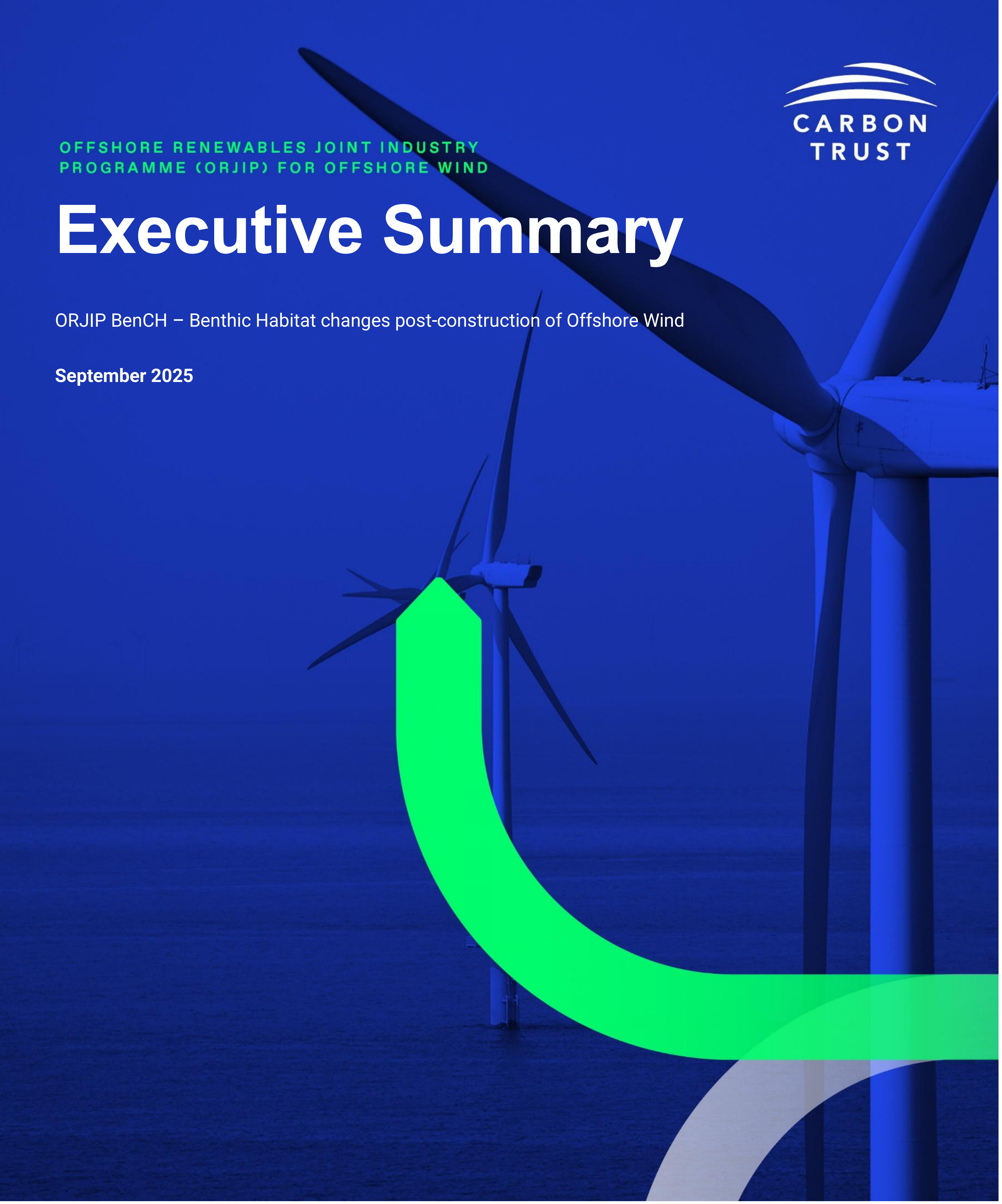

OFFSHORE RENEWABLES JOINT INDUSTRY PROGRAMME (ORJIP) FOR OFFSHORE WIND

Executive Summary

ORJIP BenCH – Benthic Habitat changes post-construction of Offshore Wind

September 2025

ORJIP Offshore Wind

The Offshore Renewables Joint Industry Programme (ORJIP) for Offshore Wind is a collaborative initiative that aims to:

- Fund research to improve our understanding of the effects of offshore wind on the marine environment.
- Reduce the risk of not getting, or delaying consent for, offshore wind developments.
- Reduce the risk of getting consent with conditions that reduce viability of the project.

The programme pools resources from the private sector and public sector bodies to fund projects that provide empirical data to support consenting authorities in evaluating the environmental risk of offshore wind. Projects are prioritised and informed by the ORJIP Advisory Network which includes key stakeholders, including statutory nature conservation bodies, academics, non-governmental organisations and others.

The current stage is a collaboration between the Carbon Trust, EDF Energy Renewables Limited, Ocean Winds UK Limited, Equinor ASA, Ørsted Power (UK) Limited, RWE Offshore Wind GmbH, SSE Renewables Services (UK) Limited, TotalEnergies OneTech, Crown Estate Scotland, Scottish Government (acting through the Offshore Wind Directorate and the Marine Directorate) and The Crown Estate Commissioners. For further information regarding the ORJIP Offshore Wind programme, please refer to the Carbon Trust website, or contact Ivan Savitsky (ivan.savitsky@carbontrust.com) and Žilvinas Valantiejus (zilvinas.valantiejus@carbontrust.com).

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- Joint Nature Conservation Committee (JNCC)
- Natural England
- Natural Resources Wales
- NatureScot
- Scottish Government's Marine Directorate

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Who we are

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Executive summary

The UK Government has committed to delivering 50 gigawatts (GW) of offshore wind by 2030, with 13.9 GW currently operational and another 77 GW in development. As this sector rapidly expands, understanding the environmental impacts on benthic communities becomes increasingly important. This project, undertaken as part of the Offshore Renewables Joint Industry Programme for Offshore Wind (ORJIP Offshore Wind), aimed to strengthen the evidence base on how offshore wind farms affect benthic habitats and species post-construction.

The primary aim of the project was to evaluate five research questions, developed by the ORJIP steering group, relating to post-construction benthic habitat change and recovery:

- RQ1: Are there suitable metrics to detect changes in benthic habitats that could be applied to offshore wind assessments?
- RQ2: Is there a measurable change (increase/decrease) in biodiversity and/or species composition?
- RQ3: Are there localised and regional ecological effects around the infrastructure?
- RQ4: Is there change in ecological function (e.g. functional groups) as a result of biological changes?
- RQ5: Can recovery and/or enhancement be demonstrated and in what timeframe?

The project was delivered through several work packages:

- WP1: Literature review covering all five research questions.
- WP2: Data mapping and collation of benthic monitoring datasets.
- WP3: Interim workshop with the project steering group to decide which questions could be further investigated in WP4.
- WP4: Benthic analyses using AMBI (AZTI Marine Biotic Index) and biological traits analysis on a subset of UK offshore wind farm datasets to further investigate research questions one, two and four.
- WP5: Final reporting

The literature review included a comprehensive review of scientific and grey literature including benthic monitoring reports from 18 OWF monitoring programmes. The main findings of the literature review included:

RQ1: Existing metrics such as abundance, diversity indices and multivariate analyses are widely used and appropriate for detecting changes in benthic habitats. However, the review recommended exploring supplementary metrics, such as AMBI and biological trait-based approaches, to enhance ecological interpretation and potentially detect changes in ecological function that may not be detected by traditional approaches.

RQ2: Changes in biodiversity and species composition were observed in the reviewed OWF monitoring reports. However, these were attributed to natural variability rather than OWF impacts across all 18 monitoring reports. This contrasts with findings from the scientific literature, which reports measurable OWF-related impacts on benthic communities. This difference highlights the need for evaluation of

monitoring design and approaches, spatial resolution and duration to ensure that potential effects are not masked by natural variability in benthic communities.

RQ3: The literature review found that localised ecological changes are evident in close proximity to turbine structures, regional-scale impacts are less well understood and underrepresented in existing monitoring programmes and datasets. This aspect remains a knowledge gap requiring further investigation.

RQ4: Few studies directly link benthic habitat changes to functional ecological shifts in benthic communities. The review highlighted the value of trait-based approaches in understanding potential changes in ecological function that may not be evident where diversity and abundance metrics remain the same. Changes in functional traits of benthic communities may interfere with normal ecosystem functioning by disrupting processes such as bioturbation and nutrient cycling. The review recommended investigating RQ4 further through conducting biological traits analysis in WP4.

RQ5: Recovery timelines for benthic communities vary by habitat and exposure, with soft-sediment communities often recovering within 2–3 years. However, the absence of long-term monitoring limits understanding of enhancement potential and the direction of post-construction changes.

Following confirmation from the steering group during the mid-project workshop, AMBI and biological traits analyses were used to analyse collated OWF benthic datasets as part of WP4 to further investigate research questions RQ1, RQ2 and RQ4.

The AMBI analysis was undertaken across four OWF sites and found no significant spatial differences between array areas and reference stations, supporting the conclusion of the monitoring reports that natural variability was the primary driver of observed changes. Traditional diversity and abundance related approaches typically used in analysis of benthic communities can detect change and identify where changes in community structure are associated with environmental variables, but do not readily explain the nature of such changes. The advantage of AMBI is that it also identifies the ecological response to changes, identifying shifts from disturbance sensitive to disturbance tolerant or opportunistic taxa and providing a standardised disturbance classification. This means that AMBI can both detect change and also identify the type of change that has taken place within the benthic community within a readily accessible single metric. This is important for understanding the ecological implications of impacts to benthic habitats and communities.

Similarly, biological traits analyses at three sites revealed no significant influence of OWF construction on the functional composition of benthic communities. Community structure remained consistent across traits including size distribution, lifespan categories, feeding modes and bioturbation activities, with observed variability attributed to natural factors rather than OWF presence. This suggests that while species composition may vary, ecosystem functions were maintained. The metrics currently used in benthic analysis are not designed to indicate potential disturbance of the benthic communities beyond structural changes (relative abundances, diversity and dominance of species) and do not consider the functional aspects of benthic communities. A trait-based approach can address a range of ecological issues and reveal how altered communities influence ecosystem processes, such as nutrient cycling, sediment bioturbation or organic matter decomposition.

It should be noted that the testing of these two approaches was undertaken using datasets that were not specifically designed for these analyses and from areas where other analyses had concluded no significant impact from OWF construction. As such, it is difficult to draw firm conclusions on the potential value of these metrics in benthic monitoring assessments. However, given the advantages detailed above, it is considered that their use in benthic monitoring, to complement traditional analyses, warrants further investigation.

The project findings have informed a series of policy considerations including:

- Improving environmental impact assessments (EIA) processes and monitoring frameworks.
- Supporting licensing and mitigation standards.
- Informing compensation strategies and marine spatial planning.
- Contributing to the development of marine net gain approaches.

In addition, the project has contributed to recommendations across research, planning, environmental assessment and monitoring practices. These recommendations emphasise the need for enhanced research, planning and monitoring approaches that go beyond traditional analyses and assessments to include functional ecology assessments and ecosystem services. Key recommendations include conducting longer-term studies on benthic community succession and ecosystem functioning, the inclusion of trait-based approaches to more fully understand ecological effects and developing standardised monitoring protocols with adequate statistical power using BACI designs. The recommendations suggest improved spatial planning tools that integrate predicted ecological changes with biodiversity indicators, consideration of cumulative regional effects across multiple OWFs, and the incorporation of nature-positive infrastructure such as reef-forming scour protection and restoration zones. Benthic community analyses and the environmental impact assessment process should include functional group composition metrics and comprehensive cumulative assessments, while monitoring programmes should be extended with standardised methodologies, appropriate reference stations, and apply the consistent use of centralised data repositories to facilitate cross-site comparisons.

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