck Jeanette Kristina with abundant marine life (Udo van Dongen).

2.4.2 Location description – wreck 2803

Date and time	21-09-2021 14:20 and 22-09-2021 8:30
Name of location / type	Wreck 2803
Coordinates	N 55.12.483, O 3 32.469 n.b. we had coordinates of several wrecks nearby 2803: old steamer of approximately 29 meter, but sunken deeply in sand, 55 degrees 16 min 00 sec, 3 degrees 31 minutes 88 seconds (Emilie literature search). And wreck 2801: north of 2803 also a steamer 26 meters, standing straight on seabed with tiles and steamer present 55 12.460 3 32.460 (Klaudie, dive in 2015)
Depth	29.3
Describe location:	Dogger Bank (Dutch section, middle/center part), at 5.6 nm distance or 45 min steaming from Jeanette Kristina
Information about wreck:	55 meters length, metal. Old steamer. Bow and stern relatively intact, broken up in the middle section
Route to horse mussels:	N/A
Number of horse mussels:	approximately 20-30 (suspected) horse mussels, not able to count exactly underwater without breaking off mussels, which we did not want to do (because of risks to survival)
Number of clumps:	2 clumps of juvenile (suspected) horse mussels with about 10 little Individuals of few mm per clump on larger strands of intertwined knotted wrackweed

- Dimensions of clump: dimensions of seaweed that (suspected) horse mussels are attached to
  Approximately 20 x 20 cm (see pictures below)
- Smallest (suspected) horse mussel 2.5 mm
- Largest (suspected) horse mussel 32 mm
- Presence spat / juveniles: at least 7 individuals are larger than 10 mm, lots of very small ones (only few mm) in clump together, 2 clumps on seaweed.
- Description of placement Not attached to wreck, loose on seabed, right next to wreck on seabed
- Sediment description / size within 2-3 meters:
  Lots of empty shells, some whole, many fragmented
- Type of substrate that (suspected) horse mussel is attached to:
  No substrate, (suspected) horse mussels on strands of knotted wrackweed, potentially came in rolling across seabed
- Elevation from seabed 0 meters; on seabed
- Species attached to (suspected) horse mussels:
  knotted wrackweed and tiny starfish
- Species nearby (suspected) horse mussels (unattached)
  -
- Predator species present starfish, lobster, crab, possibly lemon sole
- Size of predators (starfish, crab, peacrab, boring sponge etc):
  large, adult individuals, not many
- Approximate number of predators
  Crab and lobster density, every few meters??
  Few starfish compared to other wrecks on the North Sea.
- Description human activities/signs of activity etc
  Fishing nets, fishing, plastic (sharkegg attached to fishing gear filament)
- Source, sink ideas? Where might source be?
  Cannot be said, as knotted wrackweed with mussels was loose
- Other information: shark eggs found

- Attach marker for translocation experiment:
  Knotted wrackweed with 20-30 blue mussels placed in net and later on plastic crate 35 (that has attached to it the cocoswrap on the outside with (suspected) horse mussels from Jeanette Kristina) 35 placed on wreck 2803. Mussels found on 2803 and placed in plastic crate never left the sea, whereas JK (suspected) horse mussels placed on cocos 35 had been on board in aquarium for couple of hours.
- Sediment sample(s) We took samples of the sediment:
  [2803/SED/22-09-2021/HM-CLOSE]
  [2803/SED/22-09-2021/HM-FAR]
  CLOSE was representative of close proximity to wreck (within 1 to 2 meters from wreck).
  FAR was taken a few meters out, but visibility was ok and sediment sample FAR was representative for at least up until 10 meters out from wreck.
- Horse mussels like horse mussels around; look around to see if there are more:
  None other found, surroundings appear sandy, we looked around for horse mussels further out from wreck

- Take reel out to 25 meter distance from wreck / horse mussels and describe area: Couple of meters, but not enough time to go 25 meters
- Temperature 17 degrees celsius
- Depth N/A
- Depth profile from HM location to 25 meters out: N/A
- Seabed description quite flat, sand is fine and heavy
- Sediment description very little sand dune type movement in seabed
- Sediment sizes measure: very fine
- Large sandwaves/ripples: no
- Idea of seabed movement flat, very little movement
- Shell fragments: only close to wreck and loads within the wreck; not so far out
- Presence shellfish: none found, only on wreck (suspected) horse mussels
- Elasmobranch eggcase: two shark eggcases on the wreck (Lesser spotted dogfish Scyliorhinus 18anicular)

Photo 6. Shark egg case: Egg Case of lesser spotted dog fish (Udo van Dongen).

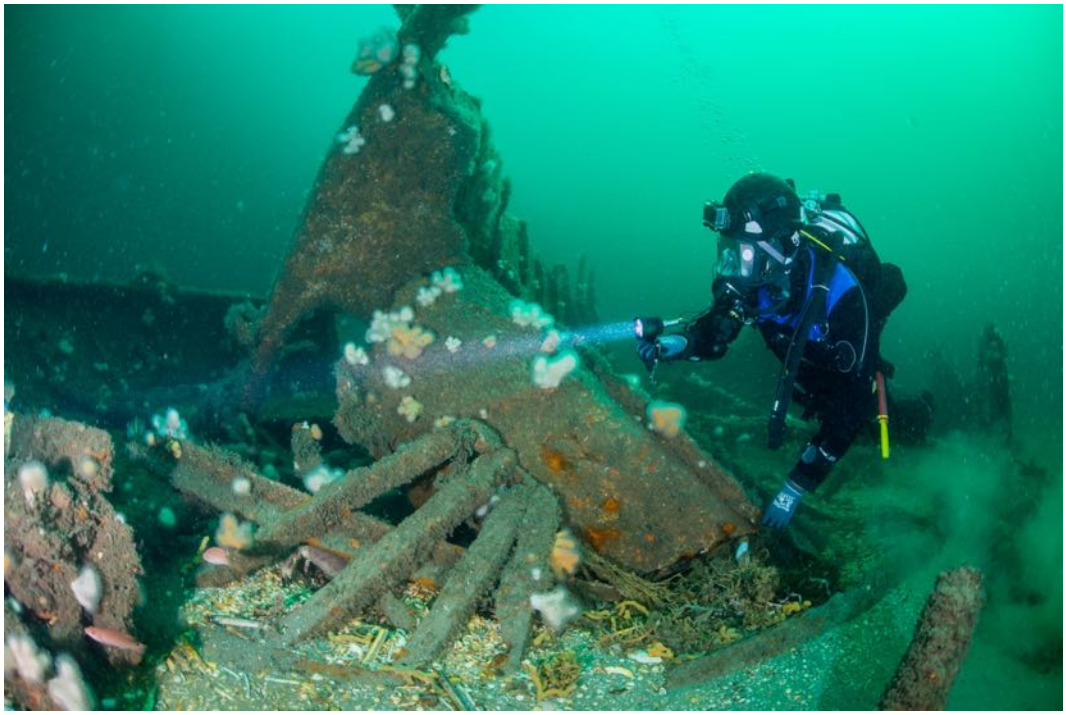


Photo 7. Wreck 2803 (Udo van Dongen).

2.4.3 Location description– wreck Ernst 38

Date and time	22-09-2021 13:50
Name of location / type	Wreck Ernst 38
Coordinates	N 55 26.090 E 3 51.170 (correct; Frank's coordinates) N 55 26 5.4, E 3 51 10.2 (converted by Emilie)
Depth	32.5 meter
Describe location:	Dogger Bank (Dutch part, northern side), at 5.6 nm distance or 45 min steaming from Jeanette Kristina
Information about wreck:	Metal. Broken in half, large and parts standing upright. Few meters high from seabed upwards
Route to horse mussels:	bow, with the 5 beams [1]
Number of horse mussels:	1 large adult
Number of clumps:	0
Dimensions of clump:	N/A
Size horse mussel	100 mm
Presence spat / juveniles:	none found
Description of placement	Attached to fishing rope, which in turn was attached to wreck bow
Sediment description / size within 2-3 meters:	Trench (scour hole) around wreck, filled with shells, around the wreck sand.

[1] More information on Ernst 38 from Duik de Noordzee Schoon expedition in 2019 can be found here: https://www.duikdenoordzeeschoon.nl/wp-content/uploads/2019/12/Rapportage-onderwater-archeologen-Duik-de-Noordzee-schoon-2019.pdf

- Type of substrate that horse mussel is attached to: Thick rope probably from fishing nets
- Approximate density N/A
- Elevation from seabed 1.5 meters from seabed
- Species attached to horse mussel: Bryozoans, Spriobranchus triqueter
- Species nearby horse mussels (unattached): Squid eggs, lobster
- Predator species present lobster, crab, fish species
- Size of predators (starfish, crab, peacrab, boring sponge etc): large, adult individuals lobster and crab, but not many
- Approximate number of predators few starfish compared to other wrecks on the North Sea.
- Description human activities/signs of activity etc Fishing nets, fishing line
- Source, sink ideas? Where might source be? No other horse mussels found on the wreck
- Other information:

Actions + Samples at horse mussel location wreck 2803:

- Attach marker for translocation experiment: This large individual horse mussel never left the sea, it was tied to the anchor line for the professional divers to pick up and translocate the individual into iron rack number 1, on the inside of the wreck (see picture below).
- Take picture zoomed out to see location/surroundings (to be able to find location again) see below
- Sediment sample(s) We took samples of the sediment:
  [ERNST38/SED/22-09-2021/HM-CLOSE]
  [ERNST38/SED/22-09-2021/HM-FAR]
  CLOSE was representative of close proximity to wreck (within 1 to 2 meters from wreck).
  FAR was taken a few meters out, but visibility was ok and sediment sample FAR was representative for at least up until 10 meters out from wreck.

Relevant data from horse mussels / wreck ERNST38 to surrounding 25 meters

- Horse mussels like horse mussels around; look around to see if there are more: None other found, surroundings appear sandy
- Take reel out to 25 meter distance from wreck / horse mussels and describe area: Couple of meters, but not enough time to go 25 meters
- Temperature 17 degrees celsius
- Depth 32.5
- Depth profile from HM location to 25 meters out: N/A
- Seabed description quite flat, sand is fine and heavy and dark
- Sediment description very little sand dune type movement in seabed
- Sediment sizes measure: very fine
- Large sandwaves/ripples: no
- Idea of seabed movement flat, very little movement
- Shell fragments: only close to wreck and loads within the wreck; not so far out
- Presence shellfish: none found, only on wreck horse mussel
- Elasmobranch eggcase: none found, however squid eggs were found (close to the singular adult horse mussel).

3 Biodiversity & nature restoration

3.1 Rewilding the North Sea: restoring habitats for sharks and rays

WWF has been working on North Sea conservation and active restoration for over 15 years. The project Rewilding the North Sea, funded by WWF and the Flotilla Foundation, aims to turn the Dogger Bank from wasteland into a biodiversity hotspot and safe haven for sharks and rays. The outcomes of this project are expected to include a well-prepared permit request for large-scale active restoration of reefs for sharks and rays on the Dogger Bank, as well as raising public awareness by telling the story of marine rewilding, with the aim of generating pressure to the government to issue a nature restoration permit and to come up with protective measures for North Sea nature.

Context: The Dogger Bank has been designated as a protected nature area by the UK, the Netherlands and Germany (Denmark did not designate their part as a nature area). However, after 30 years of politics downscaling their ambition to protect the area, barely anything remains of initial plans to protect the area. To date, not even one of the smallest plans have been implemented, leaving the Dogger Bank as one of many parks only protected on paper in the North Sea. In the meantime, the UK is constructing the world's largest wind turbines in a large part of its Dogger Bank, the Dutch government is expanding gas exploration and fishing pressure is high as ever. In total less than 1% of the North Sea is protected. In other words: The Dogger Bank is mainly looked at from an exploitative point of view: how many fish can we scrape off the seabed, how many wind turbines can we build at minimum cost, can we construct artificial islands and extract oil and gas? All this human exploitation leaves a highly impoverished, relatively lifeless marine area at the heart of the North Sea. If we do not stop the decline, the area will lose its potential to recover.

Expedition goals: WWF's goals for this expedition are: to do research across at least 4 locations on the Dutch Dogger Bank to assess opportunities of active restoration of habitats for sharks and rays. Species of particular interest – based on an inventory by Van Moorsel (2021)[1] – are Modiolus modiolus, Arctica islandica, Neptunea antiqua, reefbuilders in general and stoney reefs. During the expedition research will be carried out including a baseline assessment of biodiversity, species richness (flora and fauna) through EDNA and visual observations (diving, ROV, dropcam, cetaceans and seabirds above water), specific presence of shark and ray species and biogenic reefbuilders such as horse mussels, performing a translocation experiment with (suspected) horse mussels if these are found; collecting soil samples for determining carbon content and habitat suitability assessment; collecting images of Dogger Bank under and above water, investigating and mapping the location suitability for active restoration of reefs for sharks and rays.
A secondary objective is to assess the distribution of oysters placed on the Borkum Reef Ground in in May 2018, as the oysters appear to be widely distributed over the initial trial area. The question now is where the oysters have migrated to. The intention is therefore to make a stop on the Borkum Reef Ground and to look for these flat oysters with divers.

[1] Van Moorsel, G.W.N.M. 2021. Doggersbank, mogelijkheden voor actief natuurherstel. Ecosub, Leersum. pp. 38, incl. 11 figuren, 1 bijlage.

Whether this objective can be met depends on whether there is time left after completing our work on the Dogger Bank and whether conditions are suitable to dive on Borkum Reef Ground.

3.1.1 Methods

For this project, there is an elaborate description of the materials and methods that were to be deployed during the expedition. This description is added in Annex 2 and is written in English. It describes the location criteria, the data and sample collection on dive-sites and non-dive sites (transects with dropcam and ROV), the translocation protocol and the pushcore sampling for measuring carbon content. The main research methods include:

- Seabed exploration: Exploring the seabed and biodiversity by visual means, using divers, a dropcam and a remotely operated vehicle (ROV : chapter 4).
- Carbon sampling
- Translocation of (suspected) horse mussels. Including recording and collecting (suspected) horse mussels, measuring and translocation.
- Biodiversity recording: MMO, recording species during dives, sampling of eDNA

3.1.2 Seabed exploration (visual)

Transects with dropcam and ROV were taken on northern and southern part of the Dogger Bank. A detailed description is given in Annex I

Table 3. Dogger bank biodiversity inventory – summary of dropcam transects

Transect	Coordinates
Northern Transect	N 55.12.483, E 3 32.469 END N 55 35.711 – E 3 34.412.
Southern Transect	N 55.351270 – E 3.954140 END N 55 17.650 – E 4 02.498

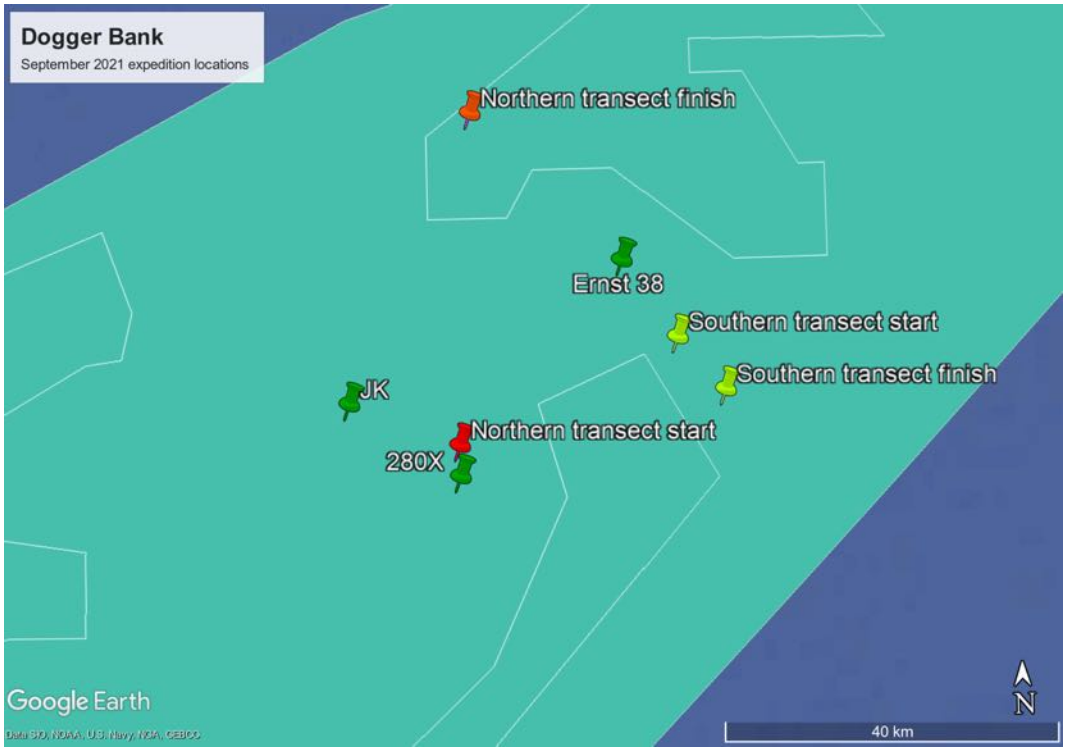


Figure 2. Dogger Bank Dropcam transect locations

3.1.3 Carbon sampling

On 3 separate locations (wrecks), we collected a total of 6 cores that we sliced and froze within 30-90 min after collection. For each sample a push core sample from the seabed was taken, transported and processed on board. Per wreck, professional divers took two samples: one sample right next to the shipwreck -referred to on the samples as 'Close', one some meters distance from the shipwreck, referred to on the samples as 'Far'.
The samples were dense and drained enough to take slices. The core samples were each at least 20 cm deep, but many had more than 20 cm. Each core sample was cut up into 8 slices. Each of the slices were individually put in a plastic ziplock bag, labelled with roman number corresponding to a specific sliced section of the core, where the seabed's top layer is 'i' and the deepest layer is 'viii'. Slices were put in a freezer container and frozen at -18 to -20 degrees Celsius.

i.0-5 mm
ii. 5-10 mm
iii. 10-20 mm
iv. 20-30 mm
v. 30-40 mm
vi. 40-50 mm
vii. 50-100 mm
viii. 100-200 mm

Here the samples await analysis by Caterina Coral as part of the REVIFES project. We opted to wait with processing the samples for their carbon content and the full analysis so that we could process core samples from several expeditions, thereby cutting costs.
If all goes according to plan, the results of the carbon content of these samples will be reported in the expedition report of the 2022 expedition.

Photo 8. Carbon sampling by professional divers (Udo van Dongen)

Photo 9. Carbon sample processing on board (WWF/ ARK)

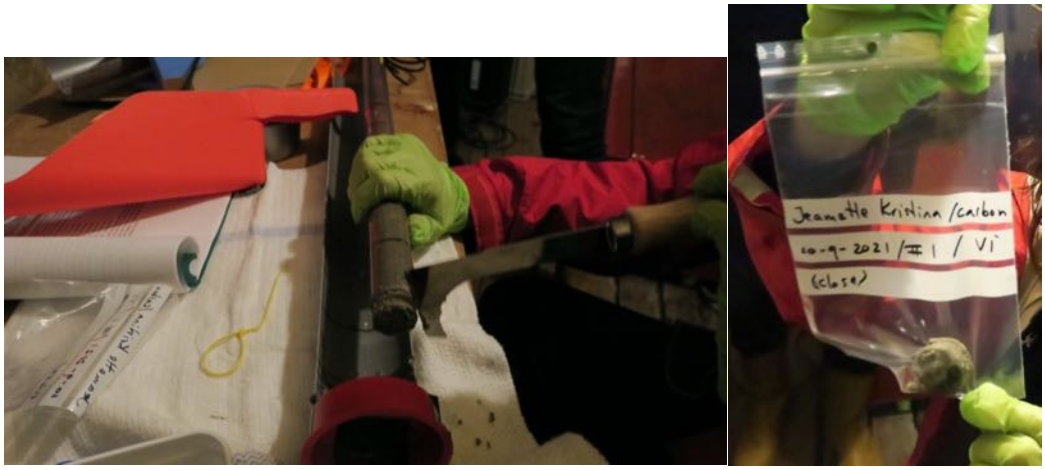


Photo 10. Carbon sample processing and labelling on board (WWF/ ARK)

3.1.4 Translocation experiments horse mussels

For future attempts for nature restoration, it is important to understand the potential. A first inventory of available literature (van Moorsel, 2021) has indicated that the Dogger bank area might contain the necessary biodiversity with potential target species that would require extra attention: One of the potential target species is the common horse mussel (*Modiolus modiolus*). This is a large mussel species that can reach lengths of more than 20 cm. The horse mussel is capable of forming reefs. Reefs are considered worldwide as the basis for a great marine biodiversity. In the Netherlands, such reef-forming organisms (including flat oysters and sublittoral blue mussel beds) have largely disappeared as a result of overfishing, harmful fishing techniques and diseases. Horse mussel reefs are listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR agreement 2008-6)

Three translocations were used for translocation of mussels. It is particularly difficult to determine whether these are true horse mussels, due to taxonomic similarities with blue mussel. The eDNA analysis finalized after the expedition has helped to determine whether all three translocations with suspected horse mussels were horse mussels (*Modiolus modiolus*) or blue mussels (*Mytilus edulis*) (Table 4).

Table 4. Translocation – summary

	From – To	**No. of mussels and species**	**Method**	**Size range (mm)**
Translocation 1	Jeanette Kristina – wreck 2803 anchor	5 blue mussels	cocoswrap	4.5 – 14
Translocation 2	Wreck 2803 – 2803 anchor	20-30 blue mussels	Plastic rack	2.5-10
Translocation 3	Wreck Ernst 38 – Wreck Ernst 38 inside	1 horse mussel	Metal rack	100

Translocation 1:
On wreck Jeanette Kristina we found 7 juvenile mussels, of which we translocated 5 individuals (1 lost on the seabed and one kept for eDNA analysis). After the expedition, they were identified as blue mussels. The individuals measure 14 mm, 10 mm, 10 mm, 7 mm, 4.5 mm and were all tied to goose barnacles and knotted wrackweed. They have been brought up to the MS Tender for measurement and pictures and were kept in an aquarium with seawater. Later in the day they were put in cocoswrap 35 with a few empty oyster shell substrate and placed on wreck 2803.

Photo 11. Blue mussels from wreck Jeanette Kristina (WWF/ARK).

Translocation 2:

On wreck 2803 we found 20-30 mussels on knotted wrackweed, that after eDNA analysis turned out to be blue mussels. The smallest juvenile was measuring 2.5 mm and the largest mussel measuring 32 mm, whereby at least 7 individuals are larger than 10 mm, lots of very small ones (only few mm) in clump together, 2 clumps on seaweed. These mussels never left the water and were placed in plastic crate 35, together with a few clean, empty oystershell substrate. This crate has attached to it cocoswrap 35 on the outside with blue mussels from Jeanette Kristina. The crate 35 with cocoswrap 35 were placed at the anchor or stern side of wreck 2803.

Photo 12. Measuring mussels on wrackweed, wreck 2803 (WWF/ ARK). eDNA analysis identified these later as blue mussels.

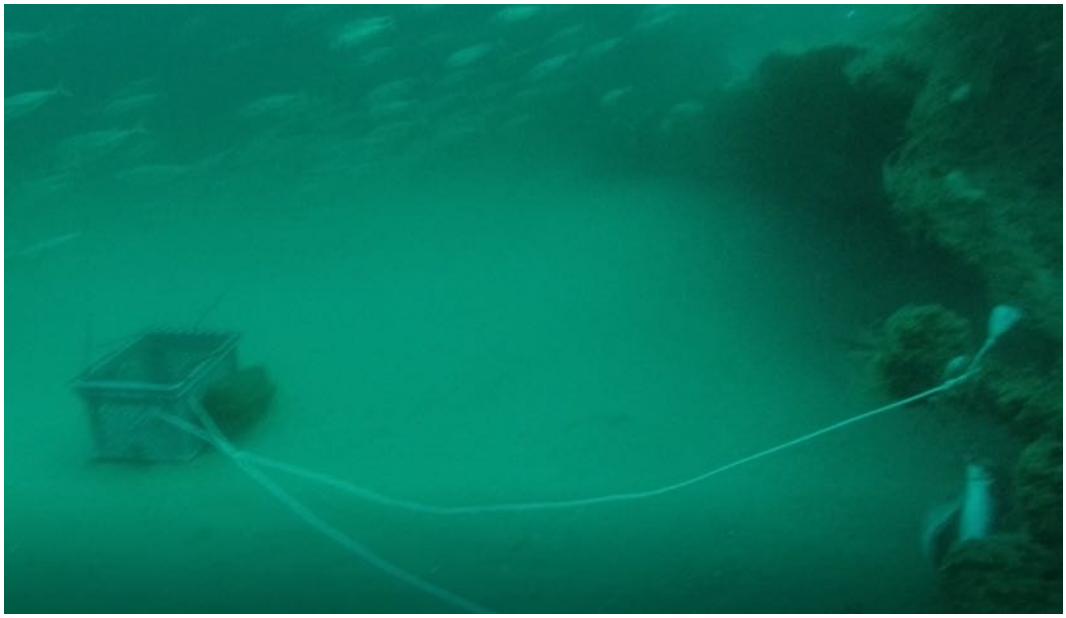


Photo 13. Translocated crate near wreck 2803 (WWF/ ARK).

Translocation 3:

On wreck ERNST38 we found 1 large individual horse mussel on the wreck attached to fishing rope. Adult horse mussels are easier to identify and distinguish from blue mussels compared to juvenile stages. The individual, measuring 100mm and this adult never left the sea. It was cut at the rope, so a little rope is still attached to the mussel (not to rip it and damage the mussel). The individual was translocated to metal rack 1. The bottom of the rack was lined with cocosmat and the top was closed with metal mesh. A few empty, clean oyster shells were added for substrate. The metal rack was placed on the inside of the (same) wreck Ernst38.

Photo 14. Metal racks used for translocation.

Photo 15. Location of iron rack 1 with horse mussel of 100 mm, translocated from bow to middle section and on inside of wreck ERNST38 (Udo van Dongen).

3.1.5 Biodiversity

To maximise the options for recording species MMO observations, biodiversity observations during dives and eDNA results were combined to get a general overview of biodiversity on site.

MMO and bird observations

During daytime bird spotters noted down observations on sea birds and marine mammals (Table 5). Standard methods for counting birds and mammals on the high seas were developed in the 1980s and 1990s (Tasker et al. 1984, Komdeur et al. 1992 & Camphuysen et al. 2004). The general standard for this is the European Seabirds at Sea method (ESAS). A similar methodology was used for the counts on the route to the Dogger Bank in 2021. Counting takes place from a boat, where from the flank of the ship perpendicular to the shipping line all waterfowl with area boundary are counted. The outer distance boundary was taken to be 300 m from the sailing line. All observations are spatially divided into segments of 300 m length, which are in turn divided into distance classes calculated from the shipping line. The distance classes consist of the following bandwidths: 0-50 m (A), 50-100 m (B), 100-200 m (C) and 200-300 m (D). Every minute a block of 300 by 300 meters is counted and noted on the field form, so to speak. In the table below (Table 5), results are aggregated into 30-40 minute time frames.

Photo 16. MMO and bird observations took place from the MS Tender on the way to Doggersbank, example of several bird species and harbour porpoise (not visible) feeding on forage fish (Daniel Beuker).

The observations resulted in the finding of twelve different (sea)bird species and one mammal specimen (Table 5). The species Atlantic murre turned out to be the most present, followed by the presence of Manx Shearwater and the Northern Gannet. The observation of a Black redstart is exceptional, since the species is more related to land-based habitats. Remarkable observation was the “feeding frenzie”, where seabirds feed on fish (Photo 16) chased upon by mammals, in this case Harbour porpoises.

Table 5. MMO and bird observations 20 sept 2021 - biodiversity summary

Transect				Time			Species													Notes
Start		End		Start	End	Duration (minutes)	Harbour porpoise	Black-legged Kittiwake	Common Swift	Great Black-backed Gull	Northern Gannet	Lesser Black-backed Gull	Pomarine Skua	Manx Shearwater	Mew -/ Herring Gull	Atlantic Murre	European Herring Gull	Black Redstart	Mediterranean Gull	
Lat	Lon	Lat	Lon																	
99351,00	734699,00	94791,00	741199,00	08:37	09:07	0:30	2	2			5			8		19	9		1	09:02 Feeding frenzie
94791,00	741199,00	89059,00	748693,00	09:07	09:47	0:40		1			4			8		13				
89059,00	748693,00	82081,00	756961,00	09:47	10:27	0:40		7	1	2	8	3	1	12		45				09:57 Pomarine Skua hunting a trush
82081,00	756961,00	75824,00	764521,00	10:27	11:09	0:42		8	1		9	11		6	1	282				
75824,00	764521,00			11:09	11:52	0:43					1			2		95		1		

eDNA

The technical aspects of this method are described in §4.3.

Diver observations

An overview of visual observation gives a species list per wreck, sand and pelagic (Table 6) and is based on a detailed analysis of species on underwater photographs by a taxonomist.

Table 6. Diver observations – biodiversity summary. AHS = Artificial hard substrate (combination of wreck data). • *= present* • * *= eggs*

Scientific name	Dutch name	English name	AHS	Sand	Pela-gic	Wreck Ernst 38	Wreck Jean. Krist.	Wreck 2803
Laniche conchilega	Schelpkokerworm	Sand mason worm	•				•	
Serpulidae sp.	Kalkkokerworm sp.	Tube building annelid	•			•	•	
Spirobranchus triqueter	Driekantige kalkkokerworm		•				•	•
Caprellidae sp.	Spookkreeftje sp.	Skeleton shrimp	•				•	•
Cancer pagurus	Noordzeekrab	Edible crab	•	•		•	•	•
Homarus gammarus	Europese zeekreeft	European lobster	•	•		•		•
Inachus sp.	Sponspootkrab sp.	Sponge crab sp.	•			•		
Necora puber	Fluwelen zwemkrab	Velvet swimming crab	•				•	
Diogenes pugilator	Kleine heremietkreeft	South-claw hermit crab		•		•		•
Galathea sp.	Galathea sp.	Galathea sp.	•				•	
Sessilia sp.	Zeepok sp.	Barnacle sp.	•			•	•	•
Alcyonidium sp.			•				•	•
Bugulidae sp.•			•			•	•	•
Bugulidae sp.2			•			•		•
Cheilostomatida			•			•		•

Scientific name	Dutch name	English name	AHS	Sand	Pela-gic	Wreck Ernst 38	Wreck Jean. Krist.	Wreck 2803
Electra pilosa	Harige vliescelpoliep		•			•		
Flustra foliacea	Breedbladig mosdiertje		•				•	•
Diadumene cincta	Baksteenanemoon	Orange anemone	•			•	•	•
Metridium senile	Zeeanjelier	Plumose anamone	•			•	•	
Sagartia elegans	Sierlijke slibanemoon	Elegant anemone	•			•	•	
Sagartia troglodytes	Gewone slibanemoon	Mud sagartia	•			•	•	•
Ectopleura larynx	Gorgelpijppoliep	Ringed tubularia	•			•	•	•
Halecium halecinum	Haringgraat	Herring-bone hydroid	•					•
Hydractinia echinata	Ruwe zeerasp	Rough hydroid	•			•	•	•
Kirchenpaueria pinnata			•					•
Nemertesia anteninna	Gewone zeespriet		•					•
Tubularia indivisa	Penneschaft	Oaten pipes hydroid	•			•		•
Cyanea sp.	Haarkwal				•	•		•
Scyphozoa sp.	Schijfkwal (poliep) sp.		•			•		
Alcyonium digitatum	Dodemansduim	Dead man's finger	•			•	•	•
Asterias rubens	Gewone zeester	Common seastar	•			•	•	•
Marthasterias glacialis	Ijszeester	Spiny starfish	•			•		
Ophiotrix fragilis	Brokkelster	Common brittle star	•			•	•	•
Ophiuroidea sp.	Slangster sp.	Serpent star	•					•
Arctica islandica	Noordkromp	Ocean quahog		•			•	
Modiolus modiolus	Paardenmossel	Northern horsemussel				•		
Pecten maximus	Grote mantel	Great scallop		•				•
Loliginidae sp.	Pijlinktvis sp.				•			•
Octopus sp.	Octopus sp.	Octopus	•				•	
Pijlinktvis sp.	Loligo sp.	Squid sp.	•*				•*	
Simnia patula	Gestreepte pegelhoren		•			•	•	•

Scientific name	Dutch name	English name	AHS	Sand	Pela-gic	Wreck Ernst 38	Wreck Jean. Krist.	Wreck 2803
Doridoidea sp.	Citroenslak of Millenium wratslak		•*			•*		
Doto pinnatifida	Zeespriet-kroonslak		•					•
Eubranchus vittatus	Geringde knuppelslak		•					•
Flabellina lineata	Witgestreepte waaierslak		•					•
Flabellina pedata	Paarse waaierslak		•					•
Flabellinidae sp.	Waaierslak sp.		•*			•*		•*
Polyceridae sp.	Harlekijnslak sp.		•*			•*		
Veelstippige kroonslak	Doto dunnei		•					•
Callionymus sp.	Pitvis sp.	Dragonet p.		•				•
Ctenolabrus rupestris	Kliplipvis	Goldsinny wrasse			•	•	•	•
Gadus morhua	Kabeljauw	Cod			•	•	•	•
Gobius sp.	Grondel sp.	Goby sp.		•				•
Molva molva	Leng	Common ling		•	•	•		
Mullus surmuletus	Rode mul	Red mullet		•			•	
Myoxocephalus scorpius	Gewone zeedonderpad	European sculpin	•				•	•
Pleuronectidae sp.	Platvis	plaice or flounder		•			•	
Microstomus kitt	Tongschar	Lemon sole		•			•	
Scyliorhinus canicula	Hondshaai	Lesser-spotted dogfish	•*					•
Trachurus trachurus	Horsmakreel	Atlantic horse mackerel			•		•	
Trisopterus luscus	Steenbolk	Pout			•	•	•	•
Porifera sp.	Korstspons sp.	Sponge sp.	•			•	•	•
Suberites ficus	Vijgspons	Sea orange sponge	•			•	•	
Botrylloides sp.	Slingerzakpijp sp.		•					•
Didemnum sp.	Druipzakpijp		•			•		•
Diplosoma sp.	Grijze korstzakpijp		•				•	•
	TOTAL		**50**	**10**	**7**	**35**	**34**	**44**

Sea floor exploration with dropcam

The main purpose of the seabed exploration was the recording of reef building species, that were not observed (Table 7). Additional biodiversity has been recorded during observations (Annex 1)

Table 7. Dropcam observations of reef building species

Date	Video identification	Reef building species
21-sep	21-09-2021 22-33-38 C dropcam video	not observed
22-sep	22-09-2021 17-49-16 C dropcam video	not observed

3.2 BENSO

The BENSO project stands for Biodiversity Enhancement in North Sea Offshore wind farms (BENSO). This is a TKI project focused on biodiversity in offshore wind farms. Waardenburg Ecology works together with partners Waterproof and Wageningen Marine Research on techniques that can enhance North Sea nature.

Context: As part of the transition from fossil fuels to sustainable energy, the Dutch government is aiming for five 700 MW offshore wind farms by 2023 and another 1,000 MW between 2023 and 2030. To achieve the climate goals, a further increase in offshore wind energy to more than 35 GW by 2050 is needed. The Dutch government has identified a number of challenges for successfully scaling up offshore wind energy. One is the ecological impact of offshore windfarms on the North Sea ecosystem (bird collisions, disturbance, construction effects, introduction of hard substrate into a predominantly soft sediment ecosystem, ban on bottom trawling etc). The BENSO project contributes to the integration of offshore wind energy into the marine environment and aims to:
1) Create economic value by developing, testing and implementing a smart eco-design to protect the turbines from sand runoff around the foundation in offshore wind farms to improve biodiversity locally and in the wider ecosystem.
2) Implementing smart monitoring techniques during monitoring and maintenance work.
Outcomes of this experiment can help to better understand opportunities for nature and biodiversity in the design of new offshore windfarms.

Expedition goals: The project focuses on scour protection: boulders that protect the seabed around wind turbine piles against erosion. Scour protection can be designed to benefit certain species such as fish, crabs and lobsters. For the BENSO project, with this expedition the aim is to place various sizes of rocks used in scour protection. We will set up an experiment in which we mainly want to encourage larger mobile species to be attracted, as well as growth and development. In the experiment we are going to place two different gradings (sizes) of hard substrate on the North Sea bed. It is expected that the different in sizes attract other species. The underlying questions are: does the size of hard substrate and scour protection determine the population composition of mobile species? And what effect exists on biodiversity in general? Also, the biodiversity development on

rocks will be a good indication of restoration potential of this specific location with stony reefs, and thus goes beyond testing scour protection for windfarm development.

3.2.1 Methods

The main research methods include:

- Preparations of stony reef material
- Exploring the site by visual means, using divers
- Placement of stony reef experiment
- Recording

3.2.2 Preparation

For the deployment of the experiment, 2 different grades of potential scour protection material were selected. In doing so, the trade-off between manageability and applicability within scour protection construction was made. The gradings used are: 45-50 cm (60-300 kg) and 25-30 cm (10-60 kg).
The material used is Grauwacke rock, sedimentary rock, formed by transformation of sandstone, originating from Germany. This material is not yet widely used in wind turbine construction. In the current experiment however, the dimensions are more important than the material to be used. The advantage of the material used is that the surface is relatively rough and the stones angular, this provides fouling possibilities and good interstices where mobile organisms can settle. From both gradings 3 stacks (1/2 cubic meter each, approximately 1000 kg) were set out, a total of 6 stacks.
A condition for being allowed to set out the experiment is that it can also decommissioned afterwards. For this reason, a net was developed that was both strong enough to carry the stones and fine-meshed enough to also allow smaller organisms to be brought on board during removal for analysis of the overall biodiversity. The mesh size of the net is 2 cm, the dimension is 2 by 2 meters. The net consists of 2 layers, with the outer layer providing the necessary strength. In total, there are reinforcements at 6 points of the net to prevent "lifting" from the seafloor and to enable the construction to be hoisted. All nets and contents are numbered (see photo).
Based on existing knowledge, a choice was made from a number of potential wreck locations where the experiment could be carried out. The wreck should be located on the NCP and at a working depth for Waardenburg Ecology's professional diving team (max 30 meters depth). The choice for a wreck location is based on fishing pressure (and possibly damaging fishing gear) reduced to a minimum. The first choice is the wreck of the Jeanette-Kristina.
The implementation of the experiment was reported to RWS.

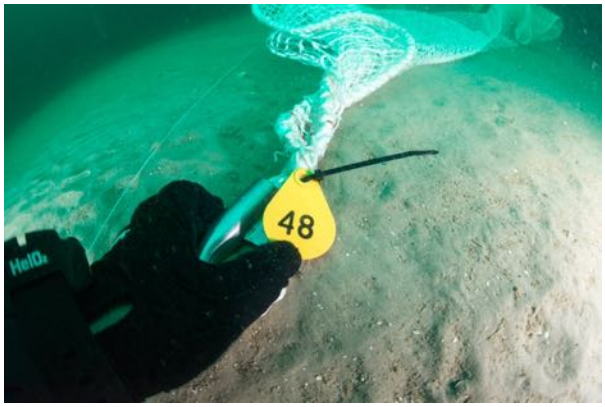


Photo 17. Labelling of reefs (Udo van Dongen).

3.2.3 Site exploration

After locating the wreck, divers descended to inspect the site and determine where best to place the stacks of rocks without damaging the wreck in the process. The identified site appeared to be flat and consist of a sandy bottom (photo). The location was marked with buoy lines so that orientation at the water surface was possible. The marked location was approximately 20 meters from the cabin of the wreck, 240 degrees relative to the roof.

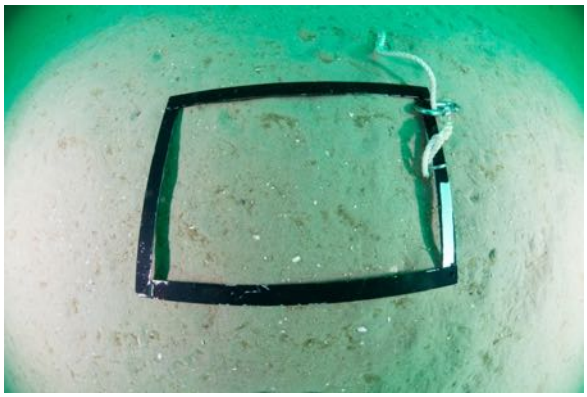


Photo 18. Site exploration (Udo van Dongen).

3.2.4 Installation of stony reef experiment

Based on the marking (buoys) and the sonar signals, the ship was positioned so that the stones could be hoisted overboard. This required clear coordination between deck and bridge crew. The nets containing the stones were hoisted using a quick release hook. When the stones hit the sea bottom, the hook was successfully opened, and the pile of stones remained on the seabed.

The exact locations of where the vessel was during the descent of the stones was recorded using a GPS handheld field tablet.

3.2.5 After installation recording

After placing the nets with the stacks of stones, divers descended again to assess their condition. The deployment appeared to be successful. The stacks were placed at reasonable intervals. The divers opened the nets and connected them to each other (photo 19), so that they can still be easily located in the event of subsidence.
Subsequently the stacks of stones were photographed. With the photos the zero situation has been determined and calculations can be started regarding the size of the created holes and cavities.

Photo 19. Installed stone reef experiment (Udo van Dongen).

4 Marine Science – Marine Ecology Research Techniques

For this expedition, a Remotely Operated Vehicle (ROV) and baited camera (BRUV) were tested to assess their operational use in the offshore North Sea and to assess the quality of data for ecological research purposes. At the same time eDNA extraction was used as an additional for biodiversity assessment of the Dogger Bank locations.

4.1 ROV

Context: There are various methods to do research on or above the seabed. NOAA describes ROVs: ROVs are unoccupied, highly maneuverable underwater machines that can be used to explore sea and ocean depths while being operated by someone at the water surface. These underwater machines are controlled by a person typically on a surface vessel, using a joystick in a similar way that you would play a video game. Most ROVs are equipped with at least a still camera, video camera, and lights, meaning that they can transfer images and video back to the ship. Additional equipment, such as a manipulator or cutting arm, water samplers, and instruments that measure parameters like water clarity and temperature, may also be added to vehicles to allow for sample collection. ROVs are used for many applications, many of them scientific and they range in size from that of a small computer to as large as a small truck. While using ROVs eliminates the "human presence" in the water, in most cases, ROV operations are simpler and safer to conduct than any type of occupied-submersible or diving operation because operators can stay safe (and dry!) on ship decks. ROVs allow us to investigate areas that are too deep for humans to safely dive themselves, and ROVs can stay underwater much longer than a human diver, expanding the time available for exploration.[1] Another advantage is the ability to cover larger distances faster compared to diving.

Expedition goals: Wageningen Marine Research (WMR) is testing novel monitoring techniques to monitor nature restoration projects as part of two Joint Industry Projects BENSO and ECOFRIEND. The focus is on monitoring biodiversity of scour protection and oyster reefs. During this expedition, WMR tested the use of a small ROV to take video footage of the seafloor. The aim was to get familiar with the ROV, to problem solve whatever issues would arise, and get insight in the pros and cons of the monitoring method. On the Dogger Bank, the ROV was towed behind the ship across long stretches of seabed (kms) during which the ship drifted on the wind and current. This went very well. At the Borkum Reef Grounds, the ROV was used to monitor the release of painted oysters in a small area. This was harder, because the ship stayed on a fixed position, and the visibility was not good. The painted oysters were placed on the seabed near the WWF/ARK Borkum Reef Ground oyster reef to better understand their spread over the seafloor due to currents and storms and will be revisited during the 2022 expedition. This experiment is done to

[1] Explanation of ROVs comes from website of NOAA: https://oceanexplorer.noaa.gov/facts/rov.html

obtain insight in what happens with adult oysters when they are deployed on the seafloor to better understand the success or failure factors of oyster reef restoration efforts.

Findings

- Operational: it took some time to get familiar with operating the ROV and find a good set-up. Towing the ROV behind or next to a ship, while drifting, proved to be a safe method. The speed should not be too high (preferably max ca 1 m/s). When the ship's engine is switched off, the cable cannot get stuck in the propellor. To reduce the drag of the cable that connects the ROV to the computer onboard the ship, the cable was equipped with a weight, which we tried to position just above the seafloor. This worked out well. The acoustic system connected to the GPS system failed to work. Positions were therefore obtained from other GPS soures. At the Borkum Reef Grounds, the ROV was deployed next to the ship, but at some point it was smashed against the ship by the waves, and one GoPro camera was lost.
- Biodiversity: At the Dogger Bank transects, some gobies (*Pomatoschistus* sp), flatfish (dab, plaice) and starfish (*Asterias rubens*, *Astropecten irregularis*) were seen on a sandy seafloor with fragmented dead shell material. At the Borkum Reef Grounds, Ross worm *Lanice conchilega* was dominant.

Photo 20. ROV image recording (WWF/ARK).

Photo 21. ROV (WWF/ARK).

4.2 Baited Camera

Context: There are various methods to do research on or above the seabed. NOAA describes Baited Remote Underwater Camera's (BaitCams or BRUVS). They are camera's on a frame, baited with oily fish and used as nonextractive monitoring method for bottomfish species. The use of baited remote underwater video (BRUV) for examining and monitoring marine biodiversity in temperate marine environments is rapidly growing, however many aspects of their effectiveness rely on assumptions based on studies from the Southern Hemisphere. These underwater set-ups are installed from a surface vessel, using a hoisting device, and retrieved afterwards. BRUVs are equipped with at least a video camera, and lights, and they can record moving images of fish and other mobile species that can be analysed afterwards. Additional equipment, such as abiotic data loggers may also be added to the frame. BRUVS are used for many years with recent efforts for standarisation of the methods in temperate waters (Jones et al. 2020) as well as continuous studies on its efficicacy.

Expedition goals: Waardenburg Ecology and the BENSO project are testing novel monitoring techniques. Hence the baited cameras were tested on the Dogger Bank.

Methods: The baited camera was installed and hoisted at the night of 22nd of September near the wreck 2803. The bait consisted of mackerel and some crabs.
The frame (based on Cappo et al. 2006) was equipped with 12 kg extra weight + a sand anchor to prevent displacement.
The system stood overnight (approx. 12 hours) on the bottom, in this time frame 50 minutes were filmed.

Findings:

- Technical: After retrieval, the bait was hardly eaten. The lights were still burning well. Unfortunately, the connection between battery and camera was not optimal. The recordings therefore have only lasted 50 minutes. In the recorded images we observed that the construction had not been displaced.
- Biodiversity: During the time the camera was in operation the following organisms were observed: 2 flatfish (common dab, *Limanda limanda*), 1 juvenile whiting (*Merlangius merlangus*), some starfish (*Asteria rubens*) and a hermit crab.
- Operational: Hauling the structure aboard was done manually. For the future, a mechanical hoisting operation is preferable.

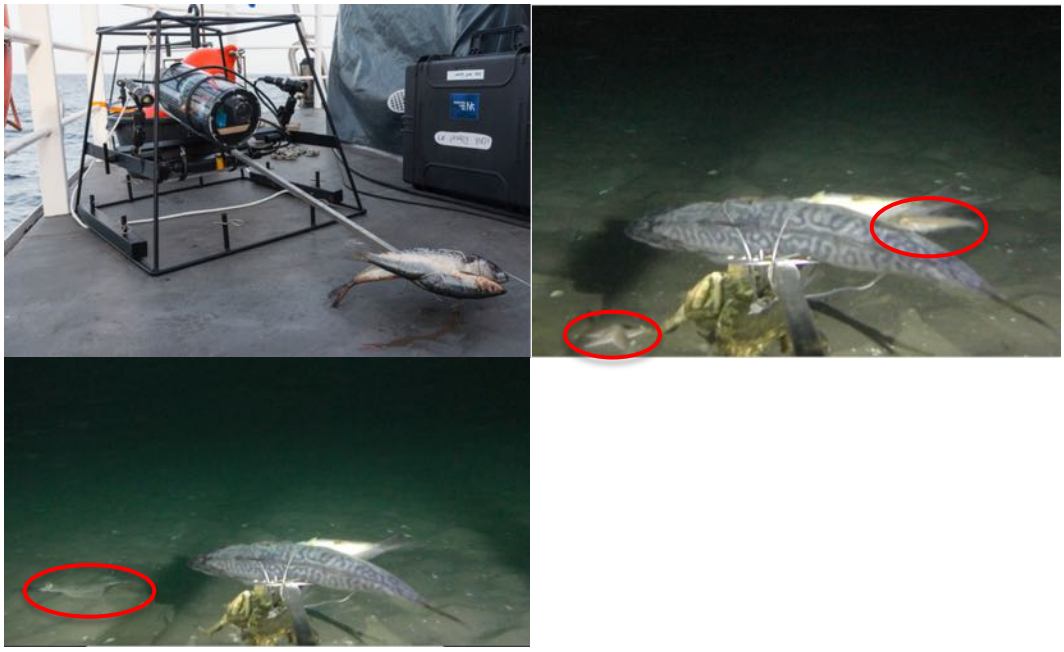


Photo 22. Top left: Baited camera. Top right: juvenile whiting and common starfish. Bottom left: common dab (Waardenburg Ecology).

4.3 eDNA

Methods

During the expedition water samples for eDNA analysis were taken by divers. All eDNA water samples were taken at or near the bottom. Some of the samples were filtered on board the MS Tender, some were filtered after arrival in the harbor in Lauwersoog because it was not possible to do this on board because of the strong winds.

A volume of 1.5L of water was used per sample or sub-sample to filter out the DNA. The filters with eDNA are preserved and stored in the -20 freezer until first processing. Reprocessing, DNA isolation, metabarcoding and sequencing were performed in the laboratory of the Marine Animal Ecology chair group of Wageningen University in Wageningen. Detailed procedures are described in Doorenspleet et al. 2021. All samples

were processed with one set of semi-universal metabarcoding primers for the detection of fish and other vertebrates. This primer set amplified DNA with a length of at least 2000 base pairs. This ensures a species identification with a high degree of certainty because the fragment length allows a clear distinction to be made between closely related species such as plaice and flounder or the different species of sandeel. A disadvantage of this primer set is that especially recent eDNA is picked up, and more degraded DNA is often not detected. See Doorenspleet et al. 2021 for more information about this method.

DNA sequencing Horse mussel

In addition to analyzing eDNA samples, a number of small – juvenile - mussels were also collected, which were suspected to be Horse mussel *Modiolus modiolus*. Some of these mussels have been reintroduced around the wreck, two of these have been collected and identified by means of DNA sequencing. These turned out to be *Mytilus edulis* (§3.1.4).

Locations and samples

eDNA samples were taken (Table 7):

- September 20 on the Jeanette Kristina, on the wreck (in triplicate) and 20 meters outside the wreck on the sand, upstream (in triplicate)
- September 21 on Wreck 2803, on the wreck and on the sand immediately next to the wreck (in triplicate).
- September 21 with a Niskin bottle next to the Tender, when we were still near the wreck, depth was 27-28 meters, about 1 meter above the sea floor (duplicate).
- September 22 on the wreck Ernst 38 at 32 meters depth. On that wreck we found 1 large *Modiolus* that was collected by WWF. On the shotline about 4 meters above the wreck we took another water sample next to the collected mussel.

The eDNA samples were taken in triplicate. Some of the isolated replicas gave problems in the PCR amplification, and despite several attempts, it was not possible to obtain a good PCR product. At least two samples are successful from each location (Table 1). The fish species found are listed per sample location, in order of occurrence in the eDNA dataset.

Table 7. Samples taken for eDNA analysis.

Date	Sample	Description
20-Sep	Wrak 1A	Jeanette Kristina, in wreck
20-Sep	Wrak 1B	Jeanette Kristina, in wreck
20-Sep	Wrak 1C	Jeanette Kristina, in wreck
20-Sep	Negative 20/09	0,75l demi water filtered, negative control
20-Sep	Zand 2A	Jeanette Kristina, 20 meter upstream, sand
20-Sep	Zand 2B	Jeanette Kristina, 20 meter upstream, sand
20-Sep	Zand 2C	Jeanette Kristina, 20 meter upstream, sand
21-Sep	Zand 3A	Wreck 2803, on sand next to wreck
21-Sep	Zand 3B	Wreck 2803, on sand next to wreck
21-Sep	Zand 3C	Wreck 2803, on sand next to wreck
21-Sep	Negative 21/09	1,5l demi+drinking water as negative control
21-Sep	Niskin 1	Niskin at ~26m dept next to Tender near wreck 2803

21-Sep	Niskin 2	Niskin at ~26m dept next to Tender
22-Sep	5A	Wreck Ernst 38, 32m depth, no current, on wreck, 2m above bottom
22-Sep	5B	Wreck Ernst 38, 32m depth, no current, on wreck, 2m above bottom
22-Sep	5C	Wreck Ernst 38, 32m depth, no current, on wreck, 2m above bottom
22-Sep	6B	Wreck Ernst 38, on shotline, 4m above wreck (6m above bottom)
22-Sep	Negative 22/09	

Photo 23. eDNA filtration on board of the MS tender (WWF/ARK).

Results

Table 8. eDNA results: Identification of fish species based on eDNA at the sampled locations. The order of species listed is related to the abundance detected eDNA.

Location	**Successfull replica's**	**Fish species present**
Jeanette Kristina, wreck	3 replicates	Red mullet, mackerel, plaice, cod, dragonet, sardine, lesser sand eel (*Ammodytus marinus*), goby (*Potamoschistus minutus*), clingfish, pout
Jeanette Kristina, upstream on sand	2 replicates	Goby (*P.minutus*), mackerel, red mullet, sardine, solenette, lemon sole
Wreck 2803, sand next to wreck	2 replicates	Dragonet, sardine, mackerel, lemon sole, red mullet, dab, grey gurnard, lesser sandeel, goby (*P.minutus*)
Niskin	2 replicates	sardine (>95%), red mullet, solenette
Ernst 38, wreck	2 replicates	sardine, plaice, lemon sole, lesser sandeel, cod, red mullet

Conclusion and discussion

In the eDNA analysis, we mainly find fish species that have also been visually observed on the wrecks by divers, few species that have not been observed by divers (solenette, clingfish, mackerel, sardine) and a number of species that have been seen a lot by divers, such as horse mackerel, but were not detected. An important reason for this may be that the method used with the 2000bp amplicon has the disadvantage that the sensitivity to DNA of species where only little DNA is in the water is too small. Another drawback is the sampling by divers. The divers in the water are often the largest and closest source of eDNA at the time of sampling, which is also evident in the data, as human DNA has been found in all samples, often as the most common DNA fragment, or second place. This high amount of human DNA makes the total sensitivity of the eDNA analysis lower, because a large part of the sequencing resolution is taken up by human DNA. This means that DNA from species that were only present in a low concentration is hardly or not found. This can be the explaining factor for the missing eDNA from five fish species - common ling, European sculpin, horse mackerel, goldsinny wrasse, lesser spotted dogfish and - that have been observed by divers but not by sampling of eDNA. In conclusion, additional methods – diver observations and eDNA- give additional information on fish biodiversity for these Dogger bank locations.

The samples will be further individually analyzed for the specific presence of eDNA from reef building species such as flat oysters and horse mussels. These animals do not appear in the eDNA analysis used, because the method is suited to only detect vertebrates. The experiments for the identification of specific species have not yet been performed yet.

5 Film Making

Context: We think we know every square inch of our continent, and yet our largest wilderness, the North Sea, lies mostly hidden. It's true that the North Sea has the busiest shipping routes in the world, is intensively fished and serves as a platform for the energy transition. In this hive of human activity it is easy to forget that first and foremost, the North Sea is our largest nature area, with a fascinating and undiscovered underwater world, home to a staggering wealth of marine life. Dutch Maritime Productions is a storyteller for the underwater world. DMP engages in productions with impact to show the beauty of this world. Driven by an unbridled passion for diving, humankind and nature, DMP has been exploring the waters of the world with curiosity, care and joy. Located in 's-Gravenzande, the Netherlands, Klaudie Bartelink and Peter van Rodijnen travel the world to create productions that change our view of the sea. Dutch Maritime Productions and EMS FILMS are developing a major media project called 'North Sea, Nature Untamed', including a 4-part TV series, a 90-minute cinema feature, online educational materials and an immersive movable projection unit, supported by events and merchandise. The goal is to share the many secrets and wonders of the North Sea with a wide ranging public.

Expedition goals: Priority was to find locations on the Dogger Bank where two or three consecutive dives can be made to shoot subjects from different perspectives, with different camera lenses. This is important to at least create content and potentially create a story for the series and the film.

Photo 24. Video still of egg capsule of lesser spotted dog fish (DMP).

Findings: The expedition gave DMP sufficient opportunity to search for suitable locations. DMP has selected two locations for the media project on the Dogger Bank, with which the goal has been achieved. The scene is about a wreck as a (colorful) biodiverse habitat, a

safe haven for sea creatures. The viewer sees the octopus and (young) cod as appealing species. DMP will lead a nature expedition in 2022 and will partly pay for the actual filming of the scenes. During this expedition a minimum of 5 dives will be made per location. This activity is combined with projects of the other partners. DMP was also able to take unique images of a shark egg on wreck 2803: a nice 'catch' in the context of nature conservation and communication.

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Annex I Annotation seabed exploration with dropcam

The main purpose of the seabed exploration was the recording of reefbuilding species, however additional biodiversity has been recorder during observations:

NORTHERN TRANSECT

Coordinates Start N 55.12.483, E 3 32.469 End N 55 35.711 - E 3 34.412.
21-092-201 at 22:15 we started the transect in the northern part of the Dogger Bank [to 00:18 when we took out the dropcam at Drifting with a speed of about 0.6 kts. The transect covered a depth gradient from approximately 30 meter to 40 meters and a length of 40 km, although not the entire length was dropcammed, we also skipped a part in the middle, as there was very little variation.

22:33 We see an octopus. Many (approximately 15 or more) spiny combstar (*Astropecten irregularis),* also lion's mane jellyfish (*Cyanea capillata)* About 5% coverage of sandy seabed with shellfragments. We see tiny sandripples, muddy sand, a few fish lemon sole *Microstomus kitt*.

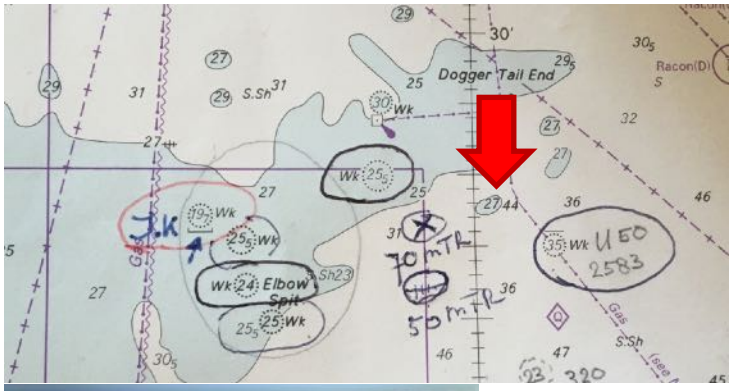
22:51 The seabed overall looks relatively raked and uniform. 35 meter depth. Finer siltier and darkgrey sand. Individual fossil oyster and mussel shell. Somewhat larger sandripples
22:54 another few spiny combstar, brittlestar, swimming crab, perhaps signs of shellfish below sand? Some hermit crabs
23:03 Scaldfish/schurftvis (*Arnoglossus laterna*), Grauwe poon / grey gurnard (*Eutrigla gurnardus*), more spiny combstars, several common dab / schar / *limanda limanda*, some sponges.
23:17 we decided to head to deeper waters as picture is quite uniform. Now at 35.2 meters depth
23:55 38.5-39.5 meters depth, starting at 55 35.053N and 3 34.895E
00:00 40 meters depth spiny combstar, common dab, bit more holes in the sand. Going 0.8 knt, images are clear still.
00:06 scaldfish, hermit crab, starfish, spiny combstar,
00:18 taking out dropcam at 55 35.711N and 3 34.412E 40 meters depth (converted by Emilie N 55 35 42.7, E 3 34 24.7 / N 55.59518, E3.57353)

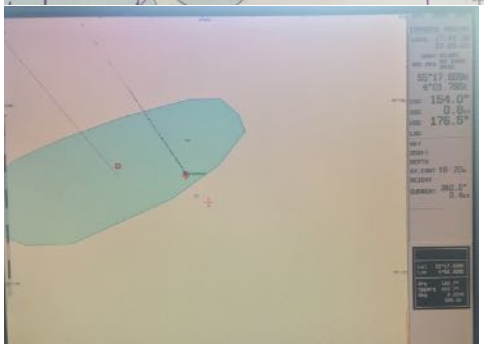
Photo 25. Octopus (Waardenburg Ecology – dropcam image)

Photo 26. Hermit crab (Waardenburg Ecology – dropcam image)

SOUTHERN TRANSECT

In the southern transect we dropcammed and ROV'd large sections across a distance of approximately 8.45 km or 4.56 nm distance (direction south, southeast approximately 140 degrees from the startpoint). The objective was to cover a depth gradient. On the map from 27 meters to 44 meters, as can be seen on this map. The actual gradient we covered was 30 m to 44 meters max





The start point was on 22-09-2021 at 16:49 at N 55.351270 – E 3.954140 (Frank's coordinates), converted by Emilie to N 55 21.076 E 3 57.248 or N 55°21'4.6" E 3°57'14.9" about 11.5 km southeast of wreck ERNST38. Depth here was 30 meters.
The southern transect was not covered by images entirely:. As we drifted into the north-east, parallel to the depth contour we wanted to pass, we decided at 17:09 to take out the dropcam and ROV and sail south, to then let ourselves be drifted again but in the right direction.

17:53 our course on the ground was 71 degrees, sailing 0.6 knots. Location 55°17.607N 4°01.866E. Depth is 42 meters. We see burrowing holes in the seabed, it appears more silty compared to northern track. Occasional hermit crab. Fewer animals compared to northern transect, more underneath the seabed it appears. Longer mudtracks. The conditions are 6BFT winds, 1.5 to 2 meter waves; dropcam is still ok to do. On the ROV we can observe starfish, lots of jellyfish and occasional flatfish. Sponges, dead Echinocardium chordatum, star fish, in general not many species visible and bare sea floor.

18:18 double track, appears to be a trawltrack at 55°17.633N and 4°02.249E. The southern transect ended on 22-09-2021 at 18:31 at N 55 17.650 – E 4 02.498 (Frank's coordinates), converted by Emilie: 55°17'39.0"N 4°02'29.9"E or N 55.294167, E 4.041633.

Photo 26. Watching dropcam images (Waardenburg Ecology)

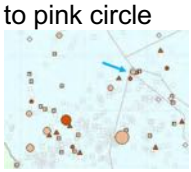
Diver observations

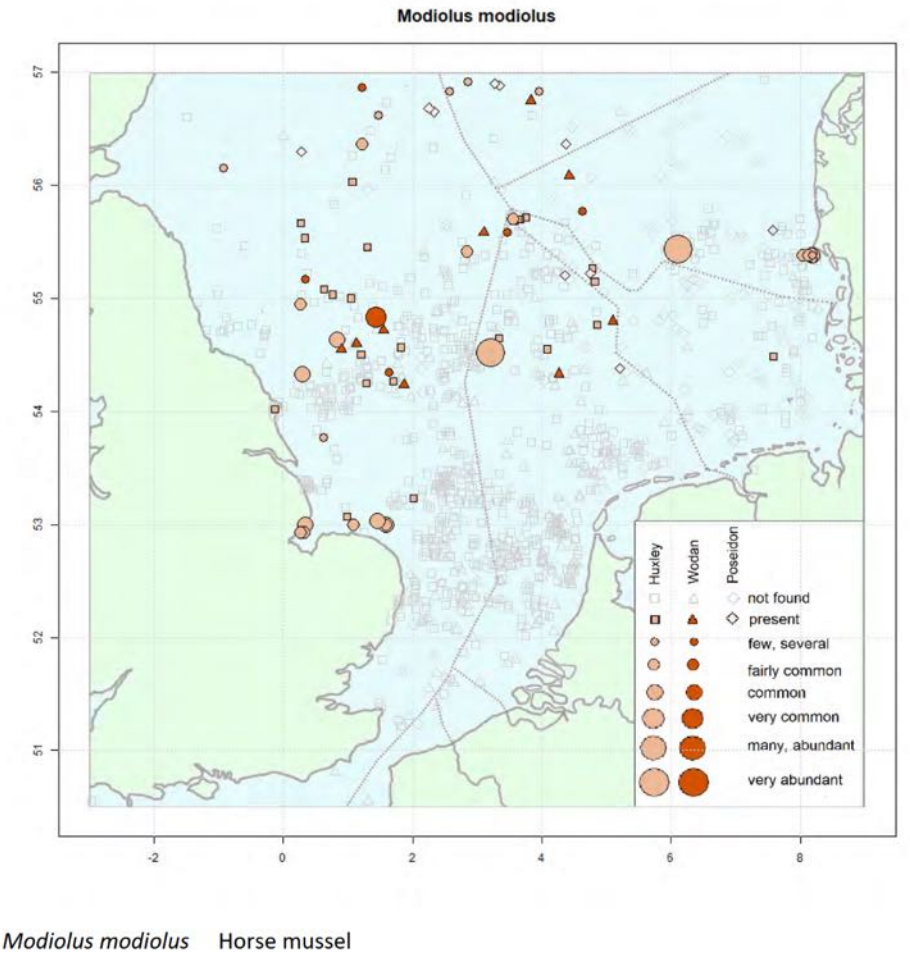
Diver observations on biodiversity were recorded after dives and included:
Rhodophyta – Roodwier - Red algae
Cyanea capillata – Gele haarkwal Lion's mane jellyfish
Alcyonium digitatum – Dodemansduim – Dead man's finger
Sagartia elegans – Sierlijke slibanemoon – Elegant anemone
Metridium senile – Zeeanjelier - Plumose anemone
Octopus vulgaris – Octopus (achtarm)– Common octopus
Cancer pagurus - Noordzeekrab – Edible crab
Homarus gammarus – Europese zeekreeft – European lobster
Hermit crab
Astropecten irregularis – Kamster - Sand sea star
Echinocardium cordatum – Zeeklit - Common heart urchin
Acanthocardia echinata – Gedoornde hartschelp – Prickly cockle
Neptunea antiqua - Noordhoren – Red whelk
Microstomus kitt –Tongschar - Lemon sole
Mullus surmuletus - Rode mul – Red mullet
Trisopterus luscus - Steenbolk - Pout
Gadus morhua – Kabeljauw - Atlantic cod
Ctenolabrus rupestris – Kliplipvis - Goldsinny wrasse

Annex II Dogger Bank Expedition 2021 – additional information

Location 1: Northern Edge of Dogger Bank

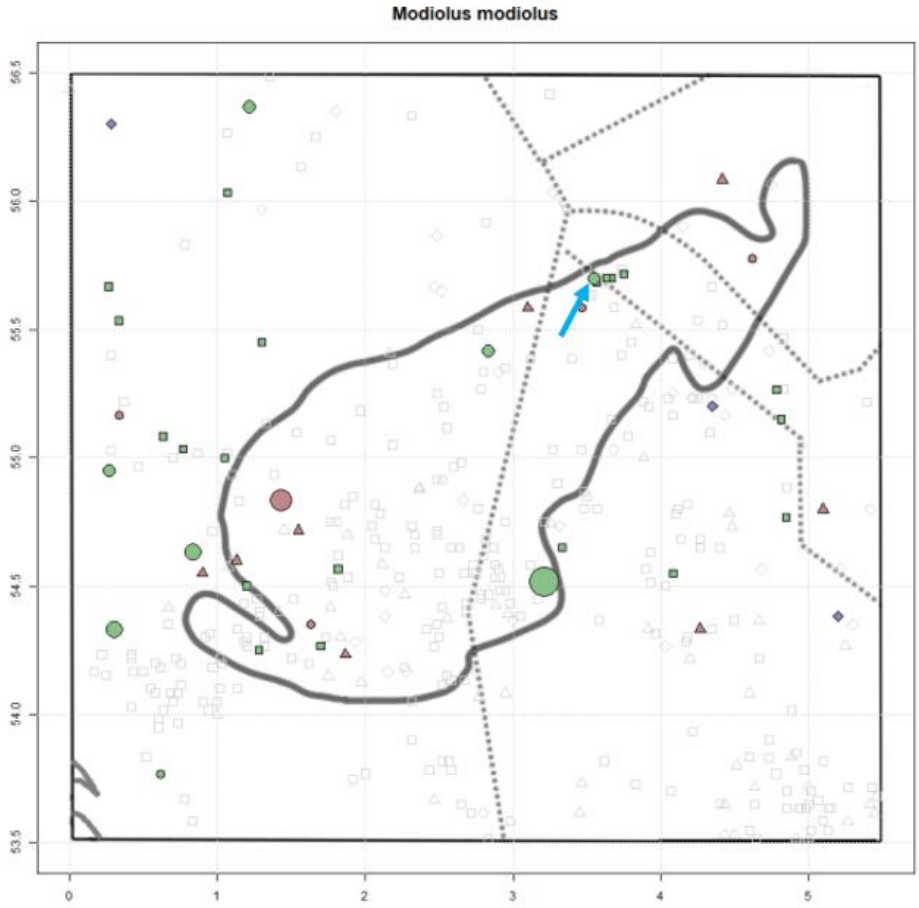
At the northern edge Dogger Bank, in the top (northern) corner of Dutch EEZ, bordering on German northern end/tip of EEZ. Source: Bennema 2021 page 72: see blue arrow pointing to pink circle





Modiolus modiolus Horse mussel

Map 1. Horse mussel. Source: Bennema



Map 2. Source: Horse mussel Van Moorsel 2021, page 26, green circle (notice different location vis a vis EEZ borderlines, compared to Bennema map above)

Rationale for choice location 1:

- Historic presence and abundance of Modiolus modiolus; Fairly common 'historical' (not before the age of trawling, but North Sea benthos 1902-1912 – Distribution based on Huxley, Wodan and Poseidon surveys data) abundance
- Favourable habitat see van Moorsel report 'The roughs'.
- Roughs also potential for shark and ray habitat restoration
- Location lies within future closure to all bottom towed fishing gear (aka Dogger Bank JFMP management zone)

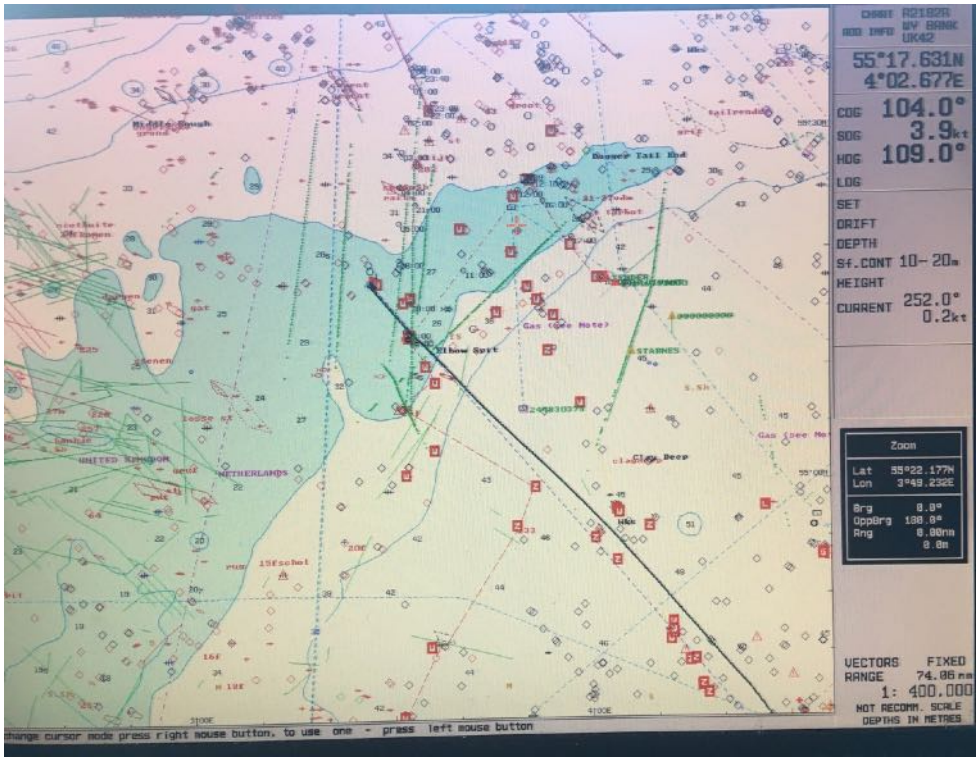
Location 2: Wreck Jeanette Kristina

N 55°17'14" / E 03°20'07"

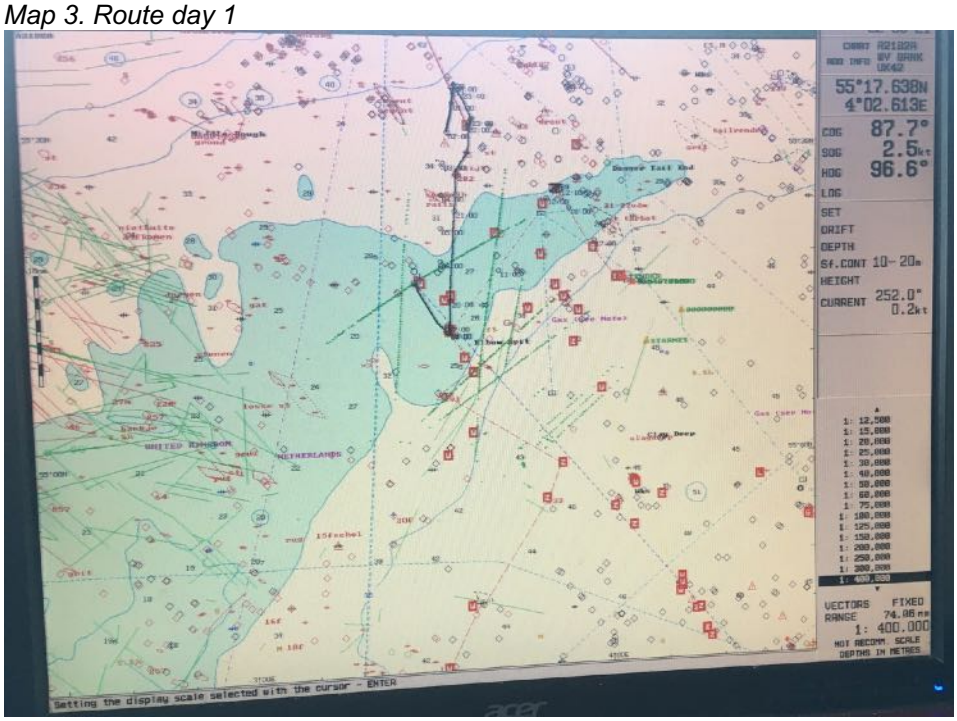
Rationale for choice location 2:

a. Well documented wreck, DDNS expedition in 2011, 2012, 2015
b. Presence of juvenile horse mussel in 2015
https://www.strandwerkgemeenschap.nl/vindplaatsen/doggersbank/ number unknown
c. Depth max 22-30 meters; suitable location for translocation
d. Previously big school cod, wolffish

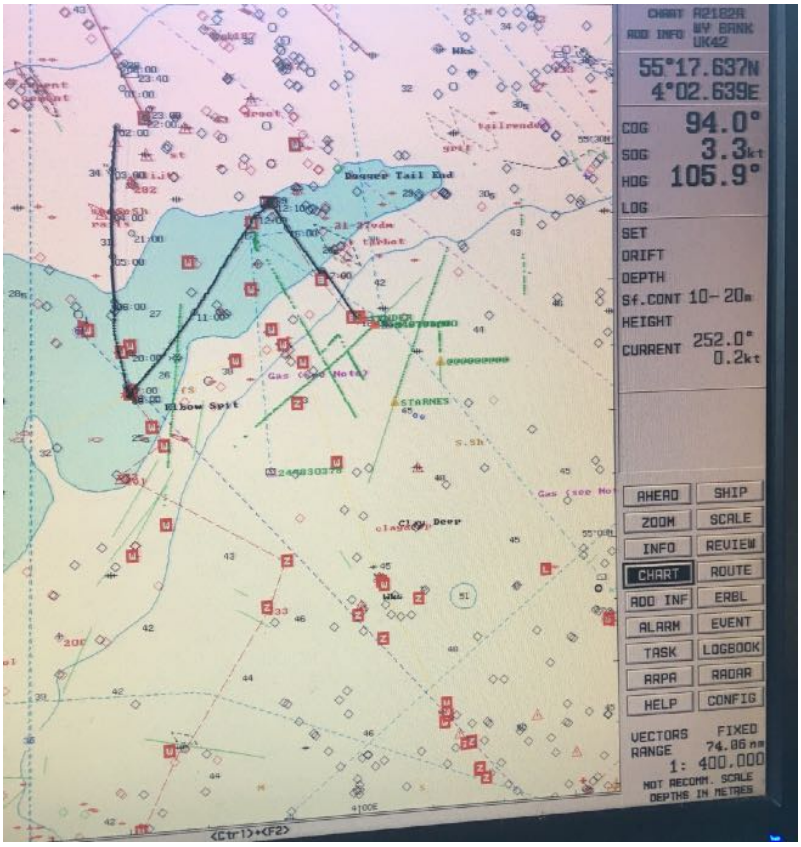
Route day 1:



Map 3. Route day 1



Map 4. Route day 2.



Map 5. Route day 3.

Annex III Dogger Bank Expedition 2021 – additional photos

Photo 27. Collected materials, shell material and sediment, near wrecks (WWF/ARK)

Photo 28. Collected materials, shell material and sediment, near wrecks (WWF/ARK)

Photo 29. Marine life near wreck Ernst38; Above Atlantic lobster (Homarus gamarus).

Photo 30. Dropcam survey

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