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Benthic Biodiversity in Offshore Wind Farms

Investigating the impact of offshore construction on species richness and abundance in benthic ecosystems

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Project details

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Abstract

The present report details an investigation into the changes to species mix and biodiversity in benthic habitats following the construction of offshore wind farms (OWFs). It uses post-construction survey data, accessed through the Cefas Open Science “OneBethic” portal, to compare the changes at Walney OWF between 2012 and 2013. Unfortunately, due to technological issues and time constraints, the project was unable to use The Crown Estate’s Marine Data Exchange (MDE) to access pre-construction or control data, and so only partial analysis was possible. A further study is recommended looking into this issue across wider time and spatial scales.

Of the 277 genera identified in the post-construction surveys, only 34 showed “significant change”, defined here as unit change greater than 25 individuals and percentage change greater than 50%. Of these species, 9 showed a decrease in abundance compared to 25 showing an increase in abundance. The 2013 survey found 9 more taxa than the 2012 survey, considered an indicator of species “richness”, and 2616 more individuals, used as a measure of abundance. The biodiversity index, created for this study as a sum of richness and abundance, was 15% higher for 2013 than 2012.

The sampling locations for the 2012 and 2013 surveys were very consistent, with only 3 additional surveys in 2012 and the majority of the 2013 sampling points matching the 2012 location exactly. However, the sampling effort was significantly great for 2013, with 441 more samples being taken, accounting for a 17% increase in sampling effort, compared to a 15% increase in biodiversity index. Unfortunately, the biodiversity index for this study did not include a measure of sampling effort, however this is recommended for further studies.

As baseline data could not be used in this study, due to technological issues and time constraints, conclusions cannot be drawn as to the cause of the changes in individual species abundance, however it is thought that the perceived increase in species abundance and diversity is primarily due to the increase in sampling effort in the 2013 survey.

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1. Introduction

1.1 Background Context

In 2019, The Crown Estate carried out a study into the pre-and-post-construction monitoring data for 76 offshore wind farms (OWFs), focusing on 4 key areas: Fish Ecology, Benthic Ecology, Marine Mammals, and Birds. Of the 45 wind farms for which comparable benthic data was available, it was found that abundance of benthic species increased in 38% in the first 2 years following construction, compared to 15% where abundance decreased and 45% with neutral change.

The introduction of infrastructure and the resulting changes to the seabed habitat type can change the composition of benthic communities in the area surrounding a wind farm. However due to the large volumes of data and limited timespan, the study was not able to explore the changes to species mix for each individual wind farm. Site-specific analysis of the survey data was undertaken to identify how such communities were affected and whether or not offshore development was impacting some species more than others.

Walney OWF was selected for investigation, as the historic increase in the nearby grey seal population monitored by Cumbria Wildlife Trust had been anecdotally linked to increased food supply around the wind farms in West of Walney MCZ, and further information was needed on the resulting species mix and food web interactions.

1.2 Walney Offshore Wind Farm

Walney OWF is operated by Ørsted and lies to the west of the Furness Peninsula in South Cumbria, between the Barrow and Walney Extension OWFs. It has been fully operational since March 2012 and is made up of two stages with 51 turbines each, named Walney 1 and Walney 2. Benthic surveys of the area were taken prior to construction of the wind farm, at interim stages during development, and post-construction once the windfarm was operational, to monitor any possible impacts on the species and habitats in the area.

1.3 Aims & Objectives

The following study investigates the impact on species mix, by analysing the changes to species richness and abundance, identifying the species showing the most significant change in population, and attempting to highlight potential causes of this variation.

It focuses primarily on comparisons between the 2012 and 2013 benthic monitoring datasets, which have been incorporated into the standardised OneBenthic database from the Marine Data Exchange; time and technological constraints meant that the pre-construction survey data held within the MDE and not yet incorporated into the OneBenthic database could not be accessed for this study.

This limits the conclusions which can be drawn from the data, as it was not possible to use the baseline dataset to compare the natural changes in species abundance prior to construction, and the timespan is too short to track ongoing changes. However, it is hoped that the report will provide some insights into methodology and useful scope for future research projects.

2. Methodology

The 2012 and 2013 monitoring data for Walney OWF was downloaded via the OneBenthic data extraction tool by Cefas Open Science: https://openscience.cefas.co.uk/ob_obdetgc/

The data was then examined and grouped by genus name to compensate for variation in detail between the two surveys and allow for better comparison between datasets.

2.1 Species Richness & Abundance

The data was sorted using Microsoft Excel into a pivot table of genus vs abundance for each survey, and the following measures were calculated:

1. Richness= total number of taxa recorded in each survey
2. Abundance= total number of individuals recorded in each survey
3. Biodiversity Index= Richness x Abundance x 10^{-6}

These measures give a high-level indication of the changes between the surveys, however their reliability depends on consistency in sampling method, sample location, and survey effort, so they should not be used as standalone conclusions.

2.2 Composition Change

The unit change and percentage change for each genus was then calculated as follows:

1. Unit Change= 2013 Abundance - 2012 Abundance
2. Percentage Change = (2013 Abundance - 2012 Abundance)/ 2012 Abundance

As this study aims to highlight the species which showed the most change, the following filters were applied to the datasets to select the species of interest:

1. Unit Change must be greater than 25 individuals, to account for differences in sampling method, sampling effort, and random localised variation.
2. Percentage Change must be greater than 50%, to highlight only species showing significant population change.

The remaining species were then ranked in order of percentage change, and the species with most significant increase or decrease were highlighted.

Finally, the 2012 and 2013 abundances were plotted on a histogram to compare the relative abundances and highlight the species with the largest unit change in abundance. Two histograms were created; one including all of the selected species, and one with the three most abundant species removed in order to better show the variation in the other species.

2.3 Species Interpretation

For each of the selected species, the genus was compared to the original species list, and the individual species within each genus group was identified. For each identified species the common name was recorded or, where there was no common name, the taxonomic class was recorded along with a qualitative description of the species.

2.4 Survey Effort and Location

Finally, the latitude and longitude of each sample location, and the total number of grab samples taken, was recorded and compared for each survey, using the survey name to identify the year, and the sample code to identify each individual sample.

3. Results

3.1 Species Richness & Abundance

Table 1 shows the species richness, abundance, and biodiversity index for each post-construction survey, and highlights the most abundant genera for each survey:

Table 1: Changes to species richness and abundance between 2012 and 2013

Survey	Richness	Abundance	Biodiversity Index	Most Abundant Genera
2012	170	29728	5.05	1. *Amphiura* (3331 individuals) 2. *Phoronis* (2958 individuals) 3. *Pygospio* (1797 individuals)
2013	179	32344	5.79	1. *Phoronis* (3713 individuals) 2. *Amphiura* (2748 individuals) 3. *Scalibregma* (966 individuals)

3.2 Composition Change

Tables 2 and 3 show the species whose population declined and those whose increased respectively, ranked in order of percentage change.

Table 2: Species whose population declined between the 2012 and 2013 benthic surveys at Walney OWF

Genus	2012 Abund	2013 Abund.	Unit Change	Percentage Change	Species Name (s)	Common Name (IA)
Corystes	107	11	-96	-90%	*Corystes cassivelaunus*	Masked Crab
Lagis	344	50	-294	-85%	*Lagis koreni*	A bristleworm
Scoloplos	49	9	-40	-82%	genus only	A bristleworm
Pygospio	1797	422	-1375	-77%	*Pygospio elegans*	A bristleworm
Actiniaria	59	15	-44	-75%	genus only	A sea anemone
Eteone	55	17	-38	-69%	genus only	A bristleworm
Mediomastus	55	17	-38	-69%	*Mediomastus fragilis*	A polychaete
Polydora	309	100	-209	-68%	*Polydora ciliata*	A bristleworm
Sthenelais	90	42	-48	-53%	*Sthenelais limicola*	A polychaete

Table 3: Species whose population increased between the 2012 and 2013 benthic surveys at Walney OWF

Genus	2012 Abund.	2013 Abund.	Unit Change	Percentage Change	Species Name (s)	Common Name (s)
Balanus	0	177	177	N/A	*Balanus cretanus*	Acorn Barnacle
Leitoscoloplos	0	43	43	N/A	*Leitoscoloplos mammosus*	A polychaete
Ophiuridae	0	41	41	N/A	genus only	A brittlestar
Edwardsia	3	70	67	2233%	*Edwardsia claparedii*	A sea anemone

Tellimya	4	68	64	1600%	*Tellimya ferruginosa*	A bivalve mollusc
Scalibregma	59	966	907	1537%	*Scalibregma inflatum*	A polychaete /segmented worm
Eudorella	6	44	38	633%	*Eudorella truncatula*	A long-tailed, shrimp-like crustacean
Spirobranchus	6	38	32	533%	*Spirobranchus lamarcki*	Keelworm
Echinocardium	8	47	39	488%	*Echinocardium cordatum*	Sea Potato
Goneplax	7	39	32	457%	*Goneplax rhomboides*	Angular Crab
Corbula	70	321	251	359%	*Corbula gibba*	Basket shell
Eumida	12	54	42	350%	*Eumida bahusiensis*	A polychaete
Galathowenia	16	69	53	331%	*Galathowenia oculata*	A polychaete
Ampharete	21	80	59	281%	*A. acutifrons; A. falcata; A. finmarchica*	A polychaete
Spio	10	38	28	280%	*S. aramata; S. decorata; S. filicornis*	A polychaete
Prionospio	17	59	42	247%	*P. fallax P. polybrachiata*	A spionid worm
Campanular-iidae	12	41	29	242%	genus only	A hydrozoan
Nematoda	21	62	41	195%	genus only	A roundworm
Chamelea	73	207	134	184%	*Chamelea striatula*	Striped venus clam
Fabulina	44	117	73	166%	*Fabulina fabula*	Bean-like Tellin
Amphictene	35	77	42	120%	*Pectinaria auricoma*	A polychaete
Lanice	408	863	455	112%	*Lanice conchilega*	Sand mason worm
Ampelisca	88	184	96	109%	*A. brevicornis; A. spinipes; A. tenuicornis*	A amphipod/ shrimp-like crustacean
Thyasira	37	76	39	105%	*Thyasira flexuosa*	Wavy hatchet shell
Magelona	250	492	242	97%	*M. alleni; M. filiformis; M. johnstoni; M. mirabilis*	A polychaete/ segmented worm
Gattyana	50	77	27	54%	*Gattyana cirrhosasc*	A scaleworm

Figures 1 and 2 show the histogram graphs of species abundance in the 2012 and 2013 surveys; Figure 1 with all genera included and Figure 2 with the three most abundant genera removed, namely Pygospio, Lanice and Scalibregma.

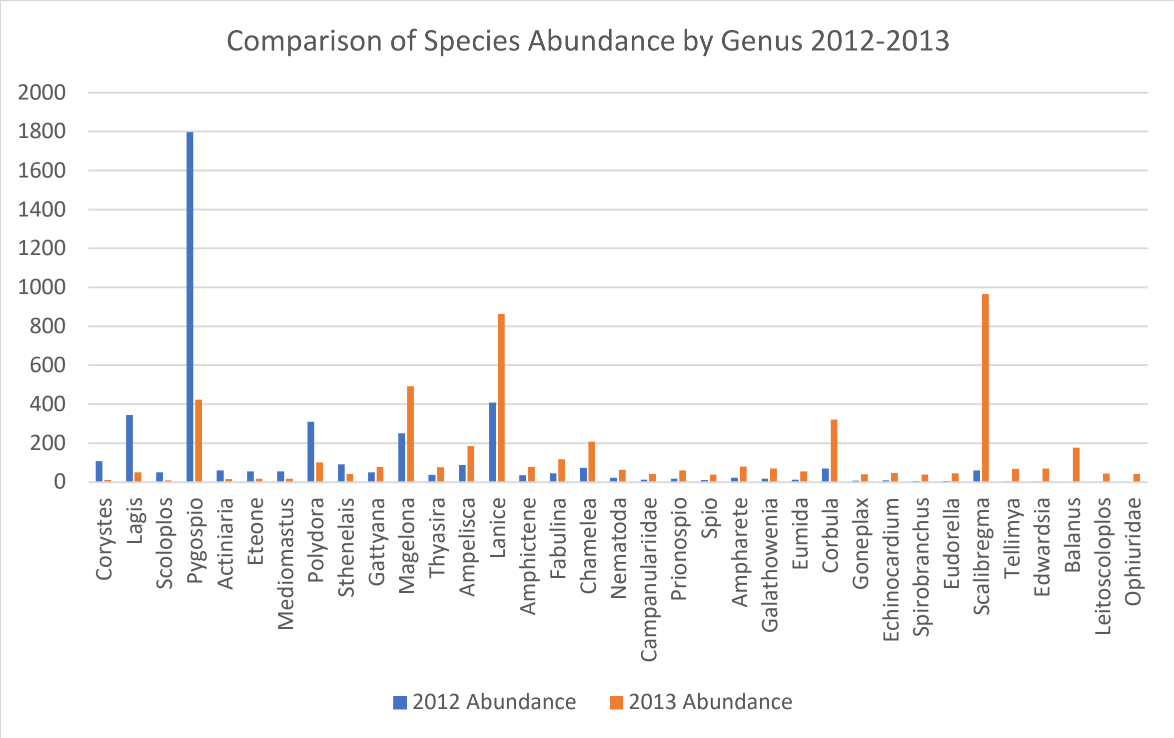

Figure 1: Histogram of species with abundance changes of more than 50% and 25 individuals between 2012 and 2013.

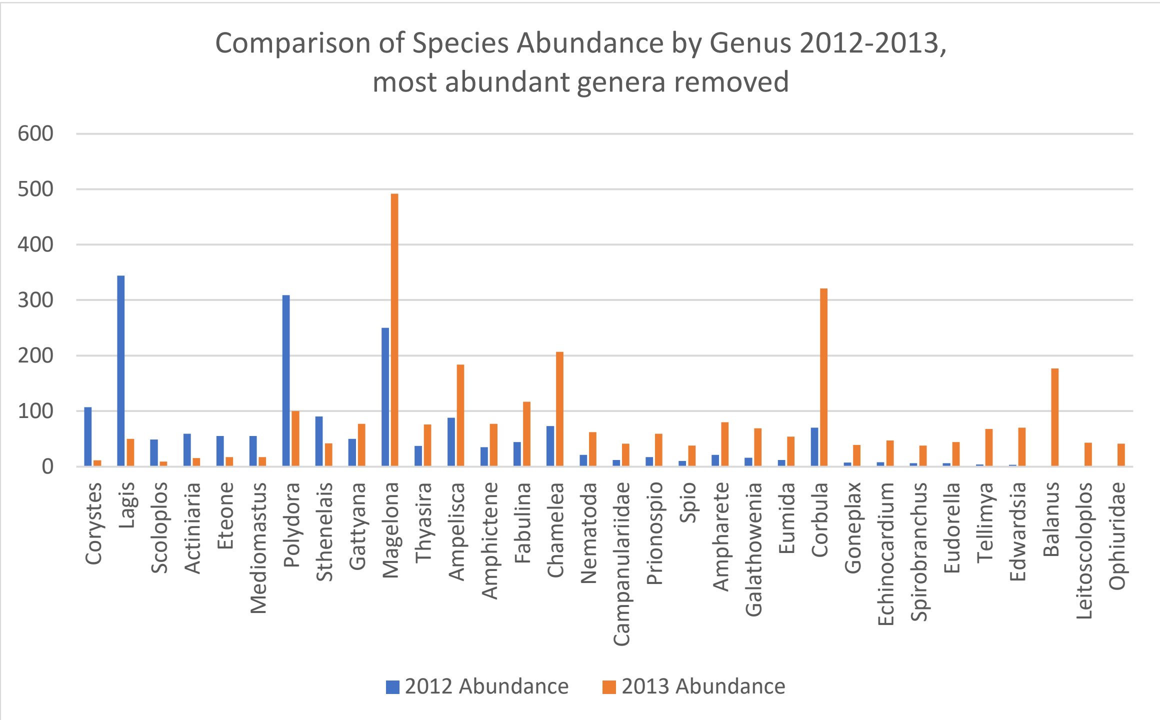

Figure 2: Histogram of species with abundance changes of more than 50% and 25 individuals between 2012 and 2013, with most abundant species removed.

In order to estimate how comparable, the two datasets should be, the latitude and longitude of each sample location, and the number of individual samples taken at that location, were compared. If one survey took significantly more samples than another, it would stand to reason that more species would be found. Similarly, if the samples were taken in different locations, then it is more likely that different species would be found.

Figure 3 shows the sampling locations, by latitude and longitude, for the 2012 and 2013 surveys. The 2012 survey took samples at three more locations than the 2013 survey, and some of the 2013 survey points were taken at new locations, as can be seen by the more transparent orange circles.

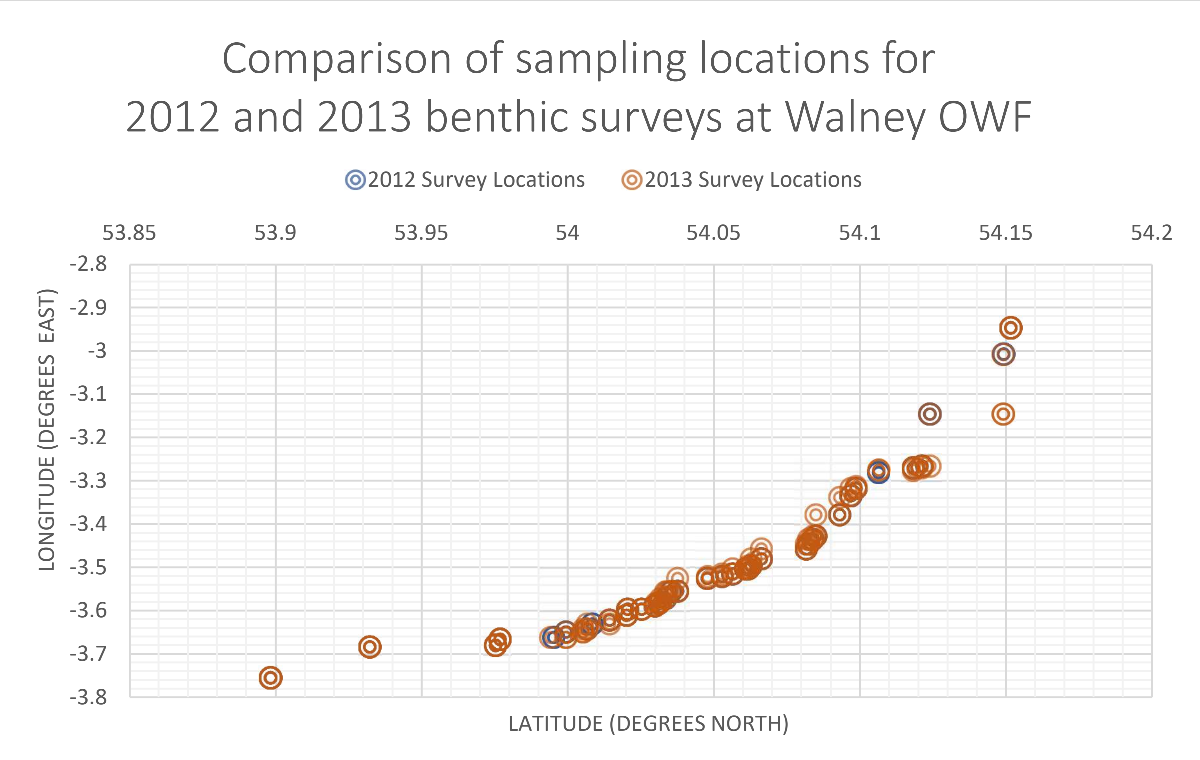

Figure 3: Scatter graph showing the latitude and longitude of each sampling location in the 2012 and 2013 surveys.

Table 4 shows the total number of samples taken in each survey, along with the richness and abundance calculated for each survey. The 2013 survey had 441 more individual samples recorded that the 2012 survey, corresponding to 9 more taxa identified, and 2616 more individuals recorded.

Table 4: Number of grab samples taken in 2012 and 2013 compared to changes in richness and abundance

	2012	**2013**	**Unit Change**
Number of grab samples taken	2197	2638	441
Number of taxa found	170	179	9
Total species abundance	29728	32344	2616

4. Discussion

The change in species richness and abundance between the two surveys was relatively low, and the change in the "biodiversity index" created for this study was just 15%, indicating that the changes to the ecosystem as a whole are likely to be fairly small. This is supported by the habitat changes observed in TCE's previous study which indicated no difference in sedimentary habitat between 2012 and 2013. The extract below gives the comparison drawn between in the original study for Walney OWF:

"The 2012 & 2013 surveys found no difference in sedimentary habitat between the pre- and post-construction surveys, with sandy mud dominating. The 2012 survey recorded 14864 individuals and found Echinodermata and annelida were the most abundant taxa; A. filiformis, Phoronis spp. and P. elegans were the most abundant species. Similarly, the 2013 survey found Echinodermata, annelida and mollusca were the most abundant taxa, with A. filiformis, Phoronis spp. and K. bidentata being the most abundant species and 16081 individuals were recorded. The 2013 underwater video survey also found high abundances of M. edulis, M.senile and N. puber around the turbines. The 2014 survey found a significant increase in the mud contents of the sediments, and a high abundance of Echinoderms, phoronids, molluscs and annelids. A. filiformis, Phoronis spp. K. bidentata and S. inflatum were the most abundant species with 14914, 12405, 7176 and 4352 individuals recorded respectively." (Pearson, 2019)

The increase in "muddy" sediment found in the 2014 surveys could cause much more significant changes to the species and communities in the area, however the faunal data for this survey year was not yet available on the OneBenthic portal.

Of the species which showed a significant change between the two surveys, bristleworms seem to have generally declined in abundance, whereas many polychaetes have increased in abundance. However without baseline data it is impossible to say whether this variation due to natural fluctuations. *Pygospio* had the largest decrease between 2012 and 2013, with abundance changing by 77% from 1797 to 422 individuals, whereas *Lanice* and *Scalibregma* showed the largest increase with *Lanice* increasing by 112% from 408 to 863 individuals, and *Scalibregma* increasing by 1537% from 59 to 966 individuals.

- *Pygospio elegans* is a type of bristleworm, found around the British coast and across Northern Europe. It is commonly found on sandy shores and mudflats, where it buries itself in the mud (MarLIN 2021a). It reproduces by recruitment of larvae, so it's population could have been affected by the increase in filter feeders such as mollusc bivalves who may consume the larvae in the water column (Hines et al., 1989). This would include species such as *Mytilus edulis* and *Corbula gibba*, both of which showed an increase at this site, however without baseline data it is impossible to know.
- *Lanice conchilega* is more commonly known as the sand mason worm, and is a filter feeding worm found all around the coasts of Britain and Ireland (MarLIN 2021b). It builds tubes from sand and shell fragments and extends a crown of white tentacles to trap particles of food. As a bioengineering creature, it's presence has often been linked to an increase in species diversity, community composition, and density of macrofauna – that is, larger and more mobile species- (Rabaut et al., 2007); however, without further baseline data it is impossible to say whether that is the case here.
- *Scalibregma inflatum* is a polychaete- or segmented worm- with a swollen end. It is typically found in deep-water, at around 1000m (MarLIN, 2021c); however, it can occur in huge numbers in shallow waters around Northern Europe, and has been found to increase in population when exposed to pressures relating to organic input, such as organic enrichment, maintenance dredging and mariculture (Hiscock et al., 2004).

As well as pressures from OWF construction and maintenance, there are many possible explanations for the changes in abundance for these species, including natural food-web interactions, human activities such as fishing and dredging, and wide-scale changes such as ocean acidification and climate change.

However, benthic communities such as these commonly show large changes in abundance from year to year, and without comprehensive baseline data to compare the changes to, it is impossible to know whether they are caused by natural or manmade phenomena. To compare these datasets reliably, multiple surveys of the same area at different times would be required, as well as multiple surveys of a nearby “control” area, which would not be impacted by the OWF construction. This is known as the BACI method; surveys are taken of Before, After, Control, and Impact, such that the changes could be compared to determine whether the OWF is having an impact, or whether the changes are due to natural variation or other wide-scale changes such as climate change.

Another factor which could affect the benthic surveys is sample locations. The locations for the two surveys used in this study were reasonably consistent; the majority of the 2013 locations aligned exactly to 2012 points, and where variation did occur it was only slight. The 2012 survey had three additional locations recorded, however the more significant change was that the sampling at each location increased significantly from 2012 to 2013, with 441 additional samples being taken. This represents a percentage increase of 17% in sampling effort, compared to 15% increase in biodiversity index.

Though the locations and method are reasonably consistent, and some species have shown significant increase, the increase in sampling effort is likely to be the main driver behind the increase in perceived biodiversity, and better monitoring is needed to determine the true impacts.

Conclusions

1. The data used in this study did not include any baseline data or control data, so no reliable comparisons could be drawn about the changes in individual species abundance.
2. The percentage increase in biodiversity index corresponds closely to the increase in sampling effort in the 2013 surveys, suggesting that the increased abundance is due primarily to increased sample rate.
3. *Pygospio elegans* showed a decrease of 77%; *Lanice conchilega* showed an increase of 112%; and *Scalibregma inflatum* showed an increase of 1537%. These variations could be due to the wind farm construction and resulting changes in disturbance, nutrient availability, or sediment type; however, they could also be linked to a range of non-related factors such as climate change, food web interactions, fishing patterns, and high natural variation in benthic communities from year to year. Without further baseline and control data, it is impossible to estimate the cause of these changes.

Recommendations for further investigation

The scope of this study was too narrow to fully investigate the changes to benthic communities in Walney OWF. A further study is recommended using baseline and control data to understand the community composition outside of the windfarm and prior to construction and draw comparisons with post-construction data. Further development of the biodiversity index is also recommended to account for changes in survey location and sampling effort between surveys. Barrow and Walney Extension OWFs could also be included in the study, to compare changes across a wider area.

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