



NOTE

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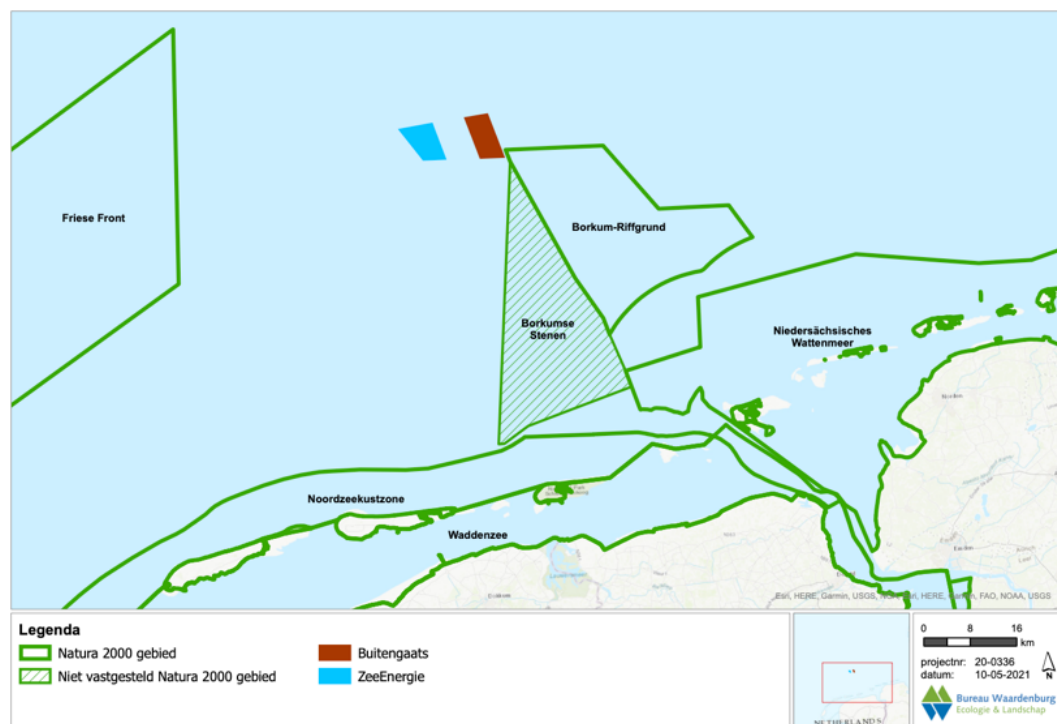
Exploring Grid Surveys at OWF Gemini: *Insights into the status of Ostrea edulis.*



1 Introduction

The primary objective of the Rich North Sea (DRN) is the creation of reefs and elevate biodiversity within North Sea offshore wind farms (OWFs). This goal is pursued through developing and implementing Nature Enhancement Options within multiple offshore windfarms (OWFs).

Reefs will be constructed using species like flat oysters (*Ostrea edulis*) and tubeworms, along with artificial structures. This program addresses supply chain issues for reef-building organisms in nature enhancement projects. Simultaneously, advocating for new policies encouraging the integration of nature development and offshore wind energy. The knowledge developed will be openly accessible through a 'Toolbox for Nature Development in OWFs', aiming for the long-term goal of establishing rich underwater life and making nature-enhancing measures the new standard in OWF construction.

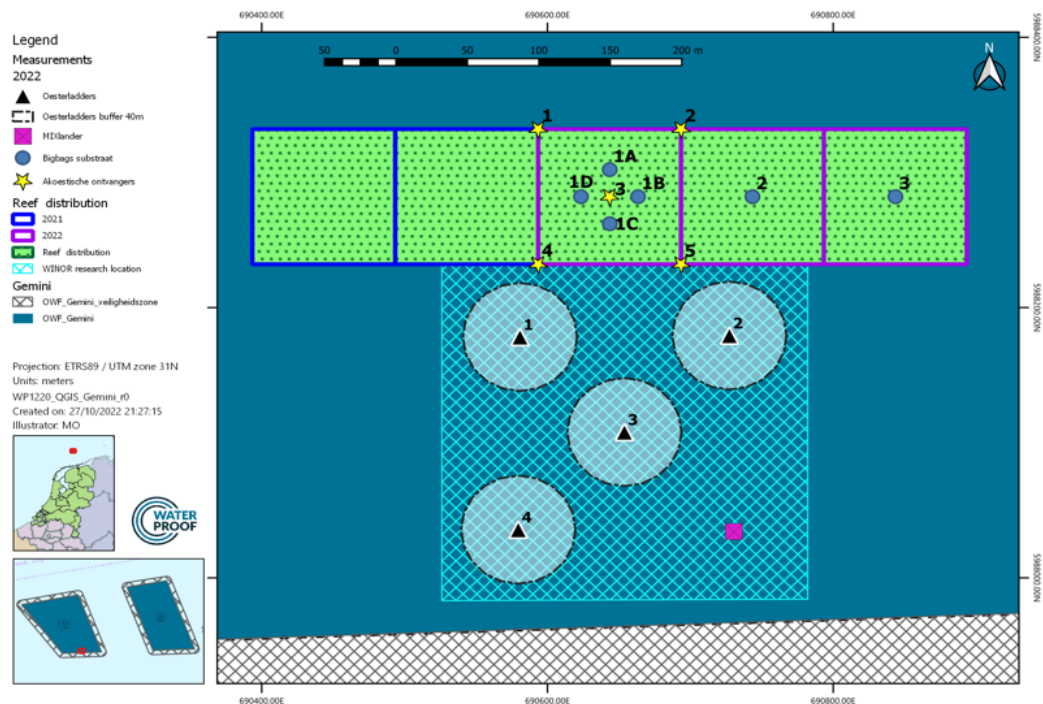


Map 1: Location of Gemini, existing out of two locations, Buitengaats (red) and ZeeEnergie (blue). ZeeEnergie is the scope of this project.

At the Dutch Offshore Wind Farm Gemini, situated within the ZeeEnergie area (depicted as the blue grid on Map 1), DRN is conducting research on a nature enhancement project focused on (re)introducing native *O. edulis*. To achieve this, bigbags containing BESE-reef paste, (oyster) shell material, and living adult *O. edulis* were deployed on November 11th and 12th, 2022. These deployments were executed across three specific areas, as indicated



on Map 2. In Area 1, a total of 10 big bags were deployed, utilizing oyster shells as substrate, and containing 560 *O. edulis* from which 55 tagged. Moving to Area 2, 12 big bags were strategically placed, employing BESE-reef paste as substrate, and accommodating 672 *O. edulis*. Area 3 featured 11 big bags, incorporating shell material as substrate, and hosting 616 *O. edulis*. For a comprehensive overview of the deployment details in each of these three areas, refer to Table 1.



Map 2: The location of the three areas within ZeeEnergie.

Table 1: Information regarding the amount of bigbags and the content of them deployed across the 3 areas.

Date	Area	Bigbags	Amount <i>O. edulis</i>	Tagged <i>O. edulis</i>	Substrate
12-11-2022	1A	2	112	11	Oyster shell
12-11-2022	1B	3	168	18	Oyster shell
12-11-2022	1C	2	112	11	Oyster shell
12-11-2022	1D	3	168	15	Oyster shell
12-11-2022	2	12	672	0	BESE-reef paste
13-11-2022	3	11	616	0	Shell material

On May 28th 2023, at area 1A-D and 2, a Remotely Operated Vehicle (ROV) was deployed to assess the current status of the (oyster) shell material and *O. edulis* that were placed earlier in. Building upon this project's objectives, the current endeavor involves analyzing the conducted grid surveys specifically targeting the status of the restoration affords. Aiming to assess the location of deployed (oyster) shell material/BESE-reef paste and evaluate the current presence and health condition of *O. edulis* within the designated areas.



2 Methods

The video analysis aimed to assess the status of the restoration efforts, looking at location and presence of (oyster) shell material/BESE-reef paste and *O. edulis* health condition, within the Gemini windfarm site using ROV video footage. The following section outlines the procedures followed during the analysis, including data collection, observation parameters, and documentation.

2.1 Data collection ROV

The ROV system was acquiring video footage during a controlled drift over the deposited (oyster) shell material, artificial structures and *O. edulis*. A total of 2 grid surveys were conducted, survey 1 at area 1 and survey 2 at area 2 (overview *Map 2* and *Table 2*). All acquired footage was recorded as video at a resolution of HD (1280 x 720 pixels). The camera angle to the crossbeam varied but was centered around 45° and the ROV was usually less than 1 m from the crossbeam. Both surveys were conducted at the same speed (about 3.2 knots or approximately 0.65 m/s) using a B/W and color video camera with dimmable lights. During acquisition the camera was controlled and monitored from the surface.

2.2 Data Collection Video's

Two grid surveys were conducted at the Gemini research site to obtain comprehensive underwater footage; Grid survey 1, at area 1, included three videos with a total duration of 01:03:31, Grid survey 2, at area 2, comprised four videos with a total duration of 01:38:13. Videos were initially analyzed at normal speed (1x) and subsequently at double speed (x2), facilitating a check on the recorded data. The observations were documented in real-time during pauses, resulting in a total of 67 notes from grid survey 1 and 73 notes from grid survey 2.

Table 2: Information regarding the videos of the two grid surveys.

Area	Grid survey	Total video's	Duration	Notes
1	1	3	01:03:31	67
2	2	4	01:38:13	73

Figure 1 A-D are stills extracted from the video footage, providing a visual representation of the environments in the two grid surveys. In *Figure 1A*, the presence of *O. edulis* is shown amidst shell material and BESE-reef paste, accompanied by an edible crab (*Cancer pagurus*). *Figure 1B* portrays the relatively barren sandy sea bottom, while *Figure 1D* showcases the transition towards the oyster shell-covered area. *Figure 1C* captures the shell-covered region with BESE-reef paste, featuring the presence of a *C. pagurus*.

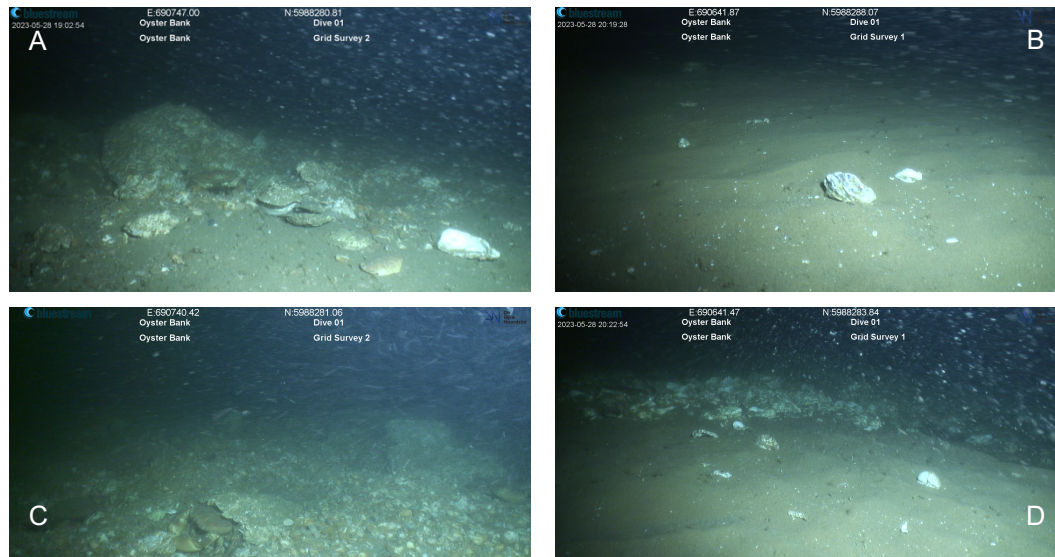


Figure 1: Typical stills of the environment at grid survey 1 and 2. **A:** Grid survey 2 displaying the distributed shell material and BESE-reef paste with some *O. edulis* present next to an *C. pagurus*. **B:** A rather barren sand bottom with some purple pacific oysters (*Crassostrea gigas*) at grid survey 1. **C:** Grid survey 2, deployed shell material and BESE-reef paste with three edible crabs beside it. **D:** The barren sandy bottom turning into one covered with oyster shell material at grid survey 1.

2.3 Observation Parameters

During the video analysis, specific parameters were carefully observed and documented to characterize the *O. edulis* restoration. The primary focus was on identifying the presence of the deployed (oyster) shell material/BESE-reef paste and *O. edulis* and assessing their vitality. Notable observations included:

- Documentation of (oyster) shell material: The analysis involved the presence of the deployed (oyster) shell material (see Figure 1 and 2).
- Identification *O. edulis*: Distinguishing the *O. edulis* from other species like the *C. gigas*. The differentiation involved morphological distinctions, with a focus on the flattened, irregular shape of *O. edulis* (Figure 2A-C), complemented by consideration of color differences (Figure 1B). Occasional confusion arose due to the possibility that the observed oysters might belong to a species other than *O. edulis*, and this uncertainty could not be definitively ruled out (Figure 2D).
- Determination of the *O. edulis* condition: This involved assessing whether they formed doublets (indicating live and healthy status, see Figure 2B & C and the *O. edulis* at the center and right of Figure 2A) and observing the degree of their valve opening (ensuring they were not excessively open, indicative of potential mortality) (see oyster at the left Figure 2A). When (partly) covered in sand and or observing the oyster from a certain angle this assessment was not always made possible (Figure 2D and the right *O. edulis* at Figure 2A).

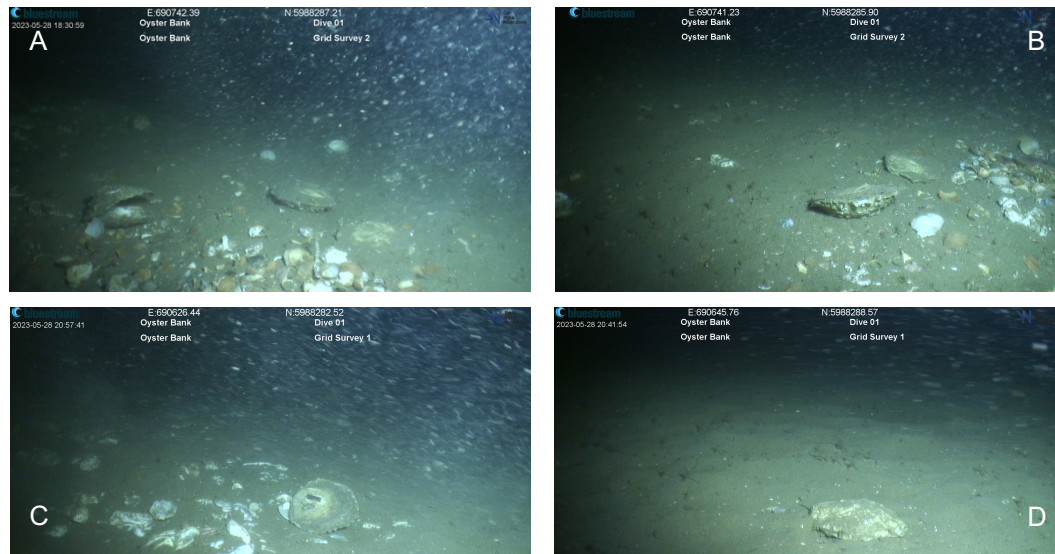


Figure 2: Stills that supporting the parameter assessments. **A:** Grid survey 2 with left a *O. edulis* being dead, in the middle one that is alive and at the right one that is partly covered in sand and noted with an unclear condition. **B:** Grid survey 2, two *O. edulis* alive. **C:** Grid survey 1, number 39 tagged *O. edulis* found alive. **D:** An oyster exhibiting an unclear health condition as well as an unclear species determination.

2.4 Documentation

To ensure educate documentation, each video analysis session involved the systematic recording of relevant information. The following parameters were recorded:

- Date and time: The precise date and time of each video analysis session were noted to establish when the information was gathered and to establish temporal patterns and variations.
- Grid survey information and related video number: This was recorded to correlate findings with the designated survey areas.
- Geospatial coordinates: Geographic coordinates of the analysis location were documented, providing a spatial reference for observed conditions. Proximity of the ROV to the observation was ensured during this documentation.
- Presence of (oyster) shell material: The presence of (oyster) shell material/BESE-reef paste was noted, shedding light on the location remnants of the deployed (oyster) shell material/BESE-reef paste. Resulting in the documentation of where the (oyster) shell material/BESE-reef paste is still present.
- *O. edulis* presence: The presence of *O. edulis* was recorded, specifying whether they were observed during the analysis, contributing to the overall assessment of the restoration effort. Resulting in the three possible answers; **Yes/No/Unclear** ("Unclear" where it cannot be definitively determined whether the oyster is indeed an *O. edulis*).
- *O. edulis* condition: The health of the oysters, being *O. edulis*, was measured regarding whether the oyster consisted out of doublets combined with the degree



of valve opening. Resulting in the three possible answers; **Alive/Deceased/Unclear** (“Unclear” when the assessment of their vitality could not be done due to limits of the ROV).

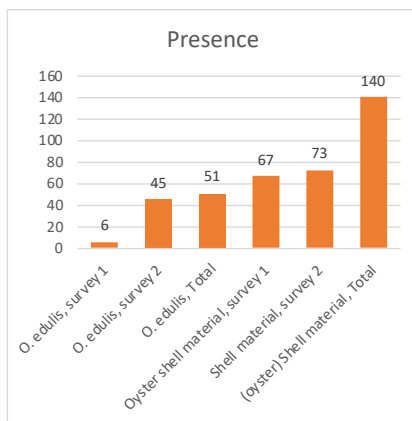
- *O. edulis* quantity: The number of individuals being alive, deceased or with a unclear vitality were counted to quantify the species on the ROV footage.
- Additional comments: Any additional noteworthy observations or environmental factors were recorded to supplement the quantitative data.



3 Results

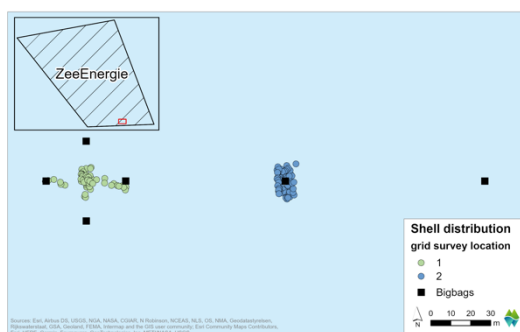
In the results section, the presence of (oyster) shell material/BESE-reef paste and *O. edulis* is covered first. The distribution of both (oyster) shell material and *O. edulis* is elucidated through a detailed map, highlighting key geographic locations. Subsequently, the health conditions of the *O. edulis* is explored, categorized as alive, deceased, or unclear. A depiction of the *O. edulis* conditions and their spatial presence is provided through a map. This analysis is accompanied by a breakdown of some general observations concerning: the difference in distribution of the *O. edulis* and (oyster) shell material/BESE-reef paste, and state of the (oyster) shell material/BESE-reef paste before and after a half year of deployment, and quantities corresponding to each health state for *O. edulis*. These results offer a view into the state of the restoration affords inside the study area.

3.1 Presence

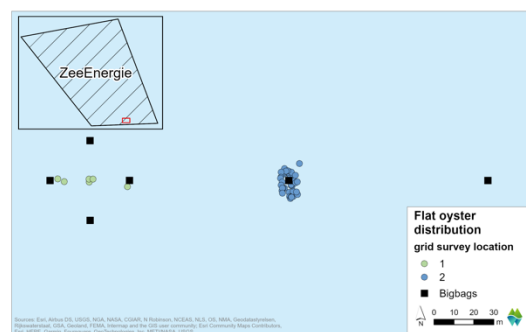


Graph 1: The presence distribution of the *O. edulis* at grid survey 1 and 2.

In total, 140 locations of (oyster) shell material were identified, distributed across two grid surveys (*graph 1*). The distribution of these shells and the *O. edulis* among them is shown on the two maps below. Survey 1, situated on the west side, identified oyster shell material at 67 distinct locations, while survey 2, positioned on the east side, documented shell material at 73 locations (*graph 1, map 1*). Examining the overall presence of *O. edulis*, survey 1 recorded 6 individuals, containing 1 that is tagged with number 39 (*Figure 2C*). Survey 2 documented a presence of 45 individuals (*graph 1 & map 2*). This resulted in a combined total of 51 *O. edulis* distributed across both grid surveys (see *graph 1*).



Map 4: The location of the deployment sites of the bigbags and present (oyster) shell material, distributed across survey 1&2.



Map 3: The location of the deployment sites of the bigbags and present *O. edulis*, distributed across survey 1&2.

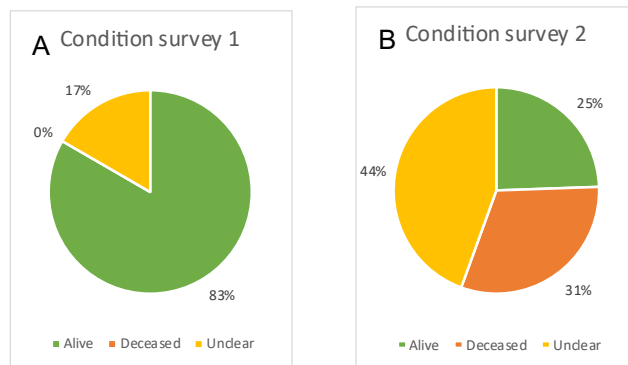


3.2 Condition

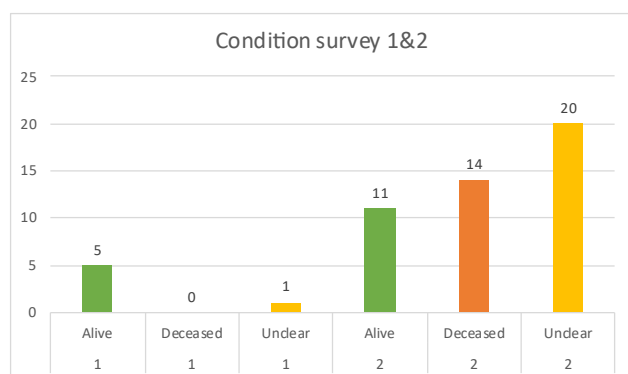
Analysing the health condition of the *O. edulis*, both *graph 2 (A & B)* and *graph 3* provide a visual representation of the distribution of alive, deceased and unclear *O. edulis* within the respective surveys.

In Survey 1, as illustrated in *Graph 2A*, 83% of *O. edulis* are found alive in the central and western part, with 0% recorded as deceased and 17% exhibiting an unclear condition at the east part of location 1 (*Map 3*). The Contrarily, in Survey 2 (*Graph 2B*), the distribution varies, with 25% alive, 31% deceased, and 44% exhibiting an unclear condition. These conditions are all spread across location 2 (*Map 4*).

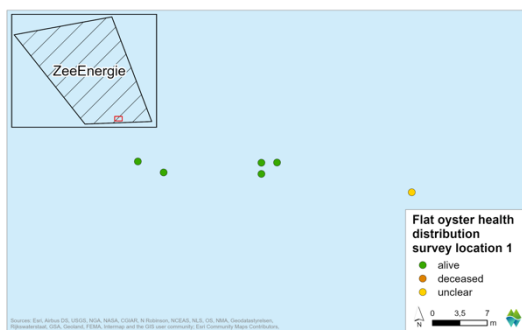
Graph 3 provides a better essence of the health conditions across both grid surveys, offering a broad perspective. The contrasting ratios in alive, deceased, and unclear conditions underscore the variability in the well-being of *O. edulis* between the surveyed areas.



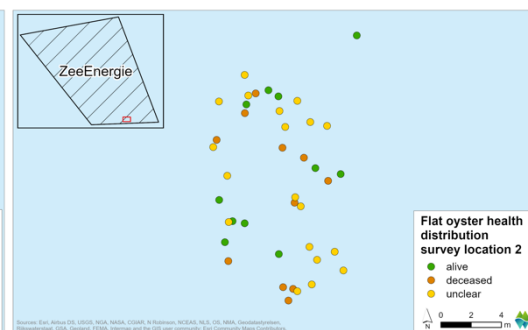
Graph 2: Health condition of the O. edulis. A: Percentages of alive, deceased and unclear O. edulis in survey 1. B: Percentages of alive, deceased and unclear O. edulis in survey 2.



Graph 3: Health condition in values of the O. edulis in survey 1&2.



Map 5: Distribution of the O. edulis health condition across survey 1.



Map 6: Distribution of the O. edulis health condition across survey 2.



3.3 General

Analyzing the deployment sites of both (oyster) shell material and *O. edulis*, and the examination after six months, grid survey 1 reveals that deployed oyster shell material and *O. edulis* have been recovered within the four points, and around the areas at the most eastern and western points (see location 1 on *Maps 2* and *3*). Similarly, in grid survey 2, shell material and *O. edulis* were located around the deployment site (see location 2 on *Maps 2* and *3*).

The BESE-reef paste blocks are often seen in great condition, with some broken down and others partly. However, the squared BESE-reef paste was less present and seen only once in a broken state (*Figure 3*). The *C. pagurus* are often seen with the BESE-reef paste making ditches for themselves and moving them around seen on *Figure 1 A & C* and *Figure 3*.

Quantifying the presence of *O. edulis*, based on the ROV footage, got the results shown in table 2. In Grid Survey 1, six individuals were observed in a state of vitality, with no recorded deceased individuals and one exhibiting an unclear condition. In contrast, Grid Survey 2 revealed a more varied scenario, with 23 alive, 21 deceased, and 32 *O. edulis* exhibiting an unclear health condition. Survey 1 and 2 consist out of a total of 83 *O. edulis* (when looking at quantities).

These results give an insight into the location of the (oyster) shell material and *O. edulis*, the state of the BESE-reef paste and the amount of *O. edulis* that were found back after a half year of deployment.

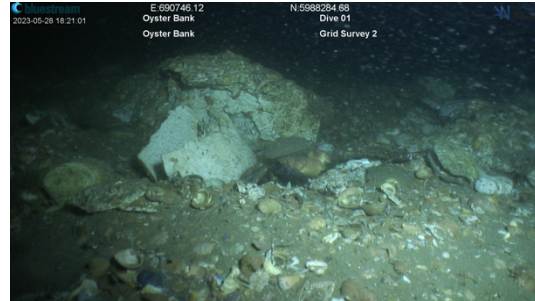


Figure 3: The BESE-reef paste squares with some other BESE-reef paste blocks behind it in the presence of a C. pagurus.

Table 3: O. edulis quantities distributed over the health conditions.

Grid survey	Condition	Quantities
1	Alive	6
	Deceased	0
	Unclear	1
2	Alive	23
	Deceased	21
	Unclear	32
Total	Any	83



Conclusion

The aim of this research segment is to ascertain the status of the restoration efforts at Gemini ZeeEnergie windfarm focusing on area 1 and 2. Assessing the current locations of deployed (oyster) shell material/BESE-reef paste, distribution of *O. edulis* within designated areas, and evaluate their health condition. It can be concluded that the findings indicate that grid survey 2, with 73 locations and 45 *O. edulis* individuals, had the highest ratio of presence in shell material and *O. edulis*. In comparison, grid survey 1 recorded 67 locations containing oyster shell material with 6 *O. edulis* individuals and 1 tagged *O. edulis* marked with the number 39. A total presence of 51 *O. edulis* was found, however taking quantity into consideration a total of 83 *O. edulis* were found back (in any health condition). The geographic distribution of the (oyster) shell material/BESE-reef paste and *O. edulis* exhibits minimal variance, compared to the deployment locations. The BESE-reef paste blocks are in great condition, they are present with only a few/partly broken down. However, the squared BESE-reef paste has only been once detected through the surveys. The highest survival ratio was observed in grid survey 1, with 83% alive oysters, 0% deceased, and 17% with an unclear condition, while Grid Survey 2 exhibited 25% alive, 31% deceased, and 44% unclear. A correlation between spatial distribution and survival rate is not detected.



Discussion

The outcome of this research has provided insights into the presence of the deployed (oyster) shell material/BESE-reef paste, assess the current distribution of *O. edulis* within designated areas, and evaluate their health condition. However, the results should be interpreted with caution due to the limitations of the current research. The limitations and the potential consequences of the research are discussed, as well as the implication for the interpretation of the results.

The results provide a small section of the quantification of the *O. edulis* and their health condition, indicating an even bigger differences between the grids. Conclusive statements about abundance could not be made. Nevertheless, these quantity observations provide a foundation for understanding the amount *O. edulis* found back after the deployment of the restoration efforts within area 1 and 2. Another noteworthy factor contributing to differences between grid survey 1 and grid survey 2 is the significant discrepancy in video footage duration, with survey 2 being 00:34:42 longer. This temporal difference should be considered when interpreting the data to prevent misinterpretation. The additional duration may have allowed for more comprehensive observations and potentially contributed to differences in the recorded data between the two surveys. Besides this factor the sample size of grid survey 1 consisted out of 6 individuals which affects the reliability of the results.

For the determination of the presence of *O. edulis*, the observation parameter "Identification *O. edulis*" was assessed (refer to "2.3 Observation Parameters"). Distinguishing *O. edulis* from other species involved morphological distinctions, primarily focusing on the flattened, irregular shape, complemented by consideration of color differences. However, uncertainties occasionally arose, leading to cases categorized as "unclear." These instances were excluded from the overall presence assessment, potentially introducing the risk of underestimating the species' actual presence in the area. A similar challenge arose by assessing the health condition of *O. edulis*. Factors such as the formation of doublets and the degree of valve opening were considered. Unfortunately, these features were not always clearly visible due to coverage under the sand or the angle at which the ROV observed the *O. edulis*. In instances of uncertainty, the health condition was classified as "unclear". This introduces the possibility of underestimating their vitality.

Furthermore, the locations of the observed oysters are specified by using coordinates provided by the ROV. The proximity of the ROV is therefore crucial for the accuracy of oyster location. Considering an accuracy radius of 2 meters is recommended, as the ROV occasionally maintained a distance from the *O. edulis*. This is for ensuring the reliability and precision of the spatial data, preventing potential inaccuracies in the recorded *O. edulis* locations.



For questions about this note, please contact Edwin Kardinaal.

Signed for publication: Team Manager Bureau Waardenburg bv
dr. W.E.A. Kardinaal,



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