Marine Management Organisation

Standardisation of Post-Consent Environmental Monitoring for Wind Farms in English Waters

Final Report

...ambitious for our seas and coasts

Contents

Acronyms Used

BACI	Before - After - Control - Impact
BAG	Before - After - Gradient
Cefas	Centre For Environment, Fisheries & Aquaculture Science
COWRIE	Collaborative Offshore Wind Research into the Environment
DDV	Drop-down video
Defra	Department for Environment, Food & Rural Affairs
EMF	Electromagnetic Fields
eDNA	Environmental deoxyribonucleic acid
ESAS	European Seabirds At Sea
EUNIS	European Nature Information System
GLS	Global Location Sensor
GPS	Global Positioning System
ICES	International Centre of the Exploration of the Sea
IHO	International Hydrographic Organisation
IPMP	In-Principal Monitoring Plan
ISO	International Organization For Standardization
JCDP	Joint Cetacean Data Programme
JNCC	Joint Nature Conservation Committee
LiDAR	Light Detection and Ranging
MCMS	Marine Case Management System
MBES	Multibeam Echosounder
MarLIN	The Marine Life Information Network
MEDIN	Marine Environmental Data and Information Network
MESH	Mapping European Seabed Habitats
MMO	Marine Management Organisation
MMOb	Marine Mammal Observer
MMMP	Marine Mammal Mitigation Plans
MNCR	Marine Nature Conservation Review
MNR	Marine Noise Registry
NE	Natural England
NMBAQC	Northeast Atlantic Marine Biological Analytical Quality Control
NPL	National Physical Laboratory
OMP	Ornithological Monitoring Plan
OWEIP	Offshore Wind Environmental Improvement Package
PAM	Passive Acoustic Monitoring
QAF	Quality Assurance Framework
ReSCUE	Reducing Seabird Collisions Using Evidence
RSMP	Regional Seabed Monitoring Programme
SEL	Sound Exposure Level
SNCBs	Statutory Nature Conservation Bodies
SRU	Strategic Renewables Unit
SSS	Side Scan Sonar
UXO	Unexploded Ordnance
WoRMS	World Register of Marine Species

Executive Summary

This report examines outcomes and conclusions from the Marine Management Organisation's (MMO) Strategic Renewables Unit's (SRU) project to progress the implementation of post-consent monitoring standards for offshore wind farms in English waters, for receptors where agreed standards already exist and where standardisation would be appropriate. The project team have worked with other government departments, Statutory Nature Conservation Bodies (SNCBs) and the offshore wind industry to standardise the monitoring of offshore wind farms, aiming to make post-consent monitoring requirements clear and enable data to be more easily discovered, shared and re-used by stakeholders.

In recent years there have been many publications which identify best practice in collecting and reporting offshore wind monitoring data. The project team reviewed these publications and further literature on existing standardised approaches to environmental surveying and monitoring to then create a list of the most widely recognised standards. These best practice documents and monitoring standards were then also used as evidence to determine which environmental receptors were considered by stakeholders to be best suited to standardised monitoring. These were marine mammals, seabirds, benthic habitats, underwater noise, fish and shellfish and geophysical surveys.

Through a review of literature and post-consent monitoring data the project team created a list of standardisation recommendations. This involved reviewing English offshore wind developments from the past 10 years and their associated post-consent monitoring documentation available through the MMO's Marine Case Management System (MCMS). Documents were reviewed for explicit references or methodology that closely aligned to the monitoring standards identified in the initial research. The results were then recorded to allow for a systematic analysis of the consistency or deviation in standards applied for each receptor and any trends that emerged in alternative monitoring approaches. This database was used to create an initial list of recommendations for agreed standards, which became the focus of a stakeholder workshop.

The project team organised a workshop, hosted at The Crown Estate, where the recommendations were presented and discussed with various government departments and SNCBs. The workshop saw attendees split into breakout groups, in which facilitators for each group asked for opinions with a set of pre-determined questions regarding key issues that had been identified in the previous research stages. Opinions on the recommended standards and their appropriateness were shared by attendees and their responses were recorded, then analysed qualitatively and written up formally.

A key piece of feedback from the stakeholder workshop was the need to engage directly with developers and organisations that carry out monitoring to aid the projects teams understanding of practical challenges associated with the proposed standards. To understand the industry perspective, the project team collaborated with RenewableUK to produce a summary of the recommendations, alongside a questionnaire, which was distributed to the RenewableUK Offshore Consents and Licensing Group. The same short summary of the recommendations, and

questionnaire was also shared with further stakeholders including The Wildlife Trust, an industry consultancy and the Isle of Mann Government. The results of the survey were then analysed qualitatively and written up formally in a report.

Following extensive feedback from both the stakeholder workshop and the industry survey, the final standards were created as recommendations for applicants to follow when finalising their post-consent monitoring plans. These will be implemented through the MMO Licensing Team as a checklist, in which applicants are expected to use them.

Lastly, this project does not aim to suggest *what* must be monitored, but rather *how* surveys must be completed. The monitoring required for each offshore wind farm project is agreed on a case-by-case basis and will include discussions between developers, the relevant SNCB and MMO's Marine Licensing Team to deem what is applicable for the project area.

This report recommends that the following standards are used for post-consent monitoring:

Marine Mammals

MM1: The Joint Cetacean Data Programme (JCDP) data guideline to be used for boat based and aerial surveys, and data to be uploaded to the International Centre of the Exploration of the Sea (ICES) Data Portal within 6 months after the monitoring report has been discharged.

MM2: Reporting of marine mammal mitigation used during unexploded ordnance (UXO) clearance should follow section 3 of the Joint Nature Conservation Committee (JNCC) Guidance (2025).

MM3: Reporting of marine mammal monitoring during piling to follow section 3.1 of JNCC Guidance (2010).

Underwater Noise

UWN1: The National Physical Laboratory (NPL) Good Practice Guidance Note no. 133 for monitoring of underwater noise levels generated by wind turbines using hydrophones, pre-, during and post-construction.

UWN2: The Marine Environmental Data and Information Network (MEDIN) standard for noise surveys is the MEDIN data guideline for underwater noise data, as requested through the NPL Guidance.

Seabirds

SB1: The development of each wind farm ornithological monitoring plan includes engagement with Natural England (NE).

SB2: Ornithological monitoring plans to consider NE's best practice guidance for post-consent monitoring relating to seabirds (Parker et al., 2022) which provides advice in relation to common monitoring solutions and key considerations for implementation.

Fish & Shellfish

FS1: Species to be recorded using the World Register of Marine Species (WoRMS) list of accepted scientific names.

FS2: Fish & shellfish surveys to use the MEDIN standard. These are the MEDIN data guideline for species and benthos data by trawl or dredge, video surveys of species and benthos and shellfish stock assessment data.

FS3: The JNCC Marine Monitoring Handbook to be used for sampling benthic and demersal fish populations on sediments.

FS4: If eDNA-based methods are used then this should follow NE's Monitoring methods for assessing inshore fish communities (Franco et al. 2020a).

Benthic

BE1: Standards in the Northeast Atlantic Marine Biological Analytical Quality Control (NMBAQC) Scheme to be followed for benthic sample analysis, including the use of MEDIN standard for benthic data recording.

BE2: The JNCC Marine Monitoring Handbook, including Guidelines No. 3-9 and the Procedural Guidance 4-3 should be followed for benthic sample collection.

Geophysical

GE1: International Hydrographic Organisation (IHO) standards S44 and S57, for hydrographic surveys. If completed alongside a side-scan sonar survey, bathymetric coverage should comply with Order 1a or Order 1b. If not accompanied by side scan sonar surveys, hydrographic surveys should provide 200% coverage (Exclusive Order).

GE2: Side-scan sonar & multi-beam echosounder surveys should follow Mapping European Seabed Habitats (MESH) Remote Operating Guidelines and MESH Remote Operating Guidelines for swath Bathymetry, respectively.

GE3: Geophysical surveys to use the MEDIN standard. These are the MEDIN data guideline for seismic data, bathymetry data, sampling sediment and rock characteristics and for side scan sonar data.

All Receptors

AR1: Monitoring plans and reports to include clear signposting of monitoring/data standards.

The project team acknowledge that these recommendations may need to be revisited at timely intervals to update to newer standards and methodologies, as well as to encompass new technologies in monitoring. The first review is expected to be 12-24 months after this initial publication.

1. Introduction

Monitoring carried out by developers during the development and operational lifetime of an offshore wind farm is crucial to understanding and managing the environmental impacts of development. Monitoring aims to validate predictions made in statutory environmental assessments, detect any unforeseen impacts, and ensure effectiveness and compliance with measures used to mitigate significant impacts.

In recent years there have been publications which identify best practice in collecting and reporting offshore wind monitoring data[1,2]. A standardised approach to monitoring (i.e. the formalisation of best practice through formal guidance, and implementation in decision-making) would lead to several benefits. A standardised approach to monitoring would allow data to be compared more easily between projects, making it easier to draw robust conclusions about cumulative impacts and allowing the conclusions from one monitoring programme to be used in assessing the impacts of another project. Over time this would reduce the uncertainty in assessments by creating a stronger feedback loop between data, evidence and decision-making. Standardised approaches to monitoring would also enable data to be more easily discovered, shared and re-used by stakeholders including industry, government bodies, regulators and academics, by ensuring that data is presented in an accessible and widely understood format. For the Marine Management Organisations (MMO) Licensing Team, a considerable amount of time is spent discussing monitoring programmes with other regulators and SNCBs during the application and post-consent process (*See Annex A*). By producing monitoring standards, this will reduce time spent on these conversations and increase certainty that best practice will be followed, reducing the potential for disagreement and providing clarity to industry organisations on what is expected of them. Therefore, standardisation of monitoring, along with a more strategic approach to monitoring, is understood to be a key opportunity for enabling the sustainable deployment of offshore wind[3].

This project has identified offshore wind monitoring standards in English waters, for receptors where agreed standards already exist and where standardisation would be appropriate. The project was led by the MMO's Strategic Renewables Unit, working with MMO's Marine Licensing Team, RenewableUK, The Crown Estate, JNCC, Natural England (NE), Defra, Cefas, Nature Scot and Scottish Government: Marine Directorate.

2. Scope

The scope of this projects was as follows:

[1] (Natural England, 2022) Offshore wind – best practice advice to facilitate sustainable development: https://naturalengland.blog.gov.uk/2022/04/13/offshore-wind-best-practice-advice-to-facilitate-sustainable-development/

[2] Marine Data Exchange: https://www.marinedataexchange.co.uk/content/info/data-delivery-requirements

[3] See for example - Tim Pick's Offshore Wind Champion Report, Defra's Offshore Wind Environmental Improvement Package, and Pathways 2 Growth's 2024 Focus Areas.

1. Two types of standards were considered: standardised methodology for collecting data, and standardised approaches to recording and storing data.
2. Six environmental receptors were selected by the project team to be standardised, these are: marine mammals, seabirds, benthic habitats, underwater noise, fish and shellfish and geophysical surveys.
3. Standardisation will be applied to wind farms within MMO jurisdiction[4].
4. The project focused on post-consent monitoring, which the MMO has the most ability to influence through the Marine Licensing Team and where data is readily available to the MMO. However, where there are existing requirements/standards for pre-consent monitoring (e.g. as set out in SNCB guidance and The Crown Estates specification[5]), the project has looked to align with these.
5. This project did not aim to suggest *what* must be monitored, but rather *how* surveys must be completed. The receptors chosen for each offshore wind farm project is agreed on a case-by-case basis and will include discussions between developers, the relevant SNCB and MMO's Marine Licensing Team to deem what is applicable for the project.

Please note that the development of new standards was not in scope of the project.

3. Methodology

Please see *Annex B* for methodology figure to display the actions of the project.

3.1. Existing Standards Research

The project team reviewed the literature on existing standardised approaches to environmental surveying and monitoring which allowed the team to create a list of the most widely recognised standards. This included approaches such as:

- The Joint Cetacean Data Programme (JCDP)
- European Seabirds At Sea (ESAS)
- The Northeast Atlantic Marine Biological Analytical Quality Control (NMBAQC) Scheme
- The National Physical Laboratory (NPL) Guidance
- The International Coastal Exploration of the Seas (ICES)
- The International Hydrographic Organisation (IHO)
- The Marine Environmental Data and Information Network (MEDIN)

Other key documents which informed the research on existing standards were NE's reports on Offshore Wind Best Practice Advice[6] and on assessing the potential for offshore infrastructure as platforms for environmental monitoring[7].

[4] English inshore (MHWS tidal limit to 12nm) and offshore (12-200nm or territorial limit) waters.
[5] Pre-Consent Survey (The Crown Estate, 2023):https://www.marinedataexchange.co.uk/details/TCE-3880/2023-the-crown-estate-pre-consent-surveys-geophysics-survey-scope-and-specification
[6] (Parker et al., 2022) Phase IV Best Practice Advice for Post-Consent Monitoring: https://naturalengland.blog.gov.uk/2022/04/13/offshore-wind-best-practice-advice-to-facilitate-sustainable-development/
[7] (Natural England, 2022) Assessing the potential for offshore infrastructure as platforms for environmental monitoring (NECR446): https://publications.naturalengland.org.uk/publication/6671138330771456

These best practice documents and monitoring standards were then used as evidence to determine which environmental receptors were considered by stakeholders to be best suited to standardised monitoring and should be considered throughout the rest of the project. The list of topics taken forward for further research was: marine mammals, seabirds, benthic habitats, underwater noise, fish and shellfish and geophysical surveys.

Other types of monitoring identified included scour and accretion, water quality and electromagnetic fields. However, the project team found that monitoring of these receptors is less standardised compared to the six focus receptors above. For both water quality and electromagnetic fields, monitoring methodologies were not identified in the wider literature and only in NE's "Offshore infrastructure as platforms for environmental monitoring". As stated by NE, integrating sensors into turbine design comes with many challenges, including the design, cost and operation of embedded sensors. Little information was also found on monitoring approaches for scour and accretion. Furthermore, the project team also discovered at the following stage of the project that the methods used for this receptor were mainly discussed in the geophysical monitoring reports. Therefore, none of these receptors were considered beyond this stage of the project.

For each receptor taken forward, the relevant guidance was reviewed, and a detailed breakdown of the data and monitoring standards was produced. This information was recorded in an excel spreadsheet and formed the basis of the next stages of the research.

3.2. MCMS Overview Research

The next step of the project sought to 'ground truth' the findings of the team's initial research on monitoring standards. This involved reviewing English offshore wind developments from the past 10 years and their associated post-consent monitoring documentation available through the MMO's Marine Case Management System (MCMS). A ten-year cut off was applied, as it was felt that the approach taken for monitoring older wind farms may no longer be relevant. Overall, the project team reviewed 136 monitoring reports.

The project team used MCMS to locate and review each wind farm's monitoring programmes and reports from the pre-construction phase through to the post-construction period (*See* *Annex C*) for each receptor. Documents were reviewed for explicit references to the monitoring standards identified in the initial research as well as to identify methodology that closely aligned with these. Furthermore, this review also identified some new standards that were not previously mentioned in the literature.

The results were then recorded on a database to allow for a systematic analysis of the consistency or deviation in standards applied for each receptor and any trends that emerged in alternative monitoring approaches. The project team then used this database to create an initial list of recommendations for agreed standards, which became the focus of the Stakeholder Workshop.

3.3. Stakeholder Workshop

Based on the existing standards research and MCMS research, a list of recommendations for agreed standards were collated and shared with key stakeholders in advance of a hybrid engagement workshop, hosted at The Crown Estate in Autumn 2024. The research methodology was also shared with workshop attendees. The organisations in attendance (both in person and online) included:

- RenewableUK
- The Crown Estate
- NatureScot
- Scottish Government's Marine Directorate
- Cefas
- Natural England (NE)
- JNCC
- Defra
- Marine Licensing from the MMO

The workshop included 3 breakout groups, 2 in person and 1 online with 3 facilitators (1 per breakout group) from the project team. Once attendees split into breakout groups, each facilitator discussed 2 receptors with the attendees in 45 minutes. The receptors were grouped into marine mammals and noise, ornithology and fish and shellfish, and benthic and geophysical. Each facilitator asked the group for opinions on the recommended standards and their appropriateness and then also prompted additional thinking with a set of pre-determined questions regarding key issues that had been identified in the previous research stages. The project lead then led a summary session to bring all attendees together and ask some pre-prepared holistic questions and allow for any further general points to be made by attendees.

The responses from the stakeholders were recorded in a scribe template and each facilitator produced a 'headlines' summary across the 3 breakout groups for their 2 receptors alongside outstanding questions, which were shared with the attendees for validation and any further comment. These responses were then analysed qualitatively and written up formally in this report.

3.4. Further Feedback

A key piece of feedback from the stakeholder workshop was the need to engage directly with developers and organisations that carry out monitoring – to understand any practical challenges associated with the proposed standards. To understand the industry perspective, the project team collaborated with RenewableUK to produce an industry questionnaire. The project team presented the methodology to date to the RenewableUK Offshore Consents and Licensing Group, and the questionnaire was distributed to all members.

During the feedback window, further stakeholders were also consulted including The Wildlife Trust, an industry consultancy and the Isle of Mann Government. To gather their feedback, the same short summary of the recommendations, and questionnaire was shared with them. The results of the survey were then analysed qualitatively and written up formally in this report.

4. Results

This section presents the results for all receptors from each stage of the research, including a summary of feedback from stakeholders. The final list of recommended standards is then presented in section 5, Recommendations and Discussions.

4.1. Marine Mammals

4.1.1. Existing Standards Research

The JNCC and other organisations have developed the Joint Cetacean Data Programme (JCDP)[8]. This is a guideline for effort related cetacean survey data which promotes collection and storage of high-quality data. Compliant cetacean survey methods require the users to record environmental, effort and sighting data. The JCDP currently focuses on data collected from transect methodologies based on either vessel or aerial platforms. This method involves travelling along set transects within a study area to count all individuals of a population encountered, then the total population estimate can be calculated. Furthermore, the JCDP Data Guideline for effort related survey cetacean data (2022)[9] includes data standards for these survey methods and records, identifier and environmental data, effort data and sighting data.

In NE's "Assessing the potential for offshore infrastructure as platforms for environmental monitoring", it is noted that many of the methods relevant to fish surveys, including the use of submersible cameras, Multibeam Echosounders (MBES), as well as tagging individuals, can also be applied to marine mammal monitoring.

NE's "Expectations for monitoring at the post consent phase" states that Marine Mammal Mitigation Plans (MMMP's) are required for activities that may result in injury or lethal effects in marine mammals. The plan should include:

- Description of the project and worst-case scenarios for each noisy activity.
- Results from underwater noise modelling
- Defined marine mammal mitigation zones
- Description and methodology for all mitigation measures
- Roles for marine mammal observers (MMObs) and Passive Acoustic Monitoring (PAM) operators
- Predicted effectiveness of applied mitigation measures
- Description of how relevant licence conditions will be met
- A reporting and communication protocol.

The NE report also states that as well as validating impacts and effects upon marine mammals due to offshore wind farm construction and operation, post-consent

[8] (JNCC JCDP, 2024) Joint Cetacean Data Programme: Data submission and data use resources: https://hub.jncc.gov.uk/assets/1b35ddf6-c469-4bf8-8300-86ec21da1c2d#jcdp-data-standard-v1-1.pdf

[9] (JNCC JCDP, 2022) Joint Cetacean Data Programme Data Guideline for effort related survey cetacean data: https://gis.ices.dk/geonetwork/srv/eng/catalog.search#/metadata/f7b9234a-8f9c-4db3-bcd3-898952b5cd9a

monitoring can also be used to evaluate the effectiveness of mitigation measures. Mitigation measures include MMObs and PAM, Acoustic Deterrent Devices, soft start/ramp up and Noise Abatement Systems. If post-consent monitoring has been used to record the effectiveness of any of these measures, this should be outlined in the Monitoring Plan.

4.1.2. MCMS Overview Research

Of the 136 monitoring reports reviewed on MCMS, 25 of these reports on were on monitoring marine mammals.

Despite no specific mention of the JCDP in any of the reviewed monitoring reports, some matched the survey standards set out in this guidance, without a direct referral to it. These reports focused on data collected following transect methodologies using either vessel or aerial platforms. This highlighted a lack of clear signposting of monitoring/data standards that the project team continued to see throughout this research period. Second to this, only one report mentioned the MEDIN standard for survey data. It would be expected for these reports to have clear signposting to data standards.

The JNCC guidance 2010[10] was mentioned in over half of the reports reviewed in the research, despite not being identified in the initial research. This guidance is JNCC's protocol for minimising the risk of disturbance and injury to marine mammals from piling noise. Industry use the JNCC guidance to create an MMMP document to submit to the MMO for approval, this is because it is a standardised mitigation, not monitoring procedure. Some of the "mitigation" measures recommended are monitoring both through acoustic monitoring (such as PAM) and through visual monitoring (such as MMObs).

There are also reporting requirements outlined in the JNCC guidance on observations of marine mammals, piling operations and any mitigation applied (section 3.1). MMObs were used by many projects to record periods of marine mammal observations, details of environmental conditions (sea state, weather, visibility, etc.) and sightings of marine mammals around the piling vessel as per JNCC marine mammal recording forms and guidelines. Despite this, there is some challenge with MMObs as they only see the cetaceans/evidence above the water line and cannot account for any below. They also only work during daylight, whereas PAM can operate 24/7.

Lastly, BACI (Before - After - Control - Impact) monitoring was mentioned in some of the reports. Despite not being mentioned in the initial research for marine mammals, it was recognised as a monitoring standard and therefore, it formed part of the discussion at the stakeholder workshop.

4.1.3. Stakeholder Workshop

Through discussion, there was widespread support from attendees for use of the JCDP as a standard for recording digital aerial surveys and boat-based survey data for marine mammals. It was also decided that there is a need to understand why the

[10] (JNCC guidance, 2010) Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise: https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/JNCC-CNCB-Piling-protocol-August2010-Web.pdf

standard is not currently widely used and whether there are any barriers to its use, and therefore, this became a question for the further feedback. However, it was also noted that the standard was only introduced in 2022, so the lack of use may be due to the programme remaining moderately unknown to industry.

Standardisation of acoustic monitoring for marine mammals was viewed as less feasible at this stage as the technology is fast evolving. It should also be noted that acoustic monitoring equipment is very expensive to deploy so the widespread use of it needs careful consideration (i.e. should be targeted at a specific monitoring aim rather than a standard applied to all projects).

In terms of the recommendations/discussion points raised by MMO at the workshop, it was noted that there is a requirement to be clear in separating monitoring for the purposes of mitigation (e.g. use of marine mammal observers during construction) from monitoring for the purpose of understanding environmental impacts. Monitoring carried out as part of mitigation is very localised and collected during noisy construction activity so does not provide a representative sample. Therefore, data collected as part of marine mammal observation work should not be collated with data collected during digital aerial surveys and boat-based survey.

Two workshop participants referred to the Morlais Tidal Project[11] as taking an innovative approach towards monitoring.

The project team took the following questions on marine mammal monitoring forward for the next round of further feedback, following the discussion at the Stakeholder Workshop:

- Are there any barriers to the use of the JCDP standard for marine mammals?
- Does the MEDIN data guideline on underwater noise provide an appropriate minimum level of information that should be captured during acoustic monitoring?

4.1.4. Further Feedback

Further comments were analysed from the industry questionnaire on the project teams draft recommendations.

One organisation stated that despite agreeing with the standards for marine mammals, there is currently a clear lack of monitoring on responses of marine mammals to development activities, across marine sectors. English waters currently lack data on the distribution of marine mammals, particularly in offshore waters far from the coast and despite studies attempting to fill these evidence gaps, it is not enough to understand marine mammals in offshore wind farms and their overall distribution over time. It was suggested that MMO licences need to start including monitoring of marine mammal behavioural responses from outset to operation to understand the impact on distribution over this period, and to provide data to support adaptive management if necessary. The project team noted that this feedback was not in scope of the project.

[11] Morlais Tidal Project: https://www.morlaisenergy.com/

It was also suggested that the presentation of recommendations in monitoring reports from pre-consent to post-consent should also be standardised. Some of the recommendations are already largely employed by industry, but the reporting formats vary.

As there may be a shift towards the use of PAM in marine mammal monitoring, the feedback received suggested that this will also need standardised guidance, alongside the use of MMObs. Both JNCC guidance documents in the final recommendations provide links to advise on how to report on PAM, with the second specifically reporting the requirements needed during PAM as well as for MMObs.

Organisations agreed that mandatory standardisation in this regard would dramatically improve the marine mammal evidence base in English waters, however, Best Practice Guidance will need to be updated to reflect these recommendations, and temporal deadlines must be added to ensure timely uploads of data. Another organisation agreed that temporal deadlines should also be added, however, this deadline should consider the potential sensitivity of information for consent discharge. Due to this, the project team agreed to recommend for data to be uploaded within 6 months of the monitoring report being discharged. This means that the report will already be made public at this time and there would be no sensitivity for the data collected. The responsibility for this is ultimately with the developer to upload this in the suggested timely manner.

4.2. Underwater Noise

4.2.1. Existing Standards Research

NE has endorsed that best practice for offshore wind projects undertaking piling activities is to monitor underwater noise levels at various distances from the noise source, following the National Physical Laboratory (NPL) Good Practice Guidance Note no. 133[12]. This guidance states that monitoring of underwater noise levels generated by wind turbines during the operational phase can be undertaken using hydrophones to validate predictions within the Environmental Statement, by recording noise levels pre- and post-construction. It was also stated that data should be recorded using the MEDIN[13] data guideline for underwater noise data. Furthermore, predicted noise from piling by modelling should be validated by monitoring during the construction phase.

NE's "Expectations for monitoring at the post consent phase" states that best practice is to do this from varying distances from the noise source typically on the first 4 piles. Furthermore, it's suggested to extend this to include varying substrates as the first 4 piles may not be representative of worst-case scenario. No set level has been agreed beyond this suggestion. The MMO employ standard licence conditions which require impulsive noise data to be uploaded to the Marine Noise Register (MNR)[14]. This is a requirement under the Marine Strategy Framework Directive and

[12] (Robinson et al. 2014) NPL Good Practice Guidance for Underwater Noise Measurement: https://www.npl.co.uk/gpgs/underwater-noise-measurement
[13] MEDIN guidelines: https://medin.org.uk/data-standards/medin-data-guidelines
[14] (JNCC) Marine Noise Registry: https://mnr.jncc.gov.uk/

is also recommended in NE's "Offshore infrastructure as platforms for environmental monitoring".

4.2.2. MCMS Overview Research

The project team reviewed 15 monitoring reports on underwater noise, in which, the NPL Good Practice Guidance Note no. 133. for underwater noise monitoring was mentioned in 12 of the reviewed monitoring reports and was therefore taken forward as a recommendation.

Sound Exposure Level (SEL) measures in accordance with the NPL good practice guidance was mentioned in four of the reports. The SELs are estimated for each piling to estimate the dose response of marine mammals exposed to the piling noise source, therefore it was decided this would be taken for discussion at the stakeholder workshop.

No reports mentioned the MEDIN standard for survey data. This may be because in some cases the report had already stated that they were following another standard which contained the requirement for the MEDIN data standard.

4.2.3. Stakeholder Workshop

No strong opinions were raised on the NPL Good Practice Guidance Note, neither positive nor negative. As this is already widely used, the project team propose to continue with this as a standard approach to monitoring underwater noise during construction. It was noted that some aspects of noise monitoring may be contentious (e.g. the approach to modelling) but JNCC have recently begun work to develop some guidance on this.

The current approach to monitoring during construction is to monitor the first four piles installed. The rationale is to ensure that MMO and SNCBs have early sight of whether noise modelling predictions are accurate and allow them to respond accordingly. Several reports have recommended that this condition should be changed (including MMO1031[15] in 2014) to ensure that the piles that are reported on cover a representative range of substrates and/or include those predicted to be the noisiest.

The following feedback was raised on this in the workshop:

- One stakeholder noted that they would want this to be in addition to the first four piles to ensure they still had early sight of any increased noise levels.
- Two attendees noted that reports on the first four piles are not submitted until 6-8 weeks after they've been installed, therefore it is difficult to be reactive if noise levels exceed those predicted in the modelling.
- Two attendees stated that changing the approach to monitoring piling would likely increase cost and would pose significant logistical challenges.

[15] (MMO, 2014) Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/317787/1031.pdf

The project team welcome further thoughts on this condition and will share them with colleagues working on underwater noise – however, reviewing the piling condition is outside the scope of this project as the focus is on standardisation of data rather than amending marine licence conditions.

It was noted that noise from unexploded ordnance (UXO) clearance is not routinely monitored, however with the emergence of low order techniques[16,17], this is becoming more of a requirement. An example of this is monitoring in the Moray Firth[18], which was raised by attendees as a good example of UXO noise monitoring.

4.2.4. Further Feedback

Further comments were analysed from the industry questionnaire on the project teams draft recommendations.

Feedback stated that whilst organisations agreed with the general principle of the recommended standards, they do not believe they go far enough to improve standardisation in monitoring. Furthermore, some of the monitoring requirements, such as the condition to only report on the first four piling activities, are not sufficient.

It was suggested that there is more up-to-date guidance from the SNCBs that could be used over the NPL Good Practice Guidance. It was also noted that the NPL Good Practice Guidance was produced as an interim guidance and was intended to be superseded by the International standards for piling noise in the form of International Organization For Standardization (ISO) 18405:2017 & ISO 18406:2017. The MMO do not currently have enough information about the benefits of the ISO standards to suggest a move away from the most currently used methods from NPL. They will not be refused if used by applicants, however, they do not form part of the recommendation.

It was also suggested that there should be a time limit for data uploads to the MNR after the completion of an activity as these delays are currently a major limiting factor for gaining useful insight from the MNR. Further discussions within the MMO identified that newer licences and DCO's include conditions to upload data to the MNR within a specified timeframe.

Feedback also noted that any mitigation/abatement used during the data collection should be reported. It is important to note that abatement systems are registered during uploads to the MNR, therefore, this will be recorded. Furthermore, abatement systems are also required to be registered under MMMP's.

One organisation stated that the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) are currently producing a Regional

[16] (Defra, 2025) Reducing Marine Noise Policy Paper: https://www.gov.uk/government/publications/reducing-marine-noise/reducing-marine-noise
[17] (Defra, 2025) Marine environment- Unexploded Ordnance Clearance Joint Position Statement: https://www.gov.uk/government/publications/marine-environment-unexploded-ordnance-clearance-joint-position-statement/marine-environment-unexploded-ordnance-clearance-joint-position-statement
[18] (Ocean Winds, 2014) Low order deflagration of unexploded ordnance reduces underwater noise impacts from offshore wind farm construction: https://www.oceanwinds.com/wp-content/uploads/2024/05/OW-UXO-BusinessCase.pdf

Action Plan for reducing underwater noise in the North Sea, including potential for standardisation of monitoring across nations. As of January 2025[19], since the UK is a contracting party to OSPAR, the UK Government has agreed to continue working with all other contracting parties to agree a regional action plan for the North-East Atlantic by 2025. Once complete, this will set out a series of national and collective actions to reduce underwater noise pollution.

4.3. Seabirds

4.3.1. Existing Standards Research

It is expected that NE will be engaged during the development of Ornithological Monitoring Plans (OMPs).

European Seabirds At Sea (ESAS)[20] is a collaborative partnership between the JNCC and seabird researchers in north-west Europe to provide a standardised recording methodology for seabird surveys, to allow comparison across offshore wind farm projects. This includes standardised bird codes, sampling campaign details, sampling categories, position of surveyor and observations. The ESAS standards were originally described for boat-based survey data but are also applicable for the results from digital aerial surveys.

Furthermore, a report by the Collaborative Offshore Wind Research into the Environment (COWRIE) group has outlined a recommended methodology for ship-based and aerial seabird surveys for offshore wind Environmental Impact Assessments (Camphuysen et al., 2004)[21]. NE also highlighted the COWRIE funded review of digital aerial survey techniques, technical parameters and initial protocols from Thaxter & Burton, 2009[22] and Thaxter et al. (2016)[23] in their "Expectations for monitoring at the post consent phase" report.

NE also highlight the potential for 'Light Detection and Ranging' (LiDAR) to be used to collect data on flight height distributions and the proportion of birds at collision risk height (Cook et al. 2018)[24]. This method indicated a high degree of accuracy. Lastly, the NE report on current best practice dictates that a Before-After-Gradient (BAG)

[19] (Defra, 2025) Reducing marine noise: https://www.gov.uk/government/publications/reducing-marine-noise/reducing-marine-noise#:~:text=The%20UK%20government%20will%20continue,to%20reduce%20underwater%20noise%20pollution.
[20]European Seabirds At Sea (ESAS) https://www.ices.dk/data/data-portals/Pages/European-Seabirds-at-sea.aspx
[21](Camphuysen et al., 2004) Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the UK: https://tethys.pnnl.gov/sites/default/files/publications/Camphuysen-et-al-2004-COWRIE.pdf
[22] (Thaxter & Burton, 2009) High-Definition Imagery for Surveying Seabirds and Marine Mammals - A Review of Recent Trials and Development of Protocols: https://tethys.pnnl.gov/sites/default/files/publications/Thaxter-Burton-2009.pdf
[23] (Thaxter et al. 2016) How high do birds fly?: https://www.bto.org/sites/default/files/publications/rr666.pdf
[24] (Cook et al. 2018) Estimating Seabird Flight Height using LiDAR: https://data.marine.gov.scot/sites/default/files/SMFS%200914_1.pdf

(Jackson & Whitfield, 2011)[25] should be employed in post-consent monitoring of displacement and distributional changes.

Furthermore, NE's "Offshore infrastructure as platforms for environmental monitoring" states that tagging birds with Global Positioning System (GPS), Platform Transmitter Terminal, or Global Location Sensor (GLS) can track bird movement via satellite positioning. Fixed telemetry receiving stations on offshore wind infrastructure facilitates the monitoring of birds by supporting the collection of information from such radio transmitter tags.

4.3.2. MCMS Overview Research

The project team reviewed 30 ornithological monitoring plan reports.

A stated in NE's best practice guidance, digital aerial surveys are typically conducted to quantify changes in seabird density throughout construction and operation both within the array and in surrounding buffer zones. The COWRIE funded review of digital aerial survey techniques from Thaxter & Burton, 2009 as well as Thaxter et al., 2016 were specifically mentioned in some of the monitoring reports, however, there are other methodologies that were referred to which follow very similar procedures. Very few reports mentioned using boat-based ornithology surveys, instead, the use of digital aerial surveys was found to be much more popular. According to NE, boat-based surveys can still follow the ESAS methodology if they are transect-based. To ensure the collection of high quality and standardised data, JNCC previously offered training for commercial ESAS standard surveys. Only one of the wind farms reviewed in the research mentioned using ESAS-trained field workers, therefore it was decided to discuss why this might be at the stakeholder workshop.

Some reports also mentioned GPS tracking of kittiwake, gannet and other target species to provide data pertaining to collision risk. The use of GPS tracking was highlighted in NE's report "Offshore infrastructure as platforms for environmental monitoring".

A BAG data analysis method, which is a scientifically powerful method for establishing the magnitude and spatial extent of displacement and habitat loss effects along a distance gradient, was only mentioned in some of the reports. Unlike a BACI design, which compares an impact location with an unaffected control both before and after the intervention, a BAG design would sample along a gradient with increasing distance from the turbines both before and after the intervention. Therefore, these methods were taken forward to discuss at the stakeholder workshop.

4.3.3. Stakeholder Workshop

COWRIE and ESAS were thought to be outdated by many organisations and focused solely on boat-based surveys. Technology has since evolved to digital aerial surveys since its publication. Furthermore, whilst ESAS may be applicable to digital

[25] (Jackson & Whitfield, 2011) Guidance on survey and monitoring in relation to marine renewables deployments in Scotland: https://tethys.pnnl.gov/sites/default/files/publications/SNH-2011-Volume-4.pdf

aerial surveys, there have been issues with applying this. However, all attendees agreed there is no current standard for digital aerial surveys in the UK and creating one would be useful.

Despite research suggesting the use of ESAS-trained field workers, many workshop attendees stated that ESAS training is no longer offered by JNCC, it's instead occasionally offered externally, making it an outdated practice. Despite this process previously being seen to be a useful tool, there were concerns from attendees that it may now add another blocker to achieving standardisation due to the lack of unqualified individuals, and it may not be necessary or relevant given ESAS is primarily for boat-based surveys. This is further supported by the initial discussion which noted how technology in this space is evolving.

There were some concerns over efficacy of digital aerial surveys regarding not all species of interest being identifiable in the results and incorrect recording of flight height data. New technologies including LiDAR can assist with this. Following this workshop, it was shared with the project team that standards for use of LiDAR is one of the aims of the Reducing Seabird Collisions Using Evidence (ReSCUE)[26] project. Outputs from this will be available in the next 12 – 24 months and will be published by British Trust for Ornithology, as well as incorporated into NE Best Practice Advice.

Many organisations stated that getting a license for GPS tagging is difficult and is more of a constraint than cost of tagging. There is a general industry assumption that tagging is more expensive than digital aerial surveys, however, it was seen as a more reliable technique meaning that the upfront investment may be more appropriate. This is because digital aerial surveys cannot show differences between night and day movements, due to not being operational at night, and GPS can give more data around behaviour and migration. However, there is some evidence to suggest that GPS tagging can have impacts on small bird species. As GPS is not currently a widely used standard, it was agreed that recommending the use of GPS should be outside the scope of this project.

The project team took the following questions on seabird monitoring forward for the next round of further feedback, following the discussion at the Stakeholder Workshop:

- Is there a standard for LiDAR/thermal imaging techniques that can help standardise monitoring for e.g., collision risk?
- Before-After-Control-Gradient studies are already deemed robust, however, Before-After-Gradient studies could be recommended if they were deemed to add value. Is a pilot study required to ensure this?

4.3.4. Further Feedback

Further feedback on the draft recommendations stated that the standards should focus on current Best Practice Guidance with the possibility for this receptor to be reviewed in 12-24 months once the ReSCUE project releases their standards for the use of LIDAR and it is incorporated into NE Best Practice Advice. Following this

[26] ReSCUE (Reducing Seabird Collisions Using Evidence): https://naturalengland.blog.gov.uk/2024/10/24/to-the-rescue-understanding-flight-heights-for-seabird-conservation-and-offshore-wind-expansion/

feedback, and further conversations with NE, it was agreed that due to the complexity of post-consent monitoring for seabirds, the recommendations for seabird monitoring should focus on ensuring that the development of each ornithological monitoring plan considers NE's best practice guidance for post-consent monitoring relating to seabirds.

4.4. Fish and Shellfish

4.4.1. Existing Standards Research

ICES hosts DATRAS[27] as an online database of fish and shellfish trawl surveys with access to standard data products, ICES also hosts the Acoustic data portal[28] which contains information on fisheries observations collected from various pelagic surveys. The MEDIN standard for fish & shellfish surveys are the MEDIN data guideline for species and benthos data by trawl or dredge, video surveys of species and benthos and shellfish stock assessment data.

NE's "Offshore infrastructure as platforms for environmental monitoring" states that submersible cameras, MBES, acoustic receivers, and tags have been used in academic studies to monitor fish populations, and therefore these can be hosted on offshore infrastructure to retrieve data post-deployment, or via satellite in real-time.

Furthermore, Environmental DNA (eDNA) presents an innovative method for monitoring fish species. Due to minimal human intervention relative to manual sampling, this approach could be better suited to remote deployment on offshore infrastructure, with the hope of this method becoming a commercially available solution in the future.

NE also states through the "Expectations for monitoring at the post consent phase" report, that fish species should be recorded using the World Register of Marine Species (WoRMS)[29] list of accepted scientific names. This report also suggests using species-specific methods, as well as underwater noise monitoring methods that are similar to what is required for marine mammals.

4.4.2. MCMS Overview Research

Overall, the fish & shellfish monitoring reports reviewed by the project team had the least use of standardisation across the six receptors with little information on use of standardised methods and guidance endorsed by NE and ICES. It should be noted that monitoring of fish and shellfish is not a standard requirement, with only 10 monitoring reports available, compared to approximately 20-30 for most other receptors. Therefore, a key question to take forward to the stakeholder workshop was to understand why fish and shellfish monitoring is not standardised.

Many types of survey methods were mentioned including otter trawling, potting surveys, gill nets, and beam trawling. Across the reports, it was stated these were done on a quarterly or bi-annual basis, for both pre- and post-construction. For each

[27] (ICES) DATRAS (the Database of Trawl Surveys): https://www.ices.dk/data/data-portals/pages/datras.aspx
[28] (ICES) Acoustic trawl surveys: https://www.ices.dk/data/data-portals/Pages/acoustic.aspx
[29] World Register of Marine Species (WoRMS): https://www.marinespecies.org/aphia.php?p=search

sampling station, most reports stated that start and end coordinates were recorded along with time, depth, sea and weather conditions. Species were identified and measured to assess the diversity and distribution of the fish and shellfish populations.

The practice of using WoRMS for recording species was noted in five of the reports and is the recommended standard for species identification. The ICES online data portals weren't mentioned in any of the reports; therefore, the project team took this forward to discuss if this should be recommended.

One report mentioned the use of the Procedural Guidance 4-3 of the JNCC Marine Monitoring Handbook, which states the method for sampling benthic and demersal fish populations on sediments. Therefore, this was also taken forward to discuss as despite no mentions in the previous research, it was recognised that it may aid with formalising standardisation. Furthermore, another report stated using a Herring PSA Monitoring Survey Plan using methods for benthic studies. This works by looking at the gravel, sand and mud fractions for each sample based on the sediment preferences described in Reach et al. 2013[30]. These can then be classed as 'unsuitable', 'suitable', 'sub-prime' or 'prime' herring spawning habitat. NE's report "Offshore infrastructure as platforms for environmental monitoring" states that spawning grounds for Atlantic Herring can be monitored using grab sampling or underwater imagery, in which, Katara et al.[31], should be referred to for guidelines. Therefore, it was decided to discuss the use of these methods further at the workshop too.

Lastly, no reports mentioned the MEDIN data guideline for species and benthos data by trawl or dredge. As previously mentioned, it would be expected for these reports to have clear signposting to data standards.

4.4.3. Stakeholder Workshop

Participants general view was that fish and shellfish are a less standardised receptor. This is due to variation in species, but also, they are less of a constraint on consents as they are less likely to be designated features of protected areas, unlike birds or mammals, and so monitoring is not frequently required. Overall, data from fish surveys, particularly for elasmobranchs, is sparse. A lot of surveys for fish are for demersal/benthic species and involve benthic sampling, therefore, not all species are captured.

Workshop attendees stated that they have previously used the Procedural Guidance 4-3 of JNCC marine monitoring handbook for sampling benthic and demersal fish populations. However, they suggested that monitoring must remain species and site specific. Furthermore, MEDIN is believed by participants to be widely used and was highly recommended to be used.

[30] (Reach et al, 2013) Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas. A Method Statement produced for BMAPA: Unbale to find source.
[31] (Katara et al, 2021) Conservation hotspots for fish habitats: A case study from English and Welsh waters: https://www.sciencedirect.com/science/article/abs/pii/S2352485521001377

WoRMS was generally agreed to be a well-used and appropriate database; however, one organisation did mention they prefer use of the European Nature Information System (EUNIS)[32], and The Marine Life Information Network (MarLIN)[33] database was also raised as useful.

It was stated that NE's post consent monitoring best practice guidance is useful as it states how best to monitor specific species. For example, herring, sand eel and cod are more sensitive, so specific recommendations work well. However, despite stating different methodologies across the species, the report itself does not contain much information on different data standards for these different methodologies. Furthermore, participants suggested that it would be useful to have more regional monitoring and to include species that are designated to be important for MPAs even though they are not currently significant consenting risks. For instance, individual recommendations for diadromous fish, could be useful since there is a lack of standardisation in frequencies used in this monitoring across Europe and these species move through administrative boundaries.

Some attendees mentioned that telemetry surveys may be useful to capture pelagic fish, however, it was unknown if there were data and methodology standards available for this. It was decided by the project team to take this forward for further investigation.

It was agreed by participants that ICES data portals are useful as they contain a long-time data series which feeds into the European database, but there is a need to make sure that when the data is uploaded to these portals, it is in fact used for comparison across offshore windfarms as there is a tendency for this data to not be used at all. Moreover, participants stated it is important to consider the monitoring of impacts as well as the receptors themselves, such as Electromagnetic Fields (EMF). There is not currently a standard approach for monitoring EMF, but Scottish government representatives stated they are currently working on developing this approach.

Lastly, many organisations suggested that fish species and assemblages are particularly suitable to eDNA monitoring and DNA-based methods are already widely and successfully deployed for fish monitoring programmes (Franco et al. 2020a)[34]. This report also states that eDNA methods have been shown to outperform conventional methods in terms of detection probability, costs and feasibility. There remain some limitations of the method, for example, the influence of hydrodynamics needs to be carefully considered to determine where eDNA within a sample has come from. However, the project team were willing to take this forward as a recommendation.

The project team took the following questions on fish & shellfish monitoring forward for the next round of further feedback, following the discussion at the Stakeholder Workshop:

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[32] (European Environment Agency, 2022) EUNIS, the European Nature Information System: https://eunis.eea.europa.eu/

[33] The Marine Life Information Network: https://www.marlin.ac.uk/

[34] (Franco et al.,2020a) A review of methods for the monitoring of inshore fish biodiversity: https://publications.naturalengland.org.uk/publication/4755646568464384

- Are you aware of any standards for eDNA?
- Are you aware of any standards for telemetry surveys?

4.4.4. Further Feedback

From analysis of written feedback on the recommendations, one organisation agreed that due to the nature of the data collection for this receptor, there is a greater variety in survey techniques, meaning it makes sense for standardisation to be tailored to the method and species. It was suggested that standardisation for this receptor should be regularly reviewed as certain data collection methods, such as eDNA technologies, improve.

Another organisation stated that they agreed with the recommendations, however, they believe that the MEDIN data base requires further simplification for easier input of species length measurements as the current format poses significant additional time commitments on consultancies. Furthermore, they stated that using data in this format often takes time and additional codes are required to link the different spreadsheets. Therefore, a simpler and more user-friendly format would be beneficial to industry consultants. Another organisation also stated that there may be some differences in the data requirements between the ICES Data Portal and MEDIN suggested standards. After further investigation, the project team agree with this feedback and believe that the recommendation for data to be submitted in line with MEDIN standards should remain, however, the MMO would also encourage the use of ICES data portals as a long-term repository for data.

One organisation stated that eDNA based methods are indicative of species presence or absence but do not provide quantitative results. Therefore, it would be appropriate to provide the types of application where they're considered suitable. The recommended methodology, (Franco et al. 2020a)[35], states that qPCR can accurately estimate the number of molecules in a DNA template and this method can potentially provide quantitative information, if the DNA extracted from the environmental sample is correlated with the abundance of the organism. This guidance also states the advantages and disadvantages of eDNA methods, and therefore, helps aid where the application on this methodology should be considered.

Furthermore, this feedback round suggested that consultants have a preference to use WoRMS for the most up to date species names, as MarLIN is often used for background information.

4.5. Benthic

4.5.1. Existing Standards Research

The Northeast Atlantic Marine Biological Analytical Quality Control (NMBAQC)[36] for benthic monitoring is endorsed by NE and provides quality control and assurance to the macrobenthic invertebrate elements of the Clean Seas Environmental Monitoring Programme.

[35] (Franco et al.,2020a) A review of methods for the monitoring of inshore fish biodiversity: https://publications.naturalengland.org.uk/publication/4755646568464384
[36] (NMBAQC Scheme 2024): https://www.nmbaqcs.org/

Worsfold et al., 2010[37] states that samples should be processed and analysed for infaunal communities following the NMBAQC Scheme procedures and protocols for macrofaunal analysis. Many methodologies are mentioned under the NMBAQC Scheme including Mason, 2016[38] methods for Particle Size Analysis (PSA), Turner et al. 2016[39] guidelines for epibiota remote monitoring from digital imagery and the JNCC Epibiota Quality Assurance Framework[40]. Furthermore, the NMBAQC Scheme states that the guidelines for marine monitoring methods are provided by JNCC's Mapping European Seabed Habitats (MESH) which is the recommended operating guidelines for underwater video and photographic imaging techniques (Coggan et al. 2007)[41], as well as epifaunal trawls and dredges. Under the NMBAQC Scheme, the MEDIN standard for benthic survey data includes guidelines for data by grab or core, species and benthos data by trawl or dredge, video surveys of species and benthos and transect survey data.

NE's "Offshore infrastructure as platforms for environmental monitoring" mentions the use of sonar systems to build an image of the seafloor. Both the use of MBES and side scan sonar (SSS), which are traditionally trawled by a survey vessel to send acoustic pings and allow researchers to build an image of the seafloor, could be attached to offshore wind infrastructure. Multiple devices installed in an array can collect data on several parameters such as pressure, temperature, velocity, and seafloor terrain.

The JNCC Marine Monitoring Handbook [42] for littoral sediment habitats provides high-level guidance for monitoring intertidal sediments and is endorsed by NE's "Expectations for monitoring at the post consent phase". This report also suggests the use of BACI monitoring and BAG monitoring.

4.5.2. MCMS Overview Research

The project team reviewed 24 Benthic Monitoring reports, in which, many of the different NMBAQC methodologies were stated. These included Mason, 2016 methods for PSA, Turner et al. 2016 guidelines for epibiota remote monitoring from digital imagery and the JNCC Epibiota Quality Assurance Framework. Furthermore, the NMBAQC Processing Requirements was mentioned in four of the monitoring reports and states that samples should be processed and analysed for infaunal

[37](Worsfold et al., 2010) NMBAQC Processing Requirements Protocol for Marine Macrobenthic Samples: https://www.nmbaqcs.org/media/440n1nus/guide-for-processing-marine-macrobenthic-invertebrate-samples.pdf

[38] (Mason, 2016) Particle Size Analysis (PSA) for Supporting Biological Analysis: https://www.nmbaqcs.org/media/qiybf5sd/best-practice-guidance.pdf

[39] (Turner et al. 2016) Epibiota Remote Monitoring from Digital Imagery: Interpretation Guidelines: Epibiota Remote Monitoring from Digital Imagery: Interpretation Guidelines (infomar.ie)

[40] (JNCC) Epibiota Quality Assurance Framework: https://www.nmbaqcs.org/scheme-components/epibiota/epibiota-quality-assurance-framework-and-documents/#:~:text=The%20Quality%20Assurance%20Framework%20project,and%20sharing%20in%20the%20future.

[41] (Coggan et al. 2007) MESH Review of standards and protocols for seabed habitat mapping: https://www.researchgate.net/publication/269630850_Review_of_standards_and_protocols_for_seabed_habitat_mapping

[42] (Davies et al., 2001) JNCC Marine Monitoring Handbook: https://data.jncc.gov.uk/data/ed51e7cc-3ef2-4d4f-bd3c-3d82ba87ad95/marine-monitoring-handbook.pdf

communities following the NMBAQC Scheme procedures and protocols for macrofaunal analysis. As these are NMBAQC methodologies, they were recommended as standards for their appropriate survey technique.

Under the NMBAQC Scheme, the MEDIN standard for benthic survey data are suggested to be used for data standards, however there was no mention of this in any of the reports. Therefore, it was decided to discuss the use of the MEDIN standard for benthic survey data at the stakeholder workshop.

The JNCC Marine Monitoring Handbook for littoral sediment habitats was mentioned in a third of the monitoring reports. For grab sampling work, the Handbook has the Guidelines No. 3-9 to define the methods of quantitative sampling of sublittoral sediment biotopes and species using remote-operated grabs as well as Procedural Guidance 4-3 for sampling benthic and demersal fish populations on sediments, which was specifically mentioned in two of the reports. Therefore, this also formed part of the recommendation.

Drop-down video (DDV) surveys were mentioned in a third of the reports with three reports specifically stating that the DDV survey was undertaken in accordance with Hitchin et al. (2015)[43], which forms part of the epibiota component of the NMBAQC scheme, and therefore, formed part of the recommendation. NE states through both the NMBAQC Scheme and the "Expectations for monitoring at the post consent phase" report, that species should be recorded using the WoRMS list of accepted scientific names. This practice is noted in seven of the reports and also, formed part of the recommendation.

The NMBAQC Scheme states that the MESH standards[44] should be used for mapping European seabed habitats, in which the EUNIS Classification System[45] is promoted. The EUNIS Classification System for biotope determination mapping was mentioned in eight of the reports and would also be recommended.

Two of the reports mentioned the Marine Habitat Classification (Connor et al., 2004)[46] developed by JNCC's Marine Nature Conservation Review (MNCR). The classification provides a tool to aid the management and conservation of marine habitats and is stated to be fully compatible with the European EUNIS habitat classification system. As well as this, the SACFOR Abundance Scale[47] (JNCC, 1990) comes under the MNCR methods and was mentioned in four of the monitoring reports. It was decided that both methodologies could also form part of the recommendation as they are compatible with the EUNIS classification.

[43] (Hitchin et al. 2015) Epibiota Remote Monitoring from Digital Imagery- Operational Guidelines: https://www.nmbaqcs.org/media/mirhlqmu/epibiota_operational_guidelines_final.pdf
[44] (Mapping European Seabed Habitats (MESH) standards): https://maritime-spatial-planning.ec.europa.eu/projects/development-framework-mapping-european-seabed-habitats
[45] (European Environment Agency, 2022) EUNIS Habitat Classification System: https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1/folder_contents
[46] (Connor et al., 2004) The Marine Habitat Classification for Britain and Ireland: https://mhc.jncc.gov.uk/media/1027/04_05_introduction.pdf
[47](JNCC, 1990) SACFOR abundance scale used for both littoral and sublittoral taxa: https://mhc.jncc.gov.uk/media/1009/sacfor.pdf

The use of MBES and SSS for benthic monitoring was also a common approach amongst reports that didn't specifically mention a standard. NE's "Offshore infrastructure as platforms for environmental monitoring" also mentions the use of sonar systems to build an image of the seafloor. Therefore, it was decided to discuss at the stakeholder workshop if the use of MBES and SSS is sufficient for benthic monitoring, or should it instead be used as a tool to aid the monitoring?

Despite JNCC's MESH being recommended by NE for marine monitoring, it was only mentioned in two of the monitoring reports. Due to lack of current use in the sector, it was decided to ask at the stakeholder workshop if these guidelines should form part of the recommendation.

Lastly, during this reviewing period, OneBenthic[48] was brought to the project teams' attention. This is a data platform that brings together disparate benthic datasets from grab/core, trawl and imagery surveys in a cloud-based platform. This results in a standardised dataset and creates an opportunity to add value to marine data. Outputs are shared via open-access publications and a suite of interactive web apps. OneBenthic promotes the use of the Regional Seabed Monitoring Programme (RSMP)[49] Protocol for Sample Collection and Processing, which is currently in development. The RSMP was designed for compliance monitoring adopted by the UK marine aggregate dredging sector. However, only two reports mentioned that grab sampling was conducted in line with this method, and it was not suggested in any of the Best Practice Guidance. The project team therefore decided to discuss at the stakeholder workshop whether this should be recommended for offshore wind.

4.5.3. Stakeholder Workshop

Most participants stated they were very supportive of the NMBAQC Scheme with many attendees saying they had directly used this scheme and know that it uses a high level of quality assurance, including across laboratories that complete the identification work. The scheme has been in place for over 20 years, and participants stated that it should be endorsed, and not reinvented. Furthermore, it was suggested that this methodology would work with floating offshore wind as well. Despite an overall positive impression of the scheme, some spoke around how the marine environment is very difficult to work in and despite the methodology being clear, it is still dependent on an individual completing the sampling correctly. As well as this, there are some methodologies in this scheme that are as old as 2010, and it was suggested they may need updating.

Many organisations stated that the WoRMS list of accepted scientific names should be used as the standard for species identification of benthic fauna. Furthermore, it was agreed by most attendees that the EUNIS Habitat Classification System for biotope determination and mapping should also be used. The JNCC Marine Habitat Classification and SACFOR Abundance Scale are compatible with the EUNIS classification and could also form part of the recommendation. Participants stated that there is a table that maps together the EUNIS and JNCC classifications.

[48] OneBenthic: https://rconnect.cefas.co.uk/onebenthic_portal/
[49] (Cooper & Mason, 2017) Protocol for Sample Collection and Processing, Regional Seabed Monitoring Plan (RSMP): https://rconnect.cefas.co.uk/RSMP/RSMPstoryboardv1.html

However, this was with the caveat that the system isn't always perfect, and they have found they may lose habitat details going between the two.

All participants agreed the use of MBES and SSS techniques are not sufficient for the entirety of benthic monitoring, and they are to be used as a tool to aid with monitoring. Therefore, where applicable, benthic sampling should always be applied. For some environments, such as rocky reefs, it isn't always possible for benthic sample techniques (such as grab samples) to be used, therefore digital imagery here is even more important. One organisation stated they would vouch for MBES and SSS techniques to retrieve backscatter maps of the monitored area, which can then be used to design the benthic survey. It is an important step to identify potential gradients such as specific habitats, primary marine features and archaeological sites. Furthermore, these methods help to influence where benthic monitoring samples should take place.

Despite this initial positive feedback, some participants stated that the quality of MBES and SSS surveys can vary a lot across contractors and that subtle changes in the machinery can completely change the output of the survey. For example, backscatter is dependent on the amplification on the equipment. If this is wrong, the result can make a sandy reef appear rocky. The main concern from workshop participants was that contractors are relying on their geophysical surveys for benthic monitoring without the use of ground truthing, when in fact, the equipment should be used differently between these monitoring plans. Participants stated that this distinction should be added to the recommendations.

OneBenthic has been designed for aggregates monitoring, however, the OneBenthic team are also trying to standardise across sectors. One organisation stated that they use OneBenthic, and that data repository relies on participants using the NMBAQC's Guidelines for particle size analysis. From this, the project team believe that there may be an opportunity for standardisation using OneBenthic as the scheme is already well understood. Furthermore, participants suggested that the join-up between the Marine Data Exchange and OneBenthic is relatively easy and could be improved even more through automation in the future. One participant recalled speaking to industry representatives who agreed that it is a high-quality data repository.

However, despite the initial positive feedback for OneBenthic, representatives from other organisations suggested that it may not be appropriate for use outside of aggregates monitoring as it doesn't work with EUNIS or MESH standardisation. Furthermore, many participants stated their concern with losing quality in their data by putting it into OneBenthic. The data format required for OneBenthic is less detailed than what is required from the NMBAQC Scheme, therefore, some of the survey granularity may be lost.

Furthermore, representatives from SNCB's noted issues with using the RSMP as a protocol for Environmental Impact Assessment data where it has falsely presented spatial heterogeneity. There were also further points that the RSMP is only a programme for PSA sampling and does not give guidance on the use of underwater imagery, which is agreed to be required for Benthic Monitoring, especially on rocky reefs.

One participant stated that there is a decision-support tool to guide environmental monitoring by the oil and gas industry called The North Sea Interactive Project[50]. This is a tool that would translate existing marine environmental data into an interactive mapping product for the offshore oil and gas industry. All agreed that it would be great to achieve something similar to this for the Offshore Wind Sector.

Participants were asked why they think the use of MEDIN data guidelines weren't stated across any of the reviewed monitoring reports, of which some said this may be due to a lack of advocacy previously. Despite this, participants agreed that they would still recommend MEDIN as a standard, especially as OneBenthic uses data to a lower granularity than MEDIN. Furthermore, it was mentioned that the scope of this project may need to include data analysis after collection and making sure it is significant. This would probably require recommending PRIMER as the software for this analysis.

One participant suggested that Natural Resource Wales have produced Benthic Guidance, which was renewed two years ago, and is therefore up to date. Upon investigation, this guidance aims to help developers design and plan benthic marine habitat surveys and monitoring, in support of proposed developments and activities in or near Welsh waters. Throughout this guidance, it also states that developers should comply with recommended guidelines and quality control procedures such as, the NMBAQC Scheme, as well as clearly explaining the survey method(s) that are intended to be used. This aligns with the recommendations of this project.

The project team took the following questions on benthic monitoring forward for the next round of further feedback, following the discussion at the Stakeholder Workshop:

- Some participants mentioned the Big Picture Workshop, which is hosted annually by JNCC, to share progress, explore funding opportunities, and discuss the challenges of innovation in the field of benthic imagery to yield two primary results: the creation of the Benthic Imagery Action Plan for the UK and the establishment of the Big Picture Group. Are there any notes or research from this?
- Despite the overall positivity towards EUNIS, one SNCB representative stated that they are making a steer towards JNCC's Marine Habitat Classification system. What is the reason for this?
- Would you support the use of MEDIN data guidelines for benthic monitoring?
- Would you support the use of OneBenthic for benthic monitoring?

4.5.4. Further Feedback

The feedback stated that, as work continues to integrate OneBenthic and the MDE, it would be best to omit OneBenthic from the recommendations until this work is complete. Once this work is completed, it would be useful for future standardisation reviews and therefore in the interim, the project team should continue to share this work with The Crown Estate, as well as OneBenthic.

[50] The North Sea Interactive Project: https://www.data.gov.uk/dataset/baeee418-dd34-47f7-9515-107ec6d661f4/north-sea-interactive-a-decision-support-tool-to-guide-environmental-monitoring-by-the-oil-and-gas-industry

Despite a current lack of use of MESH in the sector, the feedback stated that these guidelines should still form part of the recommendation as the projects partners include JNCC and Natural England. Furthermore, this should alternatively be identified as an area where more collaboration is needed, to enable MESH to be implemented into future standardisation reviews.

One organisation stated that as particle size analysis forms part of the recommendation, the project team should also look to include chemical and contaminants analysis. Although this is not in scope of this project, the MMO have a separate piece of work that is looking to change the way in which chemicals are consented in offshore wind farms, to reduce the risk associated with their use and reduce the requirement for chemical and contaminants analysis.

4.6. Geophysical

4.6.1. Existing Standards Research

The International Hydrographic Organisation (IHO) standards (S44[51] and S57[52]) for geophysical monitoring surveys require complete seabed coverage for detailed feature or habitat mapping, equating to 200% coverage, and is endorsed by NE. SSS surveys should follow the MESH Recommended Operating Guidelines[53], whilst MBES should follow the MESH Recommended operating guidelines for swath bathymetry[54].

Furthermore, NE state that Lurton & Lamarche (2015)[55] provide additional guidelines and recommendations for backscatter measurements for geophysical surveys. NE also states that MEDIN-compliant data standards should also be adhered too, which for geophysical surveys are the MEDIN data guideline for seismic data, bathymetry data, sampling sediment & rock characteristics and for SSS data.

4.6.2. MCMS Overview Research

All bar one of the 32 reviewed monitoring reports mentioned using MBES and/or SSS, however, only 14 of these stated that the data collected would conform to IHO standards (S44 and S57) for geophysical monitoring surveys. As they are also endorsed by NE, the project team would recommend using these standards. Furthermore, MESH Recommended operating guidelines for SSS was only mentioned in three of these reports. The project team would recommend that these

[51] International Hydrographic Organisation Standards for Hydrographic Surveys S-44: https://iho.int/uploads/user/pubs/standards/s-44/S-44_Edition_6.1.0.pdf
[52] International Hydrographic Organisation Standards for Digital Hydrographic Data S-57: https://iho.int/uploads/user/pubs/standards/s-57/31Main.pdf
[53] (Henriques et al., 2013) MeshAtlantic ROG for side-scan sonars - https://emodnet.ec.europa.eu/sites/emodnet.ec.europa.eu/files/public/mesha_rog_sidescan_sonar_v40.pdf
[54] (Hopkins, 2007) MeshAtlantic ROG for swath bathymetry: https://www.infomar.ie/sites/default/files/pdfs/MBES_ROG_0.pdf
[55] (Lurton & Lamarche 2015) Backscatter measurements by seafloor-mapping sonars, Guidelines and Recommendations: https://webstatic.niwa.co.nz/static/BWSG_REPORT_MAY2015_web.pdf

standards were adhered to and stated in the monitoring report, along with MESH Recommended operating guidelines for swath bathymetry[56].

Many reports stated that they were undertaking geophysical monitoring at 6 monthly intervals as part of a 3-year post construction monitoring program.

Further to the previous research, TCE has also announced a pre-consenting survey programme, conducted from 2023 to 2025, designed to deliver robust datasets to inform Environmental Impact Assessments and to accelerate the consenting process for these projects, The Crown Estate has provided the Scope of Work and Specification for geophysical Pre-Consent Surveys.
This includes:

- Full coverage high-resolution bathymetric data,
- SSS of the seabed and identification of anthropogenic and natural items above and below seabed,
- Seismic information down to at least 50 m below seafloor,
- Identification of geo-hazards,
- Geological information on geological structures to 50m,
- Geological conditions in the upper 10 m and magnetometer survey data.

Most of the reports conformed to these suggested methods, therefore, these were chosen to be recommended as a standard at the stakeholder workshop.

Only one Offshore Wind farm mentioned producing MEDIN-compliant discovery metadata, which also conforms to TCE's Marine Data Exchange[57] standard. NE's best practice guidance stated for geophysical surveys that the MEDIN data guideline for seismic data, bathymetry data, sampling sediment & rock characteristics and for SSS data, should be adhered to.

Lurton & Lamarche (2015) recommendations for backscatter measurements for geophysical surveys, which is suggested for use by NE, was not referred to in any of the reviewed monitoring reports. Due to lack of current use in the sector, it was decided to ask at the stakeholder workshop if these guidelines should form part of the recommendation.

Other standards that have been previously mentioned across other receptors were the JNCC Marine Monitoring Handbook, Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites and JNCC's Marine Habitat Classification of Britain and Ireland. All these standards were stated to be used in two of the reports, however, they weren't mentioned in the NE Best Practice guidance. It was decided to discuss these as potential recommendations further at the stakeholder workshop.

4.6.3. Stakeholder Workshop

Participants agreed IHO Standards S44 and S57 should be adhered to for geophysical monitoring surveys. However, the research found that the reports did not refer to the standards. It was suggested by participants that as is normal

[56] (Hopkins, 2007) MeshAtlantic ROG for swath bathymetry: https://www.infomar.ie/sites/default/files/pdfs/MBES_ROG_0.pdf
[57] The Crown Estate's Marine Data Exchange: https://www.marinedataexchange.co.uk/

practice, those producing the reports do not state that they are using it. As well as this, participants also agreed that the MEDIN data guidelines should be adhered to, and like the IHO Standards, no reports are currently stating this. The project team decided to take both these forward as a recommendation for those surveying to state that they are using these methodologies.

Attendees agreed it is important to use geophysical surveys to understand habitat mapping and allow scour monitoring, however it also aids with other planning opportunities, such as cable routing. Therefore, through the standards, the multiple purposes of these surveys must be maintained. Furthermore, according to MMO's Licensing Team, it must be clear what is required pre- and post-construction as this is where disagreements tend to occur, participants also stated that further guidance on how to survey primary marine features would be useful.

It was stated that there is a UKHO standard upload tool with 200 datasets as well as ORE Catapult datasets that will be coming out soon.

Some participants suggested investigating newer technologies including those developed under The INSITE Programme[58] which monitors biological growth on infrastructure for the Oil and Gas industry by creating 3D models, as well as Savante[59] which includes imaging, photogrammetry and laser technologies to undergo 3D subsea scanning.

Monitoring of archaeological features was previously determined to be out of scope for this project, however participants asked if this could be included as they highlighted a project that investigates archaeological data. Further to this, there was a discussion that the use of GPS should be brought back into the project as well. The project team decided that these should remain out of scope of the project as it didn't focus on the two main objectives of standardised methodology for collecting data, or approach for recording and storing data.

Some participants suggested that there should be more crossover in the standards for benthic and geophysical monitoring, however, it is important to note that geophysical survey requirements for aiding benthic surveys will differ between regions due to the conditions. Overall, participants suggested that other than new techniques in eDNA, both Geophysical and Benthic Monitoring are already very standardised, therefore progressing standards should be relatively straightforward.

The project team took the following questions on geophysical monitoring forward for the next round of further feedback, following the discussion at the Stakeholder Workshop:

- Are the MEDIN data guidelines for geophysical surveys still appropriate?
- It was suggested to look further into magnetometers and sub-bottom profiling for standardisation. Are there standards already for these surveys?

[58] The INSITE Programme - Phase 2 - INSITE North Sea: https://insitenorthsea.org/
[59] Savante Subsea and Underwater Lasers: 3D Dynamic Laser Mapping and Stereo-Imaging: https://www.savante.co.uk/

- The Centre for Seabed Mapping is trying to bring seabed mapping information together and is based on multi-beam outputs. Does anyone sit on these working groups?

4.6.4. Further Feedback

Feedback stated that organisations agreed with the recommendations as they are based on existing standards from the Marine Data Exchange.

Another organisation stated that there are some concerns on the MESH Remote Operating Guidance for SSS, in which they stated the guidance may not provide complete coverage of the seafloor. However, they also acknowledge that there is not currently another applicable standard, and therefore this could be reviewed in a future iteration of the project.

Two organisations flagged concerns over the 3-year construction monitoring programme approach, with intervals of 6 months. Instead, it was stated that standard industry practice is to complete geophysical surveys during year 1, between years 2 and 3 and between year 5 and 8.

4.7. All Receptors

4.7.1. MCMS Overview Research

Following the research on MCMS, receptor specific recommendations were made, however, some over-arching recommendations and discussion points also arose. These were formalised and taken forward to discuss at the Stakeholder workshop. These were as follows:

1. Developers to have clear signposting of monitoring/data standards so that MMO's Marine Licensing Team and SNCBs can quickly see what form the monitoring will take.
2. Should MEDIN data standard be recommended across all receptors?
3. What would be the best method of implementing standards?
4. Are there any other projects running alongside this one which may be good to highlight, e.g. Strategic Monitoring and Developer work?

4.7.2. Stakeholder Workshop

It was agreed by the workshop participants that monitoring reports do require clear signposting of monitoring/data standards so that MMO's Marine Licensing Team and SNCBs can quickly see what form the monitoring will take. Furthermore, where applicable, the MEDIN data standard be recommended.

Participants suggested that a next step is to speak to consultants and developers to ask for their opinions of the recommendations. This view influenced the decision for the "Further Feedback" stage which involved receiving comments from consultants and developers.

It was also highlighted that innovation should not be prevented by trying to enhance standardisation. Therefore, if a method is recommended as a standard for the current time, there must also be space for this to adapt over time.

It was agreed by most participants that the offshore wind industry responds well to steer and would be supportive of the standardising monitoring as it will make the consenting process easier.

Following the stakeholder workshop, some further discussion points arose across all receptors. These were formalised and taken forward to discuss within the project team. These were as follows:

- Standards should be written such that if better means of data collection come along as technology develops, they can still be used if it's still comparable with previously collected data.
- Standardised monitoring needs to also consider there are species specific and site-specific considerations.
- Monitoring/surveys must be hypothesis driven and outcome focused. The question that's being asked with monitoring will inform the kind of surveys that are done, and therefore the standards that are appropriate.
- The monitoring data collected will always have limited value unless there is a wider system of monitoring around it. Previously the UK carried out regular baseline surveys which provided an overall picture of trends.
- It was noted that the project team must think about where monitoring data will be deposited to ensure that it is accessible.
- Standard techniques for specific species regionally would be useful – an 'all tools in the armoury' approach e.g., signposting to different guidance.

4.7.3. Further Feedback

One organisation stated that they are heavily in favour of the project as it will improve decision-making for developments, and whilst they support most of the draft recommendations, in some cases they would suggest that the recommendations need to be more explicit in their demands. They have also suggested an initial review period is recommended as part of the project, in which this may be repeated on a semi-regular basis to capture updated Best Practice Guidance, as well as new technologies and data repositories. The Project team carefully considered this suggestion.

Furthermore, another organisation stated that consideration could be given to inclusion of monitoring of commercial fisheries as they are likely to be affected during construction and operation. This suggestion could be addressed once the initial review period has been decided.

Lastly, it was suggested that monitoring will involve more unmanned surface and underwater vehicles in the future, it was decided that this can also be studied after the initial review period.

5. Recommendations and Discussions

This guidance does not aim to suggest *what* must be monitored, but rather *how* surveys must be completed. The receptors chosen for each offshore wind farm project is agreed on a case-by-case basis and will include discussions between developers, the relevant SNCB and MMO's Marine Licensing Team to deem what is applicable for the project area.

5.1. Marine Mammals

The JCDP data guideline for effort-related survey cetacean data to be used for transect-based surveys (boat based and aerial) and upload this to the ICES Data Portal. We understand The Crown Estate are exploring closer integration of the Marine Data Exchange and the ICES data portal. If the two platforms do become integrated, then a separate submission to the ICES portal may no longer be necessary. It is suggested that data should be uploaded to the ICES Data Portal within 6 months after the monitoring report has been discharged.

At the start of 2025, JNCC[60] released new guidance for minimising the risk of injury to marine mammals from unexploded ordnance (UXO) clearance in the marine environment.

In addition to the JNCC 2025 guidelines, a standardised marine mammal recording form is also available within this package, to record mitigation effort for MMObs use. MMObs are to record periods of marine mammal observations, details of environmental conditions (sea state, weather, visibility, etc.) and sightings of marine mammals. The data collected by MMObs is reviewed by JNCC to check compliance with licence conditions and evaluate the effectiveness of deterrents. By standardising this data, it is easier for these checks to occur. It is the responsibility of the developer to share this information with JNCC.

JNCC guidance 2010 is the statutory nature conservation agency protocol for minimising the risk of disturbance and injury to marine mammals from piling noise. Reporting of piling to follow section 3.1 of the guidance document.

Recommended standards for marine mammals -

MM1: JCDP data guideline to be used for boat based and aerial surveys, and data to be uploaded to the ICES Data Portal within 6 months after the monitoring report has been discharged.

MM2: Reporting of marine mammal mitigation used during UXO clearance should follow section 3 of the JNCC Guidance (2025).

MM3: Reporting of marine mammal monitoring during piling to follow section 3.1 of JNCC Guidance (2010).

5.2. Underwater Noise

Monitoring of underwater noise levels at various distances from the noise source should follow the NPL Good Practice Guidance Note no. 133, using hydrophones, as well as recording noise levels before and after construction. Furthermore, Sound Exposure Level (SEL) measures should be recorded in accordance with the NPL good practice guidance.

[60] (JNCC, 2025) Guidelines for minimising the risk of injury to marine mammals from unexploded ordnance (UXO) clearance in the marine environment: https://data.jncc.gov.uk/data/24cc180d-4030-49dd-8977-a04ebe0d7aca/jncc-guidelines-marine-mammals-and-explosive-use.pdf

The MEDIN standard for noise surveys is the MEDIN data guideline for underwater noise data, as noted by the NPL Guidance. If the standard is being used, then this should explicitly be stated.

Recommended standards for underwater noise -
UWN1: NPL Good Practice Guidance Note no. 133 for monitoring of underwater noise levels generated by wind turbines using hydrophones, pre-, during and post-construction.
UWN2: The MEDIN standard for noise surveys is the MEDIN data guideline for underwater noise data, as requested through the NPL Guidance.

5.3. Seabirds

It is recommended that the development of each wind farm Ornithological Monitoring Plan (OMP) includes engagement with NE.

Due to the complexity of post-consent monitoring for seabirds, it is suggested that the development of each OMP should consider NE's best practice guidance for post-consent monitoring relating to seabirds (Parker et al., 2022). The best practice is comprehensive, setting out key considerations relating to post-consent monitoring for seabirds, and key monitoring requirements for seabirds relating to specific pressures (i.e., displacement/disturbance and collision mortality) and sources of uncertainty in the impact assessment process. This guidance will also be updated periodically with new evidence and associated advice as it becomes available.

The ReSCUE project has an aim to produce standards for the use of LIDAR. Outputs will be available in the next 12 – 24 months and will be incorporated into NE Best Practice Advice. It is recommended that the standardisation for this receptor is reviewed in 12-24 months once the outputs of the ReSCUE project have been finalised.

Recommended standards for seabirds -
SB1: The development of each wind farm OMP includes engagement with Natural England.
SB2: OMP's to consider NE's best practice guidance for post-consent monitoring relating to seabirds (Parker et al., 2022) which provides advice in relation to common monitoring solutions and key considerations for implementation.

5.4. Fish & Shellfish

Fish species should be recorded using the WoRMS list of accepted scientific names. From feedback, it was suggested the consultants have a preference to use this database.

The stakeholder workshop attendees stated that MEDIN is widely used and recommended by SNCBs. The MEDIN standard for fish & shellfish surveys are the MEDIN data guideline for species and benthos data by trawl or dredge, video surveys of species and benthos and shellfish stock assessment data. However,

feedback has suggested that this database needs to be simplified, and consultants would be more inclined to use the system if it was more user-friendly. The MMO are aware that MEDIN are currently working to improve their services.

The JNCC Marine Monitoring Handbook, which states the method for sampling benthic and demersal fish populations on sediments, is recommended. However, monitoring must remain species and site specific.

Fish species and assemblages are particularly suitable to eDNA monitoring and DNA-based methods are already widely and successfully deployed for fish monitoring programmes (Franco et al. 2020a). eDNA methods have been shown to outperform conventional methods in terms of detection probability, costs and feasibility. There remain some limitations of the method, for example, the influence of hydrodynamics needs to be carefully considered to determine where eDNA within a sample has come from.

The project team recognise that different species require different monitoring, as highlighted in NE's post consent monitoring best practice, this was agreed by the stakeholder workshop participants. During the workshop, attendees stated they want to make sure these different methods are included in monitoring standards where the standards are species/group specific.

Recommended standards for fish and shellfish monitoring -
FS1: Species to be recorded using the WoRMS list of accepted scientific names.
FS2: Fish & shellfish surveys to use the MEDIN standard. These are the MEDIN data guideline for species and benthos data by trawl or dredge, video surveys of species and benthos and shellfish stock assessment data.
FS3: The JNCC Marine Monitoring Handbook to be used for sampling benthic and demersal fish populations on sediments.
FS4: If eDNA-based methods are used then this should follow NE's Monitoring methods for assessing inshore fish communities (Franco et al. 2020a).

5.5. Benthic

The NMBAQC scheme is endorsed by NE and provides quality control and assurance to the macrobenthic invertebrate elements of the Clean Seas Environmental Monitoring Programme. Due to the large volume of standards within NMBAQC, Table 1 is provided to summarise some of the most used methodologies.

Table 1:

Methodology	Purpose
Mason, 2016	Methods for Particle Size Analysis.
Turner et al. 2016	Guidelines for epibiota remote monitoring from digital imagery.
JNCC Epibiota Quality Assurance Framework (QAF)	Standardise the analysis of epifaunal imagery data through Epibiota proformas, QAF form checks and a Comparison tool.
Worsfold et al., 2010	NMBAQC Processing Requirements Protocol for Marine Macrobenthic Samples.

World Register of Marine Species (WoRMS)	List of accepted scientific names.
Mapping European Seabed Habitats (MESH) standards	Recommended Operating Guidelines for habitat mapping.
Hitchin et al. (2015)	DDV survey methodology forms part of the epibiota component of the NMBAQC scheme.
The MEDIN standard for benthic surveys	This includes guidelines for data by grab or core, species and benthos data by trawl or dredge, video surveys of species and benthos and transect survey data.

The JNCC Marine Monitoring Handbook for littoral sediment habitats provides high level guidance for monitoring intertidal sediments. The Handbook includes Guidelines (No. 3-9, Thomas 2001) to define the methods of quantitative sampling of sublittoral sediment biotopes and species using remote-operated grabs and the Procedural Guidance 4-3 which states the sampling of benthic and demersal fish populations on sediments for epibenthic beam trawl surveys.

All workshop participants agreed the use of MBES and SSS techniques on their own are not sufficient for benthic monitoring, therefore benthic sampling should always be used in monitoring. The method of sampling used will depend on the environment.

Where biotope assignments are to be made, the NMBAQC Scheme states that these must be analysed and assigned to the appropriate level of the Marine Habitat Classification (Connor et al., 2004)[61] and/or the European Nature Information System EUNIS Classification System[62] hierarchy.

The Marine Habitat Classification developed by JNCC's MNCR provides a tool to aid the management and conservation of marine habitats and is stated to be fully compatible with the European EUNIS habitat classification system. As well as this, the SACFOR Abundance Scale[63] (JNCC, 1990) comes under the MNCR methods.

Recommended standards for benthic monitoring -
BE1: Standards in the NMBAQC Scheme to be followed for benthic sample analysis, including the use of MEDIN standard for benthic data recording.
BE2: The JNCC Marine Monitoring Handbook, including Guidelines No. 3-9 and the Procedural Guidance 4-3 should be followed for benthic sample collection.

5.6. Geophysical

The IHO standards (S44 and S57) for geophysical monitoring surveys should provide complete seabed coverage for detailed feature or habitat mapping, equating to 200% coverage. The stakeholder workshop participants stated that as it is normal

[61] (Connor et al., 2004) The Marine Habitat Classification for Britain and Ireland: https://mhc.jncc.gov.uk/media/1027/04_05_introduction.pdf
[62] (European Environment Agency, 2022) EUNIS Habitat Classification System: https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1/folder_contents
[63](JNCC, 1990) SACFOR abundance scale used for both littoral and sublittoral taxa: https://mhc.jncc.gov.uk/media/1009/sacfor.pdf

practice it is sometimes not mentioned in monitoring reports. However, it would be recommended that for clarity, adherence to these standards is noted in monitoring plans and reports.

SSS surveys should follow the MESH Recommended Operating Guidelines, whilst the use of MBES should follow the MESH Recommended operating guidelines for swath bathymetry.

MEDIN-compliant discovery metadata, which also conforms to The Crown Estate's Marine Data Exchange standard, should be adhered to. For geophysical surveys, these are the MEDIN data guideline for seismic data, bathymetry data, sampling sediment & rock characteristics and for SSS data.

Recommended standards for geophysical surveys -
GE1: IHO standards S44 and S57, for hydrographic surveys. If completed alongside a side-scan sonar survey, bathymetric coverage should comply with Order 1a or Order 1b. If not accompanied by side scan sonar surveys, hydrographic surveys should provide 200% coverage (Exclusive Order).
GE2: Side-scan sonar & multi-beam echosounder surveys should follow MESH Remote Operating Guidelines and MESH Remote Operating Guidelines for swath Bathymetry, respectively.
GE3: Geophysical surveys to use the MEDIN standard. These are the MEDIN data guideline for seismic data, bathymetry data, sampling sediment and rock characteristics and for side scan sonar data.

5.7. All Receptors

Monitoring plans and reports to include clear signposting of monitoring/data standards so that MMO's Marine Licensing Team and SNCB's can efficiently see what form the monitoring will take.

Recommended standards for all receptors –
AR1: Monitoring plans and reports to include clear signposting of monitoring/data standards.

6. Conclusions

6.1. Implementation

All recommendations will be implemented through MMO's Marine Licensing Team who are the marine licensing authority for England and consult on post-consent monitoring with SNCBs. To achieve this, a tool has been created that combines a checklist of the standards with a corresponding decision chart. This has been disseminated to case teams to help aid decisions on whether an Applicant has used the standards where required. Monitoring reports will be checked once obtained by case teams against this tool, which will determine whether monitoring reports are to proceed to the next stage, which is SNCB consultation. The project team acknowledge that the published standards are an expectation for Applicants, not an essential requirement and because of this, the Licensing tool reflects the decision

where an Applicant has stated why specific standards have not been followed, and how this may be accepted under specific circumstances.

Prior to recommendations being published, MMO have requested that the In-Principal Monitoring Plans (IPMP's) are to be updated to reference this project, where any of these 6 receptors are applicable. The MMO also requested that the IPMP's include a general commitment to ensure that any standards or best practice are adhered to during monitoring and are outlined clearly within relevant monitoring reports. The MMO licensing teams will continue to engage with Applicants to ensure that this reference is included.

6.2. Review of Recommendations

From stakeholder input, the project team acknowledge that these recommendations may need to be revisited at timely intervals to update to newer standards and methodologies, as well as to encompass new technologies in monitoring. The first review is expected to be 12-24 months after this initial publication.

Although the aim of this project is to enhance standardisation, this must not prevent innovation of monitoring techniques. Recommendations have been made on current processes and available information, but there must be space for these to adapt over time. Therefore, the team have created standardisation that allows new approaches to be phased in over time, whilst still allowing for comparison of data.

The project team believe that the first method of innovation will be the use of eDNA for species monitoring. Due to this, a standard methodology has been used in the fish and shellfish recommendations, to prevent these standards from becoming obsolete.

Furthermore, there are several live projects (e.g. ReSCUE) that are likely to provide outputs which will inform updates to best practice in the next few years, allowing the MMO to refine the recommendations and data standards accordingly. Additionally, this project has inspired SNCBs to consider whether there are other ways to improve standardisation of post-consent monitoring outputs, and the MMO would welcome the opportunity to work with them and other stakeholders to this end.

Following publication of the recommendations, the project team anticipate there may be further feedback from stakeholders who have not previously engaged with the project. To facilitate this, a survey has been created to send to any applicant or interested party to record their thoughts and compile responses into one database (*See Annex D*). Once the recommendations have reached review, these responses can also be acknowledged in any future updates to the project.

6.3. Strategic Monitoring

In support of the Government's mission, to make Britain a clean energy superpower and for nature recovery to go hand in hand with planning reform, Defra is implementing an Offshore Wind Environmental Improvement Package (OWEIP). This aims to accelerate offshore wind deployment while protecting the marine environment. The objectives for strategic monitoring are to identify better use of

monitoring data collected at offshore wind farms and to facilitate improvements to monitoring practices that can help address shared evidence gaps and areas of uncertainty.

The MMO hope that the work from this project may aid the goal of strategic monitoring as similarly, standardisation will lead to a joined-up approach to monitoring programmes to deliver more coordinated monitoring of the environmental impacts of offshore wind developments. Specifically, the goal of “Improving data sharing and standardisation” as well as “Giving a consistent approach to environmental monitoring for developers” are the key aims of this project, and therefore, the MMO would encourage coordination between this project and Strategic Monitoring, going forward.

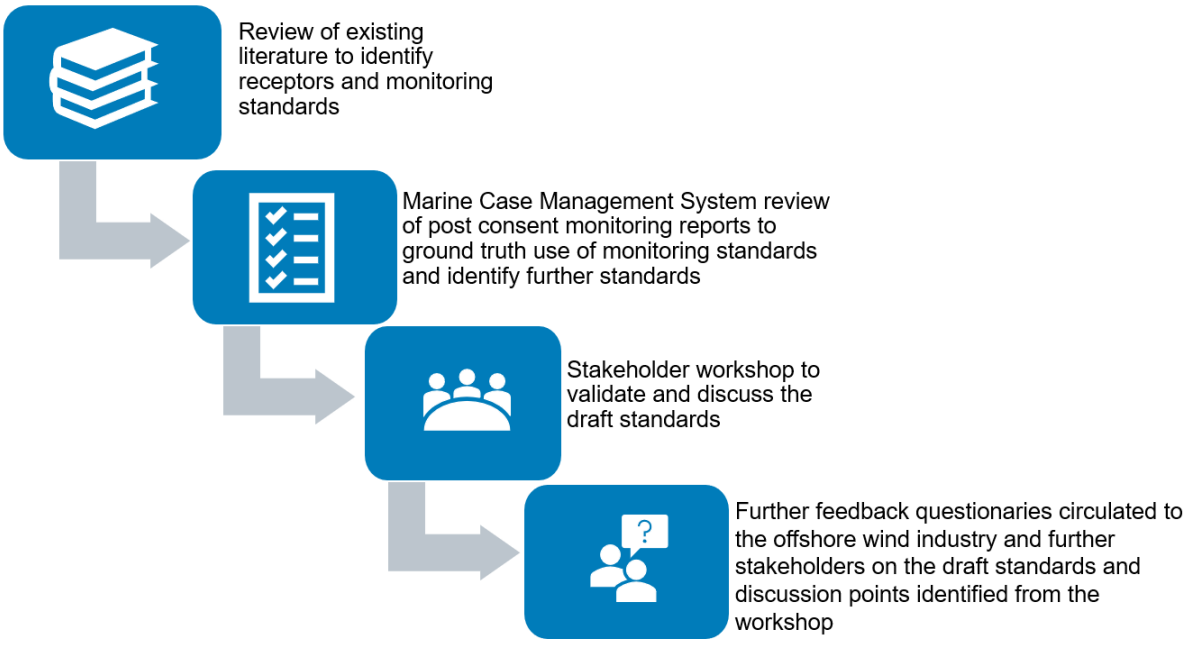
Annex

Annex A:

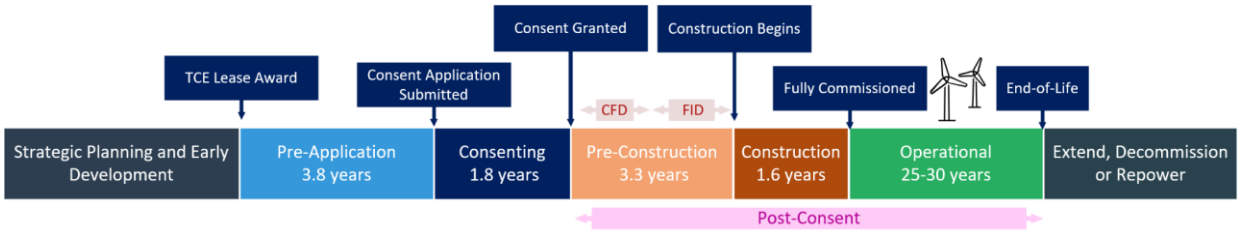
Description of Post Consent Returns process for Offshore Wind Projects:

1. Return is submitted by the developer
2. Business Support Team review the return and allocate any non-notification return. A designated case team will receive the return at the next allocations meeting.
3. Case Officer to review documents and send out to consultation with the relevant body for 20 - 28 days.
4. Consultation ends – If consultee has comments that require action, then a “changes required” letter is drafted and sent to the developer
5. If changes are required, meetings may be held with consultee and developer to resolve issues
6. Developer makes the changes and resubmits the document to the MMO
7. MMO enters another round of consultation with the relevant body
8. Stage 4 and 5 may be repeated until consultee is in agreement.
9. Once agreement has been met and there are no outstanding concerns the return is then discharged. If concerns are still present, then this may be raised to Secretary of State.

Annex B: Flow diagram of project methodology.



Annex C: Main stages of offshore wind deployment with average duration from custom RenewableUK EneryPulse Dataset (August 2024): https://www.renewableuk.com/energypulse/custom/.
"Post-consent" is used to describe the time from pre-construction to operation of an offshore wind farm development.
CFD: Contract for Difference.
FID: Final Investment Decision.



Annex D:
To facilitate further feedback, a survey has been created to compile responses into one database. Please see here: https://forms.office.com/e/1xqssrbgc0
Once the recommendations have reached review, these responses can also be acknowledged in any future updates to the project.