



NOTE

SUBJECT: Inventory of technical performance and biodiversity on structures at the Offshore Test Site
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Introduction

The Rich North Sea program aims to enhance biodiversity in the North Sea by integrating nature development measures with the construction of offshore wind farms (OWFs). These farms create opportunities to support ecological growth by focusing on key indicator species, such as biogenic reef builders and predators like rays, cod, large crustaceans, and squid. Enhancing biodiversity is thought to be most effective on hard substrates, such as scour protection, where these species can thrive.

A significant effort is dedicated to selecting suitable substrates and structures for marine organisms to attach and grow. Also, new outplacement methods for flat oysters are being developed. To support this research, specially designed structures and research cages have been deployed since February 2021 at the Offshore Test Site, operated by the North Sea Farmers, located 12 kilometers off the coast of Scheveningen.

To monitor the biodiversity development on these structures, The Rich North Sea has established a monitoring program involving divers and ecologists. This report highlights the findings from field monitoring conducted on September 23 and 24, 2024, by Waardenburg Ecology's diving team and the image and video analysis by The Rich North Sea.

Research question

The following research question is central in this study:

What is the physical condition of and the state of biodiversity development on the four structures deployed at the OTS?

The question is to be answered by following the provided steps:

1. Determine the physical condition of the structures;
2. Measure biodiversity development by using quadrants, based on the MOO-method;
3. Register presence of reef building indicator species;
4. Inventory system indicator species (predators).

Conclusion

A diving inventory and video analysis was conducted to assess the physical condition and biodiversity of four artificial reef structures: the Cephalopod and Mussel Reef Cubes® by ARC Marine, the (T)Ree(F) by NIOZ, and the Waardenburg Ecology Research Cage (WERC-dock). This inventory aimed to provide insights into biodiversity development around these structures and monitor their structural integrity.

In total, 39 species were identified across the structures, compared to 25 in 2021 and 17 in 2023. The increase in detected species this year could be attributed to better visibility, seasonal variations, ecological succession, and the inclusion of an additional structure in the survey. Notably, the highest species count was observed on the (T)REE(F) structure, suggesting its potential as a biodiversity hotspot. Further examination of its internal features, such as branches, might reveal even more species, as evidenced by burrowing worms found in similar wood used in the TreeReef structures in the Wadden Sea (Dickson *et al.*, 2023).

The findings align with a previous study by Didderen *et al.* (2013), which recorded 11 to 75 species near artificial hard substrates within 75 km of the coast. The 39 species recorded this year underscore the biodiversity potential of such structures. Scrape samples could extend the species list further, though this is beyond the current project's scope.

Efforts to enhance North Sea ecosystems are evident, particularly with the occurrence of biogenic reef builders and system indicator species. In 2024, *Owenia sp.* was found abundantly around three structures and *Lanice conchilega* at one structure, complementing earlier records of other reef building species like *Sabellaria sp.*

Predatory species observed included pout (in significant numbers), cod (rare sightings), and conger eels (also rare). This marks the first year cod and conger eels were recorded.

Clarification

Execution

All described activities took place at the OTS, approximately 12 km from the coast of Scheveningen. The investigated structures are in a plot (1x1 km) of The Rich North Sea at a depth of approx. 20 m. An inventory of the biodiversity on and surrounding the structures is obtained by professional divers. Before diving, the structures were located by sonar. The dives took place on 23 and 24 September, 2024. From the MS Tender two dives were made per day. The survey was carried out by two SCUBA divers. Visibility was limited from 1 – 4 m. During the dives, the maximum no-deco dive times were used.

All four structures (Cephalopod and Mussel Reef Cubes® by ARC Marine, (T)Ree(F) by NIOZ and the Waardenburg Ecology Research Cage (WERC-dock) were located and data collected. The following biological work was carried out:

- Photo collection of quadrants (20x30 cm): mainly overview photos were taken of the structures;
- Video recordings were made by the technical diver. The videos can be used for biodiversity and abundance according to MOO classification;
- Registration of the presence of reef building indicator species (mussels, oysters, sand mason worm, ross worm);
- Inventory of reef-associated and reef-benefitting species (Bureau Waardenburg, 2020) like predators including cod, pollack, pout, brown crab and lobster.

Physical conditions of the structures

Next to the biological work, there was also a focus on the following questions:

- Are the structures straight/how do they stand in relation to the sand?
 - o Both the Reef Cubes® and the WERC-dock are in upright position and looked fine. The (T)REE(F) was turned upside down and located 50 m away from its original position. Additionally, a few branches were collected for further research to be performed by NIOZ.
 - o Around Reef Cubes® structures there is a scour trench of ca. 1m width.
 - o At the WERC-dock, the pole was movable, and the platform could still be rotated. The legs of the construction are under the sand. The lower plateau emerges 15 cm above the sand.
- Is the buoy stone close to the structure? Is it possible for these to collide with the structure during heavy wave action?
 - o All structures, excluding (T)REE(F), are located on the original coordinates. The buoy stones of the structures were not visited by the divers and the risk of collision during heavy wave action could not be assessed. However, the (T)REE(F) structures has moved, which could pose a risk to the buoy stone, the (T)REE(F) structure and other surrounding structures in the OTS area.
- Are there physical damages?
 - o The two Reef Cubes® structures are still intact. The steel cables are showing signs of deterioration.
 - o The WERC-dock did not show any physical damages, however the attached baskets were not observed. One corner of the first turnable layer is stuck in de sand. The second layer is free of the sand and to turn around the axis.
 - o The (T)REE(F) was flipped upside down and found at an entirely different location. The tree branches attached inside the cage could still be accessed and did not seem to have any physical damages.

Biodiversity

Biodiversity measurements of the structures and on the sand surrounding the structures were performed by SCUBA divers. The biodiversity is monitored using the standardized Monitoring Underwater Organisms (MOO) forms of the ANEMOON foundation and image and video analysis by The Rich North Sea. The results are delivered as digital MOO forms (see Table 1). During the dive inventory in total 39 species were identified (Table 1).

All structures were fully covered with faunal growth, see Figure 1. On all structures the plumose anemone (*Metridium senile*) was the dominant organism. On the Reef Cube® Mussels and (T)REE(F) the oaten pipes hydroid (*Tubularia indivisa*) was also present in large numbers. The biogenic reef building species *Sabellaria sp.*, was not present in the grinding trench and on the seabed near the structures. However, the sand mason worm (*Lanice conchilega*) was observed at the WERC-dock and *Owenia sp.* was abundantly identified around three of the four structures. Additionally, a single individual of the large necklace shell (*Euspira catena*) was observed at the (T)REE(F) structure.

Inventory system indicator species (mobile species)

The SCUBA divers also made an inventory of the presence of mobile species. The species and an approximation of the number of mobile species on the bottom were noted, including crustaceans. The organisms seen on and around the structures are amongst others pouting, cod, blennies, dragonet, starfish, brittle stars, brown crab, flying crabs and conger eel. Ray, cod, other large crustaceans, cuttlefish and squids have not been observed. Including any eggs of these species.

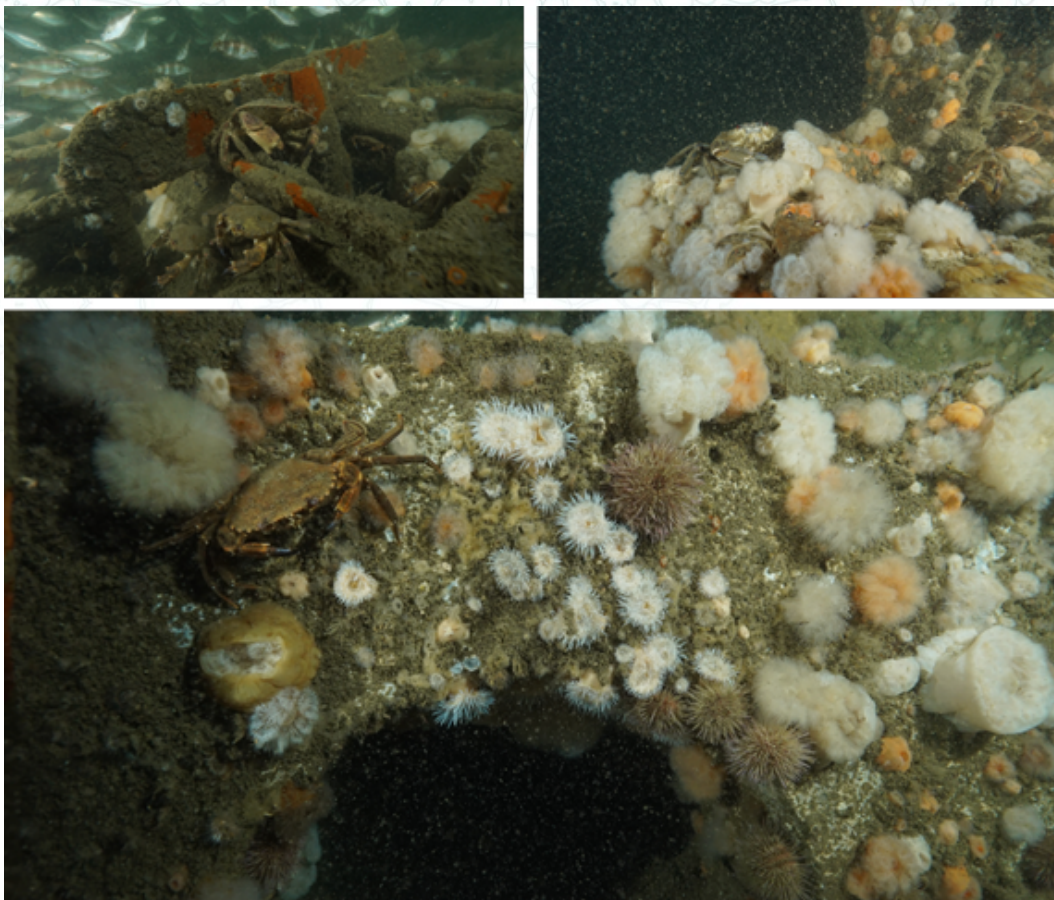


Figure 1 Top left: Brown crab located at the (T)REE(F). Top right: Velvet crab with biofouling community. Bottom: Velvet crab with biofouling community and green/shore sea urchins.

Table 1 Species abundance on and around the structures, observed by SCUBA divers. Species marked black were found both in 2021, 2023 and 2024. Species marked in green were only observed in 2024. Species marked in yellow were only observed in 2023 and 2024. Species marked in pink were found in 2021 and 2024. Species marked in grey were only observed in one previous year.

Species group	Dutch name	Scientific name	Cube Cephalopod			Cube Mussel			WERC-dock			(T)REE(F)		
			R	C	M	R	C	M	R	C	M	R	C	M
Sponges	Oranje korstspoons	<i>Prosuberites epiphytum</i>	1											
Sea anemones	Zeeanjelier	<i>Metridium senile</i>			1			1			1			1
	Slibanemoon	<i>Sagartia troglodytes</i>			1			1	1				1	
	Sierlijke slibanemoon	<i>Sagartia elegans</i>			1								1	
	Golfbrekeranemoon	<i>Diadumene cincta</i>												1
Jellyfish & hydrozoans	Pennéschaaf	<i>Tubularia indivisa</i>			1			1						1
	Ruwe zeerasp	<i>Hydractinia echinata</i>	1				1		1				1	
	Haringgraaf	<i>Halecium halecinum</i>												1
	Zeedraad (onb.)	<i>Obelia sp.</i>			1			1		1				1
	Gorgelpijp-poliep	<i>Ectoleura taraxacum</i>												1
Oorkwal	<i>Aurelia Aurita</i>												1	
Comb jellies	Amerikaanse ribkwal	<i>Mnemiopsis leidyi</i>			1		1		1				1	
Snails	Fuikhoorn (onb.)	<i>Nassarius spec.</i>						1						
	Grote tepelhoren	<i>Euspira catena</i>											1	
Bivalves	Mossel	<i>Mytilus edulis</i>												1
	Zwaardschede (onb.)	<i>Ensis spec.</i>							1					
	Nonnetje	<i>Limecola balthica</i>											1	
Crustaceans	Europese Zeekreeft	<i>Homarus Gammarus</i>	1											
	Noordzeekrab	<i>Cancer pagurus</i>		1				1		1			1	
	Fluwelen zwemkrab	<i>Necora puber</i>			1			1				1	1	
	Blauwpootzwemkrab	<i>Liocarcinus depurator</i>	1											
	Gewone zwemkrab	<i>Liocarcinus holstatus</i>	1				1						1	
	Marmekreeftjes	<i>Jassa herdmani</i>						1						1
	Gewone garnaal	<i>Crangon crangon</i>												
	Zeepek (onb.)	<i>Sessilia spec.</i>												
	Strandkrab	<i>Garcinus maehas</i>												
	Penseetkrab	<i>Hemigrapsus takanoi</i>												
Porceleinkrabbetje	<i>Pisidia longicomis</i>													
Hooiwagenkrab (onb.)	<i>Maropodia spec.</i>													
Worms	Schelpkokerworm	<i>Lanice conchilega</i>						1		1				
	Zandkokerworm	<i>Sabellaria spec.</i>								1				
	Driekantige kalkkokerworm	<i>Spirobranchus triqueter</i>								1				
Moss animals	Owenia (onb.)	<i>Owenia spec.</i>			1			1			1			
	Mosdiertje (onb.)	<i>Electra pilosa</i>			1						1			
Echinodermata	Gewone zeester	<i>Asterias rubens</i>			1		1			1				1
	Brokkelster	<i>Ophiotrix fragilis</i>												
	Gewone slangster	<i>Ophiura ophiura</i>			1			1			1			1
	Gewone zeeappel	<i>Psammechinus miliaris</i>			1			1	1					
Tunicates	Zeeplit	<i>Echinocardium cordatum</i>					1							1
	Grijze korstzakpijp	<i>Diplosoma listerianum</i>	1											1
Fishes	Steenbolk	<i>Trisopterus luscus</i>			1			1			1			1
	Pitvis	<i>Callionymus lyra</i>	1				1		1			1		
	Kabeljauw	<i>Gadus morhua</i>	1											
	Botervis	<i>Pholis gunnellus</i>					1							
	Gehoornde slijmvis	<i>Parablennius gattorugine</i>	1										1	
	Dikkopje/bodemgrondel	<i>Pomatoschistus spec.</i>			1			1						1
	Schar	<i>Limanda limanda</i>												1
	Conger aal	<i>Conger conger</i>	1											1
	Gewone zeedonderpad	<i>Myoxocephalus scorpius</i>												
	Groene zeedonderpad	<i>Taurulus bubalis</i>												
Total			25			22			17			27		
R	Rare: 1-9 living individuals/colonies													
C	Common: 10-99 living individuals/colonies													
M	Massive: more than 100 living individuals/colonies													

Reef-building indicator species

The presence of reef-building indicator species may indicate the start of increased biodiversity as the species offer food, spawning and hiding possibilities. The species in question are mainly the Ross worm (*Sabellaria spinulosa*), the Sand mason worm (*Lanice conchilega*), the Common mussel (*Mytilus edulis*) and Oysters (*Ostrea* and *Crassostrea gigas*). During the dive survey in earlier years the presence of these biogenic reef builders on and around the structures were recorded. In the 2024 survey, only the sand mason worm (*Lanice conchilega*) and common mussel (*Mytilus edulis*) were observed.

The species that was observed at the Reef Cube® Cephalopoda, Reef Cube® Mussel and WERC-dock is *Owenia sp* and the sand mason worm only at the WERC-dock. These species are considered ecosystem engineers. They build their tubes for protection from hydrodynamics and predators, which in turn provide stability to the benthic soft sediment and influence the structure of the benthic community regarding diversity, abundances and spatial distribution.

References

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For questions about this note, please contact Debby Barbé.

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