Offshore Wind

Understanding the influence of man-made structures in the marine environment

INSITE

Influence of man-made structures in the ecosystem

INSITE SUMMARY

The INSITE Programme was launched in 2014 as the first joint industry partnership between academia and oil and gas operators in the North Sea to deliver focused research to provide the independent scientific evidence base to better understand the influence of man-made structures (MMS) on the ecosystem.

The programme has developed an understanding that is contributing to the current global scientific consensus on the ecological and environmental implications of deploying MMS in the sea at scale, leaving non-operational MMS in situ, or removing non-operational MMS. Evidence gathered through INSITE supports the development of policy development and nature-positive approaches to decommissioning that can underpin the attainment of good environmental status and other actions relating to the sustainable management of UK seas.

CONTRIBUTORS

This policy brief was prepared by Howell Marine Consulting (HMC) from evidence gathered by contributing scientists and policy leads, as presented in the 'INSITEs Into: Offshore Wind' webinar:

Professor Paul Fernandes (FISHSPAMMS Project)
Heriot-Watt University E: P.Fernandes@hw.ac.uk And affiliated partners: Michael Heath, Joshua M Lawrence, and Dougie Speirs.

Dr Debbie Russell (EcoSTAR Project)
University of St Andrews E: dr60@st-andrews.ac.uk And affiliated partners: Silvana Birchenough, Matt Carter, Steven Degraer, Clement Garcia, Phil Hammond, Gordon Hastie, Claire Lacey, Chris Lynam, Maria Clara Iruzun Martins, Jacob Nabe-Nielsen, Janneke Ransijn, Jeroen Steenbeek, Sophie Smout, and Jonas Teilmann.

Cassie Rist Department of Environment, Food and Rural Affairs (Defra), OWEAP
E: Cassie.Rist@defra.gov.uk

Dr Krysia Mazik (CHASANS Project)
University of Hull
E: K.Mazik@hull.ac.uk
And affiliated partners: Ben Barton, Mike Bell, Duncan Clark, Gareth Davies, Michela De Dominicis, Mike Elliott, Anita Franco, Kate Gormley, Raeanne Miller, Joanne Porter, Bhavanna Suresh, Andrew Want, Andrea Waschenbach, and David Woolf. Other contributions include Ellie-Mae Cook and Simon Waldman.

The content was prepared by Kimberley Lloyd and edited by Professor Dickon Howell, Dr Henk van Rein, Hayley Hinchen, and Georgina Roberts (HMC) (info@insitenorthsea.org), with support and guidance from Cassie Rist (Defra).

The INSITE Phase 2 programme is funded by the Natural Environment Research Council (£5 million) and the Centre for Environment, Fisheries and Aquaculture Science (£0.6 million), and is sponsored by an industry partnership of North Sea asset operators (£1.9 million).

National Oceanography Centre · University of St Andrews · Natural England · University of Essex · University of Plymouth · NERC Science of the Environment · Heriot Watt University · SAMS Scottish Association for Marine Science · Cefas · Natural History Museum · University of Hull · PML Plymouth Marine Laboratory · aquatera environmental services and products

Front cover Illustration credit: B for Katie Chappell

SYNOPSIS

This document summarises the key findings from the 'INSITEs Into: Offshore Wind' webinar held on 25 May 2023 as part of the INSITE programme. The scientific evidence presented in these projects demonstrates that MMS, specifically offshore wind structures, create opportunities for biodiversity enhancement. CHASANS highlights the increase in biomass associated with the transition to hard substrates and the creation of offshore intertidal habitats. FISHSPAMMS reveals elevated densities of fish at greater distances than previously found around most but not all MMS, while EcoSTAR demonstrates the potential impact on marine mammal behaviour, encompassing both negative and positive outcomes. Importantly, all the projects recognise the importance of considering the wider ecological community and ecosystem shifts. While biodiversity gains and Marine Net Gain (MNG) are important targets, it is crucial to understand the specific biodiversity gains we aim to achieve alongside the conservation of essential ecological functions. As such, all the projects focus on exploring the intricate ecological relationships associated with MMS and their impact on the overall ecosystem.

INTRODUCTION

The offshore wind industry is rapidly expanding to meet ambitious renewable energy targets, leading to increased clustering and density of installations in the North Sea. This trend includes the emergence of floating offshore wind farms alongside traditional fixed structures, presenting both challenges and opportunities for biodiversity conservation and marine management. The EcoSTAR dataset highlights that over 4,250 wind turbines and associate d structures are currently present in the region. Additionally, predictions indicate that the Exclusive Economic Zones in the North Sea will become highly restricted by 2050 (Munro, Waldman & Forster, 2023, *in prep*).

While offshore wind structures offer potential benefits such as biodiversity enhancement and habitat creation, it is essential to recognise the concept of shifting baselines and the complexities of operating within a degraded ecosystem affected by climate change when considering the significance of these benefits. The scale of offshore wind development is leading to landscape changes with a significant increase in hard substrata environments and loss of soft sedimentary habitat.

These shifts can profoundly affect community types, ecosystem functioning, and primary production, and not always in a positive way. Changes in sediment dynamics and altered hydrodynamics around wind turbines also have implications for other marine activities, including fishing and aggregates industries.

This policy brief explores some of the implications of offshore wind deployment on the marine environment of the North Sea, by examining how INSITE science can support the understanding of ecological implications and shifting baselines. The results obtained from studying ecosystem changes under future scenarios will aid in the planning of offshore wind farms and guide policymakers in decommissioning decisions to achieve the most favourable marine environment outcomes.

Strategic Compensation: A measure or a series of measures to provide compensation under the Habitats Regulations that can be delivered at scale and/or extended timeframes. *This cannot be delivered by individual offshore wind project developers in isolation. This policy briefing can support strategic compensation targets by ensuring compensation efforts are science-based and aligned with the best available evidence, identify measures that replicate or enhance lost ecological functions and assist in identifying the most effective measures for strategic planning and spatial prioritisation to deliver long-term conservation benefits.*

Marine Biodiversity: Encompasses species/habitats richness and diversity and ecosystem functionality. There is a need for understanding how offshore wind structures impact biodiversity, including shifts in community types, increases in biomass and changes in predator-prey interactions. Biodiversity is considered a valuable ecological component that can be enhanced and maintained through strategic compensation measures, MNG initiatives, and the consideration of ecosystem functionality. *The briefing emphasises the importance of incorporating biodiversity considerations into decision-making processes for offshore wind development, decommissioning, and overall environmental management. This policy briefing can inform key biodiversity policies including marine conservation strategies, achieved Good Environmental Status (GES) and the Environmental Improvement Plan (EIP).*

INSITE PROJECTS

PROJECT 1

Connectivity of Hard Substrate Epifaunal Populations (CHASANS) (2019-2024)

(HIGH CERTAINTY)

Biological models of larval connectivity to predict how networks of hard substrate in the North Sea function as part of the dispersal and metapopulation structure of marine epifauna.

KEY SCIENTIFIC FINDINGS

Case studies on Offshore Wind Farm (OWF) projects indicate significant shifts in landscape-scale community type. **The studies revealed a ten to twenty-fold increase in habitat (Cook, E. *in prep*) and an increase in biodiversity biomass ranging from 50% to 150%.** The shift from soft sediment and its associated community functions, such as bioturbation and biogeochemical cycling, to hard substrata habitat leads to alterations in seabed characteristics, including particle size, microtopography, and organic matter content. Consequently, **there is a transition to an epifaunal filter-feeding community on hard substrata, accompanied by a significant increase in biomass, changes to predator-prey interactions, and the creation of offshore intertidal habitat.**

PROJECT 2

Fish Spillover, Production and Aggregation at MMS (FISHSPAMMS) (2019-2024)

(HIGH CERTAINTY)

High spatial resolution measurements of densities and spillover of fish around North Sea MMS. These data will parameterise a high spatial resolution model of fish dynamics around MMS in the North Sea.

Additional evidence *'Distribution of acoustic fish backscatter associated with natural and artificial reefs in the Northeastern Gulf of Mexico'.*

KEY SCIENTIFIC FINDINGS

Ships and Uncrewed Surface Vehicles (USVs), equipped with high-resolution acoustic surveying equipment, have measured areas of influence of MMS extended up to an average of 7 km, indicating long-range effects of increased fish densities.

An exploratory transect through one wind farm site, found fish school density to be 6 times higher compared to the surrounding 10 km area, and non-schooling fish density to be twice as high within the wind farm.

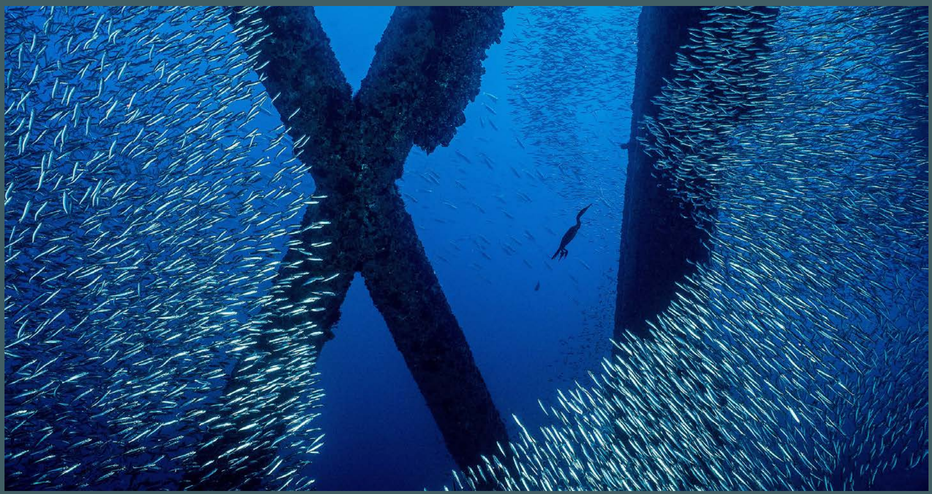


Image credit Alexander Mustard

INSITE PROJECTS

PROJECT 3

Ecosystem level importance of Structures as Artificial Reefs (EcoSTAR) (2019-2024)

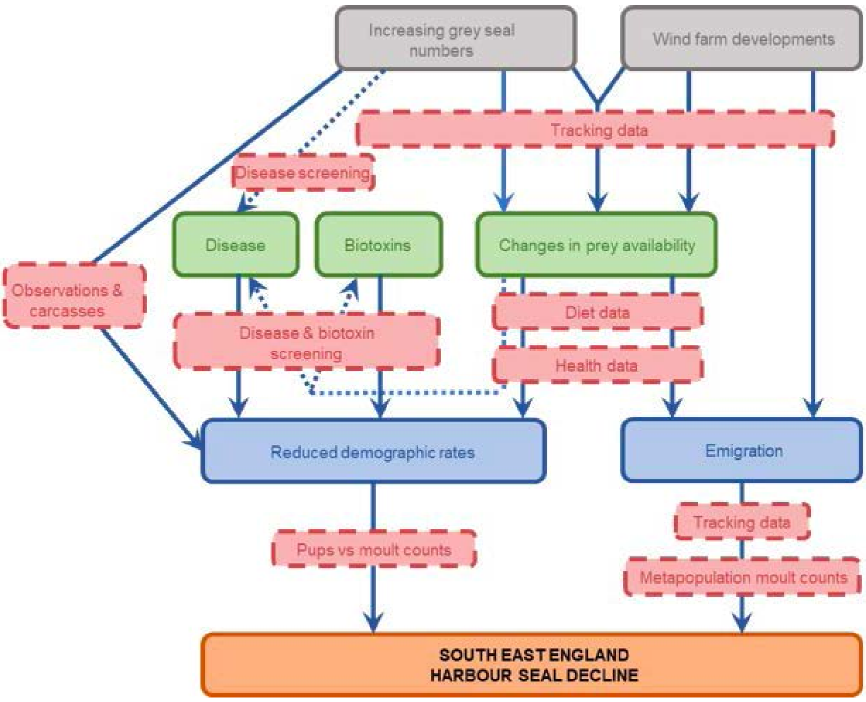
(HIGH CERTAINTY)

Ecosystem models of the costs and benefits of MMS to marine mammals, aiming to offer insights into potential shifts in trophic interactions, species composition, and overall ecosystem functioning, for long-term ecological implications. By comprehending changes in predator-prey dynamics, a more comprehensive Environmental Impact Assessment (EIA) can be achieved, encompassing the full ecological consequences.

KEY SCIENTIFIC FINDINGS

Found **temporary seal abundance decrease within 25 km of pile driving activity** (Russell et al. 2016). However, the limited extent of decrease may have been a function of the strong motivation to move between their haul-out and offshore foraging areas (risk-balancing; Hastie et al. 2021). Although some individual seals forage at MMS (Russell et al. 2014), **no observable impacts on seal density were found during the post-construction and operational phases.** MMS do impact the behaviour of marine mammals in the vicinity of structures, likely a result of changes in fish distribution, density and species composition; there are likely predictable hotspots of some fish species but potentially declines of others (sand eels) dependent on sand features. Such hotspots are the focus of foraging for some individuals but the top-down impacts on fish (ecological traps) and on inter-species competition are unclear.

In addition to primary research, **EcoSTAR showed that the commonly used databases for MMS in the North Sea,** such as OSPAR Offshore Installations or EMODnet, **were limited due to missing platforms, conflicting locational data and outdated or missing metadata. EcoSTAR has corrected these databases** and provided a unified GIS layer for offshore infrastructure.



This research aligns and links with other scientific findings, particularly concerning anthropogenic noise impacts on marine mammals. See 'Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities' and 'Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals'.

Image credit Department for Energy Security and Net Zero (DESNZ), Defra, Natural England, the Natural Environment Research Council (NERC) and Dr Debbie Russell (University of St Andrews). *(Ongoing research)*

POLICY CONTRIBUTIONS

POLICY 1

British Energy Security Strategy (BESS) and the Offshore Wind Environmental Improvement Package (OWEIP)

INSITE can contribute to improving EIAs and contribute to the evidence base for impact reduction measures. Research findings can support the sector-wide overhaul of strategic monitoring, facilitating the standardisation of techniques and data collection. INSITE has the potential to contribute to impactful strategic compensation initiatives and support smarter strategic planning at a sectoral and marine plan level.

POLICY CONTRIBUTION

CHASANS (HIGH CERTAINTY)

The CHASANS approach can be integrated as a **holistic approach to informing EIAs encompassing comprehensive changes within the entire ecosystem community, as well as facilitating discussion on strategic monitoring.** CHASANS promotes the standardisation of data analysis, aiding decision-makers in both deployment and decommissioning in making informed decisions. Understanding the shifts in ecosystem functions **can guide the identification of suitable mitigation measures and compensation strategies that preserve ecological balance.**

—

The CHASANS model can inform decisions on the placement of MMS to promote ecological connectivity. Future climate-driven scenarios will provide evidence on population viability for species of commercial or conservation interest, supporting GES assessment, HMPA network guidance and sustainable bio-resources and fisheries management.

POLICY CONTRIBUTION

FISHSPAMMS (HIGH CERTAINTY)

The unscrewed surface vehicle equipped with advanced acoustic and video technology can standardise monitoring methods. It ensures consistent, low-risk, and low-cost data collection of fish populations around offshore wind farms and allows close proximity to turbines without complex safety procedures. Together with FISHSPAMMS modelling, **the results can be used in EIAs to quantify the impacts of MMS on fish populations. Findings emphasise MMS' significance for fish populations, informing strategic compensation and MNG initiatives.** These research outcomes contribute to the establishment of an evidence base for MMS multiple uses and offer insights for decision-makers when considering decommissioning strategies.

—

The FISHSPAMMS model will demonstrate the effects of aggregation versus local production, inform optimal MMS design for increased fish abundance, and inform mitigation measures to minimise fish displacement, changes in behaviour, and potential habitat loss.

POLICY CONTRIBUTION

ECOSTAR (HIGH CERTAINTY)

The research focuses on the precise impacts of construction activities on marine mammals. The outcomes serve as a **valuable evidence base for implementing effective measures to reduce these impacts and develop targeted mitigation strategies**. This information highlights the importance of considering comprehensive changes within the ecosystem community and emphasises the necessity of implementing strategic compensation measures that support the preservation of essential ecosystem functions. The research also **emphasises the importance of standardising techniques and improving databases to enhance the reliability of EIA and support offshore wind policy decisions.** Policymakers can use this information to align with BESS objectives, making informed decisions on MMS location, design, and mitigation measures.

—

EcoSTAR ecosystem modelling forecasts broader MMS impacts on the ecosystem, which can contribute to a more comprehensive EIA on ecological consequences. Policymakers can use this information to align with BESS objectives, making informed decisions on MMS location, design, and mitigation measures.

POLICY CONTRIBUTIONS

POLICY 2

Marine Net Gain (25 Year Environment Plan)

Defra's 25 Year Environment Plan implements MNG to restore marine biodiversity. INSITE research can contribute to ecosystem service understanding, and provide insights for meaningful biodiversity gains, ecosystem restoration and designing strategic compensation measures.

POLICY CONTRIBUTION

CHASANS (HIGH CERTAINTY)

The increased biomass and biodiversity associated with MMS align with MNG policy goals. However, to achieve desired biomass and biodiversity gains, a holistic approach is necessary for MNG and decommissioning decisions. Understanding trade-offs can guide mitigation strategies and targeted restoration efforts to compensate for lost ecological functions and assists in identifying optimal locations for maximising biodiversity benefits and fostering interconnected ecological networks. **The CHASANS project reveals the creation of unique offshore intertidal habitat, which holds significance for MNG and broader ecological functioning and should be factored into decommissioning decisions**. Understanding the loss of soft sediment habitats will be important for ensuring that the ecosystem functions are compensated by providing alternative resources for affected species.

—

The CHASANS model can support net gain metrics, accurately capturing ecosystem services and pinpointing targeted restoration efforts to reduce fragmentation and enhance ecological coherence. The information can assist in balancing ecosystem characteristics and conserving ecological functions at risk of being lost.

POLICY CONTRIBUTION

ECOSTAR (HIGH CERTAINTY)

The findings contribute to identifying specific locations to achieve meaningful biodiversity gains and guide MNG project placement and design. Additionally, the results emphasise the importance of considering overall ecosystem functioning and can aid in developing targeted restoration efforts.

The findings also inform the development of strategic compensation and MNG measures, including the identification of areas where excluding fishing and establishing de facto protected areas can offset potential impacts and preserve essential ecosystem functions.

—

EcoSTAR modelling can provide future scenarios of the ecological interactions with MMS. This information can guide MNG objectives, strategic compensation measures, and habitat restoration efforts and inform decision-making processes to achieve MNG.

POLICY CONTRIBUTION

FISHSPAMMS (MEDIUM CERTAINTY)

An exploratory study demonstrated the potential of wind farms as structures that support locally increased fish densities. **By quantifying the increased fish densities and spatial distribution patterns, FISHSPAMMS can provide supporting evidence for MNG metrics.**

—

By applying the FISHSPAMMS model, it will be possible to assess the extent to which spillover from MMS could benefit fish populations and contribute to achieving MNG.

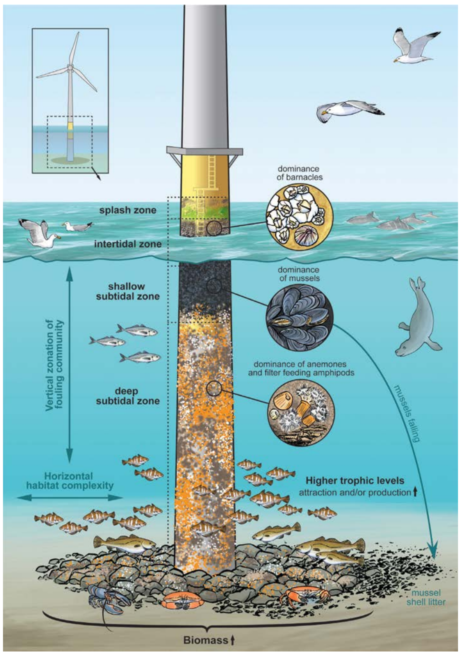


Image credit Illustration by Hendrik Gheerardyn

POLICY CONTRIBUTIONS

POLICY 3

Marine Spatial Prioritisation (MSPri), Marine Conservation and Marine Planning

INSITE research can provide evidence for identifying conservation priorities, areas of high ecological significance for highly protected marine areas, fisheries, renewables and recreation, guiding decision-makers towards maximising co-location between sea users and prioritising how to get the best out of marine space.

POLICY CONTRIBUTION

CHASANS (HIGH CERTAINTY)

The findings on increased biodiversity biomass and landscape-scale community shifts can inform the prioritisation of conservation efforts and suitable sites for marine protected areas. By understanding ecological changes, decision-makers can plan for the multi-use of areas for energy targets and biodiversity gains. An understanding of the loss of important features provides evidence to support decisions that maintain ecological balance, identify restoration efforts, and inform HMPA networks. **Evidence on hydrodynamic changes, larval settlement and predator-prey interactions can support the assessment of GES, MPA network guidance and the sustainable management of fisheries.**

—

The CHASANS model can inform decisions on the placement and design of MMS, to enhance connectivity and promote ecological connectivity in strategic areas and support the assessment of GES, HMPA network guidance and sustainable management of bio-resources and fisheries management.

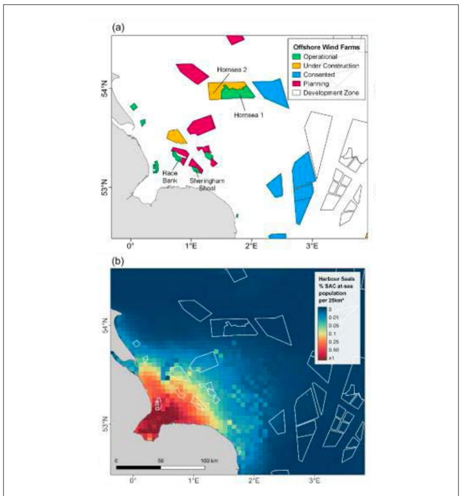
POLICY CONTRIBUTION

FISHSPAMMS (MEDIUM CERTAINTY)

Understanding fish dynamics can improve understanding of additional impacts, such as changes in the abundance and distribution of birds and marine mammals. **This knowledge can inform decisions on offshore structure design, placement, and management, therefore aiding marine spatial planning. These results can support maximising the co-location of different users by identifying areas where fisheries can benefit from spillover effects.**

—

The FISHSPAMMS model provides insights such as identifying areas of ecological significance and assessing potential impacts on fish populations. Outputs can support the co-location of marine activities and inform fisheries and sustainable resource management measures



POLICY CONTRIBUTION

ECOSTAR (HIGH CERTAINTY)

These insights aid in identifying conservation priorities and areas of high ecological significance for various marine activities. They assist decision-makers in **optimising co-location between sea users and maximising the use of marine space, supporting the development of strategic approaches for conservation and sustainable marine resource management.** *(See image below).* The EcoSTAR project addresses limitations in existing databases for MMS in the North Sea, providing valuable data to understand how structure traits impact the ecosystem. This information is crucial for informing policy decisions and future marine spatial planning (MSP) in the North Sea.

—

The EcoSTAR model will support MSPri and MSP by identifying ecologically valuable areas and informing decisions regarding HMPA and fisheries management. The model's outputs can be used in optimising the co-location of different marine activities and identifying areas with favourable benefits from MMS.

Image credit EcoSTAR, Dr Debbie Russell (University of St Andrews)