Netherlands Enterprise Agency

Assessment of Sabellaria spinulosa presence in the North Sea - WMR

Nederwiek II&III Wind Farm Zone

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Assessment of *Sabellaria spinulosa* presence in the North Sea

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1. Introduction

Sabellaria spinulosa is a reef-building polychaete that lives in a tube, usually attached to a hard substrate, or other Sabellaria tubes. When worms gather in large numbers, their tubes may stand upright and create crusts or mounds that span several meters. Unaggregated individuals can reach densities of up to 300 ind. m^{-2}, while in aggregations, densities of 4000 ind. m^{-2} have been observed (George and Warwick 1985). However, reefs can only be formed in specific geomorphological areas, such as sandy or gravelly seafloors, the edges of sandbanks, channels, and drop-offs, along with conditions, such as high turbidity, elevated sediment levels, moderate currents and a moderate amount of suspended organic particles. This species prefers areas with high bottom shear stress, mobile sand and high gravel content of the sediment (Jackson & Hiscock, 2008; Jackson-Blue et al., 2022; Gaida et al., 2023). In areas where *S. spinulosa* reefs are present, they can offer a diverse habitat for various invertebrates and juvenile fish. These reefs help stabilise sediments and promote nutrient cycling by offering access to essential resources like food and shelter (De Smet et al. 2013, Rabaut et al. 2013). Offshore anthropogenic structures, such as offshore wind farms (OWFs), may provide such habitats for this species due to the provisioning of artificial hard substrate such as scour protection layers, turbine foundations and cable crossings in combination with local scouring which can lead to high bottom shear stress and availability of mobile sand. Furthermore, OWFs in the Dutch North Sea are closed to bottom disturbing fisheries, which could facilitate the development of *S. spinulosa reefs*, as reefs experience pressures of abrasion (Baptist et al. 2024).

The reefs that *S. spinulosa* forms are listed as habitats under threat and/or declining in the North Sea by OSPAR (OSPAR Commission, 2013). This species has been observed multiple times in Dutch waters, both in relation to OWFs (Princess Amalia, Borssele) and oil and gas platforms, as well as natural reefs, such as the Borkum Reef Grounds (Vanagt & Faasse, 2014; Coolen et al. 2020; Bos et al., 2024; Kingma et al., 2024) and on ship wrecks (personal observations Joop Coolen). Within the Dutch North Sea, the species has also been observed forming reefs in sandbank troughs in the Brown Bank area (van der Reijden et al. 2019). Furthermore, it has been selected as a species of interest for nature restoration or nature inclusive design target species in OWF development (Sas et al., 2023).

For the suitability of OWF development for *Sabellaria spinulosa* reefs, further research and knowledge is needed. The Netherlands Enterprise Agency ("Rijksdienst Voor Ondernemend Nederland" or RVO) has commissioned Wageningen Marine Research (WMR), Deltares and TNO to assess the suitability of the Nederwiek II and III wind farm development site for the establishment of *Sabellaria spinulosa*. This report is part of a series of 3 reports and will focus on the results of WMR on:

(a) Reviewing published reports/articles to identify records of *Sabellaria spinulosa* within the Dutch North Sea and within offshore windfarms on a wider North Sea scale, and;

(b) Coordinating a data call and search to collect data that we (WMR and Deltares) are not aware of containing observations of *Sabellaria spinulosa*, leveraging international benthic networks within ICES, such as the ICES Working Group on Marine Benthos and Renewable Energy Developments (WGMBRED), which would provide more data points for both the WMR data analysis and the models created by Deltares.

All the data that came to our possession after the data call were used for this study. Points (a) and (b) were fully handled by WMR. The data that were collected by the data call and search coordinated by WMR were processed and provided to Deltares with the aim to construct a statistical (R-INLA) model that predicts the occurrence of *Sabellaria spinulosa* (both individuals and reefs) based on previous occurrences and abiotic properties of the wider North Sea and use this model to predict this species presence in the Nederwiek area. The final goal was to create a suitability map for the occurrence of *Sabellaria spinulosa* in the wider North Sea, the results of which are available in the Deltares report (please see report provided by Deltares entitled "Habitat suitability Sabellaria spinulosa in wind area Nederwiek Noord").

2. Materials and Methods

2.1 Literature review

A brief literature review was carried out to identify observations and distribution of *S. spinulosa* (individuals and/or reefs) initially in the Dutch North Sea and at a second step at offshore windfarms in the wider North Sea area. The search was performed using the keywords: "Sabellaria AND Netherlands AND North Sea" and "Sabellaria AND offshore AND wind" in both Scopus and Google Scholar. Only reports and research articles considered relevant to the study objectives were further examined. In total, 15 research articles and 7 reports were taken into account for the purposes of this study (see Table S1 in Annex I).

2.2 Data call and analysis

As input for the *S. spinulosa* habitat suitability model to be created by Deltares, absence/presence data was collected from several sources. A data call organized by WMR was distributed in the WMR network in April 2025. Additionally, existing WMR databases ('BEAST' and 'FRISBE') together with international databases (BISAR – Dannheim et al. 2025 – and IHM - https://www.informatiehuismarien.nl/) were scanned to extract data of *Sabellaria spinulosa*. Deltares had already in their possession the data present in the WMR-FRISBE database that contains fish survey data using beam trawls (from both BTS surveys and from surveys on bottom-trawl fishing vessels). They have used these data for their initial habitat suitability model of *S. spinulosa*. This database was, therefore, not considered any further in the current report but descriptions can be found in Bos et al. (2019, 2024), and Herman and Rees van (2022). As Deltares also has access to the Informatiehuis Marine (IHM) this data source was not considered.

Further data preparation was needed, as every dataset that we received had a different format and a different scope. Each field campaign in the different datasets was designed to target certain species (or taxonomic groups) of interest. For this purpose, they were using specific and variate gear type(s) that are targeting to collect the species of interest. When selecting the gear type and taxonomic group of interest, other species that were collected were considered as by-catch and they might not have received the same attention as the species of interest. When sediment samples were collected, they were first sieved to get rid of unwanted materials, such as inorganic matter, and the mesh-size of the sieves was selected based on the species of interest of every campaign. Depending on the different methods used in every fieldwork, it was possible that *S. spinulosa* could not be collected by the sampling gear used. Other possibilities were that *S. spinulosa* was sampled by the gear, but the mesh-size of the sieve was too large to capture the individuals, and thus, the species could not be identified/counted. To prevent reporting false absent data, a combination of campaign and gear was used to filter the data, where the possibility that Annelida (the phylum under which *S. spinulosa* falls) could be properly collected and analysed was considered. If a single campaign consisted of samplings conducted in multiple years, each sampling year was analysed separately. Phylum information for all taxa in each campaign-gear combination was used for this purpose. Only campaign-gear combinations for which at least 5% of all taxa reported belonged to the phylum Annelida were considered valid and included in the total dataset. When phylum information was not provided, it was further searched. The World Register of Marine Species (WoRMS, 2016) database was used for this purpose. AphiaID (in the cases that it was reported) was taken into account to search for Phylum information. AphiaID is a unique identifier used by WoRMS assigned to each taxon in the Aphia database, which is also backend of WoRMS and serves as a stable, persistent identifier for a specific taxonomic concept In the cases where AphiaID was not reported, then the scientific name was used instead. The software program R, R Core Team (2024) and the package ‘worrms’, Chamberlain and Van Hoorne (2023) was used to perform the search. Different notations for the same gear type (e.g. ‘box core’, ‘Boxcore’, ‘boxcorer’) were made uniform prior analysis without considering differences in sampled area. For cases where no gear type was reported, the gear type was set to ‘unknown’.

The data extracted from the databases and datasets that could be included here varied in methods and in registered units. Reported units included counts on sample level and/or densities per sampled area (usually m^2), and/or fresh- dry- or ash free dry weights, or consisted of presence / absence data. All data was converted to presence / absence as the model of Deltares requires this, regardless of the unit and without using any threshold level (so even the count of one individual worm is considered as being present, thus, even if reefs were present this was not considered into the Deltares model). This together with a sampling campaign identification number, sample date and -location were stored and sent delivered to Deltares for the incorporation of the data in their model.

3. Results

3.1 Literature review

The brief literature review aiming at identifing observations and distribution of *S. spinulosa* in the Dutch North Sea and at a second step at offshore windfarms in the wider North Sea area brought up valuable knowledge:

- The distribution of *S. spinulosa* is influenced by various environmental factors such as substrate type, sand availability, hydrodynamics, and human activities.
  - *S. spinulosa* inhabits hard substrates along exposed, open coastlines where sand is available for tube construction. While it is mainly found in subtidal zones, it can also be found in the lower intertidal areas (Jackson & Hiscock, 2008).
  - The main distribution of Sabellaria is located in highly dynamic, high-energy waters. Particularly, closer to the English coast, as well as in regions in Scotland, the Channel and the Irish Sea (Herman & Van Rees, 2022; Bos et al., 2024) This is required to resuspend sediment and bring more food particles.
  - For reef formation *S. spinulosa* requires relatively high levels of suspended sediment (Davies et al., 2009; Jackson & Hiscock, 2008).
  - Human activities, especially bottom-trawling fisheries such as beam trawling, can physically damage or remove *S. spinulosa* individuals and/or reefs (Gibb et al., 2014; Pearce et al., 2017).
- Reef structures are predominantly formed in areas with a continuous supply of suspended sand particles and mostly in regions with hard substrates for attachment (Pearce, 2014; Lisco et al., 2017). *Sabellaria spinulosa* reefs enhance local food availability, increase habitat complexity, and offer shelter and settlement surfaces for various organisms, thereby forming biodiversity hotspots (Hendrick & Foster-Smith, 2006; Pearce, 2014; Gravina et al., 2018; van der Reijden et al., 2019).
- *S. spinulosa* reefs are included as priority habitats under both the EU Habitat Directive (European Commission, 1992) and the OSPAR convention (OSPAR Commission, 2013).
- On the Dutch Continental Shelf S*. spinulosa* reefs of high densities and significant size were first documented in 2017 in the sand valleys of the Brown Bank area, a dynamic sandbank system characterized by large scale tidal ridges and smaller scale sand waves. It is hypothesized that the troughs between sand waves provide suitable substrate for settlement, are characterized by turbid conditions with a continuous supply of sand grains (necessary for the tube building) and offer refuge from abrasion caused by fishing activities in this area (van der Reijden et al., 2019).
- *S. spinulosa* was frequently observed at artificial substrates such as scour protection in windfarms, shipwrecks, and oil and gas platforms (Bos et al., 2019, Coolen et al., 2020). In particular, high densities were observed at locations north of the Nederwiek area (Bos et al., 2019). For instance, in the Hywind Scotland Pilot Park *S. spinulosa* was observed colonizing concrete mattresses used for mooring lines (Karlsson et al., 2022). Furthermore, *S. spinulosa* was found in scrape samples of offshore turbine foundations and scour protection rocks in the Princess Amalia offshore windfarm (Vanagt & Faasse, 2014).
- *S. spinulosa* colonies were also recorded at the Frisian Front in 2019 (NIOZ, n.d.).

3.2 Data availability and analysis

In the WMR-database BEAST that contains all the data collected within WMR (not specifically targeting *S. spinulosa*), species densities data originated from sampling campaigns using box corers, van Veen- or Hamon grabs, or using scrape samples of rocks or artificial hard substrates, such as shipwrecks and platform foundations. Samples are typically preserved on board in ethanol or formaldehyde and species are identified in the laboratory. Sediment samples were generally sieved over a 1 mm mesh sieve that can catch all the species that are larger than > 1 mm. This includes Annelida species such as *S. spinulosa*.

References of most datasets extracted from the BEAST are:

- Different baseline- and post drill surveys around oil- and gas platforms; Glorius and Kaag (2011), Glorius et al. (2011), Glorius et al. (2013), Glorius et al. (2014), Glorius et al. (2015).
- Inventory of biodiversity and habitats in Borkum Reef Grounds; Bos et al. (prep); Bos et al. (2014).
- Development and implementation of methods and techniques to improve biodiversity in offshore wind farms: Kingma et al. (2024).
- Other datasets from projects of WMR, such as KOBINE, H2020 UNITED, Oceans of Energy project, etc.

The BISAR database (Biodiversity Information of benthic Species at ARtificial structures) was accessed on 8th of March 2025 to extract all data. This publicly available database can be accessed via the CRITTERBASE web portal and is described in Dannheim et al. (2025). Data in BISAR that are also included in BEAST were excluded to avoid duplicated data points.

The data call that we organised in April resulted in three more datasets next to the databases that we had in our possession (BEAST and BISAR):

- Long-term monitoring data of Offshore Wind Farms in the Belgian part of the North Sea, period 2005 – 2023 and applying van Veen grab sampler (doi.org/10.24417/bmdc.be:dataset:2880).
- Rijkswaterstaat MWTL data from the Cleaver Bank, years 2018, 2019 and 2021 with the use of a Hamon grab and video surveys (Driessen et al., 2018; Verduin et al., 2020; Schellekens, 2022; Leewis and Dzon, 2022).
- ReViFES Borkum reef grounds and Voordelta sampled in 2020 using box corers and Hamon grabs (Coral et al., submitted).

The final dataset consisted of 175 campaign-gear combinations and 7192 sampling points. The most used sampling gear was the Van Veen grab (Table 1). The percentage of Annelida species in the species pool in every campaign-gear combination is shown in the left panel of Figure 1 and per gear type on the right panel. Three campaign-gear combinations were excluded as they contained less than 5% Annelida species (red dots in Figure 1). Between 7 and 54% of the species belonged to the phylum Annelida, on average 28.4% (SD = 10.8). Gear types typically used to sample soft sediment, such as box corer and Van Veen grab samplers, contain the highest percentage Annelida species as can be seen in the right panel of Figure 1.

Table 1. Number of sampling points per gear type in the final dataset.

Gear	Nr. Samples
Van Veen	4011
Scrape	970
Hard bottom frame	793
Boxcorer	629
Reinecker-Kastengreifer	360
Video	161
Hamon	111
Unkown	80
Rock	48
Marine growth sampling tool	29

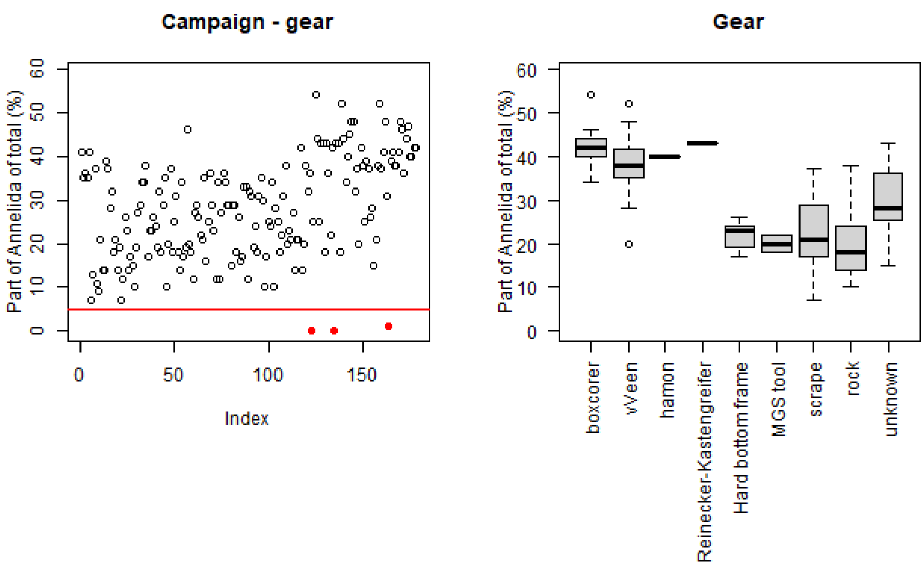

Figure 1. Percentage of Annelida species in the species pool in the combined dataset. In the left panel per campaign-gear type combination and in the right panel per gear type (excluding the three campaign-gear combinations below the 5% threshold).

A map of the location of each sample is shown in Figure 2 together with the used gear type.

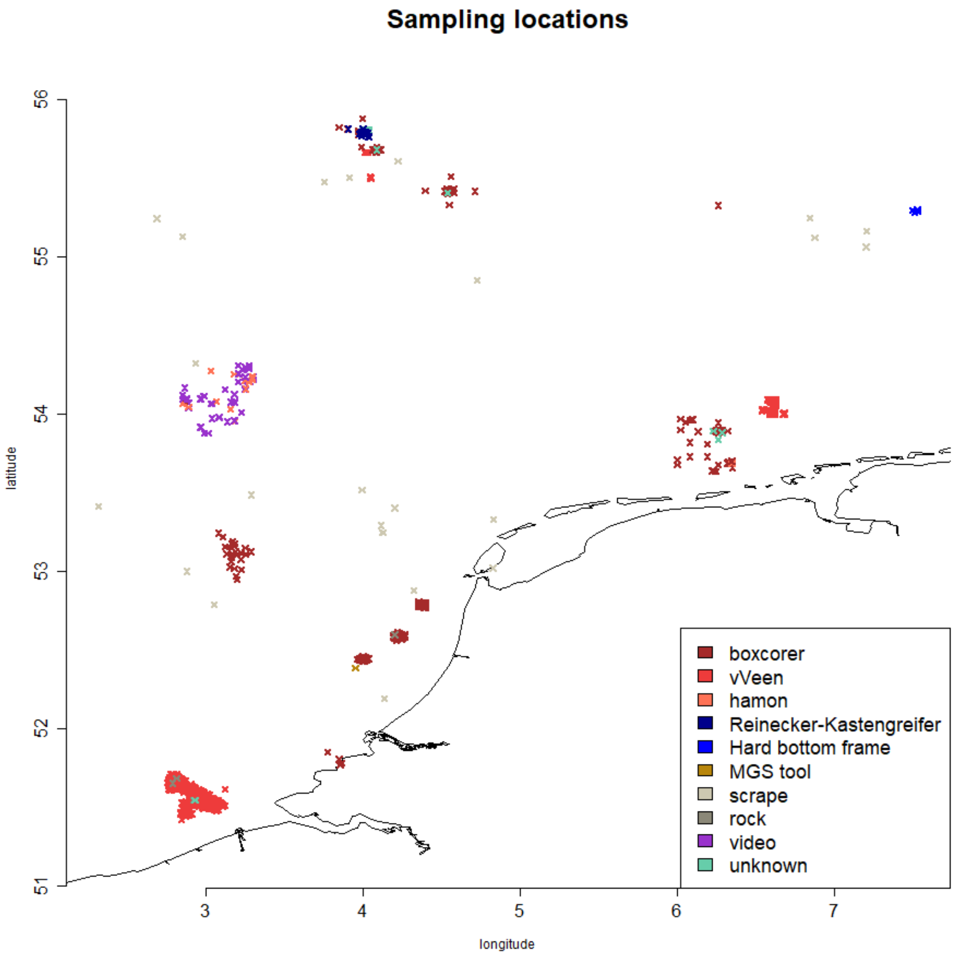

Figure 2. Sampling locations of combined dataset sent to Deltares, including gear type used.

All the relevant data described in all the datasets (excluding the three campaign-gear combinations that contained < 5 % of Annelida) were shared with Deltares for fitting the *S. spinulosa* habitat suitability statistical R_INLA model (please see Deltares report entitled "Habitat suitability *Sabellaria spinulosa* in wind area Nederwiek Noord").

4. Discussion

From the literature review, we could not find any information on the presence of *Sabellaria spinulosa* within the Nederwiek II and III areas specifically. From the review we found that *S. spinulosa* prefers a mixture of hard and soft habitats, as it needs the hard surfaces for initial attachment (Pearce, 2014; Lisco et., 2017), while sand particles are necessary for it to build its tubes and create reefs (Davies et al., 2009; Jackson & Hiscock, 2008). Moreover, polychaete larvae, including larvae of *S. spinulosa*, are considered widely distributed throughout the North Sea basin (van Walraven et al. 2023). This suggests that the primary bottleneck for *S. spinulosa* development in the Dutch North Sea is likely not larval availability or the availability on suspended particles, but the presence of settlement surface. Therefore, we hypothesize that when offshore wind turbine foundations and their scour protection layers are built in the Nederwiek II and III areas, *S. spinulosa* individuals could attach to the available substrates. Especially the scour protection layers may offer the conditions that *S. spinulosa* needs, namely the hard substrates (rocks) for the attachment and the proximity to sand particles for the tube building. Furthermore, the current exclusion of bottom trawling within offshore windfarms may promote the formation of *S. spinulosa* aggregations.

The *S. spinulosa* presence/absence data used in this study were collected to create a distribution input layer for the habitat suitability model that was created by Deltares and published in their report ("Habitat suitability *Sabellaria spinulosa* in wind area Nederwiek Noord"). There is large variation in the sampling methodologies. Sampling locations were not uniformly distributed over the area of interest; sampling moments varied largely between campaigns and many differences in gear types were observed. All these factors lead to variation in detection strength for *S. spinulosa* between campaigns and areas that will decrease the model fit and therefore the reliability of the habitat suitability map that will be generated. For instance, *S. spinulosa* reefs can be smothered with sediments decreasing their detection during video surveys. Grab samplers, like Van Veen grabs or box corers, will have an increased detection efficiency since they collect physical samples that can be thoroughly analysed. On the other hand, grab samples will in general sample a much lower surface area compared to video transects, increasing the risk of missing a reef structure. Therefore, if one location relies heavily (or exclusively) on data obtained from video transects, and another uses a grab sampler as only gear to collect information, the potential observed differences in *S. spinulosa* presence may stem from the sampling methodology rather than the actual habitat suitability. The same issue arises when there are significant temporal gaps between sampling events (e.g. several years). In areas where many samples have been collected versus those with few or no samples collected, suitable or unsuitable habitats may be over- or underrepresented in the dataset. This is particularly relevant when considering substrate type, as areas with soft substrates may be sampled more frequently than those with hard substrates (since hard substrate sampling requires more difficult techniques, such as diving), potentially skewing the perceived distribution of *S. spinulosa*. For these reasons, the most reliable data for constructing a habitat suitability map would come from a dedicated survey campaign using a single gear type (or the combination of multiple gear types) capable of consistently detecting the presence of *S. spinulosa*. Ideally, sampling effort should be uniformly distributed across the areas of interest, with minimal temporal variation between sample sites. Furthermore, sampling locations should be arranged on a grid fine enough to capture spatial variation in habitat characteristics, and especially the presence of hard substrates as they are the bottleneck for the species settlement and the reef formation. Furthermore, a fine grid on sampling locations might ensure full coverage of the area of interest (Nederwiek areas II and II), which could allow for identification of any type of hard substrate within the area.

In the current analysis, no distinction was made between the type of sampling matrix (e.g. soft sediment, rocks or artificial structures) and *S. spinulosa* densities. As a first step, explicitly incorporating the sampling matrix at each location could improve the interpretation of the resulting habitat suitability map. Secondly, using worm density data instead of simple presence/absence may lead to more informative and interpretable maps. Higher Sabellaria densities would then give greater weight to highly suitable areas and may also help distinguish between solitary individuals and reef-forming populations.

This approach would require additional effort to refine the dataset previously sent to Deltares, as well as the dataset already used in the initial modelling round of Deltares. It would also reduce the overall dataset size, since not all sampling campaigns recorded both the sampling matrix and density data. Nevertheless, we expect that a more focused, high-quality dataset would yield a habitat suitability map with greater ecological relevance. Finally, several high densities were observed at artificial structures such as the scour protection at platforms and on shipwrecks. These structures offer suitable habitats that are not affected by bottom disturbing fisheries. However, most data available today, originates from natural seabed communities which have low densities of hard substrates and are likely fished. Finally, by incorporating fishing intensity into the model fit as well, it would be possible to simulate reef suitability under scenarios without bottom trawling, adding a predictive dimension to the model.

The data sent to Deltares was processed to create a habitat suitability model for *S. spinulosa*, where it was predicted that the probability for this species to be present in the Nederwiek area is small, while it has higher chances to be present in the Brown Bank and the coast of Great Britain. Their results suggest that the suitability of Nederwiek II and III for S. spinulosa restoration might increase after the installation of the wind farm, which comes into agreement with our results. However, to verify this, monitoring of the biodiversity on and around the offshore wind turbine foundations will be needed after the wind farm is introduced.

5. Conclusion

The reef-building worm species *Sabellaria spinulosa* can be found at multiple locations in the North Sea. However, no evidence was found in the literature indicating the presence of S. spinulosa in the Nederwiek II and III areas. Given its preference for habitats that combine hard surfaces for attachment and sandy sediments for tube construction, it is hypothesized that the scour protection layers around offshore wind turbine foundations in this area could offer suitable conditions for settlement and potential reef development.

The dataset used in this study was not originally designed for habitat suitability modelling, resulting in inconsistencies in sampling methods, seasons, and spatial distribution. These variations likely affected the detection of *S. spinulosa* and reduced the reliability of the resulting habitat suitability map. Different gear types (e.g. video transects vs grab samplers) have varying detection capabilities, and then uneven temporal and spatial sampling may have led to biased representations of habitat suitability.

To improve habitat suitability modelling, future data collection should be standardized, using consistent and complementary sampling methods across a uniformly distributed grid with minimal time differences between samples. This would better capture habitat variability and improve model accuracy.

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Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

Justification

Report 2512832A
Project Number: 4315100247

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved:	Lukas Golterman Researcher
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Annex I

Table S1: List of published scientific articles and reports that were included in the literature review. The column reef indicates the presence of Sabellaria reefs (yes) or individual observations/small aggregations (no).

Title	Authors	Monitoring year	Methodology	Location	Reef presence
Scientific articles					
Discovery of Sabellaria spinulosa reefs in an intensively fished area of the Dutch Continental Shelf, North Sea	Van Der Reijden, K. J., Koop, L., O'flynn, S., Garcia, S., Bos, O., van Sluis, C., Maaholm, D.J., Herman, P.M.J, Simons, D.G., Olff, H., Ysebaert, T., Snellen, M., Govers, L.L., Rijnsdorp, A.D., & Aguilar, R.	2017	ROV video inspection and MBES	Brown Bank	Yes
Conservation Implications of Sabellaria spinulosa Reef Patches in a Dynamic Sandy-Bottom Environment	Van der Reijden, K. J., Koop, L., Mestdagh, S., Snellen, M., Herman, P. M., Olff, H., & Govers, L. L.	2017 and 2019	Boxcore, MBES, and video transects	Brown Bank	Yes
Semi-Automated Classification of Side-Scan Sonar Data for Mapping Sabellaria spinulosa Reefs in the Brown Bank, Dutch Continental Shelf	Gaida, T. C., Binnerts, B., & Bos, O.	2023	MBES, SSS, box core and ROV video inspection	Brown Bank	Yes

Historical changes in the benthos of the Wadden Sea around the island of Sylt in the North Sea	Reise, K., Herre, E., & Sturm, M.	Between 1924 and 1988	Dredge	Channels of the North Frisian Wadden Sea	Yes
Spatial variability of epifaunal communities from artificial habitat: Shipwrecks in the Southern Bight of the North Sea	Zintzen, V., Norro, A., Massin, C., & Mallefet, J.	2007	Photos and SCUBA samples	Shipwrecks on BPNS (Southern Bight of the North Sea)	No
Repeated mapping of reefs constructed by Sabellaria spinulosa Leuckart 1849 at an offshore wind farm site	Pearce, B., Fariñas-Franco, J. M., Wilson, C., Pitts, J., deBurgh, A., & Somerfield, P. J.	2014	SSS and MBES	Thanet Offshore Windfarm, UK	Yes
A texture analysis approach to identifying sabellaria spinulosa colonies in sidescan sonar imagery	Harrison, R., Bianconi, F., Harvey, R., & Wang, W.	2011	SSS	UK North Sea	Yes
Critical evaluation of ecosystem changes from an offshore wind farm: producing natural capital asset and risk registers	Causon, P. D., Jude, S., Gill, A. B., & Leinster, P.	2004	ROV video inspection and grab samples	Greater Gabbard offshore windfarm, UK	Yes
Mollusken uit opgedoken visnetten. Duik de Noordzee	Raven, H. & van Leeuwen, S.	2018	SCUBA	Friese Fronten in Nederland: Lost fishing nets and other	Yes

Schoon juni 2018				materials from ship wrecks	
Life on every stone: Characterizing benthic communities from scour protection layers of offshore wind farms in the southern North Sea	Zupan, M., Coolen, J., Mavraki, N., Degraer, S., Moens, T., Kerckhof, F., Lopez, L.L., & Vanaverbeke, J.	2024	Sampling	BelWind and C-Power in the BPNS, Princess Amalia in Dutch waters, and Horns Rev. 1 in Denmark	No
Artificial hard-substrate colonisation in the offshore Hywind Scotland Pilot Park	Karlsson, R., Tivefälth, M., Duranović, I., Martinsson, S., Kjølhamar, A., & Murvoll, K. M.	2020	ROV video inspection	Offshore windfarm Hywind Scotland Pilot Park	Crusts
Early development of the subtidal marine biofouling on a concrete offshore windmill foundation on the Thornton Bank (southern North Sea): first monitoring results	Kerckhof, F., Rumes, B., Jacques, T., Degraer, S., & Norro, A.	2008	SCUBA sample collection	Windmills on the on the Thornton Bank	No
Guardians of the seabed: Nature-inclusive design of scour protection in offshore wind farms enhances benthic diversity.	Kingma, E. M., ter Hofstede, R., Kardinaal, E., Bakker, R., Bittner, O., van der Weide, B., & Coolen, J. W.	2021	Sampling	Borssele Offshore Wind Farm Site Lot V	No

Benthic biodiversity on old platforms, young wind farms, and rocky reefs	Coolen, J. W. P., van der Weide, B., Cuperus, J., Blomberg, M., Van Moorsel, G. W. N. M., Faasse, M. A., Bos, O. G., Degraer, S., Lindeboom, H. J.	Between 2011 and 2015	SCUBA samples	Princess Amalia Windfarm, Borkum Reef Grounds, oil and gas platforms	No
Fluxes of nitrogen and phosphorus in fouling communities on artificial offshore structures	Coolen, J. W., van der Weide, B., Bittner, O., Mavraki, N., Rus, M., van der Molen, J., & Witbaard, R.	2021	SCUBA sampling	shipwrecks in the southern North Sea	No
Reports or book chapters					
Development of hard substrate fauna in the Princess Amalia Wind Farm. Monitoring 3.5 years after construction.	Vanagt T., Van de Moortel L., and Faasse M.	2013	SCUBA sampling and Video inspection	Prices Amalia Wind Farm	No
Development of hard substratum fauna in the Princess Amalia Wind Farm. Monitoring six years after construction.	Vanagt, T. & Faasse, M.	2014	SCUBA sampling and Video inspection	Prices Amalia Wind Farm	No
Sabellaria monitoring trial: summary report	Gaida T., Binnerts B., van der Stappen C., Cuperus J.	2023	Acoustics MBES and SSS, ROV, boxcores	Brown Bank	Yes
Biogenic reefs in the Dutch North Sea in	Bos O.G., Kingma E.M.,	2024	-	North Sea basin	Yes

relation to Offshore Wind Energy locations: Actual and predicted probability of occurrence of reef forming shellfish and worms in new wind farm zones and search areas for wind farm zones	van der Wal J. T.				
Hard Bottom Substrate Monitoring Horns Rev Offshore Wind Farm: Annual Status Report 2004	Leonhard, S B, and Pedersen, John.	2004	SCUBA sampling	Horns Rev Offshore Wind Farm	No
A comparison of the first stages of biofouling in two offshore wind farms in the Belgian part of the North Sea	F. Kerckhof, B. Rumes, A. Norro, J.-S. Houziaux, & S. Degraer	2008	SCUBA samples	Offshore windfarms Belwind and C-Power	No
Biogene riffen in de Noordzee. Actuele en potentiële verspreiding van rifvormende schelpdieren en wormen.	Bos, O. G., Coolen, J. W. P., & van der Wal, J. T.	2019	Modelling	DCS	-

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