Cyfoeth Naturiol Cymru
Natural Resources Wales

Mapping Environmental Considerations for Marine Spatial Planning in Wales: Methodology

Report to Welsh Government

About Natural Resources Wales

Natural Resources Wales' purpose is to pursue sustainable management of natural resources. This means looking after air, land, water, wildlife, plants and soil to improve Wales' well-being, and provide a better future for everyone.

Evidence at Natural Resources Wales

Natural Resources Wales is an evidence-based organisation. We seek to ensure that our strategy, decisions, operations and advice to Welsh Government and others are underpinned by sound and quality-assured evidence. We recognise that it is critically important to have a good understanding of our changing environment.

We will realise this vision by:

· Maintaining and developing the technical specialist skills of our staff;

· Securing our data and information;

· Having a well resourced proactive programme of evidence work;

· Continuing to review and add to our evidence to ensure it is fit for the challenges facing us; and

· Communicating our evidence in an open and transparent way.

This report has been produced by Natural Resources Wales advisory in response to a request from Welsh Government.

Publication date: June 2023

Title: **Mapping Environmental Considerations for Marine Spatial Planning in Wales: Methodology. Report to Welsh Government.**

Author(s): L.G. Murray, H. Bloomfield, L. Skates

Peer Reviewer(s): NRW Marine Spatial Approach Expert Group

Approved By: M. Lewis

Restrictions: None

To be cited as: Murray, L.G., Bloomfield, H. and Skates, L. (2023). Mapping Environmental Considerations for Marine Spatial Planning in Wales: Methodology. Report to Welsh Government. Bangor, Natural Resources Wales. 48pp.

Crynodeb Gweithredol

- Yn ystod hydref 2021, rhoddodd Llywodraeth Cymru'r dasg i wasanaeth cynghori Cyfoeth Naturiol Cymru (CNC), fel y Corff Cadwraeth Natur Statudol, i fwrw ymlaen â rhaglen o Fapio Ystyriaethau Amgylcheddol i gefnogi'r dull gofodol o gynllunio morol.

- Nod y gwaith yw casglu a chyflwyno tystiolaeth amgylcheddol i gefnogi Llywodraeth Cymru ac eraill sydd â diddordeb mewn archwilio cyfleoedd posibl yn y dyfodol ar gyfer y gwaith o ddefnyddio a rheoli ardal forol Cymru yn gynaliadwy. Amcan y cam cychwynnol hwn o'r gwaith oedd cynhyrchu mapiau o ystyriaethau amgylcheddol ar gyfer ystod o sectorau mewn perthynas â nodweddion ecolegol.

- Diben yr adroddiad hwn yw gwneud y canlynol:

  - disgrifio'r fethodoleg a ddefnyddiwyd i gynhyrchu'r mapiau a'r setiau data sy'n sail iddynt;

  - cyflwyno'r mapiau, gan amlygu ysgogwyr allweddol y gwahaniaethau ar draws grwpiau nodwedd, a'r defnydd posibl a wneir o'r mapiau ynghyd â'u cyfyngiadau;

  - crynhoi opsiynau i'w hystyried yng nghamau'r gwaith mapio hwn yn y dyfodol. Bydd hyn yn cydnabod yr ymrwymiad i'r rhaglen hirdymor o waith mapio amgylcheddol sy'n cefnogi dull gofodol Llywodraeth Cymru o weithredu'r cynllun morol a phrosesau eraill sy'n ymwneud â chynllunio gofodol.

- Cynhwysir pedwar grŵp nodwedd eang, sef:

  - adar, gan gynnwys adar y môr, ac adar dŵr arfordirol a rhydwyr;
  - pysgod, gan gynnwys pysgod môr a physgod ymfudol;
  - cynefinoedd a rhywogaethau morol gan gynnwys cynefinoedd arfordirol;
  - mamaliaid morol.

- Ystyrir graddau'r ymwneud posibl rhwng saith sector sy'n berthnasol i gynllunio morol yng Nghymru:

  - ynni ffrwd llanw;
  - ynni tonnau;
  - dyframaethu;
  - ynni amrediad llanw;
  - agregau;
  - ceblau pŵer;
  - ffermydd gwynt arnofiol ar y môr.

- Mae'r data, y dadansoddiadau a'r allbynnau wedi'u cyfyngu i ardal Cynllun Morol Cenedlaethol Cymru. Fodd bynnag, dylid nodi y gallai datblygiadau o fewn ardal y cynllun, a'r tu allan iddi, gael effeithiau y tu hwnt i'w hôl troed ac ar rywogaethau symudol.
- Rydym wedi defnyddio methodoleg sgorio sy'n cynnwys tri phrif gam: sgôr digwyddiad, sgôr pwysigrwydd cadwraeth, a sgôr effaith bosibl.
- Hyd yn hyn, mae'r gwaith hwn wedi dod â thystiolaeth ynghyd ar ddosbarthiad tua 170 o gynefinoedd, rhywogaethau a safleoedd gwarchodedig.
- Bwriad y d*ystiolaeth yw helpu defnyddwyr i ddeall rhai o'r ystyriaethau ecolegol sy'n ymwneud â sector penodol wrth weithredu ym moroedd Cymru.* Bwriedir i'r allbynnau presennol fod yn arf cynllunio morol strategol *i'w defnyddio ochr yn ochr â thystiolaeth a chanllawiau eraill.* Gyda'i gilydd byddant yn gwella dealltwriaeth o oblygiadau datblygiad morol a chyfleoedd i gefnogi rheoli adnoddau naturiol yn gynaliadwy ym moroedd Cymru.
- Mae'n bwysig nodi **nad yw ac na all** y gwaith a ddisgrifir yn yr adroddiad hwn fod **yn asesiad o addasrwydd unrhyw gynlluniau prosiect neu gynigion datblygu penodol**. Byddai hynny'n gofyn am fanylion penodol am natur a graddfa debygol gweithgaredd penodol e.e. i lywio parth dylanwad tebygol y cynnig/cynigion a chaniatáu archwiliad manylach o lwybrau effaith posibl ynghyd ag ystyriaeth benodol o ofynion lliniaru.

Executive Summary

- In autumn 2021, Natural Resources Wales (NRW) advisory, as the Statutory Nature Conservation Body, was tasked by Welsh Government to progress a programme of Mapping of Environmental Considerations to support the spatial approach to marine planning.

- The aim of the work is to compile and present environmental evidence to support Welsh Government and others who are interested in exploring potential future opportunities for sustainable use and management of the Welsh marine area. The objective of this initial phase of work was to produce maps of environmental considerations for a range of sectors in relation to ecological features.

- The purpose of this report is to:

  - describe the methodology used to produce the maps and the datasets that underpin them;

  - introduce the maps, highlighting key drivers of the differences across feature groups, and both the potential uses of the maps and their limitations; and

  - summarise options for consideration in future phases of this mapping work, recognising the commitment to the long-term programme of environmental mapping work to support Welsh Government's spatial approach to Marine Plan implementation and other spatial planning related processes.

- Four broad feature groups are included, namely:

  - birds, including seabirds, and coastal wildfowl and waders;
  - fish, including marine fish and diadromous fish species;
  - marine habitats and species including coastal habitats; and
  - marine mammals, including cetaceans and seals.

- The potential degree of interaction of seven sectors of relevance to marine planning for Wales are considered:

  - tidal stream energy;
  - wave energy;
  - aquaculture;
  - tidal range energy;
  - aggregates;
  - power cabling; and
  - floating offshore wind.

- The data, analysis and outputs are restricted to the Welsh National Marine Plan area. However, it should be noted that developments within and outside the plan area may have impacts beyond their footprint and on mobile species.
- We have applied a scoring methodology including three main stages: occurrence score, conservation importance score, and potential impact score.
- To date, this work has brought together evidence on the distribution of around 170 habitats, species, and protected sites in Welsh waters.
- The evidence is intended to help users understand some of the ecological considerations relating to a particular sector when operating in Welsh seas. The current outputs are intended as a strategic marine planning tool to be used alongside other evidence and guidance, which together improve understanding of the implications of marine development and opportunities to support the Sustainable Management of Natural Resources (SMNR) in Welsh seas.
- It is important to note that the work described in this report **does not and cannot constitute an assessment of the suitability of any specific project development plans or proposals**. Such considerations require specific details of the likely nature and scale of a particular activity e.g. to inform the likely zone of influence of the proposal(s) and allow more detailed examination of potential impact pathways and specific consideration of mitigation or compensation requirements.

Contents

1. Introduction

1.1 Background

The Welsh National Marine Plan (WNMP), published in November 2019 (Welsh Government, 2019), is the first Marine Plan for Welsh Waters. It sets out the Welsh Government's vision, objectives and planning policies for the sustainable use of our seas over the next 20 years. The WNMP aims to guide and support effective, proportionate, and consistent decision making which is underpinned by sound evidence. The plan states that developers, regulators and other users of the marine environment should make use of the best available evidence in developing their proposals and making decisions, supporting others to do so by sharing evidence wherever possible.

The **Welsh National Marine Plan vision** (Welsh Government, 2019) is that Welsh seas are clean, healthy, safe, productive and biologically diverse:

- Through an ecosystem approach, natural resources are sustainably managed and our seas are healthy and resilient, supporting a sustainable and thriving economy;
- Through access to, understanding of and enjoyment of the marine environment and maritime cultural heritage, health and well-being are improving;
- Through Blue Growth more jobs and wealth are being created and are helping coastal communities become more resilient, prosperous and equitable with a vibrant culture; and
- Through the responsible deployment of low carbon technologies, the Welsh marine area is making a strong contribution to energy security and climate change emissions targets.

In support of WNMP implementation, and in line with the UK Marine Policy Statement's direction to provide clear, spatial and locally-relevant expression of policy, implementation and delivery (HM Government, 2011), the Welsh Government is taking a **spatial approach** to understanding opportunities and constraints related to sustainable use of marine resources.

The approach includes:

- sharing spatial data through the Wales Marine planning portal;
- production of sector locational guidance;
- safeguarding of consented projects and established activities; and
- identification of Strategic Resource Areas (SRAs) to apply WNMP safeguarding policy (SAF_02: Safeguarding strategic resources) in relation to potential future resource use.

1.2 Mapping Environmental Considerations

In autumn 2021, Natural Resources Wales (NRW) advisory, as the Statutory Nature Conservation Body for Wales, was tasked by Welsh Government with establishing and progressing a programme of Mapping Environmental Considerations (MEC) for the Welsh Marine Plan Area. To oversee the MEC work, NRW have established a Marine Spatial Approach Expert Group (MSAEG), which reports to our Marine Programme Planning and Delivery Group (MPPDG).

The aim of the work is to compile and present, spatially, environmental evidence to support Welsh Government and others who are interested in exploring potential future opportunities for sustainable use and management of the Welsh marine area. The objective of this initial phase of the work is to produce a series of integrated maps showing environmental considerations for a range of sectors, in relation to ecological features.

This report and associated datasets represent the first outputs of what is an ongoing, long-term multi-year programme of environmental mapping work. The intention will be to maintain and develop the methodology and spatial outputs with the objective that, over time, the outputs will have greater applicability in supporting more detailed spatial planning and project level decision-making.

This work builds on the outputs of the European Maritime and Fisheries Fund (EMFF) Sustainable management of marine natural resources (SMMNR) project (ABPmer, 2020), which collated and mapped evidence in relation to tidal stream energy, wave energy, and aquaculture. Whilst relevant and useful, the outputs of the SMMNR project have been subsumed into this work and updated accordingly.

The evidence developed under this work programme is intended to help users understand, in an intregrated and synthesised way, some of the ecological considerations relating to a particular sector when operating in Welsh seas. The current outputs are intended as a strategic marine planning tool which should be used alongside other evidence and guidance as appropriate.

1.3 Purpose and scope of this report

The key outputs from the first year of this programme of work are a series of maps and underlying data to communicate relative spatial differences in environmental considerations for a particular sector.

The purpose of this report is to:

- detail the methodology used to produce the maps, documenting the datasets that underpin the maps and the rationale for the scoring applied (Section 2);
- introduce the maps, highlighting key drivers of the differences across feature groups, and both the application of the maps and their limitations (Section 3); and

- summarise key ideas for consideration in future phases of this work, recognising our commitment to the long-term programme of environmental mapping to support Welsh Government's spatial approach to Marine Plan implementation and other spatial planning related processes (Section 4).

Features

The focus of the report is on those species and habitats conferred protection under the Conservation of Habitats and Species Regulations 2017, Wildlife and Countryside Act 1981, Environment (Wales) Act 2016 and OSPAR Convention. This focus is to support implementation of WNMP policies ENV_01: Resilient Marine Ecosystems, ENV_02: Marine Protected Areas, and ENV_07: Fish Species and Habitats.

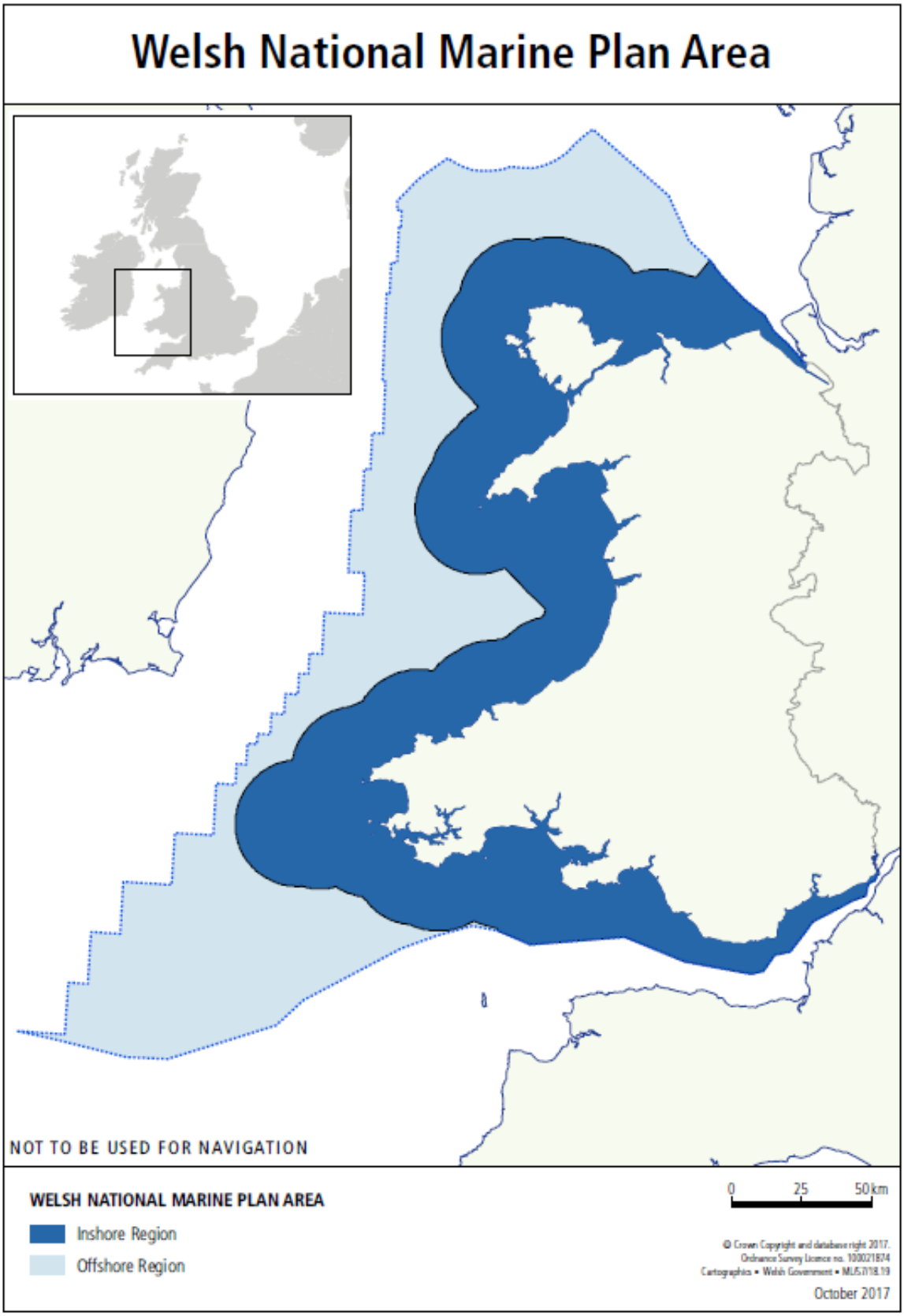
Four broad feature groups are considered, namely:

- birds, which includes seabirds, coastal wildfowl and waders;
- fish, which includes marine fish and diadromous fish species;
- marine habitats and species, including coastal habitats; and
- marine mammals, which includes cetaceans and seals.

Geographic Extent

The data, analysis and outputs cover the whole WNMP area, which includes the inshore and offshore regions (**Figure 1**). The outputs also include some coastal habitats which may extend above mean high water springs but may be affected by developments in the plan area. Developments may have impacts beyond their footprint, including outside the plan area, and on mobile species which may occur over much larger spatial scales than the plan area. Equally, developments outside the plan area may impact species and habitats within the plan area.Therefore, the outputs should be used alongside other relevant evidence, and advice should be sought from relevant authorities.

Figure 1. Welsh National Marine Plan Area (Welsh Government, 2019)



Sectors

NRW have extended the approach taken by the SMMNR project (ABPmer, 2020) to include seven sectors relevant to marine planning for Wales:

- tidal stream energy;
- wave energy;
- aquaculture;
- tidal range energy;
- aggregates;
- power cabling; and
- floating offshore wind energy.

Some sectors have been subdivided to ensure compatibility with other Welsh Government spatial approach work, including ongoing work to identify potential Strategic Resource Areas (Welsh Government, 2022). Where appropriate, potential construction impacts have been scored and mapped in addition to potential operational impacts.

2. Methodology

2.1 General approach

The methods used in the current study are underpinned by those used in the SMMNR project (ABPmer, 2020). Recognising the long-term commitment to this work, key changes include the incorporation of new and updated datasets, and development of GIS models that enable changes to the scoring process to be made in light of new evidence and understanding.

Sectors

Table 1 shows the sectors and sub-sectors that were included in the current programme of work. These were aligned with those being considered by Welsh Government in identifying potential Strategic Resource Areas for safeguarding of resources. Y = Yes, included. N = No, not included.

Table 1. Sectors and feature groups considered.

Sector - Operation	Birds	Fish	Habitats & benthic species	Marine mammals
Tidal stream energy - mid-water and surface	Y	Y	Y	Y
Tidal stream energy – seabed	Y	Y	Y	Y
Wave energy - mid-water and surface	Y	Y	Y	Y
Wave energy – seabed	Y	Y	Y	Y
Bivalve aquaculture – seabed	Y	Y	Y	Y
Bivalve aquaculture – suspended	Y	Y	Y	Y
Seaweed aquaculture – suspended	Y	Y	Y	Y
Subtidal aggregate extraction	Y	Y	Y	Y
Tidal range energy	Y	Y	Y	Y
Cabling – power	Y	Y	Y	Y
Floating offshore wind	Y	Y	Y	Y

Sector - Construction	Birds	Fish	Habitats & benthic species	Marine mammals
Tidal stream energy - mid-water and surface	N	Y	Y	Y
Tidal stream energy – seabed	N	Y	Y	Y
Wave energy - mid-water and surface	N	Y	Y	Y
Wave energy – seabed	N	Y	Y	Y
Tidal range energy	Y	Y	Y	Y
Cabling – power	Y	Y	Y	Y
Floating offshore wind	N	Y	Y	Y

The operational phase was considered for all sectors for all feature groups, and includes maintenance activities. The construction phase was considered only for sectors where potential construction impacts are substantially different from those during operation (tidal stream, wave, tidal range, floating offshore wind and cabling). However, for the bird feature group, construction phase was considered only for tidal range and cabling, as construction effects of the other sectors were thought to be too project specific to consider at this strategic level. Potential decommissioning impacts have not been examined.

Approach to scoring

The scoring methodology (**Figure 2**) included three main stages:

1. The occurrence score reflects either the presence (e.g. for sites, habitats and benthic species) scored as 3, or standardized abundance from 1 to 3 (if abundance data was available for species) of features, where 1 was the lowest density and 3 the highest for each feature. The approach taken for each dataset is shown in Appendix A.
2. The conservation importance score is an estimate of the level of protection each feature is afforded based on the legislation that confers protection. It is important to note that all the features included in this work are conferred protection under various legislation and all are important considerations in the planning of developments. This step was scored from 1 (lowest protection) to 5 (highest protection).
3. **Table 2**An impact score (**Table 2**) to reflect potential impacts on features based on the likely pressures generated by each sector was applied for the operational pressures of each of the focus sectors and, separate to this, construction pressures for some sectors. Where there was considered to be a lack of evidence then a higher score was applied to ensure a suitably precautionary approach. The current approach did not assess specific technologies individually but considered the potential pressures that could originate from a sector generally and their potential to negatively affect each of the features. This step was scored from 1 (lowest impact) to 3 (highest impact).

Scores were calculated for occurrence x importance, and occurrence x importance x potential impacts for each feature in each cell, and these were summed for each 1 km^2 hexagonal grid cell, providing a relative 'environmental considerations' score for each feature group per sector. The approach taken to the scoring differed slightly between feature groups based on the available evidence and is outlined in the following sections.

Given the high-level nature of this work, potential mitigation measures have not been considered. Therefore, it is important to note that it may be possible to mitigate potential impacts of developments. This will depend very much on the particular nature of a specific

development including its scale, location, timing, the specific technology used, and the receptors concerned.

As well as extending the SMMNR approach to consider additional sectors, extra datasets and new datasets have been included where available. The following sections highlight these for the different features. To date, this work has brought together a wealth of extensive spatial evidence on the distribution of around 170 habitats, species, and protected sites in Welsh waters.

Figure 2. Overview of methodology for calculating environmental considerations scores. Numbers in boxes show the range of scores at each step. Each row represents a species, habitat or site. The summed score for each cell is the sum of all the feature scores occurring within that cell.

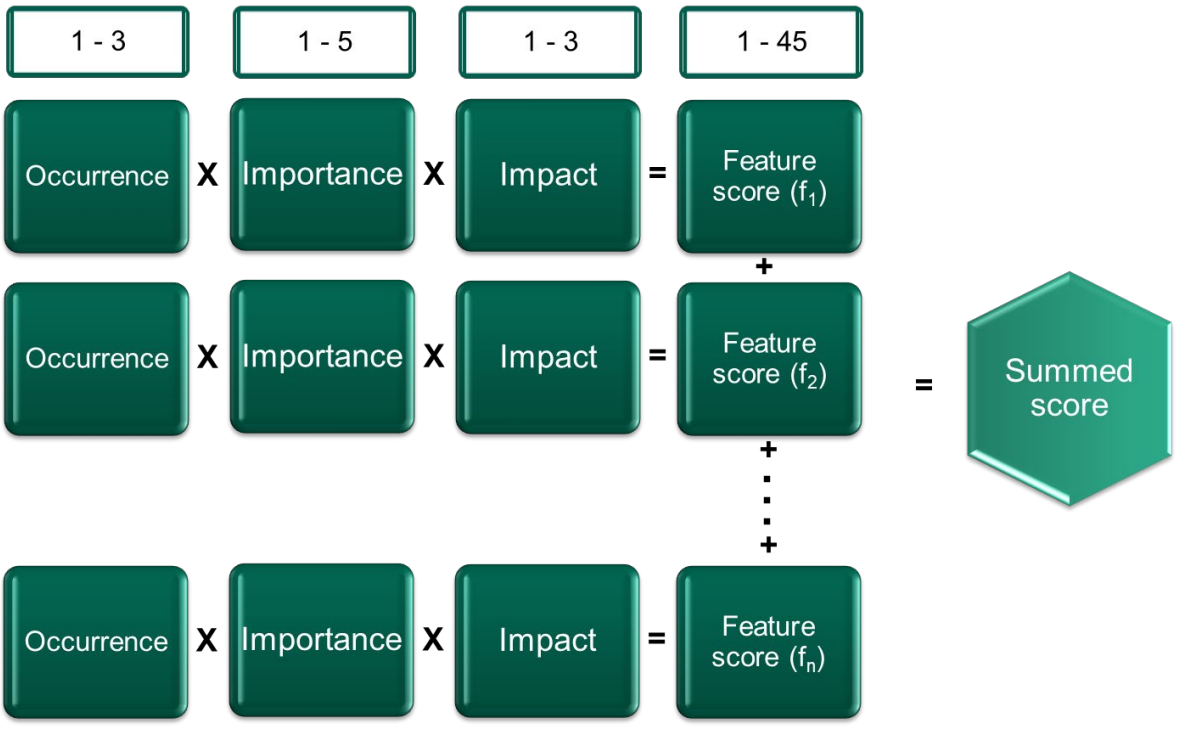


Table 2. Impact score definitions.

Impact Score	Potential impact of pressures
0	The pressures created by the sector are not expected to impact the feature. This may be because all of the resource is located in a different area to the feature
1 (Low)	The pressures created by the sector have some potential to impact the feature
2 (Moderate)	The pressures created by the sector have moderate potential to impact the feature
3 (High)	The pressures created by the sector have high potential to impact the feature

Selection of datasets

The datasets used are those that we consider to best represent the known distributions of protected features in the WNMP area and are datasets that NRW, as the SNCB for Wales, technical specialists would typically use to inform their advice. The initial selection of datasets was based on those identified by ABPmer in the SMMNR project. However, through discussion with NRW's technical specialists, additional and more recent or improved datasets were identified in some cases and included in this mapping work.

An important limitation of any work such as this is that datasets are not available on all protected features in Welsh waters or coverage is not always complete. In addition to the spatial datasets used this work draws on other evidence to inform the scoring of each feature. Details of the specific datasets used are discussed further under each feature group (Sections 2.2 to 2.5).

Geographic Information System (GIS) data processing

All spatial data processing was conducted in ArcMap (Versions 10.6 and 10.8.2). Conservation importance and potential impact scores were recorded in an Excel spreadsheet, which was joined to the spatial vector datasets. Datasets that were originally in raster format were converted to polygon datasets. The join was based on a common ID for each feature.

Features included species, habitats and protected sites. In some cases distinction was made between records within SACs and outside of SACs such that a higher conservation importance score was applied within SACs. At this stage the distinction between birds within and outside SPAs has not been applied to SPAs, though this will be addressed in future iterations.

Occurrence scores were standardized in ArcMap for each species to a scale of 1 (lowest occurrence) to 3 (highest occurrence) within the WNMP area. Habitats and sites were

scored as 3 if present. Calculations of occurrence x importance, and occurrence x importance x impact, were made in each GIS file (feature classes within geodatabases).

Each GIS file was then joined to a hexagonal 1 km^2 polygon grid. Thus for each source GIS file a hexagonal gridded version was created. The approach to joining the source files to the grid varied depending on the dataset. Where a dataset contained a single species or habitat then the maximum value intersecting the grid cell was assigned to the cell. This avoided multiple counting of the same feature type within each cell. Where a single dataset contained multiple species or sites the values were summed so that all species or sites were included in the scoring.

For polygon datasets such as the spawning and nursery ground data (see Section 2.3) which included multiple species, and which were on a standard grid it was necessary to join data to cells based on whether the hexagonal cell centre fell within each cell from the original data. This avoided multiple counting of the same species where multiple original cells intersected individual hexagons (e.g. along the source grid cell boundaries).

2.2 Birds

2.2.1 Datasets

Table 3 lists the datasets used to represent the distribution of bird species and protected sites. In addition to the datasets representing seabirds, data on the abundance of waders and wildfowl from the Wetland Birds Survey (WeBS) were included (Frost, 2021). Species that are features of protected sites were included. The data used was five-year mean peak high water counts within the coastal WeBS survey areas. New modelled distribution and abundance data has been used for 11 species (Black-legged Kittiwake, Northern Fulmar, Northern Gannet, Atlantic Puffin, Common Guillemot, Manx Shearwater, Great Black-backed Gull, Lesser Black-Backed Gull, Razorbill, and Herring Gull, European Storm Petrel) (Evans & Waggitt, 2023). Given the inclusion of these new datasets compared to the SMMNR work it was no longer considered necessary to include data on foraging radii around colonies. However, data on loafing areas around colonies were retained, highlighting the importance of the colonies and surrounding areas. Getis-Ord statistically significant hotspots for shags were included (Cleasby, Owen, Wilson, & Bolton, 2018) as WWT/ESAS data coverage was sparse for this species.

Protected sites with bird features (and supporting habitats) were included (SPAs, SSSIs, Ramsar). In addition, Skomer MCZ byelaws prohibit intentional or reckless killing, taking, destruction or disturbance of any plant or animal. A code of conduct is also in place, which includes avoiding unnecessary noise, which may disturb seabirds. Thus the MCZ was included in the scoring for the birds feature group.

Table 3. Datasets used to map bird features.

Datasets (including links to source)	Description
WWT/ESAS seabirds at sea	Density of flying and sitting birds on a 3 km grid. Used where modelled distribution data (see below) were not available for a particular species (e.g. cormorant, common scoter).
Modelled Distribution and Abundance of Cetaceans and Seabirds	Natural Resources Wales / Marine and coastal evidence reports Evans, P.G.H. and Waggitt, J.J. (2023). Modelled Distribution and Abundance of Cetaceans and Seabirds in Wales and Surrounding Waters. NRW Evidence Report No: 646. Natural Resources Wales, Bangor
RSPB seabird utilisation distributions	Getis-Ord statistically significant hotspots for shag (Cleasby, Owen, Wilson, & Bolton, 2018)
Seabird loafing areas	From 1 – 4 km range around Welsh seabird colonies based on JNCC Generic maintenance extensions around seabird breeding colonies: data collection and analysis. JNCC Resource Hub
WeBS coastal waterbirds	5-year mean peak average counts of waterbirds in WeBS survey areas (Frost, 2021)
Marine Protected Areas: SPAs, SSSIs, Ramsar, MCZ Offshore SPAs Sites of Special Scientific Interest (SSSIs) (includes marine, coastal and terrestrial) SPAs (includes marine, coastal and terrestrial	Marine and coastal protected sites for birds

2.2.2 Occurrence scores

Occurrence scores were calculated for the WeBS, WWT/ESAS and modelled seabird distribution datasets (from 1 for the lowest abundance to 3 for the highest abundance in

the plan area). For the seabird utilisation areas and loafing datasets a score of 3 was applied where these were present. Protected sites for birds were also scored as 3 where present.

2.2.3 Conservation importance scores

The approach to scoring of conservation importance was different for birds than for the other feature groups. Conservation importance scores were derived from the Birds of Conservation Concern in Wales 3 (Johstone & Bladwell, 2016) and Birds of Conservation Concern 5 (Stanbury, et al., 2021). These reviews categorise each species as red, amber or green based on a set of standardised criteria (Stanbury, et al., 2021). As a precautionary approach both reviews were consulted and the highest of the categorisations was used for each species where red was scored as 5, amber as 3, and green as 1. The fourth version of Birds of Conservation Concern in Wales was published in December 2022. This new data will be incorporated in due course. Wild birds are protected under the Wildlife and Countryside Act 1981, and several species are also protected as SPA features or Section 7 species. At this stage the conservation importance scores used in the study do not reflect the different protections for birds, though this will be addressed in future iterations. Protected sites are scored as features in their own right, reflecting the importance of the sites' designated species and supporting habitats. SPAs, Ramsar sites, and the MCZ were scored as 5. SSSIs were scored as 3.

2.2.4 Potential impact scores

Potential impact scores were derived based on the expert judgement of NRW's marine ornithologists based on consideration of overlap of the species and the resources, the pressures created by the sectors, and the sensitivity of the species to these pressures. Where there was a clear spatial separation between a feature and the resources for a particular sector then a 0 was applied and the feature effectively screened out of the scoring for that sector. A score of 3 was applied to all protected sites included in the mapping.

2.3 Fish

2.3.1 Datasets

Table 4 lists the datasets used to represent fish features in Welsh waters. New datasets were introduced that mapped density of forage fish (Campanella & Van der Kooij, 2021). This data included Environment (Wales) Act Section 7 species (herring, cod, mackerel, horse mackerel, sandeel, whiting, and herring) as well as other forage fish species (poor cod, garfish). The source files were raster datasets for Q1 (spring) and Q4 (autumn/winter) for each species. For each, Q1 and Q4 were summed and then converted to polygon files.

If species were not included in the newer data, then data on high and low intensity spawning and nursery grounds was used (Ellis, Milligan, Readdy, Taylor, & Brown, 2012). These species were hake, ling, plaice, sole, angler fish, blue whiting, common skate, spotted ray, spurdog, thornback ray, tope, and undulate ray.

Data on migration routes for diadromous fish were not available. However, it was considered very likely that diadromous fish would occupy areas well beyond estuaries. Therefore, GIS layers were created that showed indicative areas (see 2.3.2 for further details). Data on basking shark sightings were also included (Bloomfield & Solandt, 2008), as were bass nursery areas.

Table 4. Datasets used to map fish features.

Datasets (including links to source)	**Description**
RSPB/Cefas forage fish data	Spawning and nursery grounds of forage fish in Welsh and surrounding waters (Campanella & Van der Kooij, 2021).
Spawning and nursery grounds	High and low intensity spawning and nursery ground data (Ellis, Milligan, Readdy, Taylor, & Brown, 2012)
Bass Nursery Areas	Bass nursery areas and specified periods of which prohibition of fishing for bass applies according to the Bass (Specified Areas) (Prohibition of Fishing) (Variation) Order 1999.
Basking shark sightings	Basking Shark Watch sighting data (Bloomfield & Solandt, 2008)
Indicative fish areas	Indicative areas where migratory fishes and other species may be present
Marine Protected Areas: SACs, SSSIs, Ramsar, MCZ Sites of Special Scientific Interest (SSSIs) (includes marine, coastal and terrestrial) SACs (includes marine, coastal, and terrestrial sites)	Marine and coastal protected sites with fish features

2.3.2 Occurrence scores

Occurrence scores (from 1 to 3) were calculated for spawning and nursery ground forage fish datasets. For the older spawning and nursery ground datasets a score of 1 was applied for the low intensity areas and 3 for the high intensity areas.

Bass nursery areas were scored as 3 where present.

Basking shark data recorded only 1 or 2 individuals per cell. Therefore, this dataset was scored as 3 where there were records of sightings.

There is a lack of data on diadromous fish and their migration routes in Welsh waters. Consequently, indicative areas were included in the mapping. These do not represent known distributions of fish species but highlight that it will be important to consider the possible presence of fish in these areas. Indicative areas for diadromous fish were scored 3 within 3 NM of shore, 2 from 3 NM to 12 NM, and 1 from 12 NM to the outer limits of the marine plan area. This was applied for eel, sea lamprey, river lamprey, Atlantic salmon, and sea trout.

Indicative areas were created for Allis shad and Twaite shad, with a score of 3 applied in the Severn Estuary, Three Rivers Estuary, Afon Dyfi, and Afon Dwyfor. A score of 2 was applied outside of these areas to 12 NM, and a score of 1 in the remaining area.

An indicative area for smelt was included in the north-eastern area, with a score of 3 in the Dee Estuary to 3 NM offshore, a score of 2 out to 12 NM, and a score of 1 in the remaining area.

For angel shark a score of 3 was applied within 6 NM, 2 from 6 NM to 12 NM, and 1 elsewhere based on recent data on angel shark distribution in Welsh waters (Barker, et al., 2022). Ideally the modelled angel shark habitat suitability data from this study will be incorporated in due course.

Seahorses have been recorded in Pembrokeshire Marine SAC and therefore this area was scored as 3 for occurrence of this species.

2.3.3 Conservation importance scores

Conservation importance scores were estimated based on the protection conferred on each feature. SAC features were scored as 5; Section 7 species were scored as 3; and other species (blue whiting, spotted ray, poor cod, and garfish) were scored as 1. As an exception to the above criteria, given their scarcity, seahorses, angel shark and basking shark were scored as 5. At this stage species conservation importance scores do not reflect whether a species is present within a site of which it is a feature. SACs, Ramsar sites, and MCZ were included in their own right and scored as 5. SSSIs were scored as 3.

2.3.4 Potential impact scores

Potential impact scores were derived based on the expert judgement of NRW's fish specialists based on consideration of overlap of the species and resources, the pressures created by the sectors, and the sensitivity of the species to these pressures. The fish datasets do not distinguish between the occurrence of SAC features within or outside of sites. Therefore, protected sites were included in their own right to highlight their importance within the compiled maps, with a score of 3 applied.

2.4 Marine and coastal habitats and benthic species

2.4.1 Datasets

The datasets used to map marine habitats and species, and coastal habitats are listed in **Table 5**. At this stage coastal species (e.g. plants, invertebrates, otters) have not been included, although these are in part represented by the presence of protected sites and habitats.

Table 5. Datasets used to map habitat and benthic features.

Datasets (including links to source)	**Details**
Article 17/Annex I habitats: Marine Coastal	The Article 17 reporting maps are a snapshot of the most up to date spatial data for features listed on the various Annexes of the Habitats Directive at the time of reporting. They represent the current known extent / location and status of features both inside and outside of SACs.
Section 7/OSPAR habitats: Marine Coastal	Under the Environment (Wales) Act (2016), Section 7 requires biodiversity lists to be produced. These lists include types of **habitats** which are of "Principal Importance" for the purpose of maintaining and enhancing biodiversity in relation to Wales. In addition to this, habitats can be protected under the OSPAR Convention.
Marine Section 7/OSPAR species	Under the Environment (Wales) Act (2016), Section 7 requires biodiversity lists to be produced. These lists include types of **species** which are of "Principal Importance" for the purpose of maintaining and enhancing biodiversity in relation to Wales. In addition to this, species can be protected under the OSPAR Convention.
Marine Protected Areas in Welsh waters: SACs, SSSIs, Ramsar, MCZ Special Areas of Conservation (SACs) with marine components (offshore) SACs (includes marine, coastal, and terrestrial sites) Sites of Special Scientific Interest (SSSIs) (includes marine, coastal and terrestrial)	Marine and coastal protected sites with habitats and benthic species as features.

2.4.2 Occurrence scores

All features were scored as 3 where present. Where features were represented by both points and polygons then overlapping points were removed so that features were not double counted.

2.4.3 Conservation importance scores

SAC features (within the SAC of which they are a feature) were scored as 5. Annex 1 features outside of SACs in which they were qualifying features were scored as 2. In addition, given the incomplete spatial coverage of habitats and species datasets, SACs were included and scored as 5. Ramsar sites and the MCZ were also scored as 5. SSSIs were scored as 3. Section 7/OSPAR habitats were scored as 3.

2.4.4 Potential impact scores

Potential impact scores were based on the pressures identified in the Pressures-Activities Database (PAD) (Robson, et al., 2018), which identifies the pressures caused by activities. The PAD does not specifically consider floating offshore wind, but it was considered that the potential impact level in relation to benthic habitats and species would be sufficiently similar for fixed and floating wind for the high-level focus of the present work.

Where there was a clear spatial separation between a feature and the resources for a particular sector then a 0 was applied and the feature effectively screened out of the scoring for that sector.

Based on the list of potential pressures caused by each sector the sensitivity of features was identified using the Marine Evidence-Based Sensitivity Assessment (MarESA) (Tyler-Walters, Hiscock, Tillin, Readman, & Perry, 2021). Scores were assigned as 1 (low), 2 (medium) or 3 (high) based on the MarESA sensitivity classifications. Since the habitat features mapped in this study contained many biotopes, the maximum score was applied. Thus the impact score applied was the maximum sensitivity to any of the pressures caused by an activity on any biotope within each feature. Where sensitivity scores were not available for a particular species then a score of 3 was applied. A score of 3 was applied to all protected sites included.

2.5 Marine mammals

2.5.1 Datasets

The datasets used to map marine mammals (cetaceans and seals) are listed in **Table 6**. The modelled distribution and abundance data and Marine Mammals Atlas (Baines & Evans, 2012) (data used previously in the SMMNR project have been replaced with newer, modelled, higher resolution data (Evans & Waggitt, 2023).

Table 6. Datasets used to map marine mammal features.

Datasets (including links to source)	Description
Modelled Distribution and Abundance of Cetaceans and Seabirds	Natural Resources Wales / Marine and coastal evidence reports Evans, P.G.H. and Waggitt, J.J. (2023). Modelled Distribution and Abundance of Cetaceans and Seabirds in Wales and Surrounding Waters. NRW Evidence Report No: 646. Natural Resources Wales, Bangor
Grey seals at sea	Estimated at-sea distribution of grey and harbour seals (Marine Scotland) (Russell, Jones, & Morris, 2017).
Seal haul out and pupping sites	Data on seal haulout and pupping sites from multiple sources (Baines, Earl, Pierpoint, & Poole, 1995; Clarke, et al., 2020; Strong, Lerwill, Morris, & Stringell, 2006; Westcott & Stringell, 2004).
Marine Protected Areas: SSSIs, Ramsar, MCZ	Marine protected sites with marine mammal features.

2.5.2 Occurrence scores

Occurrence scores were scaled from 1 (minimum abundance) to 3 (maximum abundance) for each dataset. Seal pupping and haul out sites were scored as 3. Values were then extended to within 1 km^2 of each cell where a seal pupping or haul out site was present. SACs were not included since conservation importance scores distinguished between species within and outside of SACs of which they are features and modelled data covered the entire plan area. However, the datasets were not split to reflect the presence of features of Ramsar sites, SSSIs or the MCZ. Therefore, Ramsar sites, SSSIs and the MCZ were included and scored as 3 to ensure they were represented in the compiled maps.

2.5.3 Conservation importance scores

All the cetacean species included in the current study are Section 7 and Annex IV European Protected Species (EPS). These were scored as 3 (Minke whale, Common dolphin and Risso's dolphin) unless they were also Annex II SAC features (Harbour porpoise, Bottlenose dolphin) occurring within the sites of which they are features, in which

case they were assigned a conservation importance score of 5. Grey seals are not EPS or Section 7 species and therefore seals at sea were assigned a conservation importance score of 2 unless they occurred within SACs of which they are features, in which case they were scored as 5. This approach was also applied to seal haul out and pupping sites; sites within SACs where grey seals are features scored 5 and other sites scored 2.

This approach highlights the importance of habitats of the species within MPA boundaries as well as the level of protection within MPAs. However, it is important to note that cetacean and seal populations extend beyond MPA boundaries and the marine plan area.

While there are other Section 7, EPS and OSPAR cetacean species, as well as harbour seals, these are less commonly found in Welsh waters (i.e. Section 7/EPS: Fin whale, Long finned pilot whale, Northern bottlenose whale, Atlantic white sided dolphin, White beaked dolphin, Humpback whale, Killer whale, Striped dolphin, Cuvier's beaked whale. OSPAR/EPS: Bowhead whale, Blue whale, Northern right whale). These species have not been included in the current study.

A conservation importance score of 5 was applied to Ramsar sites and the MCZ, and 3 applied to SSSIs to highlight the importance of these areas to marine mammals. These MPAs have additional legislative requirements in relation to marine mammals.

2.5.4 Potential impact scores

Potential impact scores were derived based on the expert judgement of NRW's marine mammal specialists based on consideration of overlap of the species and the resources, the pressures created by the sectors, and the sensitivity of the species to these pressures. A potential impact score of 3 was applied to all protected sites included.

3. Environmental considerations maps

3.1 Outputs

The mapping environmental considerations work comprises three key elements:

- Scoring: Appendix B lists each feature that was included in the mapping, alongside a conservation importance score and impact scores for each of the focus sectors: tidal stream energy, wave energy, tidal lagoon energy, floating offshore wind energy, power cabling, aggregates, and aquaculture.
- Spatial datasets: GIS datasets on the 1 km^2 hexagonal grid for each feature group and including the summed scoring data.
- Maps: Appendix C contains 67 maps which were created by combining the information from Appendix B with spatial datasets to create maps showing the environmental considerations by feature for each of those focus sectors. The colour scales in each map were derived using the Jenks Natural Breaks classification to group similar values.

3.2 Interpreting the maps

3.2.1 Feature occurrence and conservation importance

The overall patterns observed in the maps are predominantly driven by the presence of features, with higher scores where multiple sites, species or habitats overlap (Figures 3 to 6). Since the occurrence and importance scores underpin the mapping, and are common to all sectors, there are similarities across all sector-specific maps within feature groups (Appendix C).

For instance, the highest occurrence x importance scores tend to be found in MPAs, the majority of which are within 12 NM of the coast. Estuaries score highly, highlighting the importance of these areas for species of conservation importance such as wading birds (**Figure 3**) and migratory fishes (**Figure 4**). Furthermore, birds, in general, aggregate in coastal areas, unless there are offshore fronts or areas of upwelling. The benthic habitats and species maps similarly show higher scores inshore, which illustrates the conservation importance of a range of habitats and species found in and around the Welsh coast, including estuaries and inlets (**Figure 5**). It should be noted that where a score is shown for areas further inland this is due to protected riverine sites extending from the coast. For marine mammals, key areas are Pembrokeshire, Cardigan Bay/west Wales and Anglesey/northwest Wales, although certain species, such as minke whales, tend to occur further offshore. In addition, there are many seal pupping and haul out sites around the coast (**Figure 6**).

Figure 3. Relative occurrence x importance scores for bird features. NB. Colour scales indicate score within the feature group but are not comparable between feature groups.

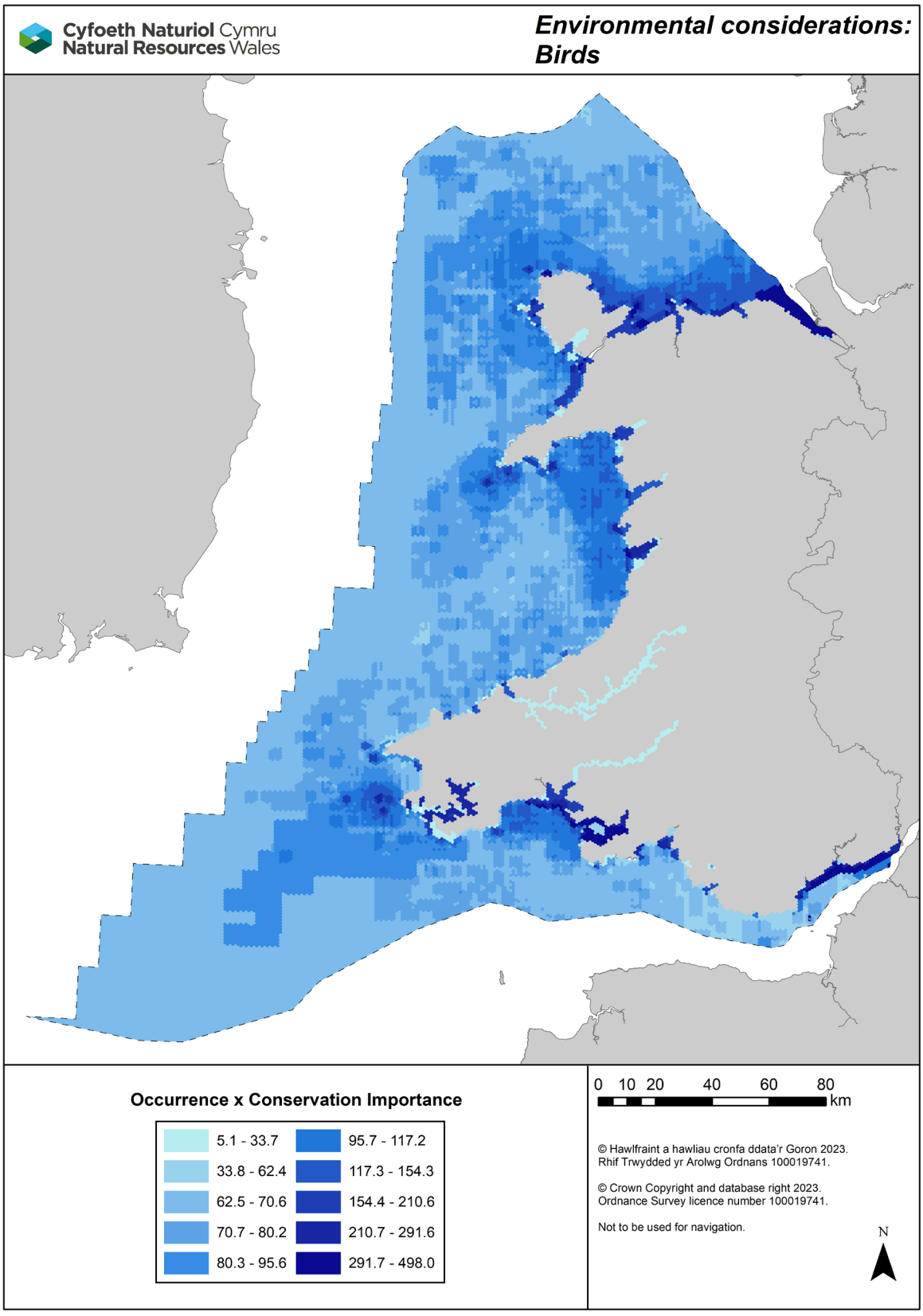


Figure 4. Relative occurrence x importance scores for fish features. NB. Colour scales indicate score within the feature group but are not comparable between feature groups.

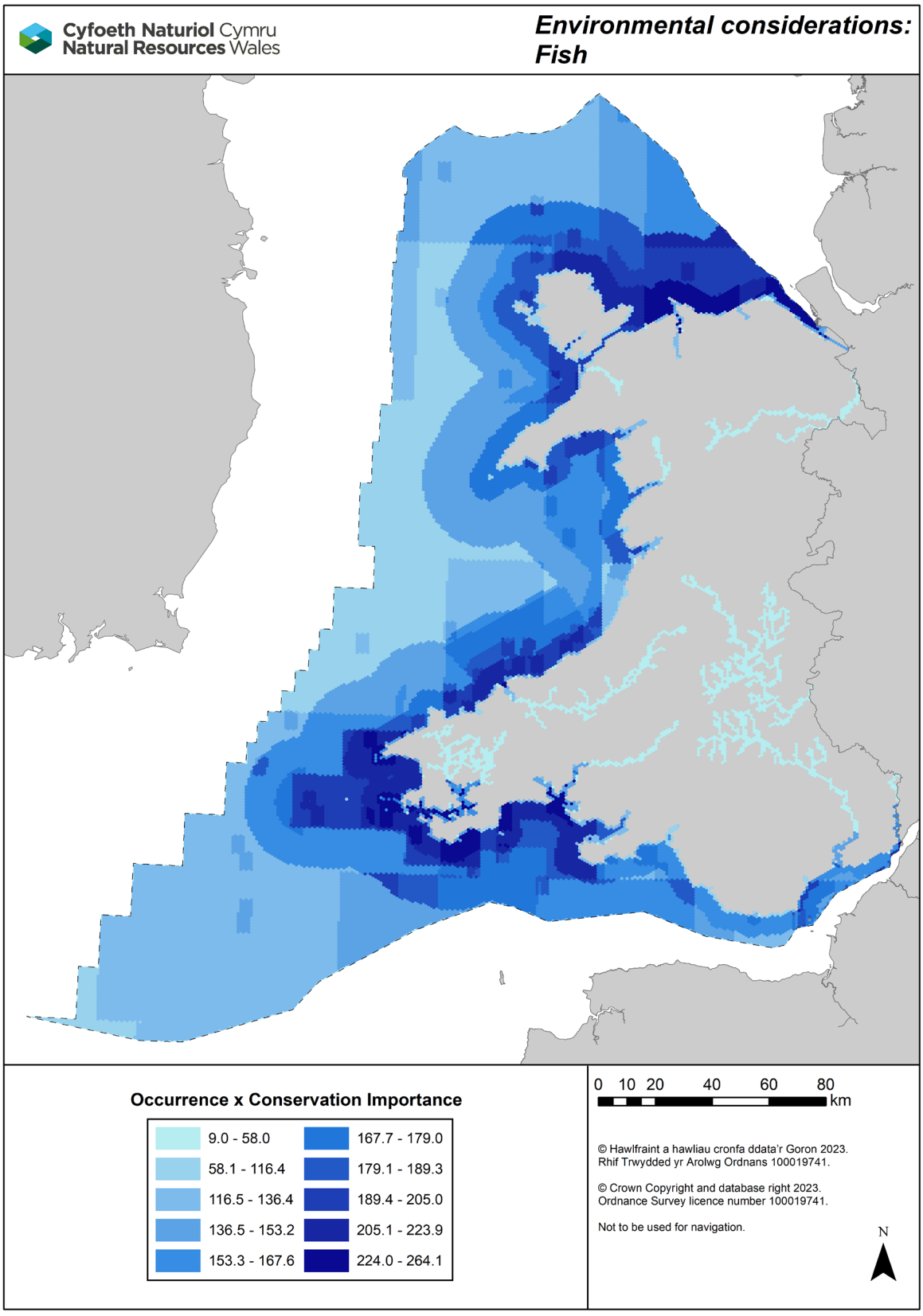


Figure 5. Relative occurrence x importance scores for habitat and benthic species features. NB. Colour scales indicate score within the feature group but are not comparable between feature groups.

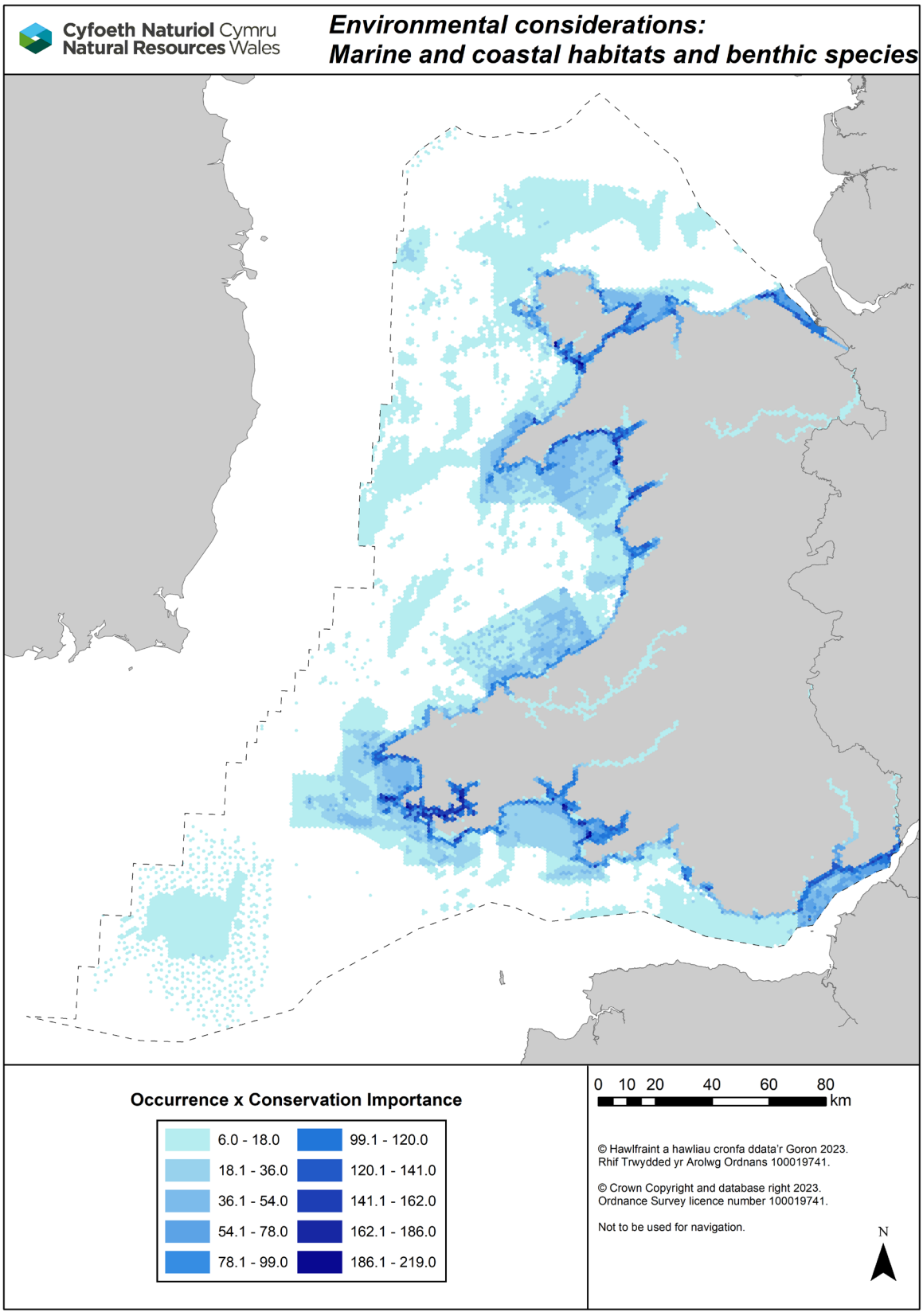
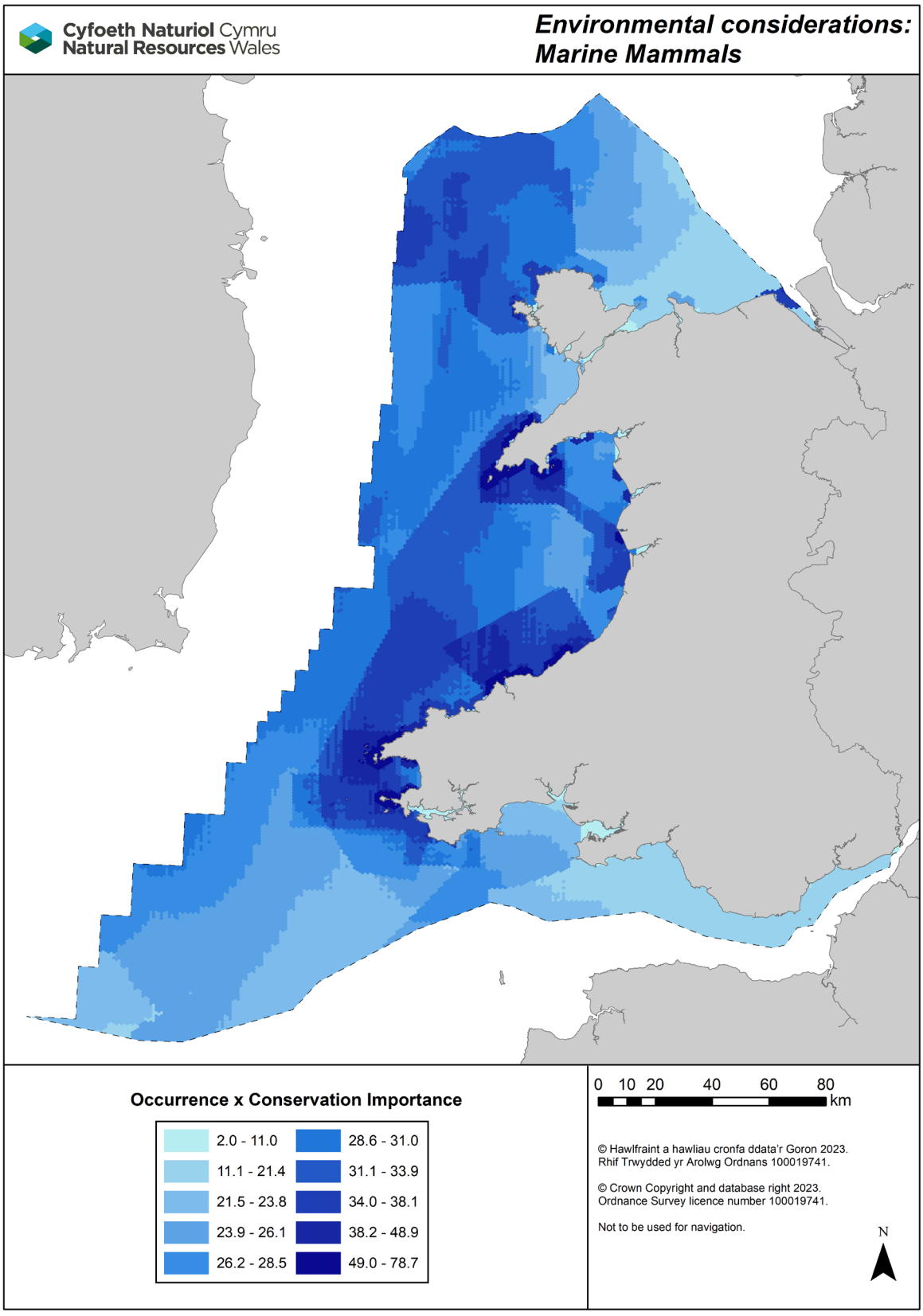


Figure 6. Relative occurrence x importance scores for marine mammal features. NB. Colour scales indicate score within the feature group but are not comparable between feature groups.



The number of features occurring in a particular area influences the overall score. Thus, for example, summed scores for marine mammals are generally lower than for birds, as fewer species are included in the mapping. Furthermore, the approach to scoring is slightly different between feature groups based on the particular datasets available and the features concerned. **This means that it is not possible at present to compare between maps for different feature groups. The scores are relative within each feature group map.**

As the maps are produced by overlaying multiple features, higher scores are found where there is data on multiple protected sites, species and habitats in an area. However, there may also be cases where there is only one feature, for example, leading to a lower score. While this does indicate that there are fewer known environmental considerations this feature may still be an important consideration. **It is also important to note that low occurrence scores in some areas may indicate a lack of data.** This is particularly apparent in the marine habitats and benthic species datasets (**Figure 5**) where the white areas of the map may indicate an absence of data, not necessarily an absence of features. Equally, additional datasets may have become available that indicate the presence of protected features that are not yet captured in the current work.

Data from Marine Recorder indicate that biotope records are concentrated inshore (and within SACs) and the majority of these records fall within the extent of the data used in the present study (**Figure 7**). Of the records from beyond the extent of the MEC habitats and benthic species datasets the majority are sublittoral. 34% of records indicate some form of sublittoral sands and muddy sands; 35% of records are of sublittoral coarse sediment (unstable cobbles and pebbles, gravels, and coarse sands); and 23% are records of sublittoral mixed sediment. The other records include a range of habitats including infralittoral rock and circalittoral rock. Within these habitats several biotopes are recorded indicating a wide range of benthic species. While these records do not include all available data they are indicative of where most data is likely to be available. Including Marine Recorder records with no biotope classification reveals some additional data outside of the extent of the present study.

Ground-truthed acoustic data is more widespread, providing information about the seabed type (**Figure 8**). These acoustic datasets are part of JNCC's EUNIS level 3 combined map (Matear, Pinder, & Lillis, 2019) and describe the physical aspects of the seafloor. Based on the ground-truthed combined map data, the area not covered by the MEC habitat and benthic species datasets consists predominantly of sublittoral sediments (96.9%): sublittoral coarse sediment (29.7%), sublittoral mixed sediment (24.1%), sublittoral sand (19.7%), and a combination of sublittoral mixed sediment, coarse sediment (21.3%), sublittoral mud (1.4%), and sublittoral bigenic reef (0.4%). The remaining habitat types are shown to be made up of smaller areas of littoral rock and other hard substrata, littoral sediment, infralittoral rock and other hard substrata, circalittoral rock and other hard substrata, and rock cliffs, ledges and shores, including the supralittoral (which total 3.1%).

The seabirds at sea dataset does not cover the entire marine plan area, and survey effort is greater closer inshore. Conversely, the fish datasets do not adequately reflect the

importance of inshore areas for fish, especially in the Severn Estuary. This is in part due to a lack of survey data in inshore waters for both marine (Campanella & Van der Kooij, 2021; Ellis, Milligan, Readdy, Taylor, & Brown, 2012) and diadromous fish.

These are unavoidable limitations of the present work and an important consideration in how the maps are used. It also highlights where additional data may be needed and may provide a useful tool to help focus survey effort. The quality of source datasets also varies. An assessment of data quality was undertaken as part of the SMMNR project (ABPmer, 2020) and many of the same datasets are used in the present work. Several additional datasets have been used in the present work to enhance the mapping outputs:

- Fish: fish spawning and nursery datasets have been added to better capture spatial occurrence. However, there remain substantial uncertainties around the distributions of diadromous fish. In particular, the data layers used to represent the importance of certain areas to diadromous fish species are indicative only.

- Birds: the WeBS data (Frost, 2021) is recent and follows a clear methodology and is expected to effectively highlight the presence of waterbird populations. However, it should be noted that the WeBS survey areas do not correspond with SSSI or SPA boundaries. Therefore, at this stage no distinction is made between those species which are site features of particular MPAs and those which are not.

- Marine habitats and benthic species: updated Section 7 datasets have been included, and subtidal reef mapped in the SMMNR project has been included alongside the Article 17 subtidal reef dataset. The addition of coastal habitat data is particularly important in the context of tidal range and cabling. However, only habitats, not species data, is included at present.

- New datasets on the likely distributions of cetaceans and seabirds have been included. These are of high resolution modelled densities and extend inshore, negating the need to use the older Marine Mammals Atlas (Baines & Evans 2012) dataset. These are modelled distributions of density (number of animals per km^2) using sightings, habitat variables and statistical models.

The maps do not reflect the potential for project level mitigation measures, which will vary by sector and the specifics of particular developments and could substantially reduce potential impacts. Furthermore, compensation may be possible in relation to impacts on protected sites.

Figure 7. Marine Recorder (MR) records per 1 km^2 and coverage of habitats and benthic species datasets used in Mapping Environmental Considerations (MEC).

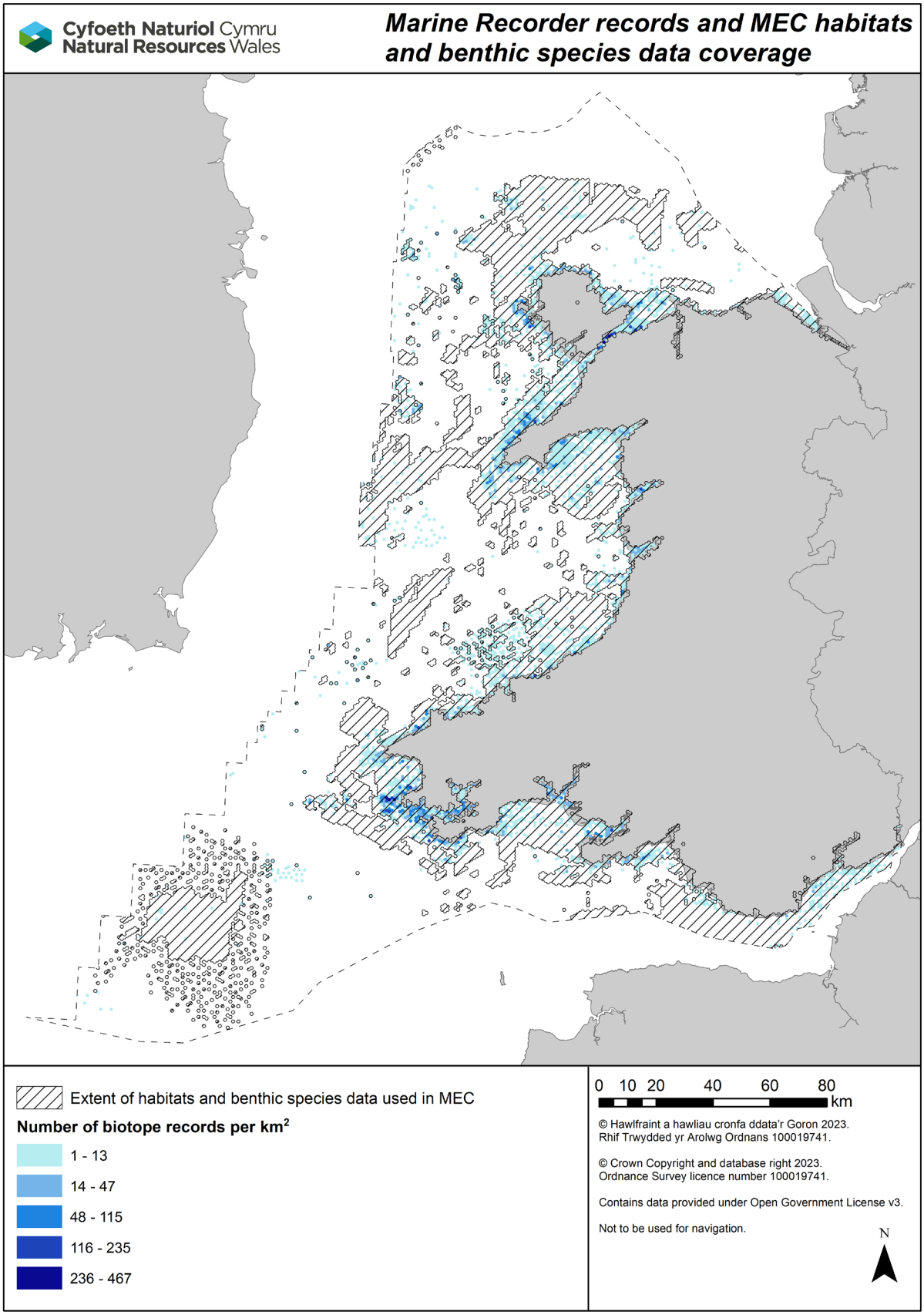
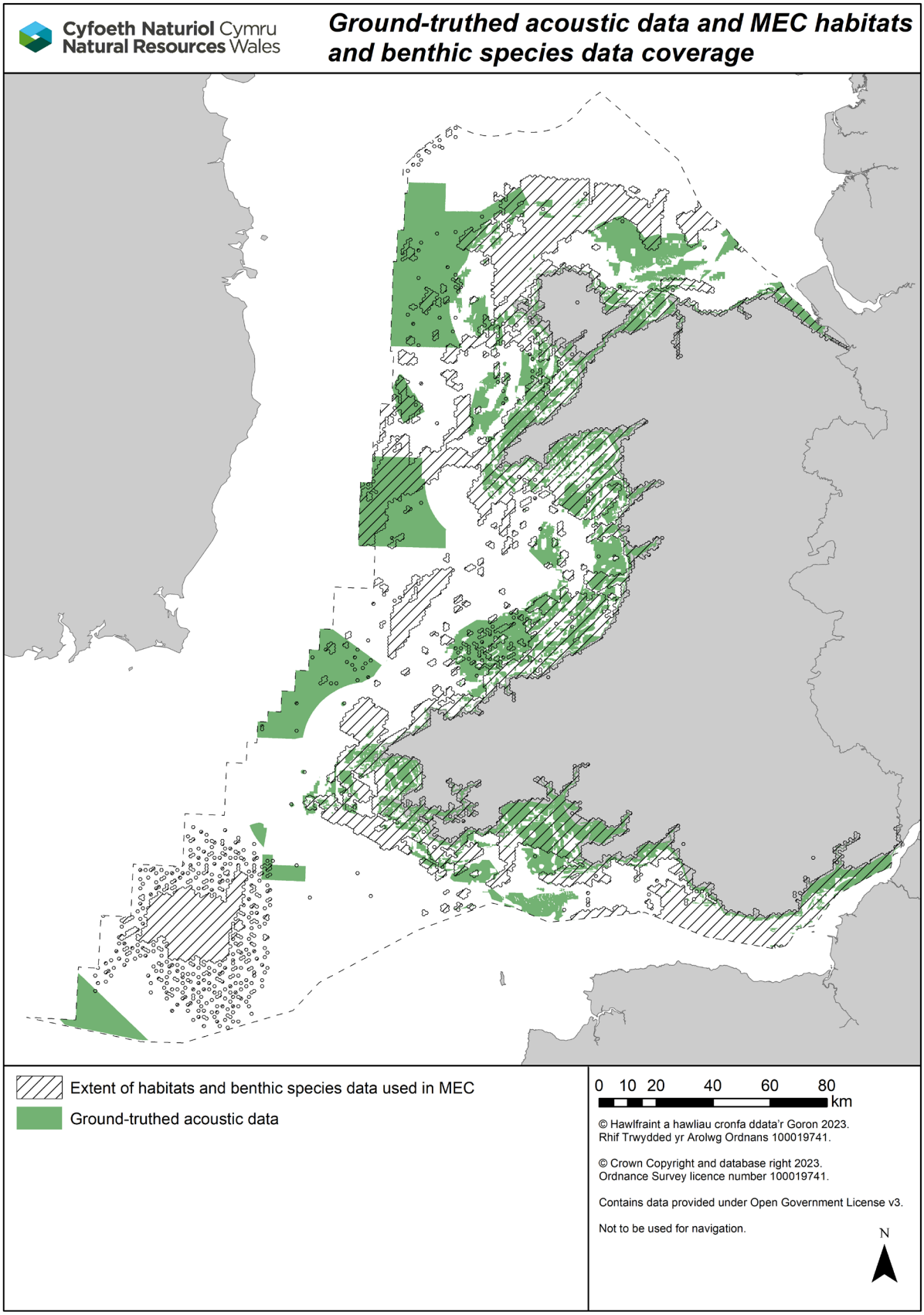


Figure 8. Ground-truthed acoustic data and coverage of habitats and benthic species datasets used in Mapping Environmental Considerations (MEC).



3.2.2 Overview of key pressures and impacts

Each sector creates a specific range of pressures that may impact receptors during construction and operational phases. The potential impact of these pressures can vary greatly depending on the specifics of the development, including the particular technologies deployed and the scale, and mitigation of effects may be possible.

The scores applied in this study and communicated within the maps (Appendix C) are therefore only indicative of relative differences in levels of environmental considerations with respect to a feature and a specific sector. Nevertheless, some distinction can be made between sectors based both on the locations of resource relative to receptors, and the pressures typically created by sectors. These differences are what drives the variation in maps between sectors. **Figure 9** provides example sector-specific maps of environmental considerations for bird, fish, habitat and benthic species, and marine mammal features in relation to operational impacts of the tidal range energy sector.

Some pressures are common to all sectors. For example, noise or visual disturbance of birds by activities associated with construction, operation or maintenance is possible for all the sectors considered. Nevertheless, there are substantial variations in the sensitivity of different species to different activities (Marine Managament Organisation, 2018). Some of the key considerations are outlined below but this is not intended to be a comprehensive review of activity pressures and sensitivities. As well as a range of advice, guidance and scientific literature that can be consulted, there are several existing resources that bring together evidence relevant to the pressures created by the sectors examined in the current study, and the sensitivities of the receptors considered. These include JNCC's Pressures Activities Database (Robson, et al., 2018), which describes the pressures from a wide range of marine sectors. This resource can be used with Marlin's Marine Evidence-Based Sensitivty Assessment (MarESA) (Tyler-Walters, Hiscock, Tillin, Readman, & Perry, 2021), which provides information on the sensitivity of benthic species and habitats.The Tethys Knowledge Base provides a searchable database of documents related to marine renewable and wind energy (Tethys, 2023).

Displacement

Displacement of animals may occur when animals are prevented from reaching or using particular habitats or travelling along migration routes. Such effects could be temporary or permanent. Displacement is considered more likely in relation to larger scale developments, which could include tidal stream, wave, floating offshore wind, tidal range or aquaculture developments. Fish, for example, may be displaced from their preferred habitats and migration routes by marine renewable energy developments. However, due to the lack of large scale deployments of marine renewable energy devices there is limited evidence (Copping, et al., 2021). It should also be considered that marine developments may result in positive biodiversity benefits, for example increased foraging habitat for marine species by increasing the surface area available for attachment of sessile species (Maxwell, et al., 2022).

Noise and visual disturbance

Noise and visual disturbance, including light, created during operation, construction and vessel traffic can cause avoidance and behavioural changes in mobile species. Noise and pressure impacts may be created by offshore energy developments, especially during the construction phase, and may impact marine mammals and fish species (Erbe, Dunlop, & Dolman, 2018; Slabbekoorn, et al., 2010; Abramic, Cordero-Penin, & Haroun, 2022). Noise generated by piling has been found to influence cod movements (Van der Knapp, Slabbekoorn, Moens, Van den Eynde, & Reubens, 2022) and impact spawning herring (Boyle & New, 2018). Marine mammals are also susceptible to auditory injury and behavioural disturbance from construction noise, for example from pile-driving (Baily, et al., 2010). However, mitigation measures can reduce underwater noise with the aim of making auditory injury less likely (Stober, 2019). Noise from aggregate dredging may also affect fish and marine mammal behaviour.

Birds are susceptible to noise disturbance. For instance, there is evidence of fulmars and Manx shearwaters avoiding offshore wind farms, particularly during construction when noise and light levels are highest (Deakin, et al., 2022).

Collision

There is potential for birds, marine mammals and fish to collide with vessels (during construction activities, for example) and with turbines or other moving parts during operation of renewable energy devices including wave, tidal stream and tidal range. Whilst there is limited evidence for emerging wave and tidal stream sectors, the potential risk of collision posed by marine renewables is likely to vary by species. For example, Furness et al. (2012) classified storm petrel and fulmar as very low vulnerability, while guillemots, razorbills and shags were considered as highly vulnerable based on variables including diving depth, tidal race usage and conservation importance. Furness et al. (2012) concluded that wave energy devices present less of a risk to seabirds than tidal stream devices and that both present a lower risk to seabirds than offshore wind. In relation to birds, Roche et al. (2016) suggested that the negative effects of interaction between tidal stream turbines and diving seabirds requires the most attention. While floating offshore wind turbines are more likely to be in areas further offshore than fixed turbines where seabird numbers are lower, there remains a risk of seabirds colliding with turbines. The risk to birds may be exacerbated by horizontal and vertical movement of turbines, and by behavioural changes of seabirds further offshore (Maxwell, et al., 2022).

Understanding the potential for collision of marine mammals with operating tidal stream energy devices or wave energy devices is an important consideration for the development of these sectors. However, collisions with wave energy convertors are thought to present a lower risk (Roche, et al., 2016). The potential effect of collisions is dependent on the probability of collisions occurring and the consequence (injury or mortality) of any collision (Copping A. , Grear, Jepsen, Chartrand, & Gorton, 2017; Onoufriou, Bronlow, Moss, Hastie, & Thompson, 2018). However, there is limited evidence on collisions and avoidance behaviour in marine mammals, and there is reliance on collision risk models to

predict the likelihood of impact (Copping & Grear, 2018), which require adequate data to parameterize the models.

Habitat loss or alteration

All the focal sectors have some potential to cause habitat loss or alteration. These changes to habitats have the potential to affect not only benthic species but mobile species which depend on particular habitats, spawning and nursery grounds, and migration routes (Copping, et al., 2021; Maxwell, et al., 2022; Balotari-Chiebao, Santangeli, Piirainen, & Byholm, 2023). The extent of the effect is dependent very much on the scale of development including both the footprint and wider zone of influence. Furthermore, species-habitat associations may not be consistent within or between populations. For example, grey seal habitat associations can vary within populations at fine spatial scales (Carter, et al., 2022), with implications for the potential impacts of developments.

Tidal range developments are likely to be large in scale and have the potential to cause multiple impacts including loss or alteration of habitats impacting subtidal, intertidal and coastal features. Tidal range developments probably have the greatest potential to impact coastal features, due to their likely locations and size, and they may also have far field effects through changes to physical processes. Cabling also has the potential to impact offshore and coastal features but can potentially be routed around sensitive features.

Entanglement

Ghost fishing by nets, ropes, traps, and lines can lead to injury and mortality of birds, fish, marine mammals and turtles (Stelfox, Hudgins, & Sweet, 2016; Ryan, 2018). Thus entanglement of these species with aquaculture gear (such as anti-predator nets) or ensnared ghost fishing gear is a risk and will potentially be exacerbated where structures act as fish aggregation devices attracting seals and seabirds. There is currently a lack of evidence on the potential environmental impacts of floating offshore wind but ghost fishing by fishing gear entangled with device moorings is possible (Maxwell, et al., 2022) and floating tidal stream devices may present a similar risk.

Pollution

There is a risk of pollution from all the sectors considered. Pollution could include spills of hydrocarbons or other chemicals, nutrient or organic enrichment, litter, or the introduction of pathogens. These could originate from vessel activity associated with construction or operation. Aggregate extraction, and construction or maintenance activities for other sectors may also lead to the resuspension of pollutants from sediments, while tidal lagoons may lead to entrapment of pollutants within the lagoons.

Bivalve aquaculture has a number of potential effects on the environment some of which are considered negative (e.g. increased deposition of faeces and pseudo-faeces) and others positive (e.g. reduced turbidity) (Gallardi, 2014). Moreover, bivalve aquaculture can

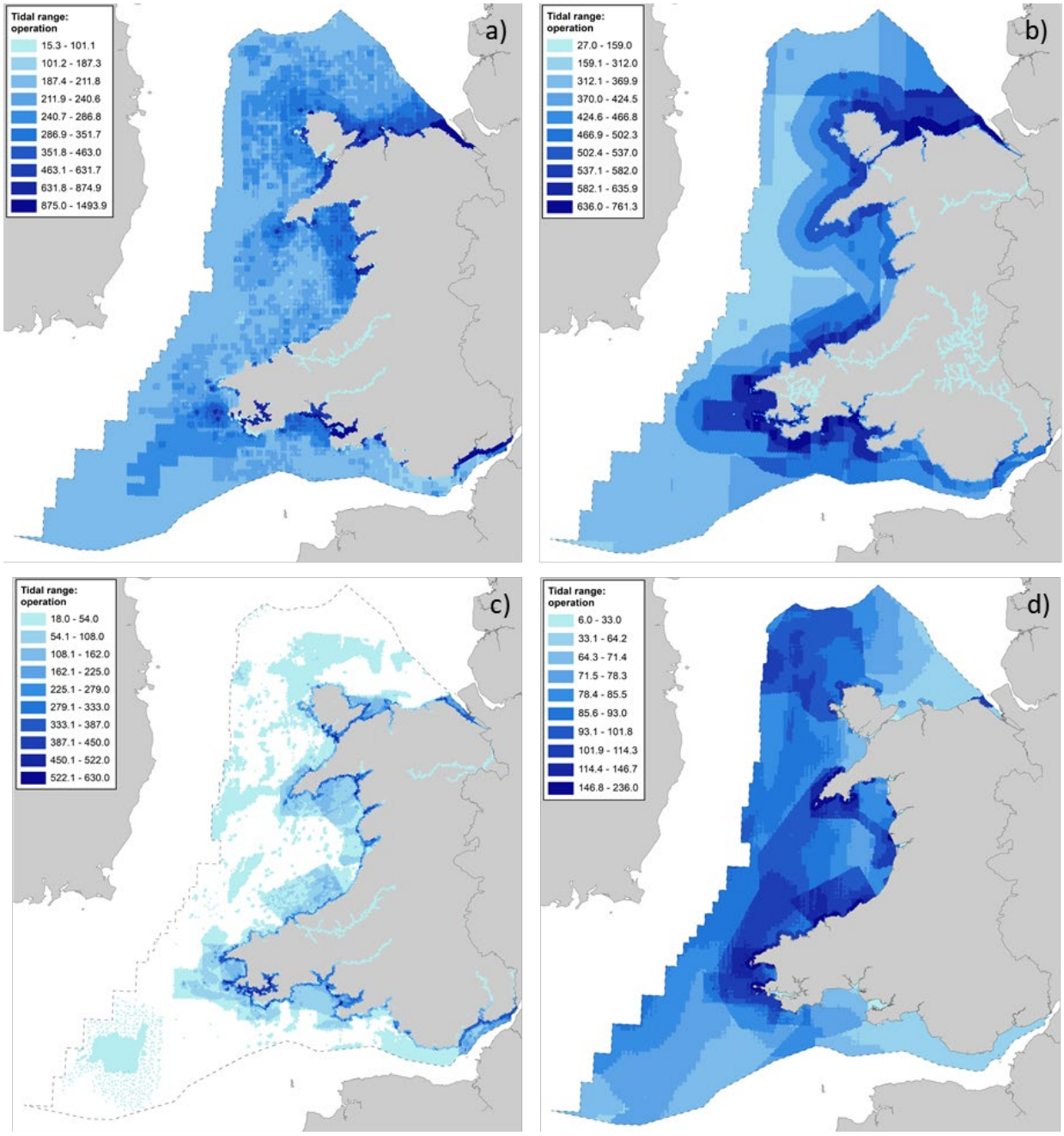
contribute nutrients (e.g. ammonium) to the marine environment, but may lead to net nutrient extraction (Petersen, Holmer, Termansen, & Hasler, 2019).

Physical processes

Changes to marine and coastal physical processes have the potential to directly and indirectly impact a wide range of environmental receptor groups such as: coastal habitats (saltmarsh, sand dune, shingle and sea cliff), water quality, intertidal and subtidal benthic ecology, marine mammals, fisheries, recreation and tourism. For the most part marine and coastal physical processes are not in themselves ‘receptors’ but are instead ‘pathways’.

Changes to physical processes and subsequent impacts on environmental receptors can arise from any stage of a project (construction, operation or decommissioning) and over a range of both temporal and spatial scales. However, these changes can be extremely variable depending on the development type and its location and in the absence of this detail it is therefore difficult to set appropriate buffers to enable mapping of potential impacts.

Figure 9. Example maps showing relative score for a) bird, b) fish, c) habitat and benthic species, and d) marine mammal features in relation to tidal range energy potential operational impacts. NB. Scores should not be compared between maps.



3.3 Application of the maps

As set out in the introduction to this report, we anticipate that the outputs of this stage of our work programme can be used to support **high level marine spatial planning** by Welsh Government and others who are interested in exploring potential future opportunities for sustainable use and management of the Welsh marine area.

In this context the maps produced are valuable in terms of being an **indicative spatial representation of relative differences in environmental considerations** for a range of sectors across the Welsh marine area and could, for example, accompany Marine Planning Notices, which (if taken forward) will introduce and activate SRAs, to support the **sustainable future use** element of WNMP Policy SAF_02. This would help to communicate a wider range of sector specific considerations in relation to particular areas of natural resources, which may be the focus of sector interest for future development opportunities and therefore help to ensure that this evidence is considered from early in the planning process.

Similarly, the maps could also help to provide a logical spatial focus for future evidence gathering and research, for example to improve the evidence base for areas of high uncertainty or low environmental data coverage; or to guide gathering of complementary socio-economic or technical constraints information in areas of relatively low consenting complexity from an environmental perspective.

It is important to note that the work described in this report **does not constitute an assessment of the suitability of any specific development plans or proposals**, which would require specific details of the likely nature and scale of any activity e.g. to understand the likely zone of influence of the proposal(s) and allow more detailed examination of potential impact pathways.

The outputs of the Mapping Environmental Considerations work are informed by and should be considered alongside a much wider range of evidence, advice, and guidance relevant to marine development some of which can be found at the links below:

- Guidance and advice on marine development
- Marine ecology datasets for marine development
- Scoping and preparing an EIA for marine development
- Marine and coastal evidence reports
- Indicative feature condition assessments for European Marine Sites
- Natural Resources Wales / Marine and coastal evidence reports Restoring marine and coastal habitats in Wales: identifying spatial opportunities and benefits (554)

- Welsh National Marine Plan Implementation Guidance
- The Crown Estate Open Data Portal
- JNCC's work in the offshore marine environment

4. Next steps

4.1 Communicating the outputs

A key priority for the next steps is to facilitate easy access to the mapped outputs. This requires effective communication around the maps, underlying datasets, evidence and methodology, to ensure stakeholders are aware of potential environmental considerations and the relevant evidence at their disposal. This is also important to avoid the risk of misinterpretation and/or application for decisions without recourse to source evidence and any appropriate guidance or other evidence in relation to any specific plan or project.

The maps in Appendix C indicate the spatial variation in environmental considerations. However, these maps are underpinned by data in Appendix B and the spatial datasets. The outputs will likely be most useful if this spatial evidence can be presented in an interactive form (such as in ArcGIS Online) to enable users to interrogate it (e.g. at a specific location of interest) and to identify which datasets contribute to the overall score and the most relevant source data.

4.2 Ongoing development of the approach

This report introduces the outputs from the first year of a long-term multi-year programme of environmental mapping work, which can be used by Welsh Government to feed into various aspects of its spatial approach to implementation of the Welsh National Marine Plan. The work may also inform other future marine planning processes. It sits alongside wider NRW evidence, guidance and advice, which together improve understanding of the implications of marine development and opportunities to support SMNR in Welsh Seas.

To ensure continued relevance and value of these outputs and to give users confidence in them it is essential that they remain up to date and draw on the best available evidence. This requires ongoing resources and an ongoing process of sourcing, reviewing and updating the evidence base. It is also important that we seek and respond to stakeholder feedback to ensure outputs are useful.

Subject to resourcing, there are several possible areas of development of the work programme that could help to communicate the value and relevance of the outputs, enhance the methodology and broaden its scope, for example:

- Develop methods to allow comparison between feature groups and potentially produce a single environmental considerations map;

- More detailed assessment of specific pressures and feature sensitivities to improve suitability of the outputs for project level use;

- Incorporation of environmental considerations that are not currently included (e.g., Water Framework Directive regulations);

- Identifying how to effectively communicate information on data coverage and confidence;

- Consideration of feature condition and conservation objectives and opportunities for enhancing marine ecosystems; and

- Using this work to help to identify spatial areas or impact pathways where there is a lack of evidence or high degree of uncertainty and exploring how these might be addressed.

These and other considerations will continue to be explored through NRW's Marine Spatial Approach Expert Group (MSAEG) and through discussion with Welsh Government, and the Marine Planning Stakeholder Reference Group, to identify the priorities and resource requirements for the work programme going forward. Proposals will then be taken to NRW's Marine Programme Planning and Delivery Group for discussion and approval. Welsh Government will work with NRW to take forward this work over the next few years as outlined in the recent Ministerial Statement (Minister for Climate Change, 2023) on the way forward for marine planning.

5. References

ABPmer. (2020). *Sustainable Management of Marine Natural Resources, Ecological Constraints and Opportunities, ABPmer Report No. R.3527. A report produced by ABPmer for Welsh Government.* Cardiff: Welsh Government. Retrieved from https://gov.wales/sustainable-management-marine-natural-resources-ecological-constraints-and-opportunities-report

Abramic, A., Cordero-Penin, V., & Haroun, R. (2022). Environmental impact assessment framework for offshore wind energy developments based on the marine Good Environmental Status. *Environmental Impact Assessment Review, 97*.

Baily, H., Senior, B., Simmons, D., Rusin, J., Picken, G., & Thompson, P. (2010). Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals. *Marine Pollution Bulletin, 60*, 888-897.

Baines, M. E., Earl, S. J., Pierpoint, C., & Poole, J. (1995). *The West Wales Grey Seals Census. CCW contract science report 131.* Bangor: CCW.

Baines, M., & Evans, P. (2012). *Atlas of the Marine Mammals of Wales. 2nd Edition. Marine Monitoring Report No. 68.* Bangor: Countryside Council for Wales.

Balotari-Chiebao, F., Santangeli, A., Piirainen, S., & Byholm, P. (2023). Wind energy expansion and birds: Identifying priority areas for impact avoidance at a national level. *Biological Conservation, 277*.

Barker, J., Davies, J., Goralczyk, M., Patel, S., Evans, J., Sharp, R., . . . Wray, B. (2022). The distribution, ecology and predicted habitat use of the critically endangered angelshark (Squatina squatina) in coastal waters of Wales and the central Irish Sea. *Fish Biology*, 640 - 658.

Bloomfield, A., & Solandt, J.-L. (2008). *The Marine Conservation Society Basking Shark Watch 20-year report (1987-2006).* Ross-on-Wye: Marine Conservation Society.

Boyle, G., & New, P. (2018). *ORJIP Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options. Final report – June 2018.* United Kingdom: The Carbon Trust.

Campanella, F., & Van der Kooij, J. (2021). *Spawning and nursery grounds of forage fish in Welsh and surrounding waters. Distribution of adult and juvenile forage fish species Cefas Project Report for RSPB.* Lowestoft: Cefas.

Carter, M., Boehme, L., Cronin, M., Duck, C., Grecian, W., Hastie, G., . . . Russell, D. (2022). Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management. *Front. Mar. Sci., 9*.

Clarke, L., Banga, R., Robinson, G., Porter, J., Lindenbaum, C., Morris, C., & Stringell, T. (2020). *Grey Seal (Halichoerus grypus) Pup Production and Distribution in North Wales during 2017. NRW Evidence Report No. 293.* Bangor: Natural Resources Wales.

Cleasby, I., Owen, E., Wilson, L., & Bolton, M. (2018). *Combining habitat modelling and hotspot analysis to reveal the location of high density seabird areas across the UK. Technical Report. RSPB Research Report no. 63.* Sandy, Bedfordshire: RSPB Centre for Conservation Science, RSPB.

Copping, A., & Grear, M. (2018). Applying a simple model for estimating the likelihood of collision of marine mammals with tidal turbines. *International Marine Energy Journal*, 27-33.

Copping, A., Grear, M., Jepsen, R., Chartrand, C., & Gorton, A. (2017). Understanding the potential risk to marine mammals from collision with tidal turbines. *International Journal of Marine Energy, 19*, 110-123. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S2214166917300590?via%3Dihub

Copping, A., Hemery, L., Viehman, H., Seitz, A., Staines, G., & Hasselman, D. (2021). Are fish in danger? A review of environmental effects of marine renewable energy on fishes. *Biological Conservation*.

Deakin, Z., Cook, A., Daunt, F., McCluskie, A., Morley, N., Witcutt, E., . . . Bolton, M. (2022). *A review to inform the assessment of the risk of collision and displacement in petrels and shearwaters from offshore wind developments in Scotland.* Edinburgh: Scottish Government.

Ellis, J., Milligan, S., Readdy, L., Taylor, N., & Brown, M. (2012). *Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep.* Cefas. Lowestoft: Cefas.

Erbe, C., Dunlop, R., & Dolman, S. (2018). Effects of Noise on Marine Mammals. In H. Slabbekoorn, & R. Dooling (Eds.), *Effects of Anthropogenic Noise on Animals* (pp. 277-309). New York: Springer.

Evans, P., & Waggitt, J. (2023). *Distribution and Abundance of Cetaceans and Seabirds in Wales and Surrounding Waters. NRW Evidence Report No. 646.* Bangor: Natural Resources Wales.

Frost, T. C. (2021). *Waterbirds in the UK 2019/20: The Wetland Bird Survey.* Thetford: BTO/RSPB/JNCC. Retrieved from http://www.bto.org/volunteer-surveys/webs/publications/webs-annual-report

Furness, R., Wade, H., Robbins, A., & Masden, E. (2012). Assessing the sensitivity of seabird populations to adverse effects from tidal stream turbines and wave energy devices. *ICES Journal of Marine Science, 69*, 1466-1479.

Gallardi, D. (2014). Effects of Bivalve Aquaculture on the Environment and Their Possible Mitigation: A Review. *Fisheries and Aquaculture Journal, 5*(3).

HM Government. (2011). *UK Marine Policy Statement.* London: HM Government.

Johstone, I., & Bladwell, S. (2016). Birds of Conservation Concern in Wales 3: the population status of birds in Wales. *Birds in Wales, 13*(1). Retrieved from https://birdsin.wales/wp-content/uploads/2017/01/Birds-of-Conservation-Concern-Wales-3-2016.pdf

Marine Managament Organisation. (2018). *Displacement and habituation of seabirds in response to marine activities. A report produced for the Marine Management Organisation,. MMO Project No: 1139.* Newcastle upon Tyne: Marine Management Organisation. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/715604/Displacement_and_habituation_of_seabirds_in_response_to_marine_activities.pdf

Matear, L., Pinder, J., & Lillis, H. (2019). *Method for updating the UK full-coverage EUNIS level 3 seabed habitat map integrating fine- and broad-scale maps.* Retrieved from https://hub.jncc.gov.uk/assets/2048c042-5d68-46c6-8021-31d177b00ac4

Maxwell, S., Kershaw, F., Locke, C., Conners, M., Dawson, C., Aylesworth, S., . . . Johnson, A. (2022). Potential impacts of floating wind turbine technology for marine species. *Journal of Environmental Management, 307*.

Minister for Climate Change. (2023). *Written Statement: Taking forward marine planning following the three-year review of the Welsh National Marine Plan*. Retrieved from https://www.gov.wales/written-statement-taking-forward-marine-planning-following-three-year-review-welsh-national-marine

Onoufriou, J., Bronlow, A., Moss, S., Hastie, G., & Thompson, G. (2018). Empirical determination of severe trauma in seals from collisions with tidal turbine blades. *Journal of Applied Ecology, 56*, 1712-1724. Retrieved from https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.13388

Petersen, J., Holmer, M., Termansen, M., & Hasler, B. (2019). Nutrient Extraction Through Bivalves. In A. Smaal, J. Ferreira, J. Grant, P. J.K., & O. Strand (Eds.), *Goods and Services Through Marine Bivalves* (pp. 179-208). Cham: Springer.

Robson, L., Fincham, J., Peckett, F.J., Frost, N., Jackson, C., . . . Matear, L. (2018). *UK Marine Pressures-Activities Database "PAD": Methods Report, JNCC Report .* Peterborough: JNCC.

Roche, R., Walker-Springett, K., Robins, P., Jones, J., Veneruso, G., Whitton, T., . . . Ward, S. (2016). Research priorities for assessing potential impacts of emerging marine renewable energy technologies: Insights from developments in Wales (UK). *Renewable Energy, 99*, 1327-1341.

Russell, D., Jones, E., & Morris, C. (2017). Updated seal usage maps: The estimated at-sea distribution of grey and harbour seals. *Scottish Marine and Freshwater Science, 8*(25), 1-25.

Ryan, P. (2018). Entanglement of birds in plastics and other synthetic materials. *Marine Pollution Bulletin, 135*, 159-164.

Slabbekoorn, H., Bouton, N., Opzeeland, I., Coers, A., Cate, C., & Popper, A. (2010). A noisy spring: the impact of globally rising underwater sound levels on fish. *Trends in Ecology and Evolution, 25*, 419-427.

Stanbury, A., Eaton, M., Aebischer, N., Balmer, D., Brown, A., Douse, A., . . . Win, I. (2021). The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain. *British Birds, 114*, 723-747.

Stelfox, M., Hudgins, J., & Sweet, M. (2016). A review of ghost gear entanglement amongst marine mammals, reptiles and elasmobranchs. *Marine Pollution Bulletin, 111*, 6-17.

Stober, U. (2019). Effect of impact pile driving noise on marine mammals: A comparison of different noise exposure criteria. *The Journal of the Acoustical Society of America, 145*, 3252.

Strong, P., Lerwill, J., Morris, S., & Stringell, T. (2006). *Pembrokeshire marine SAC grey seal monitoring 2005. CCW Marine Monitoring Report No. 26.* Bangor: CCW.

Tethys. (2023). *Knowledge Base*. Retrieved 2023, from https://tethys.pnnl.gov/knowledge-base-all

Tyler-Walters, H., Hiscock, H. K., Tillin, H. M., Readman, J., & Perry, F. e. (2021). Marine Life Information Network: Biology and Sensitivity Key Information Review Database [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Retrieved from https://www.marlin.ac.uk/data-extract

Van der Knapp, I., Slabbekoorn, H., Moens, T., Van den Eynde, D., & Reubens, J. (2022). Effects of pile driving sound on local movement of free-ranging Atlantic cod in the Belgian North Sea. *Environmental Pollution, 300*. Retrieved from https://www.sciencedirect.com/science/article/pii/S0269749122001270

Welsh Government. (2019). *Welsh National Marine Plan.* Cardiff: Welsh Government. Retrieved from https://www.gov.wales/welsh-national-marine-plan

Welsh Government. (2022). *Development of Strategic Resource Areas*. Retrieved 2023, from https://www.gov.wales/development-strategic-resource-areas

Westcott, S., & Stringell, T. B. (2004). *Grey seal distribution and abundance in North Wales, 2002-2003.* Bangor: CCW.

Appendices

Appendix A. Approach to occurrence scoring for each dataset.

Datasets (including links to source)	Occurrence scoring
Article 17/Annex I habitats: Marine	Presence (3) or absence
Article 17/Annex I habitats: Coastal	Presence (3) or absence
Section 7/OSPAR habitats: Marine	Presence (3) or absence
Section 7/OSPAR habitats: Coastal	Presence (3) or absence
Section 7/OSPAR species	Presence (3) or absence
WWT/ESAS seabirds at sea	Continuous scale (1 to 3)
RSPB seabird utilisation distributions	Presence (3) or absence
Seabird loafing areas	Presence (3) or absence
WeBS coastal waterbirds	Continuous scale (1 to 3)
RSPB/Cefas forage fish data	Continuous scale (1 to 3)
Bass Nursery Areas	Presence (3) or absence
Basking shark sightings	Presence (3) or absence
Migratory fish	Estimated presence: low (1), medium (2), high (3)
Distribution maps of cetaceans and seabirds	Continuous scale (1 to 3)
Grey seals at sea	Continuous scale (1 to 3)
Seal haul out and pupping sites	Continuous scale (1 to 3)
Marine Protected Areas in Welsh waters: SACs, SPAs, SSSIs, Ramsar, MCZ Offshore SPAs Special Areas of Conservation (SACs) with marine components (offshore)	Presence (3) or absence

Appendix B. Conservation importance and potential impact scores

Mapping Environmental Considerations Appendix B.xlsx

Appendix C. Maps for each sector and feature group.

Mapping Environmental Considerations Appendix C.pdf