Marine Monitoring

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

INSITE SUMMARY

The INSITE Programme was launched in 2014 as the first joint industry partnership between academia and oil and gas (O&G) operators in the North Sea. It delivers focused research to provide the independent scientific evidence base to better understand the influence of man-made structures (MMS) on the North Sea ecosystem. The programme 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. INSITE evidence supports the development of policy for nature-positive approaches to decommissioning that can underpin the attainment of good environmental status (GES) and other policy actions relating to the sustainable management of UK seas.

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Front cover Illustration credit: B for Katie Chappell

SYNOPSIS

This document summarises the key findings from the "INSITEs Into Marine Monitoring" webinar held on November 30th, 2023. The evidence presented demonstrates that advancements in marine monitoring offer novel data collection methods capable of addressing comprehensive ecosystem-level questions. The AT-SEA project showcased how autonomous monitoring can gather extensive high-resolution data to allow the measurement of various physical, chemical and biological parameters. The NS3D project employs fast species identification and mapping, alongside modelling volume, and biomass of marine animals. The FuECoMMS project highlighted the potential of using environmental DNA (eDNA) for understanding ecosystem processes, chemical functioning, and environmental health. Collectively, the projects emphasise how future monitoring can shift from species-focused approaches to holistic ecosystem assessments, supporting informed decision-making for strategic planning and policy.

INTRODUCTION

Marine monitoring is becoming increasingly important to inform the response to growing threats in the marine environment. With about 10% of North Sea installations already in the decommissioning phase and the remaining set to follow suit by 2050, the need for thorough monitoring during this period is crucial.

The consequences of decommissioning decisions are only starting to become more certain, potentially causing disturbances in the seabed system, altering faunal communities, and impacting ecosystem functioning. However, some decommissioning scenarios can yield positive impacts, boosting biodiversity and connectivity in marine ecosystems. As offshore wind farms (OWF) become key for achieving net zero targets, large-scale, long-term, coordinated monitoring efforts are essential. However, moving towards ecosystem level monitoring brings further challenges at larger spatial and temporal scales. At the same time, new policy areas are introducing additional monitoring needs, such as Fisheries Management Plans (FMPs), Highly Protected Marine Areas (HPMAs), and Marine Net Gain (MNG) which are being explored in England through the the marine Natural Capital and Ecosystem Assessment (mNCEA) programme.

The organic development of monitoring programmes over the years has created a fragmented and uncoordinated monitoring landscape. Strategic efforts are now necessary for efficient and effective monitoring that meets both current and future demands. Advancing monitoring strategically requires integration and collaboration that surpass individual projects and programmes. This includes coordinating survey methods, aligning data collection efforts, and sharing existing data resources effectively.

Shifting from habitat and species-focused approaches to ecosystem-level assessments will offer an understanding of whole ecosystem responses to various impacts and assist in the prediction of future scenario and ecosystem dynamics under changing climates. Standardising data and methods will ensure consistency, providing reliable and comparable datasets applicable across various scenarios and scales, which will simplify decision-making processes. However, continual innovation to broaden coverage and decrease reliance on expensive survey vessels is crucial. Thus, it's imperative to reassess current practices, select suitable indicators, and adopt the most efficient techniques, considering existing and emerging solutions.

Marine Monitoring: refers to the regular, long-term collection and analysis of environmental and socioeconomic data to evaluate state, trends, and changes within marine ecosystems. These data assist in measuring achievements against national and global commitments and serve as a scientific evidence base for decision-making processes. Although traditional monitoring methods such as trawling and sediment grabs are still prevalent and relevant for many scientific questions, this policy brief highlights the potential for innovative methods to contribute data to deliver more comprehensive and reliable assessments of ecosystem health.

Ecosystem assessments: Research and policy highlights the need to shift from habitat / species / single parameter assessments to more holistic ecosystem assessments. Unlike species-focused methodologies, ecosystem assessments offer a comprehensive view of ecosystem dynamics, resilience, and functionality, which is crucial for meeting various marine policy objectives. INSITE advanced monitoring techniques can gather detailed data on biodiversity, ecosystem health and habitat conditions using eDNA, AUV and modelling, which collectively yields diverse data expanding beyond species presence and abundance, exploring the interconnections between parameters influencing species dynamics and the physical, chemical, and biological processes shaping ecosystem health. These insights translate into actionable strategies to better understand and enhance marine ecosystems towards recovery, offering informed guidance for policymakers. This will be particularly important for Marine Net Gain (MNG), which aims to increase overall habitat quality and biodiversity, compensating for any unavoidable losses caused by development activities.

INSITE PROJECTS

PROJECT 1

Autonomous Techniques for Infrastructure Ecological Assessment (AT-SEA) (2019-2024)

(HIGH CERTAINTY)

Two successful, fully autonomous monitoring missions visiting decommissioning-related sites (Northwest Hutton and Miller platforms) and an MPA (Braemar Pockmarks) were carried out covering 1013km using under 2L of fuel, to demonstrate the feasibility of autonomous monitoring in comparison to standard approaches.

Additional evidence: *Marine autonomous systems could automate much environmental monitoring, provide cost savings with improved spatial and temporal resolution data.*

KEY SCIENTIFIC FINDINGS

The shore-launched Autonomous Underwater Vehicle (AUV) demonstrated effective remote sensing capabilities, yielding significant monitoring data including:

- 1cm resolution bathymetry data alongside high-definition seafloor photographs, enabling the production of detailed microbathymetry to identify changes in seafloor elevation around structures, seabed hazards and seabed appearance.
- Water column analysis determining current speed, direction and particulate presence.
- Chemical impact detection including oil in the water column and finding active pockmarks through methane signatures.
- Habitat and fauna data from rapid analysis of larger fauna from imagery, depicting habitat variations across wide areas, facilitating targeted focus on most relevant habitats and fauna.
- Detected debris, litter, pipeline conditions, and identifying seafloor impacts such as drill cuttings.
- Fully autonomous monitoring demonstrated substantial cost, energy, and emission savings compared to conventional methods, while also reducing risks to personnel involved.

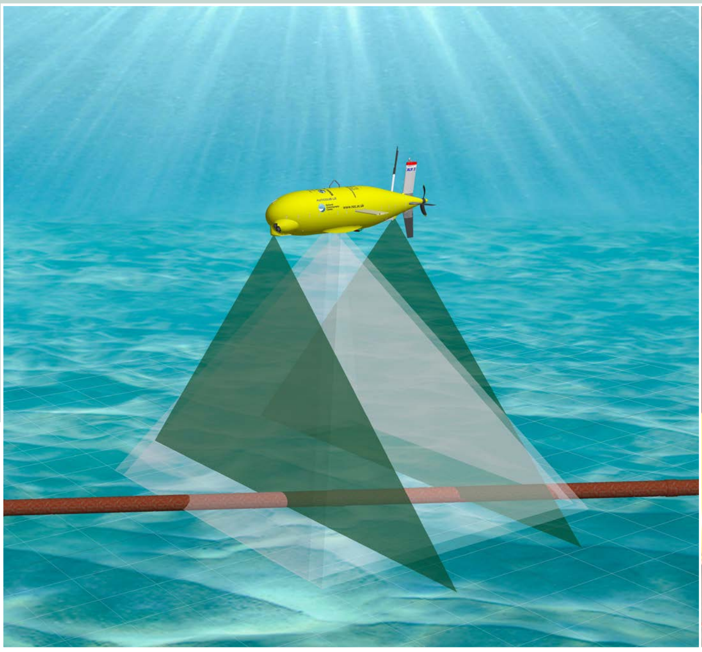

Image credit: National Oceanography Centre

INSITE PROJECTS

PROJECT 2

North Sea 3D - Automated marine growth identification and biomass estimation (NS3D) (2019-2024)

(HIGH CERTAINTY)

NS3D has applied artificial intelligence developments to the analysis of remotely operated vehicle (ROV) and AUV underwater vehicles. This innovation aims to swiftly identify and map taxa, circumventing the time-consuming, expensive, and inconsistent outcomes of manual analysis. Using 3D photogrammetry, the project team predicted the volume and biomass of organisms on MMS, potentially enabling the assessment of ecosystem health and change. They have also developed a standard operating procedure for data collection via ROVs that maximises the potential for machine-based analysis. Analysis methods are being used to identify individual fish and integrate multispectral and acoustic data into the training process, enhancing the analysis capabilities.

KEY SCIENTIFIC FINDINGS

- Generation of calibration models converting volume to biomass in key marine growth taxa, such as sponges.
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- Successful training of machine learning, to assist in image analysis across key marine growth taxa and priority marine nature conservation features.
- Auto-identification of marine growth taxa and incorporation into 3D models, enabling machine-assisted volume and biomass estimation.
- Implementation of 4D multi-camera photogrammetry, enabling measurements of behaviour and size variations over time and under different conditions such as feeding regimes.
- Recognition that machines can significantly aid in interpreting and analysing large volumes of high-resolution data, addressing the demands that will be produced by collecting extensive and detailed monitoring datasets in the field.

Recent studies: indicate a need for a shift in monitoring requirements away from species-specific focus, with current monitoring yielding limited data for ecosystem assessments – rich in detail but information poor.

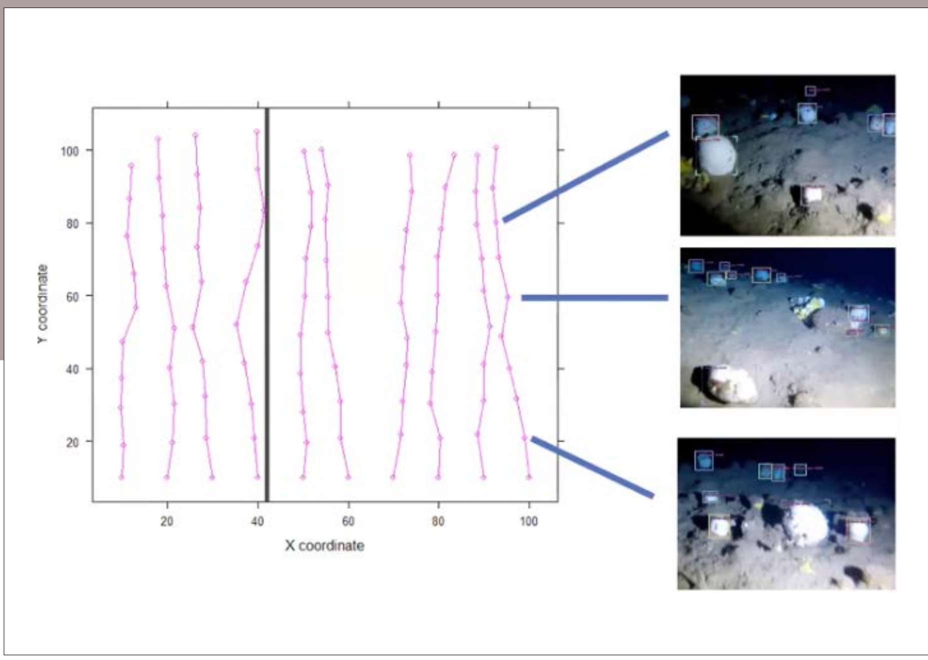


Figure: Example of ROV tracks over seabed with points showing location where data is auto-extracted from individual image-frames. These data can then be processed in the standard manner.

Image credit: Wilding/Marlow/Halpin, SAMS.

INSITE PROJECTS

PROJECT 3

Functionality and Ecological Connectivity of Man-Made Structures (MMS) (FuECoMMS) (2019-2024)

(HIGH CERTAINTY)

FuECoMMS focuses using innovative technologies including eDNA and ecosystem models to understand the impact of removing MMS and their role in ecosystem processes. Monitoring campaigns were conducted at two decommissioned sites (Miller and Northwest Hutton) where platforms were removed but the platform legs remained. The study involved sampling sediment carbon storage, biodiversity, chemistry, and metals across gradients. Traditional sediment grab macrofaunal methods were then compared to eDNA analysis.

Ongoing efforts are directed towards exploring metal concentrations and the microbial community's response using diverse eDNA approaches. FuECoMMS has been tackling important questions such as, how long will it take for the seabed to return to baseline conditions after decommissioning/hydrocarbon extraction activities, and what are the responses of communities to chemical pressures?

KEY SCIENTIFIC FINDINGS

- eDNA has the potential to enhance marine monitoring to assess seabed and ecosystem health. It offers insights into microbial driven biogeochemical function, the biodegradation potential of sediments to remove or detoxify specific pollutants, as well as micro and macrofauna biodiversity. Typically, eDNA is much quicker and has higher sample throughput than traditional macrofaunal taxonomy approaches.
- Distinct changes in microbial community structure were found closer to the MMS, most notably those microbes involved in carbon and sulphur cycling. This indicates an impact of MMS on specific taxa which could be used as potential biomarkers for monitoring the health of sediments post decommissioning.
- Chemical analyses including nutrients such as sulphate, pH, total hydrocarbons (alkanes and PAHs) and metals (e.g. chromium, copper, zinc, and lead) indicated escalated levels in close proximity to the platforms. This indicates a lasting impact of MMS on benthic ecosystems, even after decommissioning more than a decade previous.

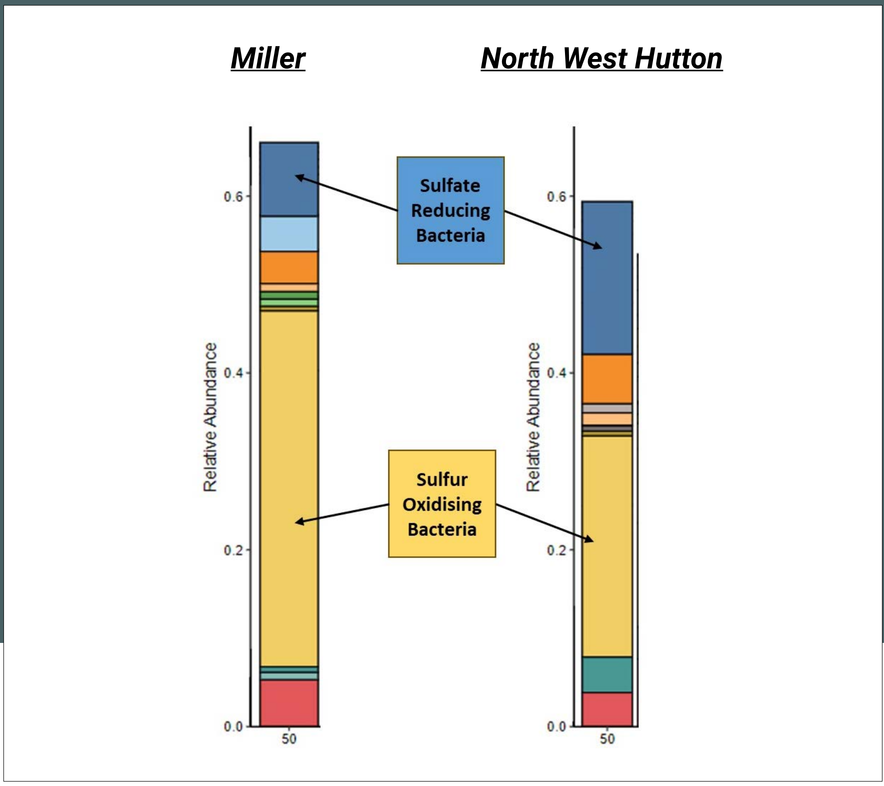


Image credit: Gareth Thomas, University of Essex

COLLABORATION

Both AT-SEA and FuECoMMS conducted surveys on the Northwest Hutton steel jacket platform, decommissioned in 2009.

Advancing monitoring strategically requires integration and collaboration that surpass individual projects and programmes. This includes coordinating survey methods, aligning data collection efforts, and sharing existing data resources effectively. Shifting from habitat and species-focused approaches to ecosystem-level assessments will offer an understanding of whole ecosystem responses to various impacts and assist in the prediction of future scenario and ecosystem dynamics under changing climates. Standardising data and methods will ensure consistency, providing reliable and comparable datasets applicable across various scenarios and scales, which will simplify decision-making processes. However, continual innovation to broaden coverage and decrease reliance on expensive survey vessels is crucial. Thus, it's imperative to reassess current practices, select suitable indicators, and adopt the most efficient techniques, considering existing and emerging solutions.

The innovative methods used by the AT-SEA and FuECoMMS projects are efficient and cost-effective, reducing the vessel time needed for these operations at small spatial scales. Data collected includes fine-scale acoustic mapping, detailed seabed imagery, bathymetry, microbathymetry, water column analysis, and chemical level of hydrocarbons, sulfate, pH, alkene, and PAH, as well as metal concentrations including chromium, copper, zinc, and lead. These surveys also cover macrofauna, meiofauna, microfauna, metagenomics, microbial communities, habitats and debris, which can all be synthesised for a comprehensive ecosystem assessment.

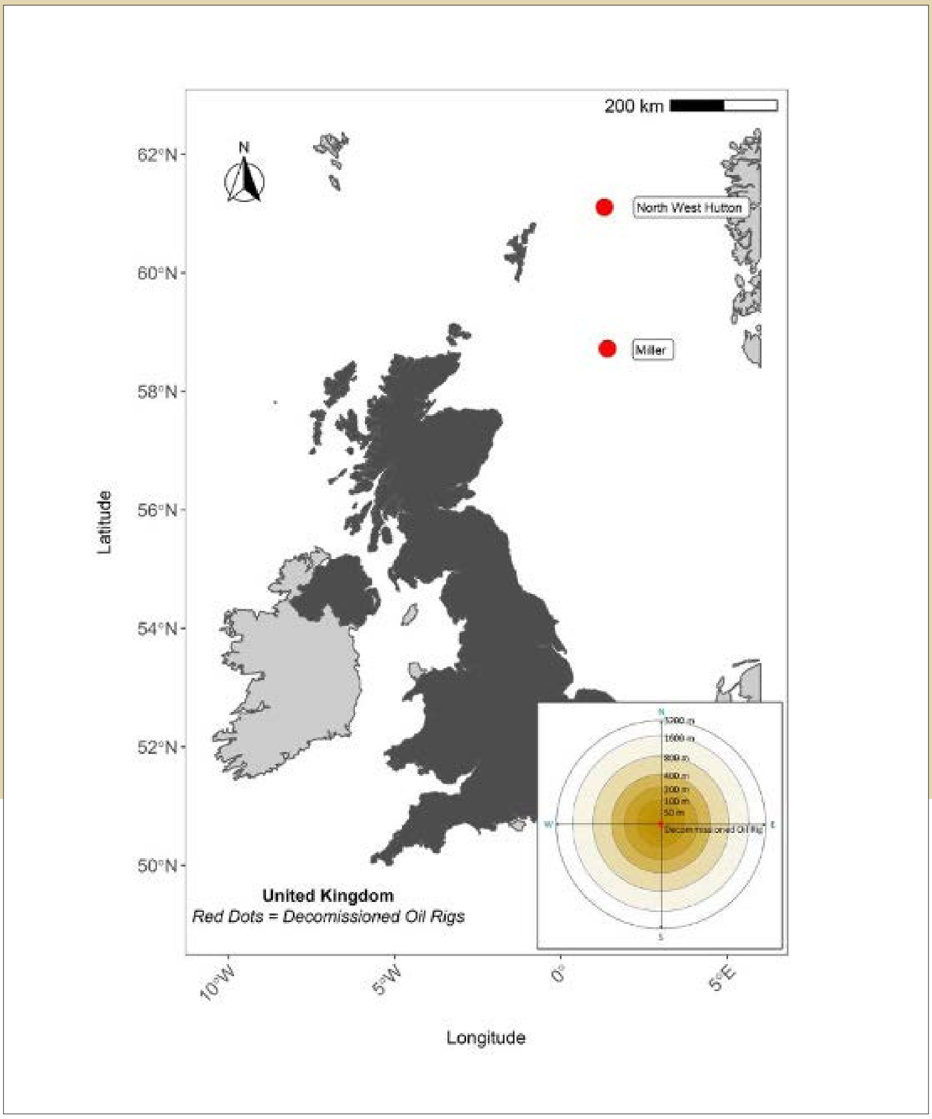


Image credit: Gareth Thomas, University Essex

POLICY CONTRIBUTIONS

POLICY 1

2023 Environmental Improvement Plan (IEP)

Aims to drive progress towards environmental recovery, with monitoring serving as the compass to achieve both long-term and interim targets. INSITE research can contribute significantly across the spectrum of EIP indicators, as well as inform the mNCEA programme and provide insights for meaningful biodiversity gains, ecosystem restoration, and designing strategic compensation measures and monitoring programmes.

POLICY CONTRIBUTION

AT-SEA (HIGH CERTAINTY)

Successful AUV missions at decommissioning sites and MPAs covered **extensive areas efficiently, and showcased AUV monitoring value** compared to traditional methods. AUV monitoring could inform the **outcome indicator framework** for seafloor habitats, status of features, habitat functioning, quality and connectivity, and abundance and distribution of species. This technology explores the role of MMS in altering water dynamics, chemical composition, and benthic habitats. The versatility of AUV technology and the range of data it can deliver at scale suggests potential applications beyond decommissioning, including contributing to MPA and natural capital ecosystem assessments. Its **cost-effectiveness enables multiple high-resolution surveys, aiding quick, broad-brush fauna and seabed assessments;** crucial for restoration or MNG monitoring. **AUV's reduce cost, carbon footprints and human risks, while enhancing temporal and spatial resolution of some data. This suggests the technology could be transformative for long-term monitoring.**

POLICY CONTRIBUTION

NS3D (HIGH CERTAINTY)

The successful implementation of AutoID techniques marks a paradigm shift in monitoring practices, bypassing laborious, inconsistent, and costly analysis by humans. This advancement is crucial for the **outcome indicator framework** and can be **used to assess seabed conditions, habitat functioning and connectivity, species supporting ecosystem functions and species distributions** more reliably. These techniques facilitate comprehensive monitoring of marine growth on MMS, **informing decommissioning decisions, and identifying scenarios beneficial for biodiversity gains.** Modelling organisms' behaviour and biomass enhances understanding of ecosystem health and responses to changing conditions, integral for **understanding ecosystem value, informing natural capital assessments, and comprehending the economic value of MMS.**

NS3D are aiming to integrate new insights into regulatory practices and hope to work closely with decision-makers to include **taxa-specific biomass estimates in ecosystem models** such as Ecopath, and potentially contribute to the **North Sea's food-web model.**

POLICY CONTRIBUTION

FuECoMMS (HIGH CERTAINTY)

Insights from eDNA approaches can expand marine monitoring capabilities, such as understanding ecosystem health, dynamics, and chemical processes. This can assist in evaluating the **outcome indicator framework** in relation to seabed conditions, species distributions, species-supporting ecosystem processes, and marine food web functioning. The findings offer crucial insights for decommissioning decisions, highlighting the lasting impacts of MMS on altering macrofauna and microfauna biodiversity, and chemical signatures

This information underscores the importance of considering the **long-term consequences of MMS** on marine ecosystems, guiding strategies for minimising impacts and prioritising restoration, as well as informing decommissioning practice. Understanding ecosystem services, such as nutrient cycling, can help to provide a comprehensive evaluation of the **ecological and economic value for natural capital assessments.** FuECoMMS data offers insights into enhancing ecological functionality, prioritising the functionality of marine ecosystems, as well as considering biodiversity gains, which will be important for MNG initiatives.

POLICY CONTRIBUTIONS

POLICY 2

UK Marine Strategy

INSITE research provides evidence that will assist in assessing and achieving GES across all descriptors. It aids in guiding decisions on ecosystem health, MPA networks, decommissioning strategies and advocates for ecosystem-based monitoring approaches, emphasising biodiversity gains and ecosystem restoration.

POLICY CONTRIBUTION

AT-SEA (HIGH CERTAINTY)

AUVs generate high-resolution data encompassing bathymetry, chemistry, and biology, enabling efficient assessments of ecosystem health. This capability holds **significant value for monitoring the descriptors essential for achieving GES** including benthic habitats, invasive non-native species (INNS), hydrographical conditions, contaminants, and marine litter. It also provides a multifaceted view of ecosystems, shedding light on reasons behind areas potentially failing to meet GES criteria. The capacity for **rapid assessments and detailed data collection enables decision-makers to take informed actions** and implement necessary measures to ensure the sustainability and health of marine environments. The targeted focus and comprehensive data on habitat status, diversity, and health render it a **valuable asset for planning, establishing and managing MPA networks and restoration initiatives.**

POLICY CONTRIBUTION

NS3D (HIGH CERTAINTY)

The NS3D project will be able to support the assessment of **GES for benthic habitats, INNS, and food webs.** Estimates of epibiota secondary production and biomass associated with MMS can inform **decommissioning decisions and biodiversity monitoring programmes.** NS3D techniques offer detailed comprehension of ecosystem health which can inform the status of MPA features and connectivity and guide necessary recovery strategies. This technology supports **ecosystem-based monitoring,** offering a holistic understanding of ecosystem health which will be valuable information for decision-making and strategic actions for reaching **GES, informing MNG, and ecosystem restoration initiatives.**

Image credit: Role of monitoring and assessment within an overall environmental management cycle.

POLICY CONTRIBUTION

FuECoMMS (HIGH CERTAINTY)

eDNA uses smaller sediment samples, reducing reliance on large volumes of sediments, which proves crucial in the **extensive assessments of GES.** eDNA can specifically contribute to assessing GES of benthic habitats, food webs, INNS, contaminants, and the suitability of habitats for commercial fish and marine mammals based on food web dynamics. Detailed insights into ecosystem processes and food web impacts enable the identification of areas where MMS may alter ecosystems, and on what spatial and temporal scale. Additionally, a detailed understanding of microbial composition can facilitate **targeted restoration measures,** therefore improving ecosystem recovery. This ecosystem-based monitoring approach can inform decommissioning and MMS planning.

The ongoing research investigating wider fish populations that inhabit MMS systems can be used to inform on the **health of fish stocks for FMP and MPA strategies.** Ongoing investigations into community and dietary responses to chemical and metal pressures can inform **proactive monitoring strategies, mitigating environmental impacts** linked to MMS decommissioning and renewable energy development.

POLICY CONTRIBUTIONS

POLICY 3

British Energy Security Strategy (BESS)

INSITE research supports the development of strategic monitoring approaches, facilitating the standardisation of techniques and data collection for Offshore Wind Farm (OWF) installations. This research addresses significant gaps and helps develop strategic monitoring plans, supporting smarter, evidence-based planning at sectoral and marine plan levels.

POLICY CONTRIBUTION

AT-SEA (HIGH CERTAINTY)

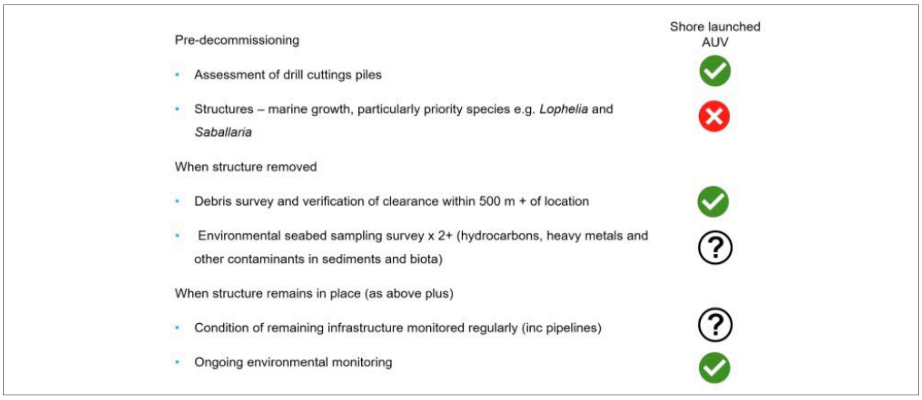
The variety and detail of data collected by AUV can strategically address data gaps and challenges. Full AUV monitoring offers a solution for **standardising techniques and data collection** across multiple target sites and wider monitoring requirements, providing a new era of simplified and consistent monitoring practices. This standardised approach could **accelerate the consenting process,** a pressing challenge for renewable energy projects, by ensuring uniform, comparable data across projects and streamlining operations. For example, simplifying regional cooperation for offshore wind, presenting prospects for joint efforts in monitoring needs, collective decision-making in addressing environmental impacts and mitigation strategies. Additionally, **AUV can support smarter planning at both sectoral and broader marine plan levels,** fostering a coordinated and informed approach to monitoring.

POLICY CONTRIBUTION

NS3D (HIGH CERTAINTY)

Through innovative AutoID technology and advanced modelling, NS3D techniques offer an evidence base that can provide significant input to Environmental Impact Assessment (EIA) while **streamlining data analysis** across MMS projects. This supports the standardisation of EIA methods, facilitating a **fast, effective, and transparent process.** This leads to a clearer understanding of performance metrics, enhancing risk and mitigation assessments, and improved project planning. A standardised approach to data analysis such as this, has the potential to **optimise the licencing process by ensuring the availability of reliable and comparable data.**

NS3D modelling capabilities enable predictions of ecosystem responses to changing conditions, which is crucial in devising adaptive monitoring strategies for offshore development and in understanding complex interactions and ecosystem dynamics.



POLICY CONTRIBUTION

FuECoMMS (HIGH CERTAINTY)

FuECoMMS will be establishing realistic timelines for seabed restoration, which will enable **more accurate EIAs,** enabling more informed decisions in MMS management and contributing to the standardisation of data collection and analysis. Understanding shifts in **trophic interactions, species composition, and ecosystem functionality** could be pivotal for evaluating **long-term implications** of MMS in the environment. FuECoMMS results stress the need to preserve essential ecosystem functions that **underpin food-web stability** when devising **strategic compensation measures** for the impacts of developments. FuECoMMS considers ecosystem processes based on microbial eDNA, offering the potential for a holistic view beyond conventional sediment sampling's diversity assessments. While eDNA might not offer dependable assessments of species abundance on its own, when combined with other monitoring methods it **contributes significantly to comprehending ecosystem health, potentially addressing our inquiries more effectively.** Policymakers can harness these ecosystem assessment insights to ensure effective decision-making regarding offshore infrastructure location, design, and mitigation measures.

Image credit: National Oceanography Centre