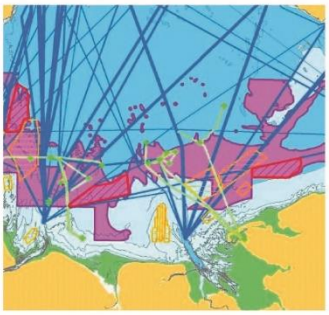
Welsh Government

Sustainable Management of Marine Natural Resources

Ecological Constraints and Opportunities

November 2020

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Document Information

Document History and Authorisation		
Title	Sustainable Management of Marine Natural Resources	
	Ecological Constraints and Opportunities	
Commissioned by	Welsh Government	
Issue date	November 2020	
Document ref	R.3527	
Project no	R/4725/3	
Date	**Version**	**Revision Details**
23/10/2020	1	Issued as Working Document for Comment
25/11/2020	2	Issued for Client Use

Prepared (PM)	Approved (QM)	Authorised (PD)
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Suggested Citation

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, November 2020.

Notice

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Summary

The Sustainable Management of Marine Natural Resources (SMMNR) project has received funding through the European Maritime and Fisheries Fund (EMFF), which is funded by the European Union and the Welsh Government. The project is part of a broader suite of spatial work to support the implementation of the Welsh National Marine Plan (WNMP).

This project constitutes part of the wider work on developing the spatial approach to marine planning and concentrates on exploring and developing the ecological evidence base in relation to three focus sectors; tidal stream energy, wave energy and aquaculture operating in the Welsh marine plan area. The over-arching aim of this project being to enhance and apply a marine evidence base to support the sustainable development of the focus sectors. This being achieved through the mapping of natural resources and understanding potential ecological constraints relevant to these sectors.

To understand the ecological constraints and opportunities specific to development of the focus sectors a linear methodology was developed by ABPmer, with input from Welsh Government and NRW to enable mapping of potential ecological constraints across Welsh waters. This report describes the general approach and detail of this methodology.

For the purpose of this study, the 'ecological constraints' were defined as those features directly associated with the natural environment with the potential to add to the complexity of marine consenting. However, the presence of constraints did not mean certain types of development could take place nor the absence of constraints that a development could occur. The objective of the work was to identify, at a high level, areas of relatively greater or lower potential consenting complexity, for a sector, in relation to an ecological feature.

In developing an understanding of the potential ecological constraints specific to a sector, it was necessary to distinguish between certain technology types or, in the case of aquaculture, activity types. This approach enabled consideration of the clear differences in the sensitivities of individual species and habitat features to the various sector technologies/activities and the potential variability to consenting complexity.

Aquaculture was divided into bivalve aquaculture and seaweed aquaculture. These aquaculture types have been identified within the WNMP as having potential for commercial development in Welsh waters. Tidal stream was divided into three major types (surface, mid-water and seabed mounted), as these have the potential for quite different levels of exposure to ecological interest features. Similarly, wave energy technology was subdivided into surface and seabed technologies. It was not considered appropriate for the purpose of this study to further subdivide these categories.

Ecological features were divided into four broad interest features: marine habitats and their associated communities; seabirds; marine and migratory fish; and marine mammals (referred to as habitats, birds, fish and mammals).

Acknowledging the variability between proposals, this plan level work required the scope of the methodology to assume that the development of the sectors would be at a commercial scale. Hence, the constraints mapping outputs represent highly conservative analyses when considered in relation to smaller-scale, demonstration level proposals.

A linear methodology was applied to the constraints mapping analysis in a series of steps, resulting in mapping outputs depicting areas of relative constraints and opportunities for a given ecological feature and specific to a sector or sector technology/activity.
Overlapping the outputs with areas of potentially suitable resource for a given sector 'Resource Areas' (RAs) identified by the WNMP provided a broad indication of areas where potentially suitable resource intersects with areas of relatively lower ecological constraint, in relation to a particular sector.

The outputs generally showed an increasing level of relative consenting complexity in near shore environments, although the location of fish spawning grounds and relative increases in cetacean density offshore were indicated through the outputs. Areas of relatively higher constraint were identified across Welsh waters in relation to each of the broad interest features and sector operational activities.

The analysis is primarily a tool to support high level decision making and sector planning initiatives, with the potential, therefore, to facilitate sustainable development of the focus sectors. It may also be used to inform the development of sector locational guidance (which would incorporate ecological evidence alongside relevant socio-economic evidence) or the consideration of identifying Strategic Resource Areas, as set out in the WNMP, where appropriate.

Underpinned by core datasets, the outputs are subject to the data which informs the analysis. Limitations on these datasets were highlighted and recommendations provided to improve the quality, including the generic requirement to update datasets accordingly as relevant data are made available.

Whilst the outputs of the SMMNR project do not substitute the requirement for project level assessment, benefits can be realised from this work at the project level. The outputs will complement baseline characterisation, highlighting gaps and/or deficiencies with existing ecological data, while indicating areas of opportunity at a regional level. Additional work, beyond the scope of this project will consider potential social and economic opportunities and constraints to these sectors.

The outputs from this work are also provided as interactive tools within online evidence packages produced for the SMMNR project and specific to each sector. Importantly, as an online dynamic tool it allows the outputs to be updated in line with changes to the knowledge/evidence base and as new and relevant data becomes available. There is also the potential for the work to encompass additional sectors in future iterations and for the methodology to evolve over time and to reflect new evidence as it becomes available.

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1 Ecological Constraints and Opportunities

1.1 Introduction

The **Sustainable Management of Marine Natural Resources** (SMMNR) project has received funding through the European Maritime and Fisheries Fund (EMFF), which is funded by the European Union and the Welsh Government. The project is part of a broader suite of spatial work to support the implementation of the **Welsh National Marine Plan (WNMP)**[1].

Through the **WNMP,** Wales has, for the first time, a statutory strategic policy framework to support the sustainable development of the seas around Wales, supporting those who wish to use the marine environment sustainably while ensuring the resilience of marine ecosystems and protecting Wales' rich and varied maritime heritage.

As noted in the WNMP, our understanding of the spatial distribution of marine natural resources and the associated opportunities and constraints in relation to their sustainable use, continues to evolve. The aim of the SMMNR project is to contribute towards the marine planning related evidence base in line with the WNMP which states:

> *'Opportunities should be taken to identify and address strategic evidence needs in line with the Plan's priorities to help de-risk future investment and consenting decisions. Reasonable steps should be taken to fill strategic evidence gaps to underpin decision making by planning authorities, regulators and sea users'.*

The SMMNR project constitutes part of the wider work on developing the **spatial approach** to marine planning and concentrates on exploring and developing the ecological evidence base in relation to three focus sectors; **tidal stream energy**, **wave energy** and **aquaculture** operating in the Welsh marine area. Developing this evidence base will help support the sustainable development of these sectors as promoted by the WNMP sector supporting policies.

As set out in the WNMP, Welsh Government policy is to support the sustainable development of emerging marine sectors such as these whilst ensuring marine ecosystems are protected and enhanced to provide for their resilience and provision of benefits for future generations. In particular, the project is examining how the distribution and potential use of these resources may relate to Marine Protected Areas (MPAs), and other sensitive and important habitats and species, while identifying potential opportunities for sustainable development.

The project directly contributes to supporting implementation of WNMP policies AQU_01 b [supporting aquaculture], ELC_02 b [supporting wave energy generation], ELC_03 b [supporting tidal stream energy generation], ENV_01 [resilient marine ecosystems] and ENV_02 [marine protected areas].

As described in the SMMNR overview document (ABPmer, 2020a), the overall SMMNR project was split into two distinct parts by Welsh Government (Part 1 and Part 2). Part 1 was completed in early 2019 and encompassed the sourcing, collation and standardisation of the existing environmental evidence for the focus sectors while also identifying knowledge gaps (ABPmer, 2019)[2].

1 https://gov.wales/welsh-national-marine-plan-document
2 https://gov.wales/sustainable-management-marine-natural-resources

Part 2 of the SMMNR project builds upon the outputs from Part 1, with the core activities driven by the recommendations and conclusions from the initial phase of work, which included:

- The collection of ecological data that would inform the knowledge and evidence base and thus aid sector planning, site selection and baseline characterisation; and
- Take steps to encourage and facilitate the provision of publicly available evidence and data relevant to the development of the focus sectors.

Hence, the over-arching aim of Part 2 was to enhance and apply marine evidence to support the planning and sustainable development of the focus sectors.

This report, the ecological constraints and opportunities report, details the approach to understanding, spatially, relative constraints and potential opportunities for future sustainable resource use in Welsh marine waters. Understanding the spatial ecological opportunities and constraints can inform decision-making on options for sustainable development and future planning in relation to the focus sectors.

An outline of the context and deliverables of the SMMNR project, as a whole, are detailed within the SMMNR overview document (ABPmer, 2020a). It is recommended that the overview document is read in conjunction with this report.

1.2 Study outline

A plan level mapping methodology, indicating the potential spatial distribution of broad ecological relative constraints in Welsh marine waters was developed by ABPmer. For the purpose of the study, the 'ecological constraints' were defined as those features that are directly associated with the natural environment and have the potential to add to the complexity of marine consenting for certain types of developments, recognising that additional complexity can lead to an increased risk in the consenting process.

The aim was to produce an initial output which could then be developed further with broader stakeholder input. Consequently, the basis of the methodology was initially presented at an NRW workshop in July 2019. Subsequent to this workshop, various dialogues between stakeholders, including NRW and Welsh Government, were used to further refine the approach.

Feedback from stakeholders indicated the need for a methodology that is readily understandable and repeatable; to encourage future use by developers, regulators and other interested parties. Clearly laid out, the methodology facilitates the incorporation of different types of datasets once the data are standardised, while allowing updates and modifications to be made to the methodology. Thus, the methodology allows flexibility in the approach, facilitating an iterative and evolving process.

In 2020 example mapping outputs were presented at Expert Panel meetings and a Consenting Strategy Action Group (CSAG) meeting, with an interactive PDF sent out to stakeholders. Feedback from stakeholders on the mapping outputs were then discussed with Welsh Government in August 2020 and acknowledged accordingly within final development of the outputs.

The final outputs from the analysis were indicative maps of the ecological constraints and opportunities specific to each of the focus sectors across Welsh waters. These maps are provided in this report and presented within evidence packages (see ABPmer, 2020a[3]) as an online resource[4] to facilitate use and understanding through an interactive interface.

[3] https://gov.wales/sustainable-management-marine-natural-resources
[4] *ibid*

This report is divided into the following sections:

- **Context** – the general approach to the ecological constraints and opportunities analysis in terms of the wider SMMNR project;
- **General Approach –** scope and broad assumptions factored into the approach;
- **Constraints and Opportunities Methodology** – detailed breakdown of each step in the methodology (see Figure 1);
- **Outputs –** a description of the outputs; and
- **Discussion** – wider consideration of the benefits and limitations to the methodology and its role within the Welsh marine planning process**.**

2 Context

The WNMP[5] has identified and presented Resource Areas (RAs) potentially suitable for each of the focus sectors. The RAs are also shown on the Wales Marine Planning Portal (WMPP)[6]. The RAs are defined as '*broad areas that describe the distribution of a particular resource that is or has the potential to be used (in terms of technical feasibility).*' These have been identified by a process of evidence collection and interpretation but will change as understanding improves, further evidence becomes available and/or sector technologies develop.

The RAs represent potential opportunities, in terms of resource, for each sector. Consequently, rather than identifying potential resource opportunities, the approach to this work has focused on the recognition and mapping of the key relative ecological constraints for each sector across all Welsh waters.

Obtaining consent for development of a focus sector is often influenced in some way or other by the ecological receptors exposed to its proposed activities. Thus, at a broad, marine spatial planning level, it is important to develop a high-level understanding of ecological considerations to highlight, for planning purposes, those areas of relatively greater constraints and opportunities in the context of such features.

From an ecological context the opportunities for a given sector can partially be inferred from those areas that have lower relative ecological constraints; in particular, where areas of lower relative ecological constraint overlap with previously identified RAs.

The potential benefits of the work to developers and regulators at early stages in the development process are clear, with the evidence packages providing a readily accessible and focussed source for information relevant to the sector, an indication of potential areas of opportunity, and highlighting relative ecological constraints of relevance to consenting decisions.

The outputs of the Study and therefore the SMMNR project do not substitute the requirement for project level assessment. Such project level assessment work is required to acknowledge the wide range of variables associated with development of a sector (e.g. scale, duration, cabling, land infrastructure etc.) and allow detailed consideration of geographically relevant ecological features. However, benefits can be realised from this work at the project level stage. The outputs will complement baseline characterisation, highlighting gaps and/or deficiencies with existing ecological data, while indicating areas of opportunity at a regional level. As an iterative process, future reviews of the outputs can be updated in line with changes to the evidence base. Understanding the evidence available and the level of confidence in the data may minimise the requirements for specific baseline surveys and allow more meaningful focussed work to be carried out to support developments.

5 https://gov.wales/welsh-national-marine-plan-document
6 http://lle.gov.wales/apps/marineportal/#lat=52.5145&lon=-3.9111&z=8

3 General Approach

A summary of the general approach to the Study is provided in this section, beginning with a broad overview to the approach, followed by the scope and the assumptions made for the analysis.

A more detailed description of the approach and the various steps to the linear methodology is then given within Section 4 (Constraints and Opportunities Methodology). As mentioned above, with stakeholder support and input the approach can develop and expand over time in response to requirements and an evolving evidence base.

3.1 Approach overview

The principles of the constraints analysis methodology broadly align with EIA process i.e. to understand the sensitivity and exposure of a feature to an impact, combined with the conservation importance of a feature to allow the significance of an effect to be evaluated. Within this Study this specifically relates to the pressures arising from the activities associated with the operational phase of the focus sectors. However, the methodology diverges from the EIA process to encompass consenting complexity i.e. consideration of those ecological features which, if present, have the potential to add to the complexity of marine consenting for certain types of developments.

The ecological features were divided into four broad categories: marine habitats and their associated communities, seabirds, marine and migratory fish, marine mammals. These are referred to as habitats, birds, fish and mammals. These 'Broad Interest Features' (BIFs) encompassed those marine ecological features with the greatest potential to affect the relative consenting complexity for the development of the tidal stream energy, wave energy and aquaculture sectors.

As an early consideration, pre-defined impact pathways relevant to the operational activities of each sector and the BIFs, were identified using the Pressure Activity Database (JNCC, 2018). Next, the sensitivities of each BIF to the relevant impact pathways were assessed. These early considerations provided the initial foundation for the Study, ensuring that all the major impact pathways had been considered. Further detail is provided below (see Risk Screening).

The method developed and applied in this Study was subdivided into a series of steps. The first step was the selection of the best available datasets relevant to understanding the respective impact pathways (Step 1). Following dataset selection, the datasets were then standardised to allow comparability (Step 2). A constraint value was then applied to each individual feature through the consideration of the feature's spatial occurrence, conservation importance and its potential to affect consenting complexity for operation of a given sector (Step 3).

As a result of the scoring process, mapping outputs relevant to each dataset for each sector and, where relevant, sector technology, were generated for each BIF (Step 4). The scores from each of these dataset constraint layers were then summed together to provide spatial constraint maps specific to each sector (or sector technology/activity) and BIF (Step 5). Lastly, resource areas were overlaid on to each of the spatial constraint maps to provide an output indicating potential areas of relative opportunity and constraint in Welsh waters for each sector and, where relevant, sector technology (Step 6).

Throughout the approach it was necessary to make a number of key assumptions. Many of these assumptions defined the scope of the approach and these are detailed below.

3.2 Scope and assumptions

3.2.1 Sectors

The sectors (aquaculture, tidal stream and wave energy) were broken down into technology types or, in the case of aquaculture, activity types. This was done to capture the clear differences in the sensitivities of individual features (species or habitats) to the various sector technologies/activities and ultimately the likely differences in consenting uncertainties and complexity.

Aquaculture

Within the method, aquaculture was divided into bivalve aquaculture and seaweed aquaculture. These aquaculture types have been identified within the WNMP as having considerable potential for commercial development in Welsh waters. The clear differences in the aquaculture types has the potential to affect certain features differently and thus vary the complexity of the consenting process.

At the time of writing, the production of farmed finfish in Wales is limited and confined to on-shore facilities (see WNMP[7]). Land-based production is limited to the cultivation of wrasse and lumpfish for the supply of cleaner fish to the Scottish salmon farming industry. Furthermore, given the increased potential for environmental impacts of finfish farming at sea compared to shellfish and seaweed farming (e.g. in relation to the use of feed and medicinal/chemical treatments, impacts of escapees etc), and the lack of economic viability to date of land-based marine finfish production with respect to competing with wild captured finfish, aquaculture of marine finfish species (beyond wrasse and lumpfish) has been considered unlikely to occur in the near future in Wales. Hence, finfish aquaculture has not been considered further within this work. Should opportunities for development of farmed marine finfish become identified then this aquaculture type could be considered in future iterations.

Within the methodology it was assumed that bivalve aquaculture could encompass any of blue mussels, oysters, clams, scallops and abalone (see WNMP[8]). Seaweed was assumed to encompass kelp, dulse and laver, to name a few. At this plan level, no distinction was made between the various bivalve and seaweed species which could be cultivated. Nor was any distinction made between seabed (e.g. bottom culture, trestles/bags), or water column (ropes/lines) culture. During the application of the methodology, as a precautionary approach, the activity with the greatest potential for an impact and constraint was always assumed to occur.

Unlike the other sectors which are considered wholly offshore (defined as seaward of the lowest astronomical tide), there is potential for aquaculture operations to occur within the intertidal zone. Within the analyses, a precautionary approach assumed a worst-case where there was likely to be relative differences between the potential impacts and constraints from aquaculture development (bivalve or seaweed) in these different environments (offshore and intertidal).

Tidal stream

As with any of the emerging wet renewable sectors there are a variety of different technology types. Tidal stream was divided into three major types (surface, mid-water and seabed mounted), as these have the potential for quite different levels of exposure to interest features. For example, on account of their foraging behaviour, diving birds such as Guillemots and Razorbills are considered more sensitive to turbine collision, and thus a greater consenting consideration to seabed mounted tidal stream devices than would surface foraging seabirds such as Terns or Gulls.

7 https://gov.wales/welsh-national-marine-plan-document
8 *ibid*

Wave energy

Similarly, wave energy technology was subdivided into surface and seabed technologies. A distinction was made within the method between these technologies to acknowledge the varying sensitivities of species and habitat features to these technologies and consequently potential differences in relative consenting complexity.

3.2.2 Project vs plan level assessment

The outputs from this plan level work are intended to assist regulators, developers and interested stakeholders to understand the potential relative ecological constraints which may relate to the development of various marine sectors across Welsh waters. The outputs provide a high-level indication of areas of potentially greater relative ecological constraint across Welsh waters. When set in the context of known potentially suitable resource (RAs) relatively lower areas of ecological constraint may provide an indication of possible opportunities for these sectors to develop sustainably.

During project level assessment key considerations will encompass such variables as scale, extent, duration, cabling and land infrastructure, along with detailed consideration of ecological features within the zone of influence (the area affected by the project activities). Acknowledging the variability between proposals, this plan level work required high level assumptions to be made. The scope of the methodology was consequently precautionary, allowing the analysis to be inclusive of all commercial operations of these sectors.

From the plan level work, the focus of interested parties will be drawn to those areas which overlap with areas of potentially suitable resource and relatively lower ecological constraints. Signposting of certain ecological evidence gaps will be indicated through the Study's outputs, enabling developers to be aware of these upfront and build them into their plans at an early stage, rather than finding out during the consenting process, with the potential consequence for delay. Highlighting features in a given area which may require greater relative attention at a project level, either through detailed desk study or a specific ecological survey programme, will thus support development of the sectors.

The outputs are primarily a tool to support high level decision making and sector planning initiatives, with the potential to facilitate sustainable development of the focus sectors in the marine environment. They may also be used to inform the development of sector locational guidance (which would incorporate ecological evidence alongside relevant socioeconomic evidence) or considerations related to the identification of Strategic Resource Areas, as set out in the WNMP, where appropriate. Additional work, beyond the scope of this Study will consider potential social and economic opportunities and constraints to these sectors.

3.2.3 Methodology focus

A key opportunity for development of the sectors is the availability of suitable resource in areas of low and manageable constraint. As previous work has already identified RAs potentially suitable for each of the sectors (see WNMP; Wales Marine Planning Portal (WMPP)), these have been used to outline areas of key resource opportunity. Whilst the focus for sectors is likely to be the identified RAs, this Study focused on ecological constraints across all Welsh waters, with the final step of the method placing these in the context of the mapped RAs.

The BIFs used to represent the relative constraints to each sector encompassed habitats, birds, marine mammals and fish. As previously stated, these features have the greatest potential to affect relative consenting risk for the development of tidal stream, wave energy and aquaculture sectors. The BIF 'habitats' methodology also included data related to marine species of conservation importance in Welsh waters (i.e. Section 7 and OSPAR species).

Bats and otter were initially considered; however, as it is unlikely that operational activities of any of the focus sectors would be significantly constrained by the presence of these species they were subsequently excluded. Furthermore, it would be anticipated that any potential adverse effects on these species could be sufficiently mitigated at the level of an individual project-level.

With the exception of aquaculture, all of the sectors were considered wholly offshore with minimal impact pathways to intertidal features (see Cabling below). In the short-term, it is likely that commercial aquaculture development in Wales will utilise sheltered coastal and estuarine environments; however, as technology advances the greater spatial constraints of these inshore environments may result in an increased focus on offshore areas.

Scale

For the purposes of the methodology, the development of the sectors was assumed to be at a commercial scale. For example, it was assumed that the potential of significant ecological impacts for demonstration level wet renewable developments would be considerably lower than for commercial arrays; with consequently lower consenting risks. Where this is the case, the constraints outputs represent an overly precautionary and highly conservative analysis when considered in the context of demonstration level proposals. Nevertheless, the relative mapped outputs can inform considerations with respect to smaller scale projects.

Cabling

While the proposed location and method of cable installation may increase consenting complexity and risk for wet renewable developments or other energy producing sectors, the potential alignments and requirements of cabling are dependent upon many variables such as the proximity of existing high voltage power lines, subsea cables and suitable onshore infrastructure. The RAs provided a useful starting point for the development of wet renewables; however, as noted within WP1, selection of these areas was not considered in relation to cabling and grid connection (ABPmer, 2019[9]).

Cabling requirements for wet renewables are on a much smaller scale than commercial offshore wind farms, reducing the relative magnitude of change to benthic features. At this significantly reduced scale, there is greater scope for micro-routeing of cabling associated with wet renewable developments. Thereby increasing the likely avoidance around patchy features, such as reefs, and the potential use of horizontal directional drilling to avoid coastal soft sediment features such as saltmarsh and seagrass.

The UK Marine Pressures-Activities Database (JNCC, 2018) used expert judgement for risk profiling of pressures, indicating that the general risk to the environment from most cabling activities taking place during installation, operation and maintenance was 'low'. Although a risk of 'medium-high' was indicated for some activities e.g. 'laying, burial and protection' of power cables, such activities assumed cabling requirements for offshore wind farms rather than wet renewable developments.

Given the above, the Study did not directly consider cable installation and routeing. However, at a high-level, acknowledgment was given to the prevalence of particularly sensitive features, such as reef habitats and seal haul-out and pupping areas, immediately inshore of RAs. For example, the north coast of Pembrokeshire has a high density of grey seal haul-out and pupping sites inshore of a recognised area of suitable tidal stream resource. Such an identifiable potential for increased constraints, because of cabling and onshore infrastructure, was addressed through the narrative in the evidence package(s)[10]. It being noted that the presence of certain features may hinder development although in most cases

9 https://gov.wales/sustainable-management-marine-natural-resources
10 https://gov.wales/sustainable-management-marine-natural-resources

careful consideration at project level could potentially avoid or minimise impacts through micro-siting of the cable and location of supporting coastal infrastructure.

Operational impacts

While there is clearly potential for ecological effects to occur from impact pathways that arise during the survey, construction and decommissioning phases of a development, these are typically expected to result in short-term, temporary effects; provided that direct effects from habitat loss are acknowledged as an operational rather than construction impact. As acknowledged in WP1, impact pathways that occur during these phases are generally quantifiable and better understood than those that occur in the operational phase. This is particularly true with emerging technologies where there is often a lack of empirical data relevant to understanding the operational effects but also developing technologies such as marine aquaculture (see ABPmer, 2019). Hence, the analysis has factored in operational impacts arising from the focus sectors.

The typically well understood and generic impact pathways within the survey, construction and decommissioning phases of a project often allow successful application of mitigation. Such mitigation is typically able to reduce an effect to a non-significant level. Ultimately, the level of consenting complexity and risk from impact pathways that occur during these phases is dependent on the site and project specifics, rather than the uncertainty or unavailability of evidence to support the assessments.

Conversely, operational impact pathways, for example, tend to relate to cumulative disturbance/displacement, collision/entanglement and long-term effects, for which data is lacking; leading to greater uncertainty. This, together with the reliance upon predictive modelling for some operational assessments, often leads to much greater relative consenting complexity and risk from the potential operational effects.

However, impact pathways that occur during survey, construction and decommissioning phases of a development are still a critical consideration and must be considered within the respective project level assessments.

3.2.4 Risk screening

As a pre-cursor to the linear methodology, impact pathways with the potential to occur during the operational phase of sector development were initially defined, with impact pathways related to habitat loss/damage assumed to occur as an operational, rather than construction phase impact.

A screening process was carried out to assist the selection of the best available datasets which were considered most suitable for understanding the constraints. This was achieved through the identification of impact pathways relevant to the operational activities of each sector in relation to the BIFs. This screening process also indicated evidence gaps, for example, where there was a potential reliance on datasets which were not explicit to understanding an impact (e.g. collision risk) and thus the constraint (see Data Recommendations). Evidence gaps and data quality issues have previously been highlighted throughout the wider SMMNR project. The outputs of WP1 (ABPmer, 2019) indicated, for example, a number of issues with ecological datasets currently being relied upon to inform planning and development of marine wet renewables and aquaculture sectors in Wales.

Impact pathways relevant to the operational phase of the sectors were identified (Table 1). At this high level, no distinction was made between the various technology types for the renewable sectors (e.g. surface/mid-water/seabed mounted tidal stream) or aquaculture activities (bivalve and seaweed), as the generic impact pathways were the same (see Scope and Assumptions).

The impact pathways were compiled according to activity-pressure relationships and derived from the UK Marine Pressures-Activities Database (JNCC, 2018), plan level HRA (e.g. Marine Scotland, 2018) and key scientific reviews (e.g. Marine Institute, 2019). With further refinement made following reviews by NRW technical specialists and Welsh Government in July and October 2019.

Pathways were detailed as cause and effect, encompassing minor/major, direct/indirect and temporary/permanent effects. To simplify the consideration of pathways, in some instances multiple effects were incorporated by a single cause e.g. introduction of litter leading to smothering, entanglement or ingestion. This rationalised the list while still considering all appropriate operational impact pathways (see Table 1).

The pathways were relevant to at least one of the BIFs and these were signified against each pathway. Each of the BIFs encompassed features of conservation importance (e.g. Birds of Conservation Concern; Article 17 (Annex I and II); Section 7 and OSPAR features).

Following collation of the pathways, at a high level the sensitivities of each BIF to each operational impact pathway for a given sector were considered. These were then reviewed by NRW technical specialists in September and October 2019. Sensitivities of the BIFs were defined as their intolerance to damage from an external factor and their ability to recover from a given impact (derived from Tyler-Walters *et al*. 2018). This process assessed sensitivity by considering the tolerance of each of the BIFs to the pathways selected as relevant to each of the sectors (see Table 1).

This resulted in a series of 'pathway-sensitivity' tables specific to the sector (see Appendix A). Only the interest feature's broad sensitivity to each impact pathway was assessed, not the level of risk/exposure or vulnerability[11]. In this context consideration of impacts was based on sensitivities only and assuming that an exposure would occur.

The identification of impact pathways and the sensitivity assessment were used as a risk screening process to inform the selection of datasets rather than within the context of an EIA. Therefore, it was only necessary to consider whether there was potential for a significant impact to arise on a feature rather than determining the level of significance. A significant impact being defined, within the Study, as '*an impact which has reasonable potential to lead to an increased relative level of consenting complexity and therefore risk, as a consequence of the likely effect on the sensitivity of a feature, determined by evidence, or lack thereof, in relation to an identified pathway*.' If no evidence of feature sensitivity was available, then a precautionary approach was taken.

The judgements made about sensitivity were based on the ecology of BIFs in combination with the predicted pressures arising from the operational activities of a given sector. As there are variations in sensitivity, and differences in the level of scientific certainty associated with determining these levels, a precautionary approach was adopted. Therefore, where an individual feature existed which was more sensitive to a given impact, then this sensitivity was assumed for the BIF as a whole.

Ultimately, where a potentially significant impact was identified during the risk screening process then this was carried through to Step 1 of the constraints methodology, 'dataset selection'. Within this Step, considerations were made as to which dataset(s) would provide the best available data for understanding the relevant impact pathway in the context of the overarching Study.

[11] Vulnerability is a function of an interest feature's sensitivity to impact pathway and its exposure to a given impact via a source-impact pathway. Where there is sufficient understanding regarding the exposure to change (i.e. the magnitude and likelihood of change) then it may be possible to assess vulnerability. However, where this is unknown, it will only be possible to determine the interest feature's sensitivity.

Table 1. Impact pathways relevant to the operation of tidal stream, wave energy and aquaculture sectors

Ref No.	Impact Pathway	Group Feature Affected	Tidal Stream	Wave Energy	Aquaculture
1	Development footprint leading to permanent loss/changes to seabed, foraging or nursery/spawning areas	H, B, M, F	✓	✓	✓
2	Presence of structures leading to permanent loss/gain of habitat resulting in changes to mobile species distribution/abundance	B, M, F	✓	✓	✓
3	Presence of structures/vessels resulting in temporary/permanent changes to seabed from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	H	✓	✓	✓
4	Presence of structures/vessels resulting in temporary/permanent changes to foraging or nursery/spawning areas from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	B, M, F	✓	✓	✓
5	Presence of structures/vessels resulting in physical damage (or mortality) to species from collision, entanglement or disorientation	B, M, F	✓	✓	✓
6	Presence of structures causing barrier to movement, migratory pathways and/or access to feeding grounds	B, M, F	✓	✓	✓
7	Operational activities resulting in noise disturbance to mobile species	B, M, F	✓	✓	✓
8	Operational activities resulting in visual disturbance (e.g. lighting) to mobile species	B, M, F	✓	✓	✓
9	Electromagnetic Fields (EMF) and thermal emissions from power cables interfering with prey location, mate detection and/or creating barriers to migration for sensitive species	H, M, F	✓	✓	n/a
10	Introduced structures resulting in exclusion/displacement of mobile species from an area	H, B, M, F	✓	✓	✓
11	Spillage of fluids, fuels during maintenance/operation leading to reduction in water quality	H, B, M, F	✓	✓	✓
12	Structures on the seabed providing new substratum that facilitates the colonisation and ingress of invasive non-native species	H	✓	✓	✓
13	Introduction of invasive non-native species as biofouling species on the surfaces of vessels or cultivated species	H	✓	✓	✓
14	Operational activities resulting in an increase of suspended sediments and turbidity, leading to displacement of mobile species	B, M, F	✓	✓	✓
15	Operational activities resulting in increased sedimentation with damage or loss of seabed features	H	n/a	n/a	✓
16	Introduction of litter leading to smothering, entanglement or ingestion	H, B, M, F	n/a	n/a	✓
17	Release of synthetic compounds associated with species cultivation e.g. pesticides, pharmaceuticals etc.	H, F	n/a	n/a	✓
18	Biological disturbance to native species from interactions with cultivated species (i.e. genetic modification)	H, F	n/a	n/a	✓
19	The import or rearing of cultivated stock leading to introduction of microbial pathogens	H, F	n/a	n/a	✓
20	Operational activities leading to increased organic enrichment or deoxygenation of substrata	H	n/a	n/a	✓
Key:	Habitats (H), Seabirds (B), Marine Mammals (M), Fish (F), Not applicable (n/a)				

4 Constraints and Opportunities Methodology

The broad methodology comprised six steps (see Figure 1), with the final step generating mapping outputs which indicated the potential ecological constraints and opportunities for the development of a relevant sector technology/activity.

The six steps are detailed in turn and cover:

1. Selection of datasets;
2. Data standardisation;
3. Applying a constraint value (scoring);
4. Dataset derived outputs (layers);
5. Spatial constraint maps and
6. Constraints and opportunities maps

The methodology is intrinsically linked to the risk screening process which provided consideration of all relevant operational impact pathways for each sector for each BIF (see Risk Screening). Thus, Step 1 of the linear methodology 'selection of datasets', systematically considered each of the operational impact pathways and the suitability of available datasets (see below).

4.1 Step 1: Selection of datasets

The first step involved selecting those datasets which were most suitable for understanding the degree of consenting constraint risk resulting from the operational impact pathways identified for each of the ecological features. Such pathways having already been determined for each sector through the risk screening process (see Table 1 and Appendix A, Table A1 - Table A4). Subsequently, these selected datasets were then used to inform the constraints analysis and mapping.

A methodical approach was used to determine the most suitable available dataset(s) for each pathway. This was designed to ensure that features were represented in a format relevant to understanding the relative implications of the pathway. This resulted in a series of sector specific tables which listed the most appropriate datasets per pathway and feature (Appendix B, Table B1 - Table B4). Initial review and then final selection of the datasets were carried out in consultation with NRW technical specialists during focussed workshops (July 2019 and January 2020). The rationale for the selection of the datasets is presented in Appendix B, Table B1 - Table B4 with the overall approach summarised below.

Datasets collated during WP1 (ABPmer, 2019) were initially considered for their suitability to the Study. In addition, datasets not previously available during WP1 were recommended by NRW technical specialists (e.g. Cleasby *et al*., 2018; Waggitt *et al*., 2019) as were the utilisation of derived datasets, these being a composite of multiple core datasets.

As a high-level initial criterion for selection, the dataset needed to represent all or most of Welsh marine waters. Hence, localised datasets were not initially taken forward although their applicability to focussed areas remained a consideration and, where feasible, it is recognised that these may be used for constraints mapping at a regional or local level. In some cases, known datasets were only deemed suitable at a project level stage, for example the Wetland Bird Survey (WeBS) dataset consists of numerous local data which would be requested once the details of a given project were understood.

A confidence assessment of the datasets was carried out against a range of criteria (see below and Appendix C). Key to this assessment was understanding the appropriateness of the dataset to the Study i.e. are the data appropriate to help inform ecological constraints with the potential to impact consenting complexity and risk.

It is important that the evidence uncertainties relating to consenting complexity and risk are fully recognised. The underlying evidence gaps that currently surround many of the operational impact pathways and/or the key limitations to available datasets (e.g. only provided at a localised level) led to many of the datasets being quite generic. Such gaps and issues with the selected datasets were highlighted and informed recommendations for future data collection which could be used to inform future iterations of the mapping (see Appendix B, Table B1 - Table B4). Aside from directing the requirements for future research and data to inform the Study, it also allowed consideration of wider outputs that may become relevant to the work in the future.

During WP1, recommendations were made for specific benthic survey work to provide a greater understanding of the condition and extent of Section 7 and Article 17 features in Welsh Waters. Acting on these recommendations a programme of focussed benthic survey work was carried out in 2019 (see ABPmer, 2020b[12]) and it is the intention of Welsh Government to incorporate these data within any future iterations of the analysis.

4.1.1 Datasets selected

Following review by NRW and Welsh Government, the datasets selected to inform the relative constraints for each of the sectors (tidal stream, wave energy and aquaculture) were listed along with an indication of which BIF they represented (Table 2). The core datasets were either available on Lle geoportal, through the Wales Marine Planning Portal (WMPP) or other open access websites with links provided to these core datasets within the derived dataset(s).

The types of data selected encompassed quantitative (e.g. bird density distribution), categorical (e.g. habitat type) and presence/absence (e.g. seal haul-out/pupping sites). In some instances, a selected dataset was a composite of several 'core' datasets. For example, the derived seabird foraging dataset was an amalgam of seabird foraging distances (Woodward *et al*., 2019), Welsh seabird colony sites provided by NRW and population counts at these colonies carried out by the Seabird Monitoring Programme. Similarly, the derived seal haul-out dataset comprised data from Baines *et al*., 1995; Westcott and Stringell, 2004; Strong *et al*., 2006 and Clarke *et al*., 2020. The derived seal haul-out dataset represented the most up to date mapping available for informing locations of seal haul-out and pupping sites. These derived datasets are Welsh Government owned and will be made publicly accessible through Lle geoportal.

Confidence assessment

The QA process carried out on data previously collated in WP1 was used to inform their suitability for identifying site selection or baseline characterisation to support sustainable development of tidal stream, wave energy and aquaculture sectors (ABPmer, 2019). Similarly, within the Study, confidence in each of the selected datasets (see Table 2) was assessed against the same criteria used in WP1:

- Appropriateness;
- Methodology;
- Timeliness; and
- Accuracy/Ground truthing.

[12] https://gov.wales/sustainable-management-marine-natural-resources

The difference between the data QA process carried out in WP1 and this Study was the question being asked in relation to 'appropriateness' of the data. In the Study, the question was 'are the data appropriate to inform potential consenting complexity and thus suitable for application within the ecological constraints and opportunities analysis?' The remaining QA criteria aligned with the QA process outlined in WP1, with criteria such as extent (i.e. Welsh waters) being crucial to their selection (ABPmer, 2019).

The QA assessment resulted in confidence being assigned to each dataset as either High, Medium or Low. However, in practice all of the selected datasets were categorised as either High or Medium confidence (see Table 2 and Appendix C). Where derived datasets comprised multiple core datasets these were each assessed individually (see Appendix C).

Table 2. Datasets selected as most suitable for informing ecological constraints. All derived datasets are owned by Welsh Government and located on Lle geoportal. Core datasets available through WMPP and/or Lle geoportal are indicated

Derived Dataset	Core Datasets	Relevant Sector	Confidence Assessment
All Features			
Designated sites (Ramsar, SACs, SPAs, MCZs, SSSIs)	Designated conservation site boundaries (various): Ramsar, SAC, SPA, MCZ, SSSI. On Lle geoportal and WMPP	All	High
Seabirds			
Seabird foraging	Bird colony locations and counts - Seabird Monitoring Programme[13] (varied years). Rationalised list of colonies produced following NRW input Mean foraging range – Woodward *et al.*, 2019	All	High
Seabird loafing	Bird colony locations - Seabird Monitoring Programme[14]. Rationalised list of colonies produced following NRW input JNCC maintenance extensions[15]	All	High
RSPB seabird utilisation distributions	RSPB metadata showing utilisation of Kittiwake, Guillemot, Razorbill, Shag - Cleasby *et al.*, 2018 On WMPP	All	High
Seabirds at Sea	Seabird distribution – Seabirds at Sea. Rationalised seabird list produced following NRW input On Lle geoportal and WMPP	All	Med
Marine Mammals			
Grey Seal at Sea	Seal at Sea - Russell *et al*, 2017[16]	All	High
Atlas of Marine Mammals of Wales	Atlas of the marine mammals of Wales - Baines and Evans, 2012	All	High
Cetacean distribution	Waggitt *et al.*, 2019[17]	All	High

13 Available at https://app.bto.org/seabirds/public/data.jsp
14 Available at https://app.bto.org/seabirds/public/data.jsp
15 Available at http://archive.jncc.gov.uk/pdf/SAS_Identification_of_generic_maintenance_extensions_to_seabird_colonies_2.pdf
16 Available at https://data.marine.gov.scot/dataset/estimated-sea-distribution-grey-and-harbour-seals-updated-maps-2017
17 Available at https://datadryad.org/stash/dataset/doi:10.5061/dryad.mw6m905sz

Derived Dataset	Core Datasets	Relevant Sector	Confidence Assessment
Seal pupping and haul out sites	Baines *et al.*, 1995; Westcott and Stringell, 2004; Strong *et al.*, 2006 and Clarke *et al.*, 2020	All	Medium
Fish			
Nursery areas	Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012) On WMPP	All	Medium
Spawning grounds	Spawning and nursery grounds of selected fish species in UK waters - Ellis *et al.*, 2012 – On WMPP Fisheries sensitivity maps in British waters - Coull *et al.*, 1998	All	Medium
Basking Shark distribution	The Marine Conservation Society Basking Shark Watch 20 year report (1987-2006) - Bloomfield and Solandt, 2010	All	Medium
Migratory fish transitional waters	Article 17 Estuaries On WMPP and Lle geoportal)	All	High
Habitats (and benthic species)			
Article 17 (Annex I)	Article 17 (Annex I habitats) On WMPP and Lle geoportal	All	Medium
Section 7 and OSPAR habitats	Section 7 and OSPAR habitats On WMPP and Lle geoportal	All	High
Section 7 and OSPAR species	Section 7 and OSPAR species On WMPP and Lle geoportal	All	High

4.1.2 Gaps and limitations

Following selection of the best available datasets, evidence gaps and limitations to the datasets were highlighted (see Appendix B). This allowed specific data recommendations to be made. Within the evidence packages the limitations of selected datasets were also indicated.

As part of the work in WP1, evidence gaps relating to the uncertainties of operational impacts from the sectors were also identified (ABPmer, 2019). Where relevant, previously identified gaps and limitations from WP1 were detailed in addition to consideration of the dataset and its limitations against the objectives of the Study. Similarly, gaps and limitations were identified on datasets used in the Study which were not available during WP1.

Any spatial data gaps in the selected datasets were also highlighted during the Study, ensuring that these gaps in the data were not misidentified as relative opportunities. For example, where a survey or surveys used to inform a selected dataset have not occurred in a specific location i.e. their extent did not encompass the entirety of Welsh waters, the narrative attached to the spatial constraint outputs recognised these omissions with a supporting mapped output provided to highlight spatial gaps (e.g. data gaps with Seabirds at Sea dataset).

4.1.3 Data recommendations

Recognising the gaps and limitations to the datasets allows recommendations to be made. Such recommendations can then be focussed upon for future work, enabling evidence and the data used to be increasingly robust. For example, key recommendations from WP1 included further benthic characterisation surveys to help inform the evidence base (ABPmer, 2019).

Generic recommendations such as ensuring data is current, that data coverage is at a national rather than local level and that data is gathered in accordance with NRW guidance (NRW, 2019) are implied for all selected datasets. Thus, the recommendations put forward largely consider how data could be provided that better addresses the question(s) being asked in relation to a given impact pathway, with an additional consideration of how selected datasets could be improved more specifically (see Appendix B).

For example, within the Study the reliance on mobile feature density distributions is used to infer collision risk and contribute towards the constraint outputs. Such an inference is flagged throughout the data recommendations as is the relative age of many of these datasets e.g. spawning and nursery grounds of fish.

Step 1: Selection of datasets
Datasets selected which best represent the features in a format relevant to understanding the relative implications of the selected pathways

Step 2: Data standardisation
Selected datasets standardised to allow comparability. Development of a grid to determine level of relative constraint

Step 3: Scoring
Feature layers 'classified' according to relative spatial occurrence and 'weighting' applied as measure of relative feature importance. Complexity adjustment then applied. The product of the processes resulted in a 'score' per grid cell for each individual feature
The 'scoring' of feature layers agreed through expert review.

Step 4: Dataset derived outputs
Dataset constraint layer generated specific to the sector/technology being considered for a broad interest feature.

Step 5: Spatial constraint layers
For each BIF, dataset constraint layers are amalgamated (summed scores) against each sector/technology to produce a sector specific feature constraint layer.

Step 6: Constraints and opportunities maps
Individual mapping output for each sector/technology indicating areas of relatively greater ecological constraint and suitable resource within Welsh waters. **Constraints and opportunities maps** generated for each feature for each sector/technology

Figure 1. Outline of linear approach to constraints and opportunities methodology

4.2 Step 2: Data standardisation

Following the selection of datasets during Step 1, datasets were then standardised to allow for integration of the mapping outputs and comparability within the Study.

Standardisation of the data allowed the generated constraint layers for each BIF, against a sector or sector technology, to be overlaid. The determination of the relative spatial constraint was then achieved through the summation of relevant grid cell scores, with opportunities visualised through the overlap of RAs and the relatively lower constraint scores.

Figure 2 outlines the generic process used to develop a constraint layer, providing an example relevant to the processing of quantitative data. Although this figure is specifically relevant to subsequent steps, and cross-referred to accordingly, it helps to understand where elements of the standardisation step are required for the methodology.

The selected spatial information layers were standardised according to:

- **Coordinate reference system (WGS 1984 UTM Zone 30N):** this ensured all the layers were spatially compatible and able to make use of metric units.

- Geographical extent (Welsh waters as defined by EEZ boundary): ensured all layers occurred over the same spatial extent

- **Range classes and weighting**: to facilitate comparability, each individual layer of a dataset was classified from 1-3 classes and conservation importance assigned ranging from 1-5 (further detail provided in Step 3) dependent on the BIF. This allowed a standardised classification and weighting system to be used across the different types of data.

- **Grid (pixel) size**: all layers, if not already, were initially converted to vector to allow vector processing tasks (e.g. calculate field tool) to be carried out (see Step 6). A 1 km^2 hexagonal vector grid cell was used for the overlapping of all input datasets. Calculations were made within the grid attributes table to account for different modifiers and weightings, enabling all technology scores for a particular constraint to be stored within a single dataset. This allows the user to interrogate the constraint layer map for further information and is a key requirement for the finalised product.

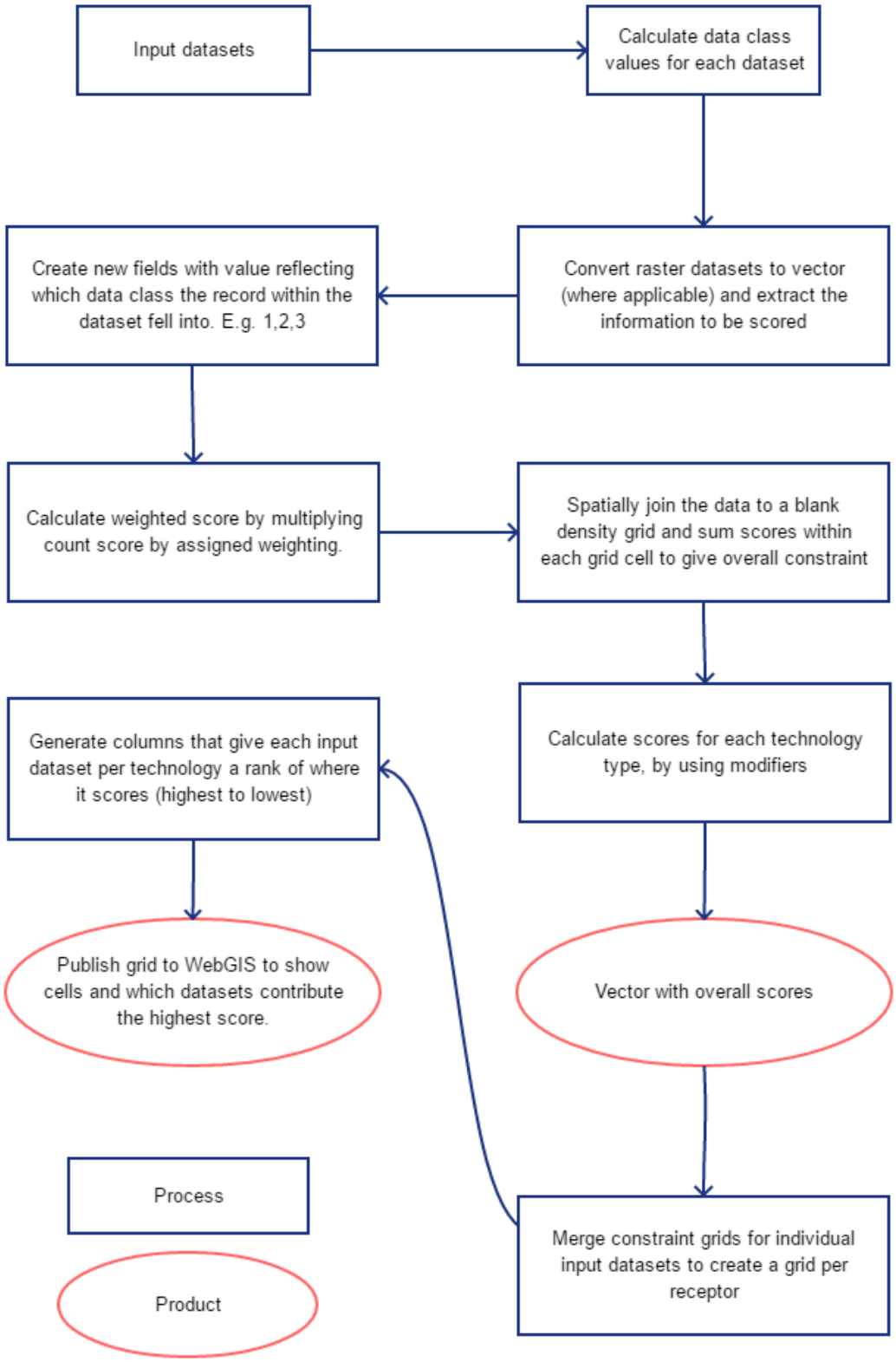

Figure 2. Generic outline showing development of constraint layer and finalised vector grid

4.3 Step 3: Applying a constraint value to an individual feature (scoring)

4.3.1 Introduction and scoring overview

Within Step 3 a standardised 'classification' and 'weighting' value was assigned to each individual feature layer of the selected datasets. The product of the classification and weighting values represented the 'initial score' applied to each 1 km^2 grid cell of each layer. To account for the potential differences in individual feature responses to operational activities from a given focus sector, a 'complexity adjustment' value was then applied to obtain a final constraint 'score' for each 1 km^2 grid cell of each layer (see Table 3 and Figure 2). The final constraint score generated being relevant to a specific sector technology/activity for a BIF.

Table 3. Overview of 'scoring' process

A. Classification (Spatial Occurrence)	B. Weighting (Conservation Importance)	Initial Score	C. Complexity Adjustment	Final Score
(1-3) or Binary (0/1 or 0/3)	**(1-5)**	**A*B [1-15]**	**(1-3)**	**A*B*C [1-45)**

Subsequent sections provide further information on the generic scoring process carried out in Step 3, including defining the phases (e.g. classification) and detailing their application. Detail on the specific scoring rules applied to each dataset, relative to each BIF, are then provided.

Classification (spatial occurrence)

The aim of this stage was to standardise dataset layers according to the relative spatial occurrence of a feature of interest. Spatial occurrence was either represented by a relative range (low, medium or high), or in a binary sense (presence/absence).

With quantitative data, such as density distribution and counts of seabirds, marine mammals or fish, classification values were separated into three classes assigned according to agreed cut-off values in the recorded density or counts of individual species and then applied to each grid pixel of an individual layer.

This resulted in classification values of 1-3 (see Table 3). Statistical functions of GIS ('Jenks' - natural breaks[18]) were used to find suitable values for class separation and assist with classification. Once these class separation values were generated, they were reviewed by NRW during workshops and discussions to ensure final agreement before being applied.

Essentially, this approach assumes that when a cut-off value is reached for quantitative data covering occurrence of a seabird, marine mammal or fish species, the likely potential to affect consenting would either increase or decrease. Thus, an exceedance in a pre-determined cut-off value would lead to an increased classification and a relatively higher value within a grid cell, ultimately increasing the contribution towards the overall constraint score.

[18] The Jenks Natural Breaks Classification (or Optimization) system is a data classification method designed to optimize the arrangement of a set of values into "natural" classes. A Natural class is the most optimal class range found "naturally" in a data set. A class range is composed of items with similar characteristics that form a "natural" group within a data set

A number of selected datasets were used in a binary fashion to a create a constraint layer i.e. classification represented presence only. Depending on the dataset and features being considered the classification was assigned as either 3 or 1 to represent presence (see Table 3). Therefore, in practice, where data were absent then no scoring was carried out. For example, in relation to seabird constraints analysis, grid cells that bordered or were within the boundary of a designated site which had birds as a qualifying feature (SPA, Ramsar, SSSI) were classified as '3' with all other cells assigned '0'.

Further detail and justification on the specific classification approach used for each dataset is provided in the subsequent dataset sections below.

Weighting (conservation importance)

The objective of this stage was to apply a weighting value to the data within the layers to reflect the differing conservation importance of ecological features (and ultimately how that influences the level of constraint).

As conservation importance of a feature is likely to be the key contributing factor towards consenting considerations, weighting was applied with due acknowledgment to conservation designations. This generic approach was adopted in a consistent manner across all datasets for all features. Weighting ranged from 1-5, where 1 indicated a feature with no conservation designation and 5 a feature with conservation designations which would potentially result in the greatest relative consenting risk. The allocation of the weighting values assigned to individual features were reviewed and agreed with NRW at focussed workshops to ensure agreement. Further detail and justification for the conservation importance applied to each dataset is provided in the subsequent dataset sections below.

Policy ENV_07 (Fish Species and Habitats) of the WNMP, recognises how certain developments or activities in the marine plan area have the potential to adversely affect feeding, breeding and migration areas and habitats for key commercial or protected species. It states how important species include those of commercial, conservation, ecological or recreational importance. It is assumed that future iterations of the analysis will provide the opportunity to assign weighting according to commercial and ecological criteria, as and when the relevant information and evidence becomes available.

Complexity adjustment

This stage of the scoring process allowed consideration of the potential differences in responses from ecological features to operation of sectors and sector technologies, and therefore consideration of differences in consenting risk.

An example is the differing sensitivities of seabirds to a sector/technology depending on their broad foraging behaviour. Diving seabirds (e.g. Guillemot) are more likely to be affected by subsurface activities than other seabirds (e.g. Herring Gull). Therefore, it is considered that the presence of Guillemot would pose a greater consenting risk upon, for example, operation of a seabed mounted tidal stream development, than would the presence of Herring Gull.

To indicate where potential differences in consenting complexity exist between individual features, or groups of the same feature type, a factor (complexity adjustment) was applied to generate a final constraint score for each grid cell (see Table 3).

The complexity adjustment (ranging from 1 to 3) was applied to individual features, or groups of features comprising the BIF according to the following criteria:

- **1** – Negative pathways exist to this feature; however, there is a general consensus that consenting complexity from operation of this activity would be minimal in Welsh waters, this possibly as a result of minimal exposure to the activity. There is a relatively good understanding of these impact pathways supported by evidence[19].

- **2** – Negative pathways exist to this feature which are considered likely to result in relatively greater consenting complexity in Welsh waters. In some instances, a degree of uncertainty with one of more of the impact pathways may exist and while some evidence may be available it is based on proxy information, relying heavily on grey literature and/or expert judgement with limited peer-reviewed papers.

- **3** – Negative pathways exist to this feature which are likely to result in considerable consenting risk within Welsh waters and/or there is a large degree of uncertainty with one of more of the impact pathways, with minimal evidence to support a definitive understanding of the impact(s). Heavily reliant on expert judgment.

A workshop in January 2020 attended by ABPmer and specialists from NRW and Welsh Government initiated discussions around the requirement for a factor (complexity adjustment) and the numerical values to be applied. In subsequent months, further focus with relevant specialists from these organisations, specific to each of the BIFs, reviewed the factors before their final application within the scoring approach.

Whilst expert judgement has informed the application of these values to individual features, or groups of features, understanding the level of uncertainty and minimal evidence that surrounds some of the impact pathways has led to a necessarily precautionary approach. Over time, with suitable monitoring in place it will be possible to refine the values based upon empirical evidence as it becomes available and perhaps develop a more nuanced approach in future iterations.

Where a selected dataset did not consider an individual species or habitat feature, or groups of these features, then the product of the classification and weighting represented the 'final' constraint score i.e. no complexity adjustment (factor) was applied. For example, the constraint layer relevant to each BIF derived from the designated sites dataset generated a score from consideration of classification and weighting only. The consideration of consenting complexity is captured implicitly within the requirements of legislation and guidance encompassing a designated site.

As new data becomes available on the potential impacts to a BIF from these sectors and their corresponding technologies and activities, the scoring can be updated in any future iterations of the work.

4.3.2 Dataset scoring

Specific scoring rules were required for each dataset to acknowledge the differences between the datasets and ultimately, to best understand how the datasets and their comprising layers contributed towards the relative BIF constraints against a given sector's development. Hence, although the generic scoring process remained consistent (as described above), the method for generating values specific to relative spatial occurrence (classification) varied according to the dataset whilst application of the conservation importance (weighting) differed according to the BIF.

[19] Evidence is defined as expert opinion or advice, data, methodology, results from data analysis, interpretation of data analysis, and collations and interpretations of scientific information (meta-analysis), peer-reviewed papers, grey literature, industry knowledge and anecdotal evidence.

This section initially provides detail on the preparation required to selected datasets prior to scoring, followed by a description of the precise scoring rules applied. It is broken down according to BIF:

- Seabirds;
- Marine mammals;
- Fish; and
- Habitats.

Birds

Five datasets were used for consideration of bird constraints (see Table 2):

- Seabirds at Sea;
- RSPB seabird utilisation;
- Seabird foraging;
- Seabird loafing; and
- Designated sites.

Detail on assigning classification is provided specifically for each dataset selected (see below). Weighting of seabirds was assigned according to conservation importance, directly relating to the Red, Amber and Green lists provided in the 2016 Birds of Conservation Concern for Wales (BoCCW3) list, across all datasets with individual bird features (i.e. not the designated site dataset).

The product of the classification and weighting stages for each dataset resulted in an 'initial score'. Acknowledging the potential differences in consenting risk that exist between individual bird features, or groups of birds, relevant to a sector technology/activity, a complexity adjustment was then applied to the initial score (Table 4) of those datasets which encompassed individual bird features. The factor was applied according to defined criteria (see Complexity adjustment) across all sector technologies and activities with guidance from NRW technical specialists.

In applying the complexity adjustment, consideration was given to the behaviour and feeding strategy of bird species and how these would affect the likely exposure to operational impact pathways of the sectors. Commic Terns, for example, are shallow surface feeders and thus would not be directly exposed to mid-water or seabed located technologies.

The differences in seabird consenting complexity across sector technologies/activities resulted in seabird spatial constraint layers (see Step 5) for each of the following:

- Tidal Stream
  - Seabed mounted
  - Mid-water
  - Surface emergent
- Wave energy
  - Seabed mounted
  - Surface emergent
- Aquaculture

Table 4.Complexity adjustment matrix for seabird features

Species	TS (SB)	TS (MW)	TS (SU)	Wave (SB)	Wave (SU)	Aq (BI)	Aq (SW)
Kittiwake	1	1	2	1	2	1	1
Cormorant	2	3	3	1	2	1	1
Shag	2	3	3	1	2	1	1
Shagorant	2	3	3	1	2	1	1
Common Scoter	2	3	3	1	2	1	1
Fulmar	1	1	2	1	2	1	1
Gannet	2	3	3	1	2	1	1
Puffin	3	3	3	2	2	1	1
Guillemot	3	3	3	2	2	1	1
Razorbill	3	3	3	2	2	1	1
Auks	3	3	3	2	2	1	1
Sandwich Tern	1	2	3	1	2	1	1
Commic Terns	1	1	2	1	2	1	1
Little Tern[20]	1	1	2	1	2	1	1
Storm Petrel	1	1	1	1	2	1	1
Manx Shearwater	2	2	2	1	2	1	1
Great Black-backed Gull	1	1	1	1	2	1	1
Lesser Black-backed Gull	1	1	1	1	2	1	1
Herring Gull	1	1	1	1	2	1	1
Common Gull	1	1	1	1	2	1	1
Black Headed Gull	1	1	1	1	2	1	1
Red Breasted Merganser	2	2	3	1	2	1	1
Red Throated Diver	2	3	3	2	2	1	1
Grebe	2	2	3	1	2	1	1
Sectors: TS (Tidal Stream), Wave (Wave Energy) and Aq (Aquaculture). Technologies Activities SB (seabed), MW (mid-water), SU (surface), BI (bivalve) and SW (seaweed)							

Seabirds at Sea

The Seabirds at Sea dataset is a composite of the European Seabirds at Sea (ESAS) and Wildfowl and Wetlands Trust (WWT) baseline datasets and is used within the Welsh Marine Planning Portal (WMPP) to provide an indication of bird distribution across Welsh waters. This dataset was assigned as medium confidence (see Appendix C).

From the Seabirds at Sea core dataset, a rationalised list of bird taxa was compiled following discussion with NRW bird specialists. The list focussed on those seabirds at potential risk from underwater or surface water operations of the sectors (tidal stream, wave energy, and aquaculture). Acknowledging previous work carried out by Smith *et al* (2011) the list covered regularly occurring offshore diving birds, in addition to surface feeders such as Gulls and Terns. It did not encompass birds relatively uncommon to Welsh waters, migrants and coastal birds specifically associated with the intertidal, such as waders; with the latter being largely encompassed through WeBS data (see Datasets selected).

The rationalised list encompassed 23 seabird taxa and was largely reflective of those seabird taxa presented on the WMPP (Table 5). Notable exceptions were the exclusion of Little Gull and Great Northern Diver from the rationalised list, both of which are rarely recorded in Welsh waters.

[20] Little Tern was not included on rationalised list for Seabirds at Sea dataset but has been acknowledged within the Seabird foraging and Seabird loafing datasets.

Little Tern was not included in the rationalised list for Seabirds at Sea dataset. As a Schedule 1 species there are no publicly available counts or locational data. However, as it is widely known that there is an important Little Tern colony at Gronant, this has been acknowledged within the Seabird foraging and Seabird loafing datasets.

The Seabirds at Sea dataset comprises records from aerial and boat surveys, with records of flying birds (n/km) and sitting birds (n/km^2). Where records existed for a bird taxon as flying and sitting then the latter was selected, as there would be an increased likelihood of an impact occurring from a development where there was an interaction or overlap with water used by the birds (i.e. for foraging, loafing and rafting). Where records only existed for flying birds (i.e. Storm Petrel, Commic (Arctic/Common) Terns, Sandwich Terns) then these were used.

A number of the seabird taxa within this dataset, and on the rationalised list, are not discriminated to species. Discrimination of Guillemot and Razorbill is often difficult at sea, with records often being recorded as 'Auks'. Although distinction of Puffin from other Auk species is easier there is potential that any Auk record could represent either one of these species (Guillemot/Razorbill/Puffin). For the same reason, records of Shags and Cormorant are often recorded as 'Shagorant'. The high number of records for Auks and Shagorants and the diving behaviour of the constituent species means these records have been included within the rationalised list.

Puffin and Shag are both red list species on the Birds of Conservation Concern in Wales (BoCCW3, 2016). Therefore, as a precautionary approach to the scoring process used to generate the dataset constraint layer, all records of Auks and Shagorant are assumed to be Puffin and Shag respectively, these having a greater level of Conservation Concern than Guillemot, Razorbill and Cormorant in Wales.

Similarly, as the Seabirds at Sea dataset provides records for Commic Terns (Arctic/Common), adopting a precautionary approach to the scoring process, all records of Commic Tern are assumed to be Arctic Terns, which has a greater level of Conservation Concern than Common Tern in Wales. There is no discrimination between species of Grebe and these records have all been assumed to constitute either Black-Necked or Red-Necked Grebe, the Slavonian Grebe being rarely recorded in Welsh waters.

The dataset also included a number of records for 'Diver sp.', which have all been assumed to represent Red Throated Divers and have therefore been amalgamated into the Red Throated Diver records.

Scoring process

Each taxon layer was classified into three classes (high, medium and low) according to recorded density values. Statistical functions of GIS (Jenks natural breaks) were applied to find suitable values for class separation and assist with classification (see Classification (spatial occurrence)). The resulting GIS outputs (data classes) were then checked visually and agreed with NRW technical specialists, to ensure that they provided a good representation of the spatial occurrence of the respective features.

Weighting was then applied to each of the classified seabird density layers to capture the relative conservation importance of the seabird taxa. As mentioned above, the weighting was assigned according to the Red, Amber and Green lists provided in Birds of Conservation Concern for Wales (BoCCW3, 2016):

- Red list 5
- Amber list 3
- Green list 1

As all seabirds on the rationalised list were either Red or Amber bird species according to BoCCW3, this resulted in weighting values of either 5 or 3 being applied (see Table 5).

Table 5. Classification and weighting for individual layers (seabird taxa) of Seabirds at Sea dataset

Bird Taxa	Classification	BoCCW3 (2016)	Weighting	Initial Score
Kittiwake	Low (1) – High (3)	Red	5	5-15
Cormorant	Low (1) – High (3)	Amber	3	3-9
Shag	Low (1) – High (3)	Red	5	5-15
Shagorant	Low (1) – High (3)	Red	5	5-15
Common Scoter	Low (1) – High (3)	Amber	3	3-9
Fulmar	Low (1) – High (3)	Amber	3	3-9
Gannet	Low (1) – High (3)	Amber	3	3-9
Puffin	Low (1) – High (3)	Red	5	5-15
Guillemot	Low (1) – High (3)	Amber	3	3-9
Razorbill	Low (1) – High (3)	Amber	3	3-9
Auks	Low (1) – High (3)	Red	5	5-15
Sandwich Tern	Low (1) – High (3)	Amber	3	3-9
Commic Tern	Low (1) – High (3)	Red	5	5-15
Storm Petrel	Low (1) – High (3)	Amber	3	3-9
Manx Shearwater	Low (1) – High (3)	Amber	3	3-9
Greater Black-backed Gull	Low (1) – High (3)	Red	5	5-15
Lesser Black backed Gull	Low (1) – High (3)	Amber	3	3-9
Herring Gull	Low (1) – High (3)	Red	5	5-15
Common Gull	Low (1) – High (3)	Red	5	5-15
Black headed Gull	Low (1) – High (3)	Red	5	5-15
Red breasted Merganser	Low (1) – High (3)	Amber	3	3-9
Red throated Diver	Low (1) – High (3)	Amber	3	3-9
Grebe	Low (1) – High (3)	Amber	3	3-9

The complexity adjustment was then applied to the 'initial score' dependent on the sector technology/activity being considered (see Table 4).

RSPB seabird utilisation

This dataset provides the outputs from a five-year tracking programme by RSPB and has been assigned as high confidence (see Appendix C). The data have identified the relative usage of UK-wide marine areas for four species of seabirds (Kittiwake, Razorbill, Guillemot and Shag). Hotspot mapping techniques were used to identify areas of high seabird density and important foraging areas for these species (Cleasby *et al.*, 2018) resulting in Utilisation Distribution (UD) outputs in UK waters for these four species.

UDs are two-dimensional probability distributions that represent the time spent in a specific area and thus the probability of encountering an animal in that location during a future observation period (Hooten *et al.* 2017). Population-level UDs can be interpreted as the amount of time the average individual spends at a particular location or as the expected proportion/ percentage of the population at a location at any given time.

At any given time, the outputs from the RSPB study predict that 50% of a defined population (for either Kittiwake, Razorbill, Guillemot or Shag) could be expected within the population-level 50% UD. Cleasby *et al.* (2018) state how the 50% UD is used to identify the area of core usage for a given species. When multiplied by population size estimates UDs can be used to depict relative or absolute expected density of birds.

Scoring process

To generate the dataset constraint layer, the scoring process was applied in a binary context to this dataset. Acknowledging that 50% UD areas represent core areas of the sea used by the birds for foraging etc., a classification value of '3' was applied to grid cells that overlapped or were within the 50% UD. Grid cells outside of the 50% UD contour, of any of these species, were classified as '0' and therefore no score was generated for these cells. Beyond the 'core areas' it is not considered that the utilisation of the water by these species would be a significant contributing factor towards overall consenting risk in relation to seabirds.

Weighting was then assigned according to the Red, Amber and Green lists provided in Birds of Conservation Concern for Wales (BoCCW3, 2016):

- Red list 5
- Amber list 3
- Green list 1

This resulted in a weighting value of '5' assigned to Kittiwake and Shag, and '3' to Guillemot and Razorbill (Table 5).

The complexity adjustment (factor) was then applied to the initial score in relation to each species and dependent on the sector (or sector technology/activity) being considered (see Table 4).

Seabird foraging

Following detailed discussions with NRW technical specialists, it was recommended that a dataset was used which encompassed foraging ranges of seabirds from important Welsh seabird colonies. The proximity of proposed developments to seabird colonies can be a significant factor in the level of consenting risk, this risk being dependent on a number of variables such as project scale, type of development and distance from the colony. Although consideration against these variables will be captured within project level assessment, at a broader planning level, the presence of seabird colonies needs to be considered.

The seabird foraging dataset was derived using Welsh seabird colony data (locational and seabird counts) from the Seabird Monitoring Programme[21] (SMP) and the revised mean foraging ranges of seabirds (Woodward *et al*., 2019). Each of these core datasets were assessed as high confidence (see Appendix C); hence, high confidence was assigned to the derived seabird foraging dataset.

As a first stage in the creation of the dataset, a rationalised list of Welsh seabird colonies was compiled from the SMP dataset following discussion with NRW bird specialists. Using the SMP dataset, bird counts for the most recent year were then collated for each species present at a given colony excluding those seabird species covered by the RSPB seabird utilisation dataset (Kittiwake, Guillemot, Razorbill and Shag). Thus, the constraint layer derived from the dataset broadly acknowledged the importance of foraging areas around colonies of seabirds; focussing on those species not already captured through the RSPB seabird utilisation dataset.

Where counts of a seabird species at a given colony were less than 10, then these were screened out from further consideration within the scoring process. This approach was taken because populations of less than 10 would be highly unlikely to contribute towards considerations of consenting risk. The key exception would be if these were a Schedule 1 bird species. However, as location and counts are not

[21] https://app.bto.org/seabirds/public/data.jsp

generally publicly available for Schedule 1 seabird species such as Little Tern, Mediterranean Gull and Roseate Tern, these are not encompassed by the core data used to create the dataset.

Nonetheless, as it is widely known that there is an important Little Tern colony at Gronant, this has been acknowledged within the Study even though counts of this population were not available through the seabird monitoring programme.

The result from this approach is provided in Table 6, which shows all colonies considered within the constraint layers for this dataset. As there were zero counts of Cormorant at the Afordir Gogleddol Penmon (Fedw Fawr to Trwyn Du in SMP) colony, this colony was screened out. As all species present at Carreg y Llam with a count of 10 or more (see Seabird Monitoring Programme data from 2019) were encompassed by the RSPB seabird utilisation dataset (i.e. Guillemot, Razorbill and Kittiwake), initially this colony was not taken forward within the constraint layer. However, after discussion with NRW technical specialists, it was considered that the exclusion of this colony from this dataset underplayed the potential consenting complexity in the waters around the colony by virtue of the breeding population of Guillemots present. This population being the second largest in Wales (~ 11,000) (Seabird Monitoring Programme data from 2020). Hence, special consideration was given to this colony within the scoring approach of this dataset (see below).

Acknowledging the most recent study on seabird foraging distances (Woodward *et al*., 2019) and following discussion with NRW technical specialists, the mean foraging distances for each seabird species screened-in, were then applied as buffers around the colonies (Table 7).

Future iterations of this work will allow bird count and colony data to be revisited and appropriate revisions made to the constraint layer, as required.

Scoring process

Each species colony (see Table 6) was classified according to their population size (spatial occurrence), as derived from the most recent SMP bird counts, from low (1) to high (3). Where more than three count values existed for a given seabird species then Jenks (natural breaks) was applied to allow classification (1-3) to be assigned. Where only a single count existed, or in the specific case of Little Tern at Gronant no count data, then a classification of '3' was applied. Where two counts existed then these were classified as '2' and '3', where 3 represents the highest count.

For example, the Arctic Tern colony at the Skerries was classified as '3' and at Cemlyn as '2'. While, the Black Headed Gull colony at Cemlyn was classified as '3' and at the Skerries as '2'. Cells that were beyond the mean foraging areas of any seabird species from the colonies were not classified.

Following the application of the relevant foraging ranges to each of the selected species around the colonies, classification, as pre-determined for a particular colony, was assigned to those cells that were within or overlapped with the range of one or more species.

Weighting (importance) was then allocated according to the Red, Amber and Green lists provided in Birds of Conservation Concern for Wales (BoCCW3, 2016):

- Red list 5
- Amber list 3
- Green list 1

The complexity adjustment (factor) was then applied to the initial score in relation to each species and dependent on the sector technology/activity being considered (see Table 4).

Taking the example of the Arctic Tern colonies at the Skerries and Cemlyn would result in the following grid cell scores for tidal stream seabed technology being applied to create the individual species layer for Arctic Tern:

Skerries

Only cells that overlap or are within the mean foraging range for Arctic Tern (6.1 km) from this colony are scored.

Classification (3) x Weighting (5) x Complexity Adjustment (1) = 15

Cemlyn

Only cells that overlap or are within the mean foraging range for Arctic Tern (6.1 km) from this colony are scored.

Classification (2) x Weighting (5) x Complexity Adjustment (1) = 10

Table 6. Seabird colonies around Welsh waters, from North to South Wales, which were used within the scoring process

Colony	Species
Shotton	Common Tern; Black-headed Gull
Gronant	Little Tern
Little Orme	Cormorant
Great Orme	Fulmar; Cormorant
Puffin Island	Puffin; Fulmar; Cormorant
Ynys Moelfre	Great Black-backed Gull; Herring Gull
Middle Mouse	Cormorant; Herring Gull
Cemlyn	Arctic Tern; Common Tern; Sandwich Tern; Black-Headed Gull
Skerries	Puffin; Black-headed Gull; Lesser Blacked-backed Gull; Arctic Tern; Common Tern; Great Black-backed Gull; Herring Gull
Holyhead Coast (South Stack)	Fulmar; Herring Gull
Ynys Feurig	Arctic Tern; Common Tern
Carreg y Llam	Guillemot
Bardsey	Puffin; Fulmar; Herring Gull; Lesser Black-backed Gull; Manx Shearwater
Ynysoedd Gwylan	Puffin; Great Black-backed Gull; Cormorant; Herring Gull; Manx Shearwater
Twyn Cilan	Herring Gull
St Tudwals West	Great Black-backed Gull; Herring Gull; Lesser Black-backed Gull
St Tudwals East	Cormorant; Herring Gull
Cregiau Pen Y Graig	Cormorant
Cardigan Island	Fulmar
New Quay Head	Herring Gull
Ramsey	Puffin; Fulmar; Great Black-backed Gull; Herring Gull; Lesser Black-backed Gull
Grassholm	Gannet; Herring Gull; Lesser Black-backed Gull
Bishops and Clerks	Puffin; Great Black-backed Gull; Herring Gull; Storm-petrel; Lesser Black-backed Gull
Skomer	Puffin, Great Black-backed Gull; Herring Gull; Lesser Black-backed Gull; Fulmar; Manx Shearwater

Colony	Species
Skokholm	Herring Gull; Lesser Black Backed Gull; Great Black-backed Gull, Puffin; Fulmar; Manx Shearwater
Middleholm	Cormorant
Castlemartin	Fulmar; Herring Gull; Lesser Black-Backed Gull
St Margaret's Island	Fulmar; Cormorant; Herring Gull
Caldey Island	Fulmar; Great Black-backed Gull; Herring Gull; Lesser Black-backed Gull
Flatholm	Lesser Black-backed Gull
Species associated with the location of the Welsh colony are listed apart from Kittiwake, Guillemot, Razorbill and Shag which were encompassed by the RSPB dataset. The key exception was Carreg y Llam (see above).	

Table 7. Mean foraging distances for seabirds (Woodward *et al.*, 2019) considered within the seabird foraging dataset

Species	Mean Foraging Distance (km)
Arctic Tern	6.1
Black-headed Gull	7
Common Tern	6.4
Cormorant	7.1
Fulmar	134.6
Gannet	120.4
Great Black-backed Gull	16.7
Herring Gull	14.9
Lesser Black-backed Gull	43.3
Little Tern	3.5
Manx Shearwater	136.1
Puffin	62.4
Sandwich Tern	9
Storm Petrel	33.6*
To acknowledge the large breeding colony of Guillemot at Carreg y Llam (see above) a mean foraging distance of 73.2 km (Woodward *et al.* 2019) was applied * Neither the Woodward *et al* (2019) study or Thaxter *et al* (2012) provide an indication of mean foraging range for Storm Petrel. For the purposes of the Study, the value used for the mean foraging range is 10% of the maximum foraging range (336 km) provided by Woodward *et al* (2019).	

Seabird loafing

Breeding seabirds, when not attending the nest or foraging, may spend time in waters adjacent to the colony engaging in maintenance activities such as preening, bathing and displaying (loafing). Hence, these waters represent areas of added importance to seabirds and are likely to be an additional consideration to consenting of the sectors.

Work by JNCC have identified the distance out to sea, from a colony, that several seabird species use for these maintenance activities (e.g. McSorley *et al.*, 2003 and 2008). Following discussions with NRW technical specialists, it was recommended that a dataset was used which considered loafing areas around Welsh seabird colonies.

Although separate datasets make consideration of potential consenting risk resulting from the presence of Welsh seabird colonies, either directly (seabird foraging and RSPB utilisation distribution) or indirectly (designated sites), the added importance of waters close to these colonies should be acknowledged during plan level assessment.

The seabird loafing dataset is derived from the amalgamation of Welsh seabird colony data (locational) from the SMP[22] and the recommended generic maintenance extensions for specific seabird species (see JNCC summary method[23]) i.e. Manx Shearwater, Fulmar, Gannet, Puffin, Guillemot and Razorbill. Each of these core datasets were assessed as high confidence (see Appendix C); hence, high confidence was assigned to the derived seabird loafing dataset.

Although other species of seabirds may form aggregations around colonies in the pre-breeding or breeding season, a study by McSorley *et al*., (2003) states how evidence of such aggregations is largely anecdotal. The study did suggest, however, that higher densities of Shag and Kittiwake were often observed within 1 km from the colony, while pre-breeding aggregations of gulls are also likely. Accordingly, as a default precautionary approach, it was assumed that waters within 1 km of a colony were important for the maintenance activities of all seabird species present. Beyond 1 km from the colony the importance for maintenance activities was also acknowledged for Fulmar and Gannet (2 km) and Manx Shearwater (4 km).

As carried out for the seabird foraging dataset, where counts of a seabird species at a given colony were less than 10, then these were screened out from further consideration within the scoring process (see above). Future iterations of this work will allow bird count and colony data to be revisited and appropriate revisions made to the constraint layer, as required. Similarly, should new data become available on loafing areas then this can be incorporated.

Following this screening stage, buffers relevant to the loafing areas afforded each species were then applied around the colonies, as appropriate.

Scoring process

The scoring process was applied in a binary context to this dataset. For each individual species layer, a classification value of '3' was applied to grid cells that overlapped or were within the relevant loafing area around a given colony. All other grid cells were assigned a classification of '0'.

Weighting (importance) was then allocated according to the Red, Amber and Green lists provided in Birds of Conservation Concern for Wales (BoCCW3, 2016):

- Red list 5
- Amber list 3
- Green list 1

The complexity adjustment (factor) was then applied to the initial score in relation to each species and dependent on the sector technology/activity being considered (see Table 4).

Designated sites for seabirds (ecological)

There are a number of International (Ramsar), European[24] (SPAs) and national (SSSIs) sites which have birds as qualifying features. Where these sites are present there is likely to be an increased consenting risk to the operation of the sectors.

22 https://app.bto.org/seabirds/public/data.jsp

23 Accessed online (04/03/20): http://archive.jncc.gov.uk/pdf/SAS_Identification_of_generic_maintenance_extensions_to_seabird_colonies_2.pdf

24 References to 'European sites' and 'Natura 2000 sites' throughout this report are to be read as references to European sites within the UK national site network (as defined in Regulation 3 of the Conservation of Habitats and Species Regulations 2017) designated before the UK left the EU: https://www.gov.uk/government/publications/uk-marine-policy-statement/guidance-to-the-uk-marine-policy-statement-from-1-january-2021

The boundaries of these sites are well defined, and the dataset encompasses Ramsar, SPA and SSSI layers publicly available on the Lle geoportal. This dataset was assessed as high confidence (Appendix C).

Other nationally designated sites, such as Areas of Outstanding Natural Beauty (AONB), are not specifically relevant to ecological features and are not encompassed by the Study.

Scoring process

The scoring process was applied in a binary context to this dataset. For each designated site layer, a classification value of '3' was applied to grid cells that overlapped or were within the designated site boundary. All other grid cells were assigned a classification of '0'.

Weighting (conservation importance) was then allocated as follows:

- Ramsar 5
- SPA 5
- SSSI 3

As previously discussed, as this dataset does not depict individual species or habitat features, or groups of these features, then the product of the classification and weighting represented the 'final' score i.e. no complexity adjustment was applied

Differences in consenting risk relative to designated sites are directly linked to the legislation which underpins their conservation protection. For example, carrying out operations from any of the sectors within the boundary of a European or Internationally designated site (SPA or Ramsar) would require a Habitats Regulations Assessment (HRA) to enable a consent decision to be made.

In some instances, there were multiple designated sites that occupied the same grid cell. This was to be expected, as many of the designated sites overlap e.g. Anglesey Terns SPA and Hen Borth SSSI. The scores of any overlapping designated sites were cumulatively scored within the grid cells to produce a single constraint dataset layer for designated sites in relation to seabirds (see Step 4).

Marine mammals

Five datasets were selected for consideration of marine mammal constraints (see Table 2):

- Grey seal at sea
- Cetacean distribution
- Atlas of marine mammals of Wales
- Seal pupping and haul out sites; and
- Designated sites

All these datasets were assessed as high confidence except 'seal pupping and haul-out sites' which was assessed as medium (see Table 2 and Appendix C).

It was agreed with NRW technical specialists that these datasets acknowledged those marine mammal species which were considered most as risk from focus sector development in Welsh waters:

- Grey Seal
- Bottlenose Dolphin
- Risso's Dolphin
- Short Beaked Common Dolphin
- Harbour Porpoise
- Minke Whale

Detail on assigning classification is provided specifically for each dataset selected (see below). Weighting of marine mammal features (species) was assigned according to conservation importance (see Weighting (conservation importance)) and directly related to the conservation protection afforded to the species under the Habitats Directive. Weighting was assigned across all datasets with individual marine mammal features (i.e. not the designated site dataset). The protection provisions are designed to ensure that the species listed in the Habitats Directive reach a favourable conservation status within the EU.

The Habitats Directive species and sub-species are protected in various ways:

- For those listed in **Annex II** of the Habitats Directive, core areas of their habitat must be protected under the Natura 2000 Network and the sites managed in accordance with the ecological requirements of the species.
- For species and sub- species listed in **Annex IV** (including many that are also listed in Annex II) a strict protection regime must be applied across their entire natural range within the EU, both within and outside Natura 2000 sites.
- For species and sub-species listed in **Annex V**, if deemed necessary as a result of surveillance work, measures will be taken to ensure that their exploitation and taking in the wild is compatible with maintaining them in a favourable conservation status.

Acknowledging the protection provisions of the Habitats Directive, the weighting was applied in a consistent manner across all relevant marine mammal feature layers (see Table 8). The highest weighting (5) was assigned to any species which was an Annex II feature. In Welsh waters, grey seal, harbour porpoise and bottlenose dolphin are all primary reasons for selection of Special Areas of Conservation (SAC) e.g. Pembrokeshire Marine (grey seal); West Wales Marine (harbour porpoise); Cardigan Bay (bottlenose dolphin). It should also be noted that all marine mammal features listed (see Table 8) are on the Section 7 list for species of principal importance to Wales.

Table 8. Weighting (importance) assigned to marine mammal features according to protection provisions of Habitats Directive

Feature	Conservation Designation	Weighting
Grey Seal	Annex II and V	5
Harbour Porpoise	Annex II and IV	5
Bottlenose Dolphin	Annex II and IV	5
Risso's Dolphin	Annex IV	3
Short Beaked Common Dolphin	Annex IV	3
Minke Whale	Annex IV	3

The product of the classification and weighting stages for each dataset resulted in an initial score. Acknowledging the potential differences in consenting complexity that exist between individual marine mammal features, or groups of mammals, relevant to a sector (or sector technology/activity), a complexity adjustment factor was then applied to the initial score (see Table 9). The factor was applied according to defined criteria (see Complexity adjustment) across all sectors and broad sector technologies and activities.

As the final marine mammal scoring outputs for a given sector were the same across all relevant technologies/activities for that sector, this resulted in spatial constraint layers (Step 5) as follows:

- Tidal Stream
- Wave energy
- Aquaculture

Table 9. Complexity adjustment matrix for marine mammal features

Species	TS (SB)	TS (MW)	TS (SU)	Wave (SB)	Wave (SU)	Aq (BI)	Aq (SW)
Grey Seal	3	3	3	2	2	1	1
Harbour Porpoise	3	3	3	2	2	1	1
Bottlenose Dolphin	3	3	3	2	2	1	1
Minke Whale	3	3	3	2	2	1	1
Risso's Dolphin	3	3	3	2	2	1	1
Short Beaked C. Dolphin	3	3	3	2	2	1	1
Sectors: TS (Tidal Stream), Wave (Wave Energy) and Aq (Aquaculture). Technologies Activities: SB (seabed), MW (mid-water), SU (surface), BI (bivalve) and SW (seaweed).							

Grey Seal at sea

Studies of grey seals have shown that they have continuously high spatial usage of large areas of sea and are not just located around haul-out sites. These studies indicate the importance of large foraging areas for this species (Russell *et al*., 2014; Thompson *et al.,* 1996).

A study by Russell *et al.* (2017) provided estimated at-sea distribution of grey and harbour seals around the UK at a spatial resolution of 5 x 5 km by combining seal telemetry data with haul-out specific population data. The Grey Seal at Sea dataset is directly derived from the Russell *et al*. (2017) study and is used to indicate the relative importance of Welsh waters to grey seal utilisation.

Data were obtained from the Grey Seal at Sea usage for the upper 95% CI of mean (Russell *et al*., 2017), the latter representing the most conservative layer available. This layer only encompassed those grey seals estimated to be at-sea rather than those at haul-out sites. The 'seal pupping and haul-out' dataset captures grey seal haul out areas (see below).

Scoring process

The Grey Seal at Sea layer was classified into three classes (low, medium and high) according to the density distribution values provided by Russell *et al*. (2017). Statistical functions of GIS (Jenks natural breaks) were used to identify suitable values for class separation and assist with classification (see Classification (spatial occurrence)). The resulting GIS outputs (data classes) were then checked visually and agreed with NRW to ensure that they provided a good representation of the spatial occurrence of the respective features.

Weighting (conservation importance) was then assigned in accordance with the conservation protection afforded to grey seal under the Habitats Directive (see Table 8). As an Annex II and V species it was assigned the highest weighting (5).

The complexity adjustment was then applied to the initial score dependent on the sector technology/activity being considered (see Table 9).

Cetacean distribution

A study by Waggitt *et al*., (2019) provides predicted density distributions for all regularly occurring marine mammals in the North-East Atlantic at monthly intervals at a resolution of 10 x 10 km. However, a notable and stated omission by the authors is the coastal ecotype of bottlenose dolphin (e.g. Cardigan Bay population). The density distribution of the coastal ecotype is considered relatively well known (see Reid *et al*., 2003) with detailed distribution maps of bottlenose dolphin provided in the Atlas of Marine Mammals of Wales (Baines and Evans, 2012). As defined by Waggitt *et al* (2019), the bottlenose dolphin

offshore ecotype encompassed by their study relates to those dolphins beyond 30 km from the coastline. Consideration of the bottlenose dolphin coastal ecotype data was thus addressed through the Atlas of Marine Mammals of Wales dataset (see below).

Acknowledging the cetacean species which were considered most as risk from focus sector development in Welsh waters (see above) the derived dataset encompassed distribution data relating to:

- Bottlenose Dolphin (offshore ecotype)
- Risso's Dolphin
- Short beaked Common Dolphin
- Harbour Porpoise
- Minke Whale

As a precautionary approach, the data represented by the 'upper' density predictions of the study were selected and the monthly data outputs summed to generate one set of values per grid cell for each species.

Scoring process

Each species layer was classified into three classes (low, medium and high) according to the spatially predicted density distribution. Statistical functions of GIS (Jenks natural breaks) were applied to find suitable values for class separation and assist with classification (see Classification (spatial occurrence)). The resulting GIS outputs (data classes) were then checked visually and agreed with NRW technical specialists, to ensure that they provided a good representation of the spatial occurrence of the respective features.

Weighting (conservation importance) was then assigned to each classified species layer according to the conservation protection afforded to these cetacean species under the Habitats Directive (see Table 8).

The complexity adjustment was then applied to the 'initial score' dependent on the sector technology/activity being considered (see Table 9).

Seal pupping and haul-out sites (grey seal)

Along the Welsh coast, there are a number of recorded grey seal pupping and haul-out sites. Grey seals have clearly defined life stages (pupping and moulting) when they may be more sensitive to impacts, such as disturbance. Haul-out sites that allow seals to carry out activities such as moulting and pupping are important for the general health of seal populations. The importance of these sites is such that previous representations of the data have been aggregated to 5 km squares to dissemble the exact location of these sites.

A seal pupping and haul-out dataset was received from NRW in 2019; however, after workshops in January 2020 it was identified that this dataset only represented data from Westcott and Stringell (2004) and Baines *et al* (1995), and that these should be merged with more recent datasets i.e. Strong *et al* (2006), and Clarke *et al* (2020). As there was a significant amount of overlap between these datasets, site locations from different survey programmes with the same site code name were removed to avoid duplication. Ultimately, the amalgamation of these datasets into one master dataset, resulted in many more seal pupping and haul out sites than had been realised through the initial dataset received in 2019.

Although the importance of pupping sites is apparent, those haul-out areas where no pupping has been observed also have an important role for the continued health of grey seal populations (Stringell pers. comm.). For example, the West Hoyle Sandbank at the mouth of the River Dee is considered one of the most important non-breeding grey seal haul-out sites in the Irish and Celtic Seas. Furthermore, despite some female seals displaying a preference for traditional pupping sites, recent trends indicate that pupping sites are expanding in their extent. Thus, a haul-out site with historic records of no pups may yet be used as a pupping site in the future. Acknowledging the importance of both pupping and non-breeding haul out sites, for the purposes of the Study the conservation importance of these sites is not differentiated. However, where the data allowed (i.e. Westcott and Stringell, 2004; Clarke *et al*., 2020) these sites were distinguished within the derived dataset to provide the user with additional information and potentially future proof the dataset.

The spatial extent of the Study matches Welsh waters as defined by EEZ boundary; however, as the classification stage for seal haul-out sites applies a score to cells at 1 km or less from the haul-out site, the spatial extent of the generated constraint layer extends 1 km from the EEZ boundary. It should be noted that haul-out sites exist which are just beyond this extent and thus will not be picked up during the analyses (e.g. West Hoyle Sandbank). Such omissions are a limitation placed on the plan-level assessment and further highlight the importance and requirement for detailed project level assessment. It is, however, considered that the general importance of waters in the wider area of such haul-out sites was acknowledged through the analysis of the Grey Seal at Sea dataset (see above).

Scoring process

The scoring process was applied in a binary context to this dataset. After a number of iterations, it was concluded that classification would need to be represented by the binary values 1 and 0, with '1' being applied to grid cells that were a kilometre or less from the seal haul-out locations (see below). All other grid cells were assigned a classification of '0'.

Weighting (conservation importance) was then assigned in accordance with the conservation protection afforded to grey seal under the Habitats Directive (see Table 8). As an Annex II and V species it was assigned the highest weighting (5).

The complexity adjustment was then applied to the initial score dependent on the sector (or sector technology/activity) being considered (see Table 9).

Applying the generic rules in a consistent manner to this dataset resulted in scores which were significantly greater than that generated from other marine mammal datasets. This occurred to such a degree that early versions of the marine mammal spatial constraint layer (Step 5) were completely overshadowed by the scores from this dataset. Interrogation of the analyses found that the comparatively higher scores generated at three grid cells directly adjacent to Ramsey Island had a significant influence on the final output. This was accountable to the grid cells overlapping with the 1 km proximity from comparatively high numbers of seal haul-out sites.

The spatial extent of the grid encompassed 32,340 1 km^2 cells. To moderate the influence of this dataset on the final outputs a cap was placed on the individual scoring value which one grid cell could attain through this dataset for a particular sector. This cap essentially affected the three grid cells adjacent to Ramsay Island only, with maximum scores of the dataset constraint layer limited to:

- Tidal Stream (all technologies) 1000
- Wave Energy (all technologies) 800
- Aquaculture (all activities) 800

Furthermore, the binary classification was assigned as 1 rather than 3 for presence, due to the high number of overlaps (see above). In all sectors it was found that these moderations allowed greater interpretation of the overall marine mammal constraints without loss of the notable constraints in relation to seal haul-outs around Ramsey Island.

Atlas of Marine Mammals of Wales

The cetacean distribution dataset (see above) does not encompass density distribution of bottlenose dolphin encountered within 30 km from the coastline (coastal ecotype). Distribution maps by Baines and Evans (2012) are thought to well-represent the distribution of the coastal ecotype of this species. Hence, the Atlas of Marine Mammals of Wales dataset (Baines and Evans, 2012) has been used to derive distribution of bottlenose dolphin in Welsh waters within 30 km from the Welsh coastline.
Unlike the Waggitt *et al.* (2019) study which uses modelled predictions to provide an indication of density distribution, the Atlas of Marine Mammals of Wales is based on sighting rates per hour for bottlenose dolphin (see Baines and Evans, 2012).

The dataset used to present cetacean distribution on the WMPP (Reid *et al.*, 2003) is older than the Baines and Evans (2012) study and at a lower resolution. Hence, the Baines and Evans (2012) data were selected.

Scoring process

Each bottlenose dolphin layer was classified into three classes (low, medium and high) according to the recorded density distribution. Statistical functions of GIS (Jenks natural breaks) were applied to find suitable values for class separation and assist with classification (see Classification (spatial occurrence)). The resulting GIS outputs (data classes) were then checked visually and agreed with NRW, to ensure that they provided a good representation of the spatial occurrence of the respective features.

Weighting (conservation importance) was then assigned to the bottlenose dolphin layer according to the conservation protection afforded to this species under the Habitats Directive (see Table 8). As an Annex II and IV species it was assigned the highest weighting (5).

The complexity adjustment was then applied to the initial score dependent on the sector (or sector technology/activity) being considered (see Table 9).

Designated sites for marine mammals (ecological)

There are a number of International (Ramsar), European (SACs) and national (MCZs and SSSIs) sites across Welsh waters which have marine mammals as qualifying features. Where these sites are present there is likely to be an increased consenting risk to the operation of the sectors.

The boundaries of these sites are well defined, and the dataset encompasses Ramsar, SAC, MCZ and SSSI layers. This dataset is available on the Lle geoportal and was assessed as high confidence (Appendix C). Scoring was only applied to those sites which encompassed marine mammals as a qualifying feature, noting that Category D features (those considered as a non-significant presence at a site) were not included.

Other nationally designated sites, such as Areas of Outstanding Natural Beauty (AONB), are not specifically relevant to ecological features and are not encompassed by the Study.

Scoring process

The scoring process was applied in a binary context to this dataset. For each designated site layer, a classification value of '3' was applied to grid cells that overlapped or were within the designated site boundary. All other grid cells were assigned a classification of '0'.

Weighting (conservation importance) was then assigned as follows:

- Ramsar 5
- SAC 5
- MCZ 5
- SSSI 3

As previously discussed, as this dataset did not consider an individual species or habitat feature, or groups of these features, then the product of the classification and weighting represented the 'final' score i.e. no complexity adjustment was applied.

Differences in consenting risk relative to designated sites are directly linked to the legislation which underpins their conservation protection. For example, carrying out operations from any of the sectors within the boundary of a European or Internationally designated site (SAC or Ramsar) would require a Habitats Regulations Assessment (HRA) to enable a consent decision to be made. Currently, the only marine conservation zone (MCZ) in Welsh waters is Skomer MCZ. There are a number of byelaws attached to the Skomer MCZ, such as the restriction of activities which would disturb wildlife, and all activities are subject to voluntary codes of conduct. Prior to being established as a MCZ in 2014, the area was a Marine Nature Reserve for 24 years. Accordingly, the highest level of conservation importance (5) is assigned to this site.

In some instances, there were multiple designated sites that occupied the same grid cell. This was to be expected, as many of the designated sites overlap e.g. Skomer MCZ, West Wales Marine SAC and Pembrokeshire Marine SAC. The scores of any overlapping designated sites were cumulatively scored within the grid cells to produce a single constraint dataset layer for designated sites in relation to marine mammals (see Step 4).

Fish

Following workshops with NRW, Welsh Government and Cefas the following datasets were used for consideration of fish constraints in Welsh waters (see Table 2):

- Spawning grounds
- Nursery areas
- Basking Sharks
- Migratory fish
- Designated sites

All these datasets were assessed as medium confidence except 'migratory fish' and 'designated sites' which were both assessed as high confidence (see Table 2 and Appendix C).

Detail on assigning classification is provided specifically for each dataset selected (see below). Weighting of individual or groups of fish features was assigned according to the conservation designations in Table 10. Specific detail on the approach for each dataset is provided below.

Within the Study there was no discrimination of migratory fish species due to the lack of sufficient data to determine their distribution and density across Welsh waters. Annex II migratory fish species in Wales are limited to sea lamprey, river lamprey, allis shad, twaite shad and Atlantic salmon. Yet, sea trout and European eel are both regularly occurring migratory fish in Wales and, although not designated under the Habitats Directive these species, along with Arctic char and sparling, are on the Section 7 list. As a precautionary approach, the migratory fish feature was afforded the highest conservation importance (5) to ensure all migratory fish were treated the same (see Table 10).

Table 10. Weighting (conservation importance) assigned to fish features according to conservation protection provisions

Conservation Designation	Weighting
Annex II species and/or migratory fish	5
Section 7/OSPAR species (only)	3
All other	1

There are a number of non-migratory fish species on the Section 7 list, which includes many commercial fish species. Detail on the conservation importance value applied to each individual fish feature is given within the dataset subsections below.

The product of the classification and weighting stages for each dataset resulted in an initial score. Acknowledging the potential differences in consenting complexity that exist between individual fish features, or groups of fish, relevant to a sector (or sector technology/activity), a complexity adjustment factor was then applied to the initial score (see Table 11) of those datasets which encompassed individual fish features (datasets in bold above). The factor was applied according to defined criteria (see Complexity Adjustment) across all sector technologies and activities.

The benthic spawning nature of cod and herring, and in the case of herring, the requirement for quite specific seabed types (Boyle and New, 2018), was acknowledged within the complexity adjustment. These considerations leading to comparatively higher values than afforded to other fish features.

Table 11. Complexity adjustment matrix for fish features

Species	TS (SB)	TS (MW)	TS (SU)	Wave (SB)	Wave (SU)	Aq (BI)	Aq (SW)
Anglerfish	2	2	2	1	1	1	1
Blue Whiting	2	2	2	1	1	1	1
Cod	3	2	1	2	1	1	1
Common Skate	2	2	1	1	1	1	1
Hake	2	2	1	1	1	1	1
Herring	3	2	2	2	1	1	1
Horse Mackerel	2	2	2	1	1	1	1
Ling	2	2	1	1	1	1	1
Mackerel	2	2	2	1	1	1	1
Plaice	2	2	1	1	1	1	1
Sandeel (Ammodytidae)	3	2	2	1	1	1	1
Sole	2	2	1	1	1	1	1
Spotted Ray	2	2	1	1	1	1	1
Spurdog	2	2	2	1	1	1	1
Thornback Ray	2	2	1	1	1	1	1
Tope	2	2	2	1	1	1	1
Undulate Ray	2	2	1	1	1	1	1
Whiting	2	2	1	1	1	1	1
Basking Shark	2	2	2	2	2	1	1
Migratory Fish	3	3	3	2	2	1	1
Sectors: TS (Tidal Stream), Wave (Wave Energy) and Aq (Aquaculture). Technologies Activities: SB (seabed), MW (mid-water), SU (surface), BI (bivalve) and SW (seaweed).							

Reflective of the varied factor values assigned (Table 11) resulted in spatial constraint layers (Step 5) relevant to the following:

- Tidal Stream
  - Seabed mounted
  - Mid-water
  - Surface emergent
- Wave energy
  - Seabed mounted
  - Surface emergent
- Aquaculture

Spawning grounds

As the most sensitive period of the fish life cycle, identification and consideration of known spawning areas is important for plan and project level assessment.

The spawning grounds dataset used in the Study was directly derived from studies by Coull *et al.* (1998) and Ellis *et al.* (2012), both of which are publicly available on the Cefas Data Hub.

The most recent herring spawning data was encompassed by the Coull *et al.* (1998) dataset. Whereas more recent data covering the period up to and including 2010 (see Ellis *et al.,* 2012) was available for the following fish taxa:

- Cod
- Hake
- Horse Mackerel
- Ling
- Mackerel
- Plaice
- Sandeel (Ammodytidae)
- Sole
- Whiting

Therefore, the spawning ground dataset was amalgamated from data from the Coull *et al*. (1998) and Ellis *et al*. (2012) studies. Data on the distribution of the planktonic stages of fish eggs and larvae (ichthyoplankton) were collated from numerous surveys carried out by Cefas and associated UK fisheries laboratories, and from internationally-coordinated ichthyoplankton surveys (for further detail on data collation and methodology see Ellis *et al*., 2012).

At over 20 years old and 10 years old respectively, the Coull *et al*. (1998) and Ellis *et al*. (2012) data resulted in an overall confidence assessment of medium being assigned to the spawning ground dataset.

The effects of warming seas from climate change and fishing pressure may have influenced the distribution of spawning areas since the data was collected. As noted by Boyle and New (2018), several of the data layers used to define the dataset are based on habitat maps of very coarse resolution. Furthermore, much of the survey work used to inform the spawning and nursery datasets was carried out in water depths of >20 m, therefore coastal and estuarine environments, which are important fish spawning and nursery areas, are not well represented (see Ellis *et al*., 2012).

Fish surveys, including those used to inform the spawning and nursery datasets, are often carried out on an annual basis, and so do not encompass seasonality in fish distributions. It is recognised that some

fish species may exhibit pronounced seasonal patterns in either distribution or abundance. Other species may have more restricted seasonal changes in distribution (e.g. moving into deeper water during the winter) (Ellis *et al*., 2012). Such seasonal considerations may be made within the required project level assessment, as appropriate. However, the data selected represent the most up to date and accurate maps of spawning and nursery grounds currently available for Welsh waters.

Scoring process

Work by Ellis *et al*. (2012) assigned the spawning grounds of the selected fish taxa into two categories: low and high intensity. A classification value was applied based on grid cell overlap with these areas. Thus, the scoring process was applied in a binary context to this dataset. For each individual layer, a classification value of '3' was applied to grid cells that overlapped or were within high intensity areas and a classification value of '1' applied to grid cells which overlapped or were within low intensity areas. All other grid cells were assigned a classification of '0'.

Weighting was then allocated according to the conservation importance of each fish feature (Table 12). The spawning data only encompasses non-migratory fish taxa, most of which are Section 7 species. Fish from the family Ammodytidae were not speciated, Ellis *et al*. (2012) noting that these are very difficult to speciate in the field. Thus, all sandeel were recorded as Ammodytidae. Within the Welsh Section 7 species list only the sandeel *Ammodytes marinus* is covered; hence, as a precautionary approach Ammodytidae were assigned the same conservation importance (see Table 12).

Table 12. Weighting (conservation, ecological and commercial importance) assigned to fish taxa encompassed by spawning data

Fish Taxa	Common Name	Conservation Importance
Ammodytidae	Sandeel	3
Clupea harengus	Herring	3
Gadus morhua	Cod	3
Merlangius merlangus	Whiting	3
Merluccius merluccius	Hake	3
Molva molva	Ling	3
Pleuronectes platessa	Plaice	3
Scomber scombrus	Mackerel	3
Solea solea	Sole	3
Trachurus trachurus	Horse Mackerel	3

Dependent on the sector (or sector technology/activity) being considered, the complexity adjustment was then applied to each taxon (see Table 11).

Nursery grounds

This dataset is directly derived from the Ellis *et al*. (2012) report and covers the following selected fish taxa many of which are commercial:

- Anglerfish
- Blue Whiting
- Cod
- Common Skate
- Hake
- Herring
- Horse Mackerel

- Ling
- Mackerel
- Plaice
- Sandeel (Ammodytidae)
- Sole
- Spotted Ray
- Spurdog
- Thornback ray
- Tope
- Undulate Ray
- Whiting

Data from national groundfish surveys were used to support the identification of nursery grounds. Detail on these surveys including the methodology is provided in the Ellis *et al*. (2012) report.

Collected over 10 years ago, the Ellis *et al*. (2012) dataset was assigned a medium confidence assessment (Appendix C). The effects of warming seas from climate change and fishing pressure may have influenced the distribution and extent of nursery areas. As noted by Boyle and New (2018), several of the data layers used to define the dataset are based on habitat maps of very coarse resolution. Furthermore, much of the survey work used to inform the spawning and nursery datasets was carried out in water depths of >20 m, therefore coastal and estuarine environments are not as well represented (see Ellis *et al*., 2012). Coastal and estuarine habitats are particularly important for the earliest life history stages of several fish species.

Fish surveys, including those used to inform the spawning and nursery datasets, are often carried out on an annual basis, and so do not encompass seasonality in fish distributions. It is recognised that some fish species may exhibit pronounced seasonal patterns in either distribution or abundance. Other species may have more restricted seasonal changes in distribution (e.g. moving into deeper water during the winter) (Ellis *et al*., 2012). Such seasonal considerations may be made within the required project level assessment, as appropriate. However, the data selected represent the most up to date and accurate maps of spawning and nursery grounds currently available for Welsh waters.

Scoring process

Work by Ellis *et al*. (2012) assigned the nursery grounds of the selected fish taxa into two categories: low and high intensity. Grid cell overlap with these areas resulted in a classification value being applied. Thus, the scoring process was applied in a binary context to this dataset. For each individual layer, a classification value of '3' was applied to grid cells that overlapped or were within high intensity areas and a classification value of '1' applied to grid cells which overlapped or were within low intensity areas. All other grid cells were assigned a classification of '0'.

Weighting was then allocated according to the conservation importance of each fish feature (Table 13). The Ellis *et al*. (2012) nursery data only encompasses non-migratory selected fish taxa, which are commercial and/or have high ecological value, most of which are Section 7 species. As noted above, (the family Ammodytidae was considered to represent the Section 7 species *Ammodytes marinus*.

The complexity adjustment was then applied to the initial score in relation to each taxa and dependent on the sector (or sector technology/activity) being considered (see Table 11).

Table 13 Weighting (conservation importance) assigned to fish taxa encompassed by nursery data

Common name	Fish Taxa	Conservation Importance
Anglerfish	*Lophius piscatorius*	3
Blue Whiting	*Micromesistius poutassou*	1
Cod	*Gadus morhua*	3
Common Skate	*Dipturus batis*	3
Hake	*Merluccius merluccius*	3
Herring	*Clupea harengus*	3
Horse Mackerel	*Trachurus trachurus*	3
Ling	*Molva molva*	3
Mackerel	*Scomber scombrus*	3
Plaice	*Pleuronectes platessa*	3
Sandeel	Ammodytidae	3
Sole	*Solea solea*	3
Spotted Ray	*Raja montagui*	1
Spurdog	*Squalus acanthias*	3
Thornback Ray	*Raja clavata*	3
Tope	*Galeorhinus galeus*	3
Undulate Ray	*Raja undulata*	3
Whiting	*Merlangius merlangus*	3

Basking sharks

Basking sharks have the potential to be impacted by operational activities of the focus sectors. The Marine Conservation Society (MCS) basking shark watch project provides sightings data of basking shark from a 20-year period covering data from 1987 – 2006 and were reviewed by Bloomfield and Solandt (2010).

The dataset represents a long-term time series of basking shark sightings that pulls together multiple sources of data. The spatial distribution score is determined by grouping the sightings data points into a 5 km^2 grid. From this dataset the resulting densities of basking sharks within Welsh waters were fewer than 1 or 2 per 5 km^2. However, the conservation importance of basking shark in Wales is recognised by their inclusion on the Section 7 species list.

Scoring process

It was the intention that the basking shark layer would be classified into three classes, low, medium and high; according to the recorded observations (see Bloomfield and Solandt, 2010) with classification applied as 1, 2 or 3 respectively. As the number of observations across the dataset ranged from 0-2, applying the statistical functions 'Jenks natural breaks' resulted in three discrete categories for 0, 1 and 2; however, to avoid scoring zero observations a value of '1', this was assigned a zero.

The resulting GIS outputs (data classes) were then checked visually and agreed with NRW technical specialists to ensure that they provided a good representation of the spatial occurrence of the basking shark data.

Weighting (conservation importance) was assigned in accordance with the conservation protection afforded to basking sharks (see Table 10). Thus, as a Section 7 species it was assigned a conservation importance value of 3.
The complexity adjustment was then applied to the initial score in relation to basking shark dependent on the sector (or sector technology/activity) being considered (see Table 11).

Migratory fish

Migratory fish species are an important consideration for consenting of marine developments and therefore their presence can affect the relative spatial constraints for a given sector. Data layers of migratory fish species across Welsh marine waters are not currently available. There are several Welsh SACs which have migratory fish (Annex II) as qualifying features and the relevant marine SACs are captured within the designated sites dataset for fish features (see below). Migratory fish are also qualifying features of the Severn Estuary Ramsar and a number of SSSIs.

Although migratory fish are qualifying features of many freshwater SACs in Wales, these designated areas are outside the consideration of this Study. It is also recognised that there are several migratory fish species which despite being a consenting consideration, are not Annex II features (e.g. European eel, sea trout, sparling).

Assuming that one or more migratory fish species (e.g. European eel, sea trout, twaite shad, Atlantic salmon etc.) would passage through estuaries, either upstream or downstream, a proxy layer was generated to highlight the importance of such estuarine areas for migratory fish. Following a workshop discussion with NRW, it was decided that a layer aligned with the NRW Article 17 (Annex I) estuaries layer but with an extension buffered to 1 km seaward of the lower boundary of all Annex I estuary features would be used to indicate areas of relative increased constraint in relation to migratory fish.

Thus, this dataset layer does not differentiate between species, distribution or densities but provides precautionary recognition of a likely constraint across a broad area consistent with marine and transitional waters i.e. the estuary and marine waters immediately seaward of the lower estuary boundary. Passage of migratory fish species through estuarine waters is often related to fairly well-defined seasonal periods. Although such seasonal considerations of migration may be made within the required project level assessment, as appropriate, at a plan level it is assumed that these constraints are always present. This approach is suitable when considering operational and therefore long-term activities of the focus sectors.

Scoring process

The scoring process was applied in a binary context to this dataset. A classification value of '3' was applied to grid cells which overlapped or were within the migratory fish layer (Article 17 estuary and 1 km extension boundary) (see above). All other grid cells were assigned a classification of '0'.

Conservation importance was then assigned a value of 5 (see Table 10), as it was not possible to accurately discriminate migratory fish species with different conservation designations i.e. Annex II species from those which are only listed on Section 7.

The complexity adjustment was then applied to the initial score dependent on the sector (or sector technology/activity) being considered (see Table 11).

Designated sites for fish (ecological)

There are a number of International (Ramsar), European (SACs) and national (MCZs and SSSIs) sites across Welsh waters which have fish as qualifying marine features. Where these sites are present there is likely to be an increased consenting risk to the operation of the sectors.

The boundaries of these sites are well defined, and the dataset encompasses Ramsar, SAC, MCZ and SSSI layers. This dataset is available on the Lle geoportal and was assessed as high confidence (Appendix C). Scoring was only applied to those sites which encompassed fish as a qualifying feature,

noting that Category D features (those considered as a non-significant presence at a site) were not included.

Scoring process

The scoring process was applied in a binary context to this dataset. For each designated site layer, a classification value of '3' was applied to grid cells that overlapped or were within the designated site boundary. All other grid cells were assigned a classification of '0'.

Weighting (conservation importance) was then assigned to those designated sites which have fish as qualifying features as follows:

- Ramsar 5
- SAC 5
- MCZ 5
- SSSI 3

As previously discussed, as the designated sites dataset did not consider an individual species or habitat feature, or groups of these features, then the product of the classification and weighting represented the 'final' score i.e. no complexity adjustment was applied.

Differences in consenting risk relative to designated sites are directly linked to the legislation which underpins their conservation protection. For example, carrying out operational activities from any of the sectors within the boundary of a European or Internationally designated site (SAC or Ramsar) would require a Habitats Regulations Assessment (HRA) to enable a consent decision to be made. Currently, the only marine conservation zone (MCZ) in Welsh waters is Skomer MCZ. There are a number of byelaws attached to Skomer MCZ, such as the restriction of activities which would disturb wildlife, and all activities are subject to voluntary codes of conduct. Prior to being established as a MCZ in 2014, the area was a Marine Nature Reserve for 24 years. Accordingly, the highest level of conservation importance (5) is assigned to this site.

In some instances, there were multiple designated sites that occupied the same grid cell. This was to be expected, as many of the designated sites overlap e.g. Skomer MCZ and Pembrokeshire Marine SAC. The scores of any overlapping designated sites were cumulatively scored within the grid cells to produce a single constraint dataset layer (Step 4) for designated sites in relation to fish.

Habitats

Following workshops with NRW and WG the following datasets were used for consideration of habitat constraints in Welsh waters (see Table 2):

- Annex I (Article 17 features)
- Section 7 and OSPAR habitats
- Section 7 and OSPAR species
- Designated sites

A confidence assessment was carried out on all these datasets (see Appendix C).

All Annex II species relevant to the Study were encompassed through the other broad interest features e.g. grey seal (marine mammals), bottlenose dolphin (marine mammals), sea lamprey (fish) etc. However, as there are benthic invertebrate species on the Section 7 and OSPAR list, these species were given due consideration within the habitats broad interest feature.

Detail on assigning classification is provided specifically for each dataset selected (see below). Weighting of habitat features (Article 17, Section 7, OSPAR) and relevant benthic species (those on the Section 7 and/or OSPAR list), was assigned according to their conservation designation (see Weighting (Conservation Importance)) (see Table 14). Specific detail on the scoring approach for each dataset is given below.

Table 14. Weighting (conservation importance) assigned to habitat (and benthic species) features according to conservation protection provisions

Conservation Designation	Weighting
Annex I (Article 17) feature (where present within a SAC as a qualifying feature)	5
Section 7/OSPAR features (habitats and species)	3
Annex I (Article 17) feature (where outside a SAC, or inside a SAC but not a qualifying feature)	2

SSSI marine habitats and benthic species features are part of the intertidal environment with the lower boundary of marine SSSIs extending to MLWS. In many cases, there are five or more habitat features within a single SSSI, some of which are already a Section 7/OSPAR or Article 17 habitat. For example, Dyfi SSSI contains saltmarsh and estuaries, both are Section 7 and Article 17 features.

While the SSSIs and their features are an important consideration for any development, a number of the intertidal features are captured within the Section 7/OSPAR or Article 17 datasets. Scoring of all the SSSI features, often five or more for an individual site, would skew the outputs, downplaying the relative consenting risk within subtidal areas and resulting in significantly higher relative consenting risk visualised within intertidal environments.

At a broader level, SSSIs are already acknowledged within the designated site dataset (see below). Owing to many overlapping designations within the intertidal environment e.g. Ramsar, SAC, SSSI and MCZ; and that intertidal and estuarine features are also captured within the Article 17 and Section 7 / OSPAR datasets, it was considered that adequate acknowledgement is made to intertidal habitats and species within the analysis without the inclusion of distinct SSSI features.

The product of the classification and weighting stages for each dataset resulted in an initial score. Acknowledging the potential differences in consenting risk that exist between habitat features and benthic species, relevant to a sector (or sector technology/activity), a complexity adjustment factor was then applied to the initial score (see Table 15 and

Table 16) of those datasets which encompassed individual habitat or benthic species features. The factor was applied according to defined criteria (see Complexity Adjustment) across all sectors and broad sector technologies and activities.

The outputs from the complexity adjustment process resulted in habitat spatial constraint layers (Step 5) relevant to the following sectors and sector technologies:

- Tidal Stream
  - Seabed
  - Mid water and surface

- Wave energy
  - Seabed
  - Surface
- Aquaculture
  - Bivalve
  - Seaweed

Table 15. Complexity adjustment matrix for habitat features

Feature	TS (SB)	TS (MW)	TS (SU)	Wave (SB)	Wave (SU)	Aq (BI)	Aq (SW)
Article 17 features							
Estuaries	1	1	1	1	1	1	1
Large Shallow Inlets and Bays	1	1	1	1	1	1	1
Saline lagoons	1	1	1	1	1	1	1
Maerl	3	3	2	3	2	3	2
Mudflats and sandflats	2	2	2	2	2	2	1
Intertidal reef	1	1	1	1	1	2	1
Subtidal reef	3	2	2	3	2	2	2
Saltmarsh	1	1	1	1	1	1	1
Sand banks	2	1	1	2	1	1	1
Sea caves	1	1	1	2	2	1	1
Methane derived authogenic carbonates	3	2	2	3	2	1	1
Section 7/OSPAR habitats							
Intertidal boulder communities	1	1	1	1	1	2	1
Sabellaria alveolata reefs	2	2	2	2	2	2	1
Estuarine rocky habitats	1	1	1	1	1	2	1
Coastal saltmarsh	1	1	1	1	1	1	1
Intertidal mudflats	2	2	2	2	2	2	1
Seagrass beds	3	2	2	2	2	2	1
Sheltered muddy gravels	1	1	1	1	1	2	2
Peat and clay exposures	1	1	1	1	1	1	1
Tidal swept channels	2	2	2	2	2	1	1
Fragile sponge & anthozoan communities on subtidal rocky habitats	3	3	3	3	2	1	1
Carbonate reefs	3	2	2	3	2	1	1
Subtidal mixed muddy sediments	2	1	1	2	1	1	1
Subtidal sands and gravels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mud habitats in deep water	2	2	2	2	2	2	1
Musculus discors beds	3	2	2	3	2	2	2
Blue mussel beds	3	2	2	3	2	2	2
Horse mussel beds	3	3	3	3	2	3	2
Maerl beds	3	3	2	3	2	2	2
Saline lagoons	1	1	1	1	1	1	1
Sabellaria spinulosa reefs	3	2	2	3	2	2	2
Seapens and burrowing megafauna	3	2	2	3	2	2	2
. Note that the Section 7 large-scale feature 'subtidal sands and gravels' is not included within the analysis							

Table 16. Complexity adjustment matrix for Section 7/OSPAR benthic species. Note that fan mussel, spiny lobster and oyster were not encompassed by the study (see below).

Species	TS (SB)	TS (MW)	TS (SU)	Wave (SB)	Wave (SU)	Aq (BI)	Aq (SW)
Lagoon sea slug (*Tenellia adspersa*)	1	1	1	1	1	1	1
Tentacled lagoon worm (*Alkmaria Romijni*)	1	1	1	1	1	1	1
Common maerl (*Phymatolithon calcareum*)	2	1	1	2	1	2	1
Peacock's tail (*Padina pavonica*)	1	1	1	2	2	1	1
Stalked Jellyfish (*Lucernariopsis campanulata*)	2	1	1	2	1	2	1
Coral maerl (*Lithothamnion corallioides*)	2	1	1	2	1	2	1
Kaleidoscope Jellyfish (*Haliclystus auricula*)	2	1	1	2	1	2	1
Seaweed (*Grateloupia montagnei*)	2	1	1	2	1	2	1
Lagoon sand shrimp (*Gammarus insensibilis*)	1	1	1	1	1	1	1
Pink sea-fan (*Eunicella verrucosa)*	3	1	1	2	1	1	1
Burrowing anemone (*Edwardsia timida*)	2	1	1	2	1	2	1
A red seaweed (*Cruoria cruoriiformis*)	2	1	1	2	1	2	1
Icelandic cyprine or Ocean quahog (*Arctica islandica*)	2	1	1	2	1	2	1
Bearded red seaweed (*Anotrichium barbatum)*	2	1	1	2	1	2	1

Article 17 (Annex I habitats)

A number of habitats in Welsh waters are classified as Article 17 features. Under Article 17 of the EU Habitats Directive, member states are required to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. In Welsh waters, habitat features under Article 17 are Annex I features (or sub-features) found in Wales (see Table 17).

Two of the Article 17 features are large scale i.e. estuaries and large shallow inlets and bays. These encompass many component and sub-feature habitats. Although the presence of component and sub-features will have the potential to increase consenting complexity, the broader large-scale features would also be considered. Thus, both the large-scale features and their component habitats were scored where they overlapped with grid cells.

Saline lagoons are partially or wholly separated from the marine environment by sandbanks, shingle, rocks or sluices. Although an important coastal feature, it is considered that their onshore situation limits the potential for impacts from operation of the focus sectors to occur. This resulted in a complexity adjustment of '1' being applied across all sectors for saline lagoons and relevant lagoonal species (Section 7/OSPAR species).

Table 17. Annex I habitats and corresponding Article 17 features and subfeatures

Annex I habitat	Article 17 Feature and Sub-feature
Coastal lagoons	Saline lagoons
Estuaries	Estuaries
Large shallow inlets and bays	Large shallow inlets and bays *Maerl (as a sub-feature)*
Mudflats and sandflats not covered by seawater at low tide	Mudflats and sandflats
Reefs	Intertidal reef Subtidal reef
Saltmarsh	Saltmarsh
Sandbanks which are slightly covered by seawater all the time	Sand banks
Submerged or partially submerged sea caves	Sea caves
Submarine structures made by leaking gases	Methane derived authogenic carbonates

Scoring process

A classification value was applied according to presence/absence of an Article 17 habitat. Thus, the classification score was applied in a binary context to this dataset with a classification value of '3' applied to 1 km^2 grid cells which captured the location of an Article 17 habitat. All other grid cells were assigned a classification value of '0'.

Weighting was then allocated according to the conservation importance of each feature (Table 14). In this dataset, weighting was applied as 5 or 2, depending on whether the feature was located within a SAC for which it was a qualifying feature, or not.

Dependent on the sector (or sector technology/activity) being considered, the complexity adjustment was then applied to each habitat feature (see Table 15).

Section 7 and OSPAR habitats

This dataset details the extent and location of those marine habitats classed of "Principle Importance" under Section 7 and are regarded as "threatened or declining" under OSPAR in Wales. Some habitats are listed under either Section 7 or OSPAR, while others are listed under both. These habitat features are considered of key significance to sustain and improve biodiversity in Wales. On account of their designations they are afforded protection and thus sustainable development of the focus sectors requires careful consideration of these features.

The Section 7 feature 'subtidal sands and gravels' encompasses a wide range of discrete habitats across Welsh waters and is thus extremely widespread. Furthermore, the Article 17 feature 'sandbanks' already captures the large subtidal sand feature in Wales. Following agreement with NRW specialists this broad feature type, 'subtidal sands and gravels', was removed from the analysis.

Scoring process

A classification value was applied according to presence/absence of a Section 7 habitat (as listed in Table 15). Thus, the classification score was applied in a binary context to this dataset with a classification value of '3' applied to 1 km^2 grid cells which captured the location of a Section 7 habitat. All other grid cells were assigned a classification value of '0'.

Weighting (importance) was then assigned in accordance with the conservation designation afforded to Section 7 features (see Table 14) i.e. a value of '3' was applied.
Dependent on the sector (or sector technology/activity) being considered, the complexity adjustment (factor) was then applied to each habitat feature (see Table 15).

Section 7 and OSPAR species

The Section 7 and OSPAR species spatial dataset details the location of those marine species classed of "Principle Importance" under Section 7 and are regarded as "threatened or declining" under OSPAR in Wales. Some species are listed under either Section 7 or OSPAR, while others are listed under both. These features are considered of key significance to sustain and improve biodiversity in Wales.

On account of their designations they are afforded protection and thus sustainable development of the focus sectors requires careful consideration of these features. It should be noted that this dataset does not include records of several Section 7 species including the fan mussel (*Atrina fragilis*), native oyster (*Ostrea edulis*) and spiny lobster *(Pagurus elephas*). At this time, there are only two records for fan mussel publicly available, both of which are >50 years old (NBN Atlas, 2020[25]), while the spatial resolution of records for oyster and spiny lobster is restricted to 10 km squares.

There are many records for the ocean quahog (*Arctica islandica*) across Welsh waters, particularly inshore; however, as a long-lived species many of these include records from >30 years ago, with at least one record from >100 years (NBN Atlas, 2020[26]). Validation of these historic records is required to confirm the continued existence of an individual at a location and if there are more individuals in the same area. However, these records are currently encompassed by the analysis.

Scoring process

A classification value was applied according to presence/absence of a Section 7 species (as listed in

Table 16 Thus, the classification score was applied in a binary context to this dataset with a classification value of '3' applied to 1 km^2 grid cells which captured the recorded location of a Section 7 species. All other grid cells were assigned a classification value of '0'.

Weighting (importance) was then assigned in accordance with the conservation designation afforded to Section 7 features (see Table 14) i.e. a value of '3' was applied.

Dependent on the sector (or sector technology/activity) being considered, the complexity adjustment (factor) was then applied to each species feature (see

[25] Accessed online 03/07/20 at: https://nbnatlas.org/
[26] *ibid*

Table 16).Designated sites for habitats (ecological)
There are many International (Ramsar), European (SACs) and national (MCZs and SSSIs) sites across Welsh waters which have habitats and/or benthic species as qualifying marine features. Where these sites are present there is likely to be an increased consenting risk to the operation of the sectors.

The boundaries of these sites are well defined, and the dataset encompasses Ramsar, SAC, MCZ and SSSI layers publicly available on a number of websites including the Lle geoportal. This dataset was assessed as high confidence (Appendix C). Scoring was only applied to those sites which encompassed habitats/benthic species as qualifying features, noting that Category D features (those considered as a non-significant presence at a site) were not included.

Scoring process

The scoring process was applied in a binary context to this dataset. For each designated site layer, a classification value of '3' was applied to grid cells that overlapped or were within the designated site boundary. All other grid cells were assigned a classification of '0'.

Weighting (importance) was then assigned to those designated sites which have habitats/benthic species as qualifying features:

- Ramsar 5
- SAC 5
- MCZ 5
- SSSI 3

As previously discussed, as the designated sites dataset did not consider an individual species or habitat feature, or groups of these features, then the product of the classification and weighting represented the 'final' score i.e. no complexity adjustment was applied.

Differences in consenting risk relative to designated sites are directly linked to the legislation which underpins their conservation protection. For example, carrying out operations from any of the sectors within the boundary of a European or Internationally designated site (SPA or Ramsar) would require a Habitats Regulations Assessment (HRA) to enable a consent decision to be made. Currently, the only MCZ in Welsh waters is Skomer MCZ. There are a number of byelaws attached to Skomer MCZ, such as the restriction of activities which would disturb wildlife, and all activities are subject to voluntary codes of conduct. Prior to being established as a MCZ in 2014, the area was a Marine Nature Reserve for 24 years. Accordingly, the highest level of conservation importance (5) is assigned to this site.

In some instances, there were multiple designated sites that occupied the same grid cell. This was to be expected, as many of the designated sites overlap e.g. Skomer MCZ and Pembrokeshire Marine SAC. The scores of any overlapping designated sites were cumulatively scored within the grid cells to produce a single constraint dataset layer for designated sites in relation to habitats/benthic species (see Step 4).

4.4 Step 4: Dataset derived outputs

Following application of the scoring process to a selected BIF dataset, a single output (dataset derived output) was generated which was specific to the sector (or sector technology/activity) and the dataset.

The number of dataset derived outputs for a sector was dependent on whether differences in the complexity adjustment values existed within a given BIF between the various sector technologies/activities. For example, with marine mammals all complexity adjustment values were the same across tidal stream technologies (Table 9), therefore the number of dataset derived outputs, five,

aligned with the number of selected datasets. Whereas, due to seabirds having varied complexity adjustment values for tidal stream technologies (see Table 4), there were thirteen dataset derived outputs for this sector in relation to seabirds.

4.5 Step 5: Spatial constraints layers

Once all BIF dataset derived outputs were generated for a sector (or sector technology/activity), then these were effectively overlaid and the score within each grid cell of the dataset outputs was summed (see Figure 2). This produced a single summed score within each 1 km^2 grid cell of Welsh waters.

The result from this step was a series of sector (or sector technology/activity) specific feature constraint layers that had distinct scoring outputs:

- Tidal Stream:
  - Seabirds
    - Seabed
    - Mid water
    - Surface
  - Marine mammals
  - Fish
    - Seabed
    - Mid water
    - Surface
  - Habitats
    - Seabed
    - Mid water
    - Surface
- Wave Energy:
  - Seabirds
    - Seabed
    - Surface
  - Marine mammals
  - Fish
    - Seabed
    - Surface
  - Habitats
    - Seabed
    - Surface
- Aquaculture:
  - Seabirds
  - Marine mammals
  - Fish
  - Habitats
    - Bivalve
    - Seaweed

4.6 Step 6: Constraints and opportunities maps (final outputs)

A key opportunity for sustainable development of the sectors is the availability of suitable resource in areas of low constraint. Previous work has already identified areas of key resource (RAs) specific to each

of the sectors[27]. With recognition to the work already undertaken to identify resource opportunities, the final step of the methodology overlaid the RAs for each sector upon relevant spatial constraints layers for each BIF.

From an ecological context, the opportunities for a given sector can partially be inferred from those RAs which have relatively lower ecological constraints in Welsh waters. As the final outputs from the Study, the constraints and opportunities maps are provided along with an accompanying narrative of the potential ecological constraints and opportunities within a RA or groups of RAs, in addition to consideration of wider Welsh waters (see Figure 3 to Figure 38). These outputs are also available through an interactive platform within the online evidence package resource[28]. Interrogation of the online outputs is recommended to understand the derivation of relative constraints and degree of the datasets' contribution to the level of constraint (per grid cell).

27 https://gov.wales/sites/default/files/publications/2019-11/welsh-national-marine-plan-document_0.pdf
28 https://gov.wales/sustainable-management-marine-natural-resources

5 Outputs

A description of the final outputs is provided which is broken down by sector technology/activity with a focus on the relative constraints within and around the relevant RAs or groups of RAs, for each sector. As previously discussed, the break down into technology types or, in the case of aquaculture, activity types was to capture the differences in the sensitivities of individual features (species or habitats) to the various sector technologies/activities and ultimately the likely differences in consenting uncertainties and complexity. However, following analysis and the production of the final mapping outputs, visible differences between the sector technologies/activities tended to be minimal resulting in the key messages from the narrative being comparable.

Within the mapping outputs, the relative distribution of constraints normalises the overall spatial representation. Therefore, when comparing a given sector's technology/activity outputs, the change to scores, resulting from changes applied to complexity values, often fell within the same gradation banding. This resulted in very similar patterning, despite cell scores varying between different technology outputs for a specific BIF. Furthermore, the scoring contributions of datasets to a cell did not generally alter between different technologies/activities of a sector because, with the exception of the designated sites dataset, all datasets were affected by the changes to the complexity values. Over time, as the approach continues to develop and more evidence becomes available, then this may result in more visibly distinct outputs between sector technologies/activities.

As previously indicated (Section 4.1.2) careful consideration has been given to gaps in the datasets which may then falsely convey an area of relative opportunity. While it has been possible to depict gaps in survey coverage for empirical datasets (i.e. Seabirds at Sea), gaps in datasets such as the Article 17 habitat features and Section 7/OSPAR features which represent an amalgamation of many different survey outputs over various years and using different methodologies, are not depicted. This should be acknowledged when viewing the habitat outputs, especially within offshore environments where survey coverage is likely to be less comprehensive. It should also be acknowledged that much of the spatial data for each of the BIFs has been derived through predictive modelling outputs.

The outputs were necessarily conservative and at various phases in both the application of the general methodology and the specific dataset rules, a precautionary approach was adopted (see Scope and Assumptions; Dataset Scoring). The outputs should be viewed with careful consideration against the key assumptions required to implement this plan level work (see Section 3.2); in addition to practical limitations placed on the Study, such as the reliance on some datasets which were more than 10 years old. Furthermore, the outputs are only representative of potential ecological constraints and do not consider social and economic opportunities and constraints which would also be of relevance to these sectors.

It is important that the mapping outputs are considered independently for each sector and each BIF. Due to unavoidable differences between the ecological feature datasets and the relative constraint scoring, it is not appropriate or beneficial to consider the cumulative outputs from two or more interest features i.e. overlaying the maps for multiple BIFs would not provide a meaningful output. Neither are the scoring outputs cross-comparable between sectors e.g. the marine mammals' output for tidal stream should not be compared to aquaculture.

5.1 Tidal stream energy

Following application of the methodology, ten discrete mapping outputs were generated for tidal stream (see Step 5) encompassing the BIFs. Tidal stream was divided into three major technology types, surface, mid-water and seabed mounted, as these have the potential for quite different levels of exposure to the BIFs (see Scope and assumptions).

5.1.1 General narrative

Tidal energy generation is an emerging industry within Welsh waters, and there are currently no commercial scale tidal stream energy arrays installed. The WNMP highlights that there is a substantial tidal stream energy resource at several locations within Welsh inshore waters, mainly where water flows are restricted, such as within narrow channels and around coastal headlands where the constriction of flow accelerates the tidal current (Roche *et al*., 2016).

Inshore, close to the coast, many areas of suitable tidal stream resource are located around headlands, peninsulas and islands. The tidal stream RAs around Anglesey, Llyn Peninsula, to the west of Pembrokeshire and off the south coast of Wales overlap with important habitats for seabirds, mammals and fish while also supporting an array of diverse benthic communities.

5.1.2 Birds

Welsh waters

In relation to birds, the areas of relatively higher potential constraint in Welsh waters are generally driven by inclusion of seabird colonies and the foraging ranges of resident populations, especially where these overlap with SPAs (e.g. around Anglesey; Bardsey, and Milford Haven) (see Figure 3). At a localised level the potential higher constraints along the coastline are largely representative of bird colonies and foraging areas. Moving offshore, the relatively higher constraints are largely defined by mean foraging distances from colonies overlapping with offshore waters. The Seabirds at Sea dataset indicated greater relative density distribution of seabirds near colonies. Away from the coastline, for example, in the waters west of Pembrokeshire, to the south and south east of Llyn Peninsula, to the west and north west of Anglesey and along the north coast of Wales, the main contributor towards constraints was from the Seabirds at Sea dataset and thus the relative density of seabirds from the rationalised list (see Table 5).

From the Seabirds at Sea dataset there were several gaps in the survey coverage which overlapped with the most offshore RAs, to the west of the Llyn Peninsula (see Figure 4). However, these had no effect on the overall scoring output.

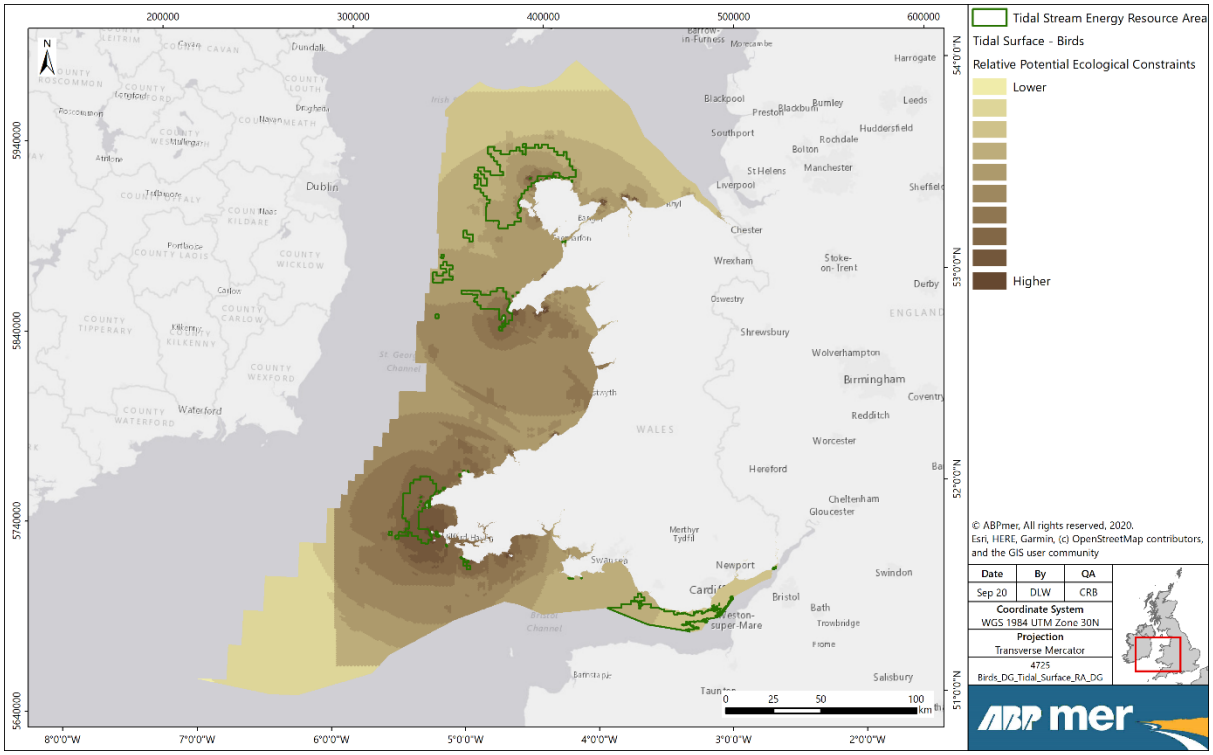

Figure 3. **Relative potential ecological constraints in relation to birds for tidal stream surface technology**

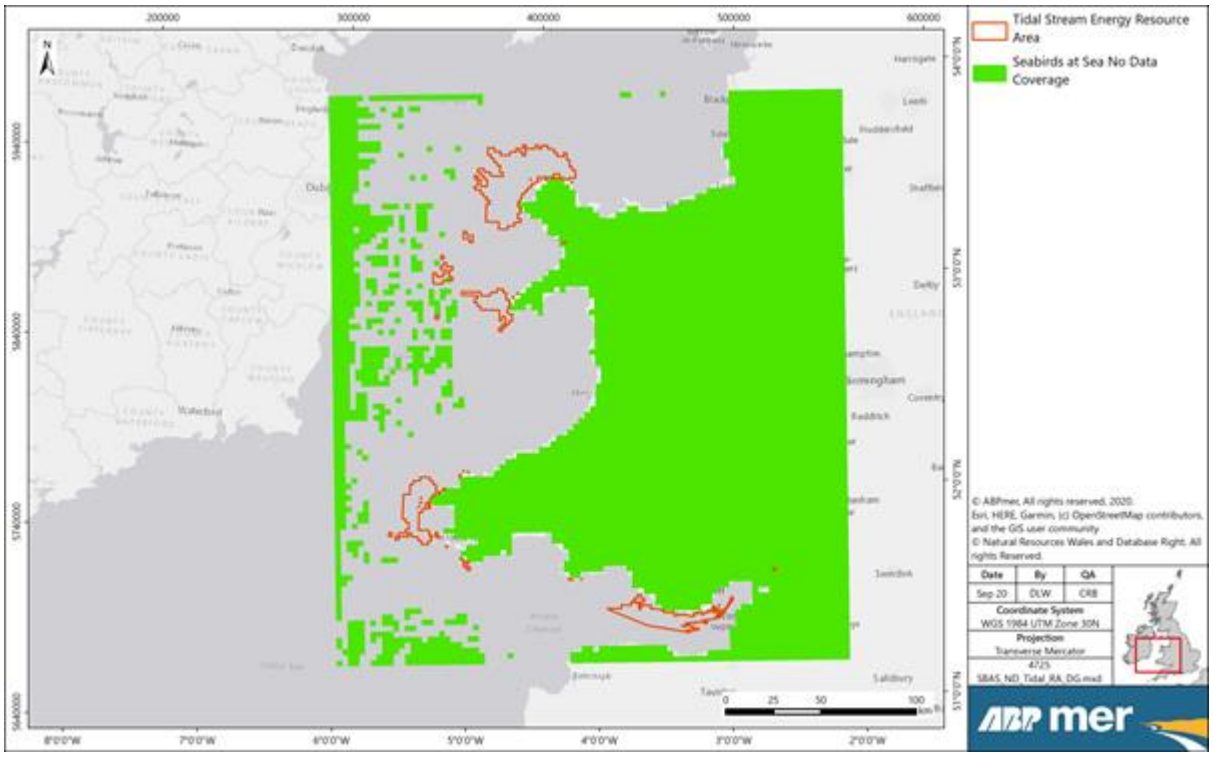

Figure 4. **Indication of those areas where no data exists for the Seabirds at Sea dataset. Tidal Stream energy RAs are shown**

Tidal Stream RAs (tidal surface)

Along the north coast of Anglesey, inshore, the relatively high constraints in relation to birds are restricted to localised areas, for example, around the Skerries and Middle Mouse (see Figure 3). There are important Tern colonies in this area (e.g. Skerries, Cemlyn Lagoon) which overlap with the Anglesey Terns SPA; however, when compared to some seabird species (e.g. Gannet, Guillemot, Kittiwake, Razorbill etc.) Terns have comparatively limited foraging ranges. In the most offshore regions of this RA, to the north-west of Anglesey, the relative constraints are comparable to those indicated within the Severn Channel, being notably lower than those indicated inshore to Anglesey and around the Llyn Peninsula and Pembrokeshire coastline.

Towards the limit of Welsh waters, about 50 km west of the Llyn Peninsula the small tidal stream RAs overlap with areas of relatively low constraints, although the foraging ranges of birds at colonies such as Carreg y Llam (Guillemot) and Bardsey (i.e. Fulmar, Puffin and Manx Shearwater) contribute to the grid scores at these offshore locations.

Around the Llyn Peninsula and Bardsey Island, the presence of the Aberdaron Coast and Bardsey Island SPA along with the seabird colonies at Carreg Llam, Bardsey and Ynysoedd Gwylan are the main influence to the relatively higher constraints indicated (Figure 3).

To the south, around the west coast of Pembrokeshire, the analysis indicated waters in this region to have extensive areas of relatively high constraints for birds. Contributing to the high scores here is the Skomer, Skokholm and the Seas off Pembrokeshire SPA, and the multiple bird colonies along the north coast, and especially at Ramsey Island, Bishops and Clerks, Skomer, Grassholm, and Skokholm. Many of the seabirds at these colonies have mean foraging ranges of >50 km (e.g. Gannet, Puffin, Fulmar). The RSPB dataset also indicates hotspots for utilisation of these waters by Guillemot, Shag and Razorbill.

In the Bristol Channel and towards the mouth of the Severn Estuary the bird constraints are relatively low when compared to the other Tidal Stream RAs. There is no overlap with SPAs; however, the eastern end of the RA is adjacent to the Severn Estuary Ramsar site. There are relatively few seabird colonies in the area, the Lesser Black Backed Gull population at Flatholm being the closest. The low number of colonies is reflected in the comparatively low density distributions indicated by the Seabirds at Sea dataset.

Tidal Stream RAs (mid water)

The final outputs relevant to mid-water technology (see Figure 5), showed a very similar pattern to that of surface technology and the text above remains relevant. Appreciating that surface feeding birds are less likely to be exposed to mid-water technologies, a slightly different complexity adjustment value was applied to these species (Table 4). This did not result in any significant changes in the overall contributions of the selected datasets within the RAs from that indicated through the surface water technology output.

The entire extent of the RA in the Bristol Channel, with the exception of the far western edge, overlapped with an area of minimal bird constraints to this device type. This is a reflection of the low number of colonies and/or low incidence of diving seabirds (e.g. Guillemot, Puffin, Razorbill etc.) when compared to the other RAs.

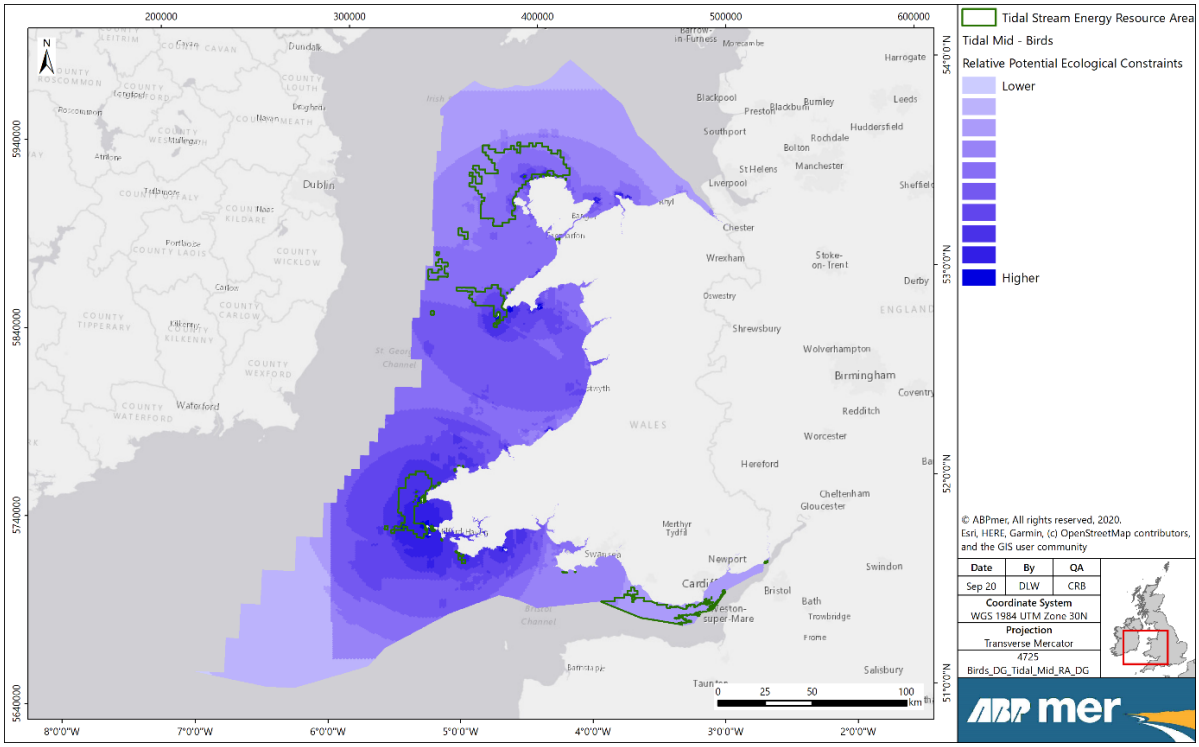

Figure 5. **Relative potential ecological constraints in relation to birds for tidal stream mid-water technology**

Tidal Stream RAs (seabed)

The final outputs for seabed technology (see Figure 6) showed an almost identical pattern to that of mid-water technology, and thus little difference from surface water outputs, consequently the text for surface water technology remains relevant.

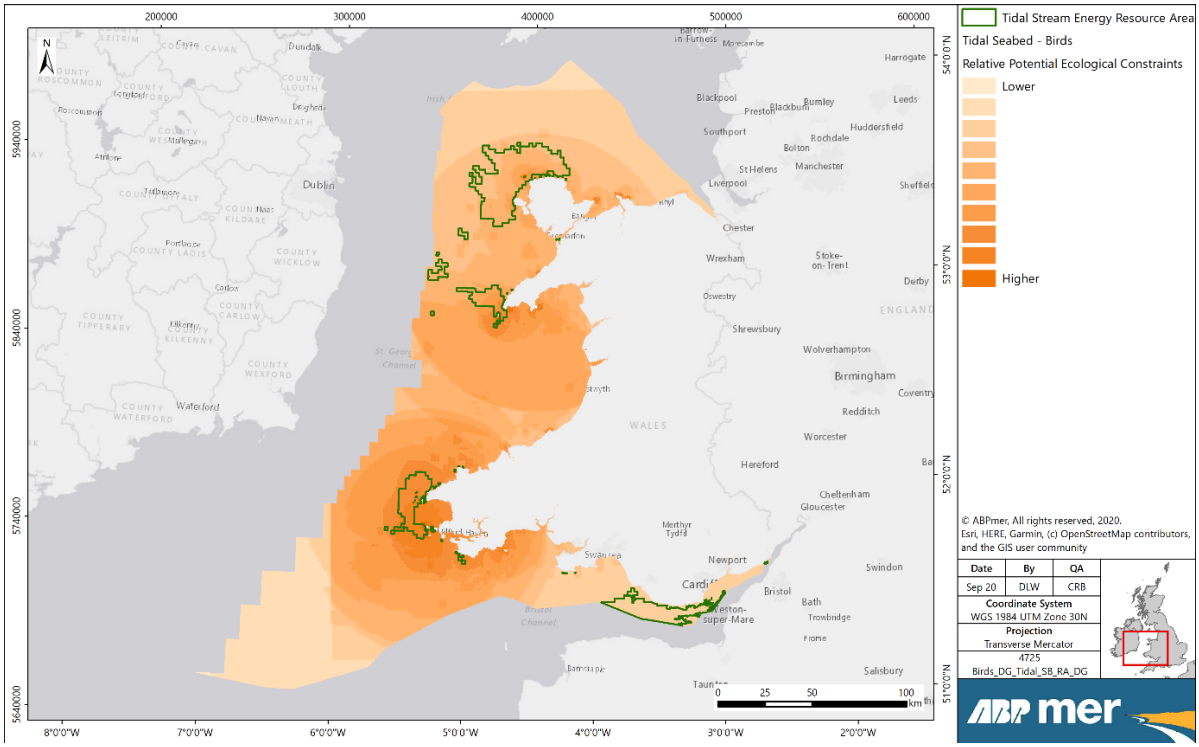

Figure 6. **Relative potential ecological constraints in relation to birds for tidal stream seabed technology**

Appreciating that only deep diving birds are likely to be exposed to seabed technologies, the complexity adjustment value discriminated these bird species (Table 4). In terms of the outputs, this did not result in any significant changes in the contributions of the selected datasets within the RAs from that indicated by the surface water or mid water technology outputs.

However, the output indicated that the entire extent of the RA in the Bristol Channel overlapped with an area of minimal bird constraint. This is a reflection of the low number of colonies and/or low incidence of diving seabirds (e.g. Guillemot, Puffin, Razorbill etc.) when compared to the other RAs.

5.1.3 Marine mammals

Welsh waters

In relation to marine mammals, very close inshore, the areas of relatively higher constraint are a result of grey seal haul out and pupping locations, especially where these overlap with SACs which have marine mammals as a qualifying feature (e.g. around Anglesey; Bardsey, and Milford Haven) and the MCZ at Skomer (see Figure 7). Slightly further offshore the key contributors to a relatively higher constraints score tend to be cetacean and grey seal distribution and the presence of designated sites. Inshore, along the mid Wales coastline in particular, but also to the east of Anglesey, the distribution of the coastal bottlenose dolphin ecotype also contributes heavily to the overall constraints.

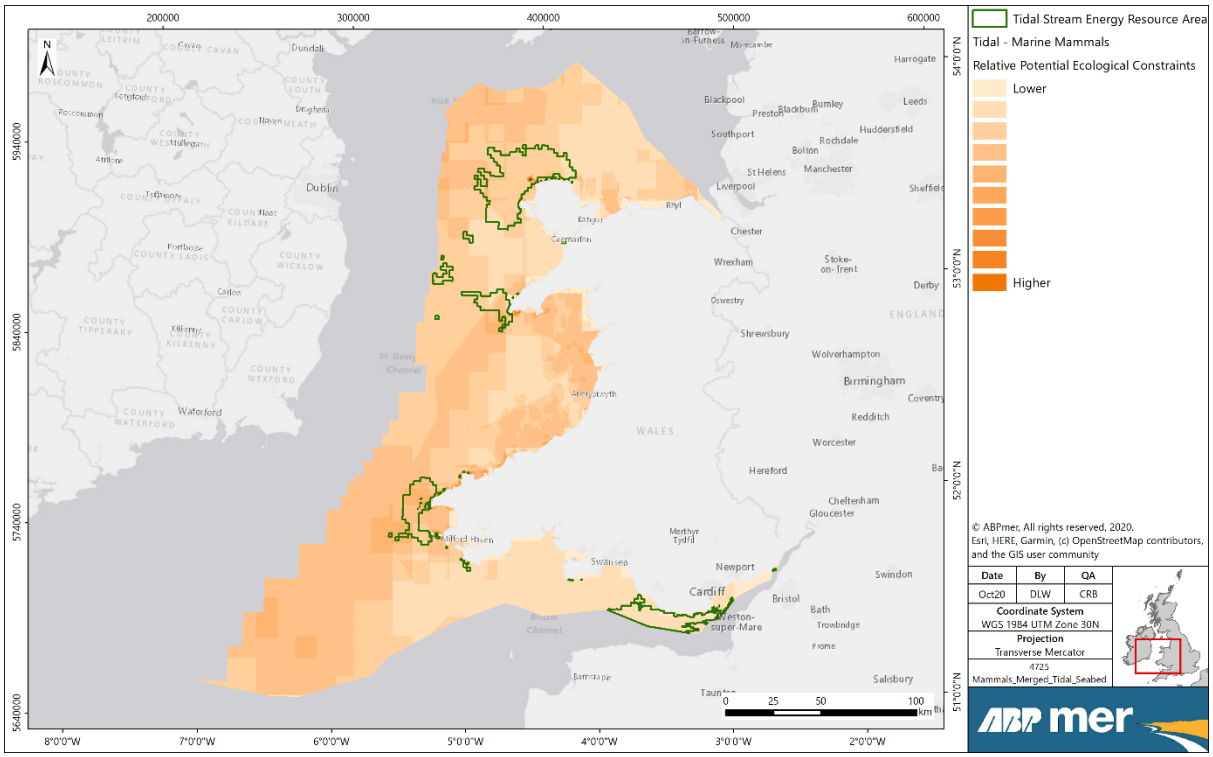

Figure 7. Relative potential ecological constraints in relation to marine mammals for tidal stream technology

From the southern coast of Pembrokeshire to the Severn Estuary, comparatively low constraints were indicated, particularly east from the Mumbles. With the exception of harbour porpoise, cetacean density distribution is indicated as low in this area. There are no important seal haul out sites and no SACs with marine mammals as qualifying features east of the Bristol Channels Approaches SAC.

Given the available evidence, it was considered that there was no potential for significantly different levels of exposure to marine mammals form the varied tidal stream technologies (seabed, mid-water, surface). Hence, the finalised mapping output was relevant to all tidal stream technologies.

Tidal Stream RAs (seabed, mid-water and surface)

Around the north coast of Anglesey high relative constraints were indicated at a localised level around the Skerries and Middle Mouse. In the water around the Skerries the higher constraints were indicative of the proximity to seal haul out sites, the relatively higher density distribution of harbour porpoise and the overlapping SAC (North Anglesey Marine SAC). The increased presence of harbour porpoise and bottlenose dolphin contributing most to the higher relative constraints around Middle Mouse. Moving offshore, the increased occurrence of cetaceans such as harbour porpoise but also minke whale, Risso's dolphin and common dolphin is the main contributor to the constraint output in this RA (see Figure 7). Similarly, this is true for the offshore RAs approximately 50 km to the west of Llyn Peninsula and the western region of the RA that extends from the Llyn Peninsula.

Close inshore to the Llyn Peninsula and Bardsey Island, the presence of multiple seal haul-out sites and consequent increases in grey seal distribution contribute most to the relatively high constraints. However, a few km from the coastline it is the density distribution of cetaceans such as minke whale, Risso's dolphin and common dolphin which are the main influence on the relative constraints, along with the presence of two SACs with overlapping boundaries (Llyn Peninsula and Sarnau SAC; West Wales Marine SAC).

Around Pembrokeshire, especially along the north coastline, are many important seal haul-out and pupping sites. The relatively high constraints shown are mainly indicative of the multiple seal haul out sites along the north coast, Ramsey Island and Skomer Island. There are also multiple European designated sites that overlap with the RA (i.e. Pembrokeshire Marine SAC; West Wales Marine SAC;) and nationally designated sites (e.g. Skomer MCZ; Skomer Island and Middleholm SSSI; St David's Peninsula Coast SSSI etc.). Offshore, it is the density distribution of cetaceans such as minke whale, Risso's dolphin and common dolphin which are the main influence on the relative constraints, along with the presence of the two SACs and north west of St Davids Head, and the increase in grey seal usage.

Relatively low marine mammal constraints are indicated across the southern-most RA for tidal stream (see Figure 7). There are no important seal haul out sites in the area, nor overlapping or adjacent SAC or SSSI sites with marine mammals as features. Along the most inshore regions of the RA the main contributor to the relative constraints reflect grey seal usage of these waters, while the presence of harbour porpoise is the main contributor to the remainder of the RA.

5.1.4 Fish

Welsh waters

The relative constraints in relation to fish are largely a result of overlaps with spawning and nursery grounds (see Ellis *et al.*, 2012). The spatial data layers from this dataset are very broad, subsequently resulting in the broad patterning visualised by the mapping outputs.

Along the north coast of Wales, coincidence with the Dee Estuary Ramsar site and SAC, important migratory fish routes and fish spawning areas to the north of Rhyl, result in relatively high constraints (see Figure 8). Across the top of Anglesey, the presence of nursery and spawning grounds contribute most to the constraint; although the overall indication is comparably lower constraints than to the east of Anglesey. Close inshore, at the mouths of estuaries along the mid-Wales coastline, constraints are indicated as a result of migratory fish corridors. Offshore, the main contributing factors to the constraints are the presence of fish spawning areas and the Cardigan Bay SAC to the south. Around the Pembrokeshire coastline there are multiple designated sites which along with fish nursery grounds contribute to the level of constraint. Spawning and nursery grounds for multiple fish species are found offshore to the south of Pembrokeshire. To the east of the Bristol Channel the overall constraints are lower than many other areas of Welsh waters, especially inshore. However, the constraints increase again heading into the Severn Estuary signifying the importance of this area for migratory fish and the presence of designated sites for fish (e.g. Severn Estuary SAC; Severn Estuary Ramsar).

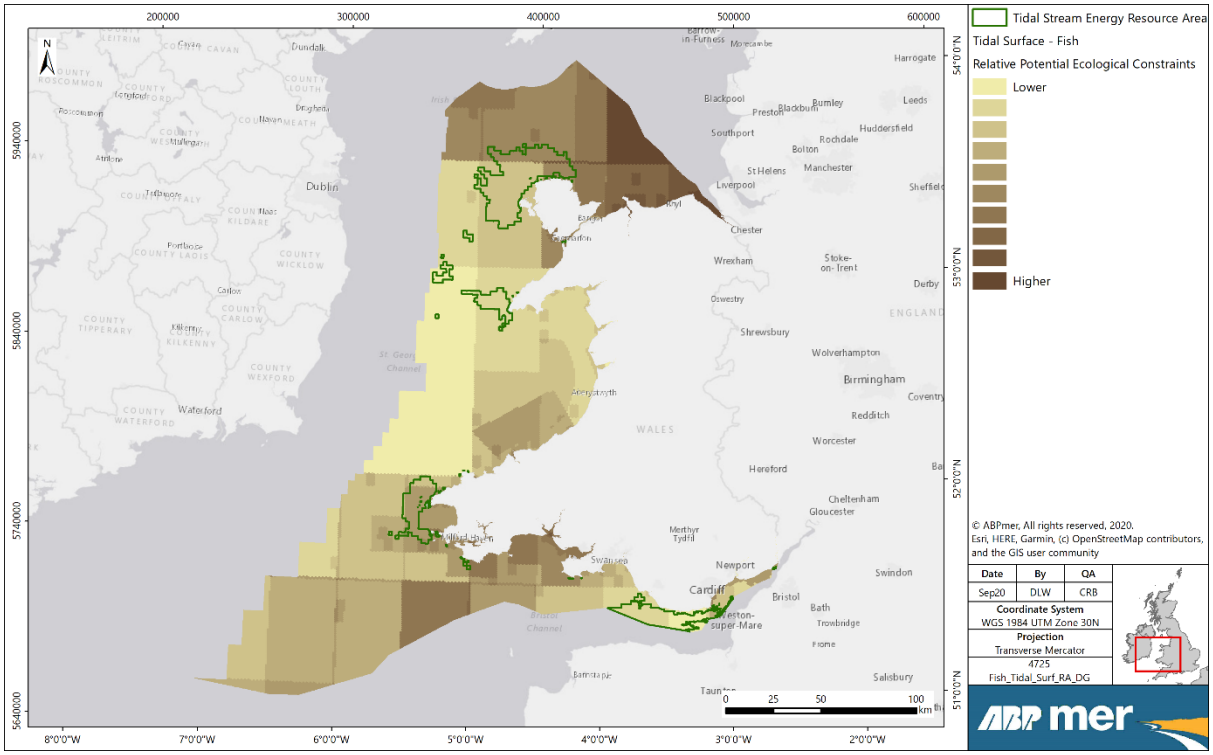

Figure 8. Relative potential ecological constraints in relation to fish for tidal stream surface technology

Tidal Stream RAs (surface)

Around the north coast of Anglesey, the higher relative constraints are in the offshore regions of the RA. This is largely the result of identified nursery grounds. However, much of the RA has comparably lower fish constraints, due to minimal nursery and spawning grounds in this region.

For the offshore RAs approximately 50 km to the west of the Llyn Peninsula, fish constraints are comparatively low, there being few identified nursery and spawning grounds of selected fish taxa in this area. There are no designated European sites with fish as qualifying features around the Llyn Peninsula, and it is the multiple spawning grounds of fish such as cod, plaice and mackerel that provide the main contributor to the constraints.

Off the west coast of Pembrokeshire, it is the presence of a number of fish nursery grounds, the overlap with the European designated site (Pembrokeshire Marine SAC) and, at a more localised level, the Skomer MCZ which lead to the comparatively highest constraints for fish indicated within a tidal stream RA. Much of the RA off the southern most coast of Wales has comparatively lower constraints than indicated in other RAs (see Figure 8). Where the eastern extent of this RA overlaps with the Severn Estuary SAC there is an important migratory route for many fish species, and the constraints here are notably higher than elsewhere within the RA. Immediately to the northeast of this area, outside the RA and along the coast, is the Severn Estuary Ramsar site which is designated for its assemblage of migratory fish species.

Tidal Stream RAs (mid water)

The final outputs relevant to mid-water technology (see Figure 9), showed an almost identical pattern to that of surface technology and the text above remains relevant. Minor changes in the outputs are generally reflective of the differing complexity adjustment values assigned to cod, sandeel and herring taxa for this seabed technology.

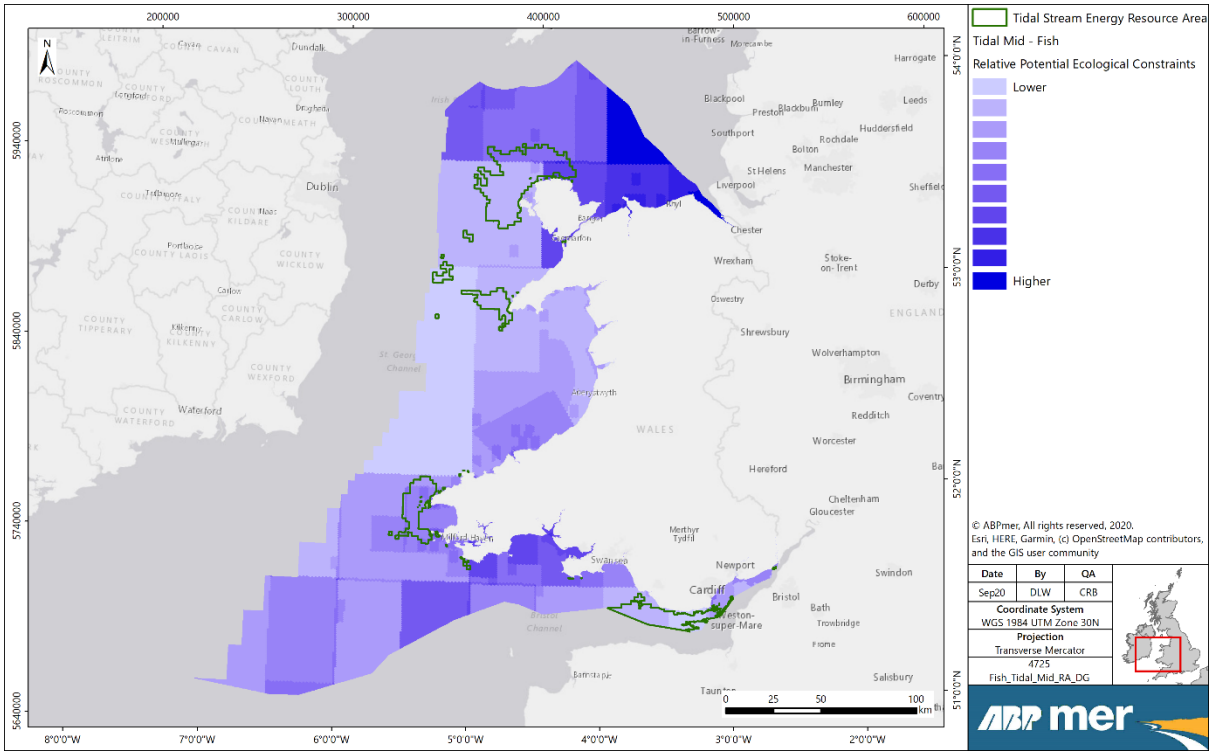

Figure 9. **Relative potential ecological constraints in relation to fish for tidal stream mid-water technology**

Tidal Stream RAs (seabed)

The final outputs relevant to seabed technology (see Figure 10), showed a very similar pattern to that of surface technology and mid-water, hence the text above remains relevant.

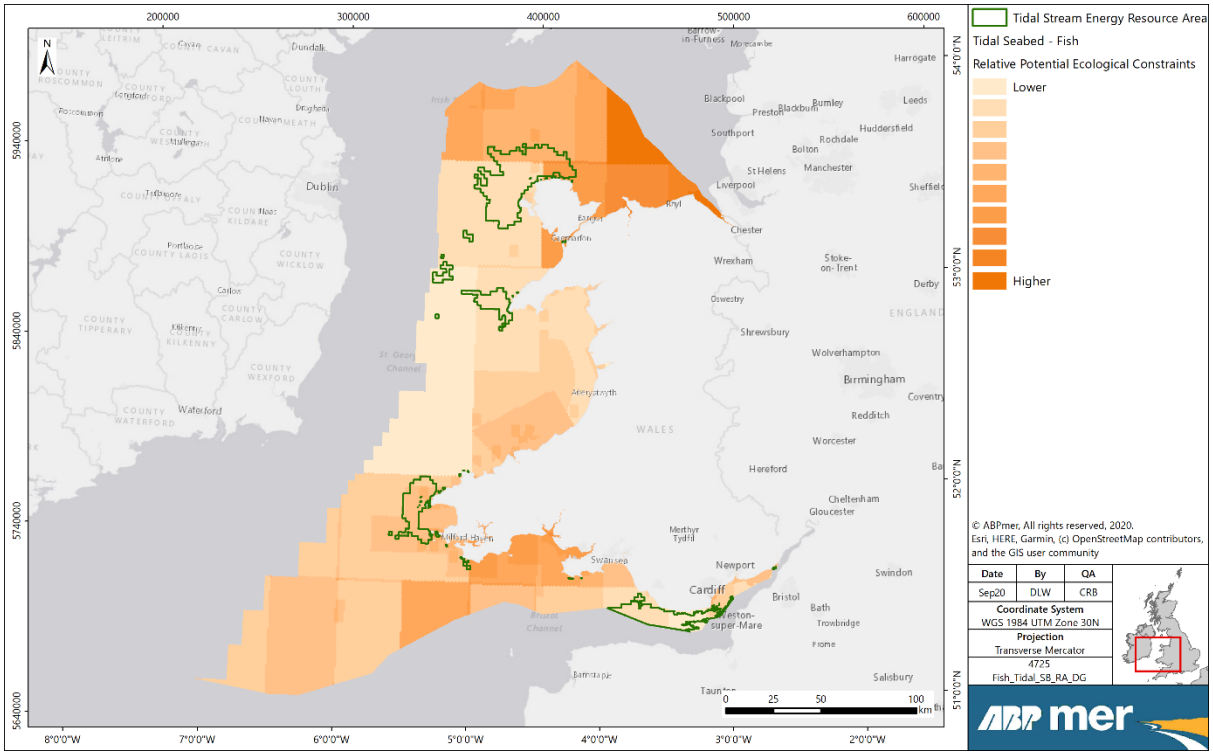

Figure 10. **Relative potential ecological constraints in relation to fish for tidal stream seabed technology**

Minor changes in the outputs are generally reflective of the differing complexity adjustment values assigned to cod, sandeel and herring taxa for this seabed technology.

5.1.5 Habitats

Welsh waters

Inshore along the Welsh coastline, the relative constraints are notably higher than offshore environments (see Figure 11), noting that data gaps are more prevalent in offshore locations (see below). More than 10-20 km offshore are extensive areas identified as being of relatively low constraints based on current data availability, such as to the east and far north of Anglesey, to the west of mid Wales, and in the south west. Offshore, the pattern of constraints is largely indicative of mixed muddy sediment or reef habitats. Within estuaries the constraints are elevated and the result of multiple Section 7 and/or Article 17 features being present.

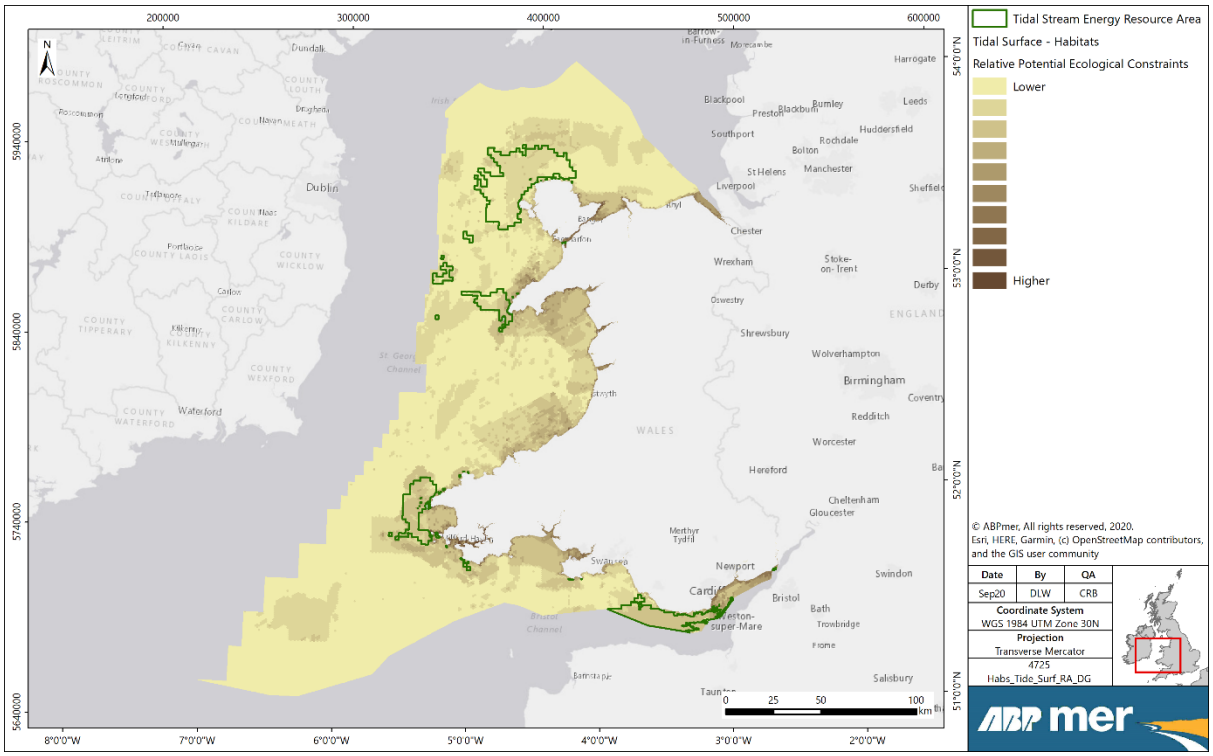

Figure 11. Relative potential ecological constraints in relation to habitats for tidal stream surface technology

Designated sites have a strong influence on the constraints e.g. Llyn Peninsula and the Sarnau SAC, Cardigan Bay SAC and Pembrokeshire Marine SAC. The pattern of constraints is also indicative to the presence of reef and estuarine features, both of which are Article 17 features encompassing a variety of other designated (Article 17, Section 7, OSPAR) habitats and species.

The habitat datasets (i.e. Article 17/Annex I features; Section 7/OSPAR habitats; Section 7/OSPAR species) represent the amalgamation of data collected during numerous and varied benthic surveys over a number of years. Much of the habitat mapping to form these datasets is based on the interpretation of various multibeam (or other remote sensing) outputs supported by a range of groundtruthing. An indication of where data gaps exist is not simply derived through the absence of Section 7/OSPAR/Annex I data, as this does not mean there is no habitat data at all in these locations, as features may be present (as derived from survey effort) that are not recognised through these

designations. Such limitations with the habitat datasets are highlighted in the Study as it should not be assumed, particularly in offshore waters, that areas absent of Section 7/OSPAR/Annex I features have survey data adequate to indicate that no features relevant to the constraints analysis exist.

Tidal Stream RAs (surface)

Around the north and west coast of Anglesey overlap between RAs and designated sites with habitats a qualifying feature are limited to highly localised areas which abut the boundaries of SSSI's (e.g. waters adjacent to The Skerries SSSI). Aside from a few scattered cells the slightly higher occurrence of constraints is driven by the presence of subtidal reef, this feature extending to the north and north east. Elsewhere, where survey point data has indicated the presence of biogenic reef (i.e. *Sabellaria* sp.) or stony/rocky reef then these indicate a relatively increased level of constraint. Inshore of the RA the results of the analysis indicated high levels of constraint. This is as a consequence of the range of designated (Article 17 and Section 7) subtidal and intertidal features along the Anglesey coastline e.g. subtidal and intertidal rocky reef, saline lagoons, sea caves etc.) in addition to numerous SSSI sites (e.g. Holy Island Coast SSSI; Cemlyn Bay SSSI etc.).

No designated sites overlap with the offshore RAs approximately 50 km to the west of the Llyn Peninsula. Constraints here are comparatively low, and the result of overlap with the Section 7 habitat 'mixed muddy sediments' (see Figure 11). The presence of multiple Article 17 and Section 7 features (e.g. sandbanks, subtidal and intertidal reef, fragile sponge and anthozoan communities, deep water mud habitats, sea caves) inshore, around the Llyn Peninsula and Bardsey Island, in addition to multiple designates sites (e.g. Llyn Peninsula and Sarnau SAC, Glannau and Aberdaron SSSI, Ynys Enlli SSSI), result in notably higher constraints. More than 10 km offshore these constraints are relatively low, and influenced by the presence of mixed muddy habitats and the western extent of the Llyn Peninsula and Sarnau SAC.

Off the west coast of Pembrokeshire, the analysis indicated comparatively higher constraints here than within other tidal stream RAs. The comparatively higher constraints were the result of overlaps with Article 17 (subtidal and to a lesser extent intertidal reefs; sea caves around Ramsey and Skomer Island; subtidal sandbanks to the west of St Davids Head and near Skomer) and Section 7 (e.g. fragile sponge and anthozoan communities, mixed muddy sediments) features. In addition to the presence of the Pembrokeshire Marine SAC, which encompasses much of the RA, at a localised level there are numerous nationally designated sites (e.g. Skomer MCZ; Ramsey SSSI; St David's Peninsula Coast SSSI; Grassholm SSSI; Skomer Island and Middleholm SSSI etc.) which influence the constraints.

Off the southern coast of Wales, a fairly uniform level of low constraint was shown across the tidal stream RA, indicative of its overlap with the Article 17 reef feature 'subtidal reefs'. However, there are only a few records of Section 7 features (excluding subtidal sands and gravels) within the RA. In the eastern extent of the RA, the overlap with Severn Estuary SAC increases the relative level of constraint. Although outside the RA, much of the coastline demonstrates high level of constraints, indicative of the various intertidal and subtidal features of importance (e.g. subtidal sandbanks around the western and eastern margins of the RA; intertidal rocky reef, seagrass beds near West Aberthaw; intertidal mudflats around Barry Island and Sully Bay etc.).

Tidal Stream RAs (mid water)

The final outputs relevant to mid-water technology (see Figure 12) showed an almost identical pattern to that of surface technology, especially within the RAs and the text above remains relevant.

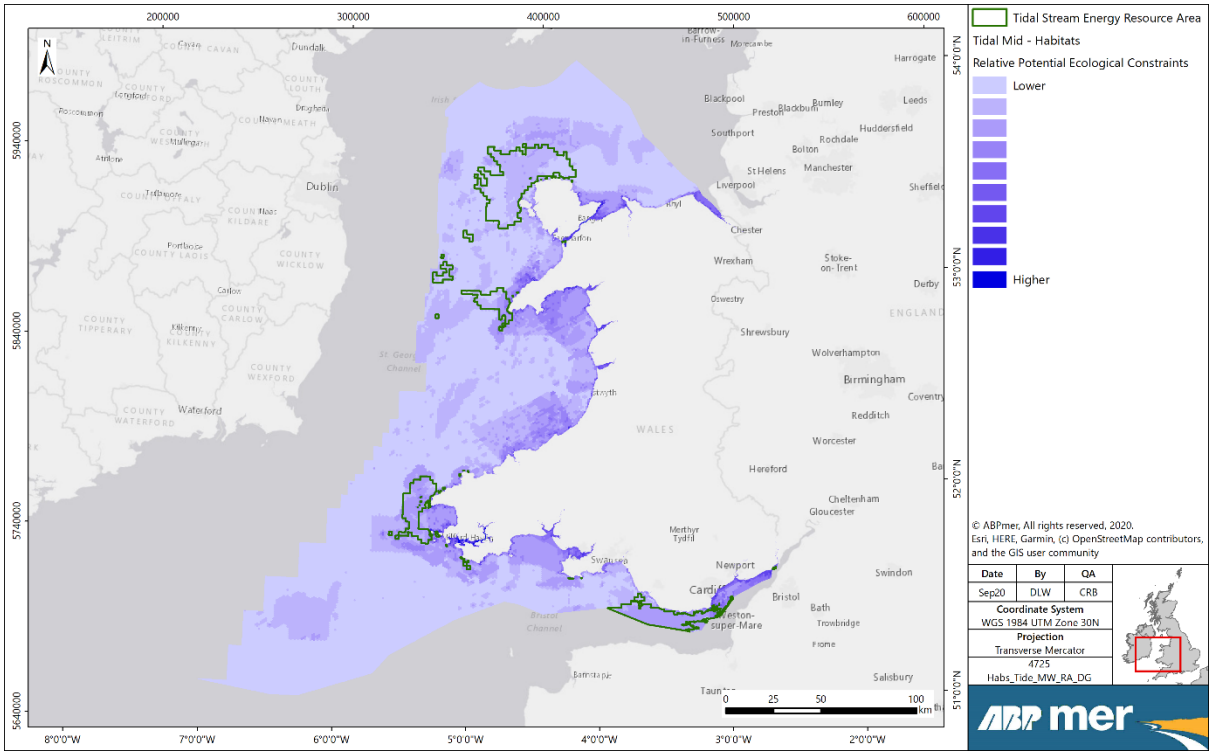

Figure 12. **Relative potential ecological constraints in relation to habitats for tidal stream mid water technology**

Tidal Stream RAs (seabed)

The final outputs relevant to seabed technology (see Figure 13) showed a very similar pattern to that of surface technology and mid-water hence the text above remains relevant.

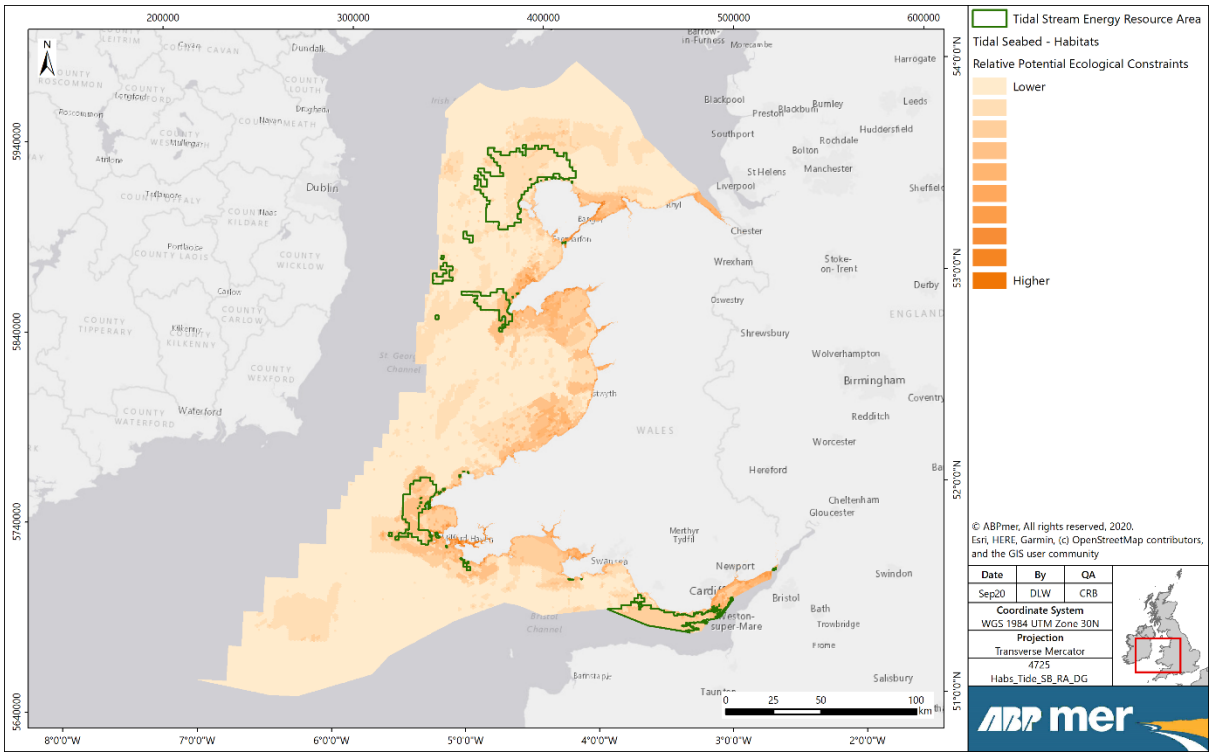

Figure 13. **Relative potential ecological constraints in relation to habitats for tidal stream seabed technology**

Minor changes in the outputs are generally reflective of the differing complexity adjustment values assigned to the Article 17 features 'reef' and 'subtidal sandbanks' and the Section 7 feature 'subtidal mixed muddy sediments'. However, these differences do not alter the overall pattern of constraint outputs within the RAs from that indicated for surface or mid-water technologies.

5.2 Wave energy

Following application of the methodology, seven discrete mapping outputs were generated (see Step 5) encompassing the BIFs. Wave energy was divided into two major technology types, surface and seabed mounted, as these have the potential for quite different levels of exposure to the BIFs (see Scope and assumptions).

5.2.1 General narrative

An extensive wave resource exists in both Welsh inshore and offshore waters, particularly in the southwest which is exposed to waves generated in the Atlantic Ocean. Pembrokeshire has the highest concentration of inshore wave resource in Wales equating to an indicative capacity of up to 5.6 GW (State of the Sector, 2020[29]).

Wave energy technologies rely on the up-and-down motion of waves to generate electricity. Energy output is determined by wave height, wave speed, wavelength and water density. Wave technologies are less well developed compared to tidal stream and may take longer to be deployed commercially (i.e. smaller scale test devices offering proof of concept followed by larger-scale arrays).

The Wave Energy RA is extensive but limited to the southwestern waters around Wales, where wave generation is suitable (see Figure 14). Much of the resource is offshore beyond the 12 nm territorial limit, with close inshore areas limited to the western and southwestern Pembrokeshire coastline.

5.2.2 Birds

Welsh waters

In relation to birds, the areas of relatively higher constraint in Welsh waters are generally a result of seabird colonies and the foraging ranges of resident populations, especially where these overlap with SPAs (e.g. around Anglesey; Bardsey, and Milford Haven) (see Figure 14). At a localised level the higher constraints indicated along the coastline are generally representative of bird colonies and foraging areas. Moving offshore, the relatively higher constraints are largely a result of mean foraging distances from colonies overlapping with these waters. The Seabirds at Sea dataset indicated greater relative density distribution of seabirds near colonies.

Away from the coastline, for example, in the waters west of Pembrokeshire, to the south and south east of Llyn Peninsula, to the west and north west of Anglesey and along the north coast of Wales, the main contributor towards the constraints was from the Seabirds at Sea dataset and thus the relative density of seabirds from the rationalised list (see Table 5).

[29] https://www.marineenergywales.co.uk/wp-content/uploads/2020/07/MEW-State-Of-The-Sector-2020.pdf

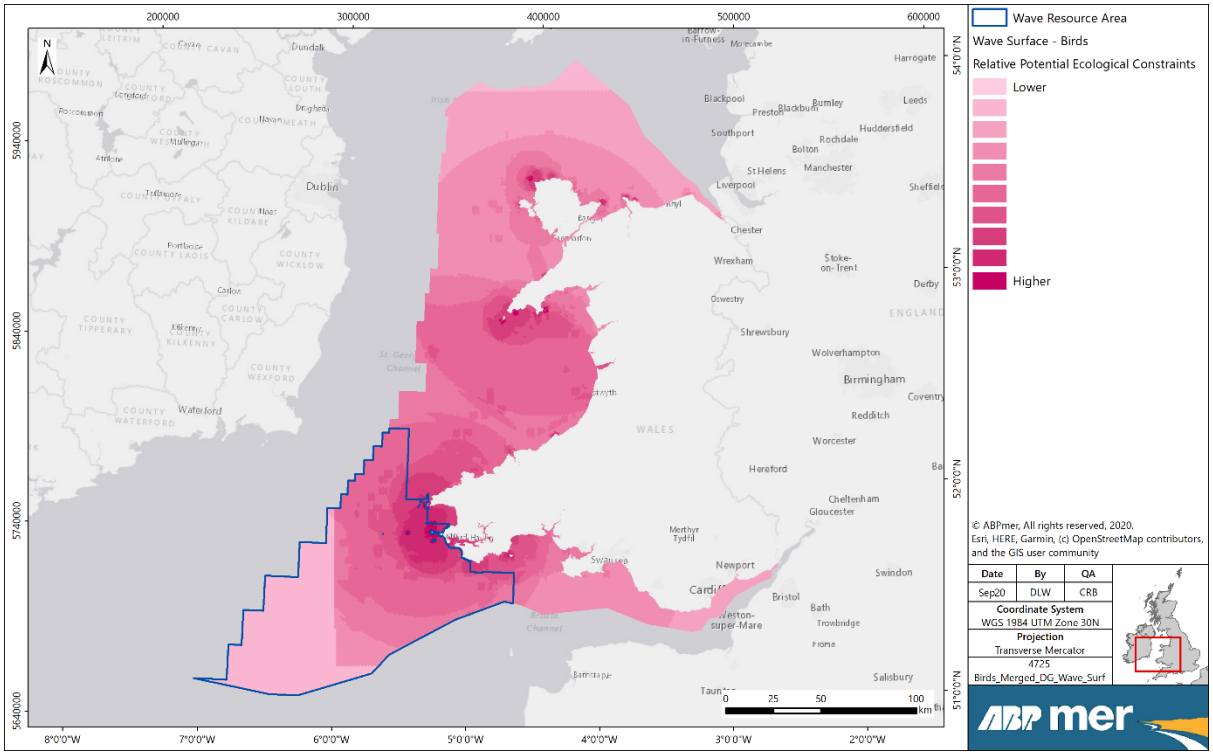

Figure 14. Relative potential ecological constraints in relation to birds for wave energy surface technology

Wave Energy RA (wave energy surface)

In relation to birds, relative constraints are notably higher the further inshore within the RA, with the highest values indicated just to the west of Milford Haven, around Skomer, Skokholm and Grassholm, and then off the coast of St David's Head, around Ramsey Island. Although gird cells overlap with the Skomer, Skokholm and the seas off Pembrokeshire SPA, it is the multiple bird colonies along the north coast, and especially at Ramsey Island, Bishops and Clerks, Skomer, Grassholm, and Skokholm which lead to the highest levels of constraints (see Figure 14). Many of the seabirds at these colonies have mean foraging ranges of >50 km (e.g. Gannet, Puffin, Fulmar) and thus multiple overlaps occur within grid cells. Work by the RSPB has also indicated the importance of these waters for Guillemot, Shag and Razorbill.

Moving offshore, away from the colonies, there is a clear reduction in relative constraints from approximately 25 km offshore. The constraints steadily reducing to the west, southwest and east. Beyond the influence of the colonies and the foraging ranges of many species, the density distribution of seabirds (as derived by the Seabirds at Sea dataset) is the greatest contributor to the constraints indicated. The clear step to minimal constraints, towards the far south west, results from the RA extending beyond the spatial extent of the Seabirds at Sea dataset (see Figure 15) and should be noted as such. At the distances where no density distribution data was available from the Seabirds at Sea dataset and beyond, there are fewer bird species which have a mean foraging range of >80 km, these being generally limited to surface feeding birds such as Fulmar, Kittiwake and Manx Shearwater, all of which have important populations off the coast of Pembrokeshire.

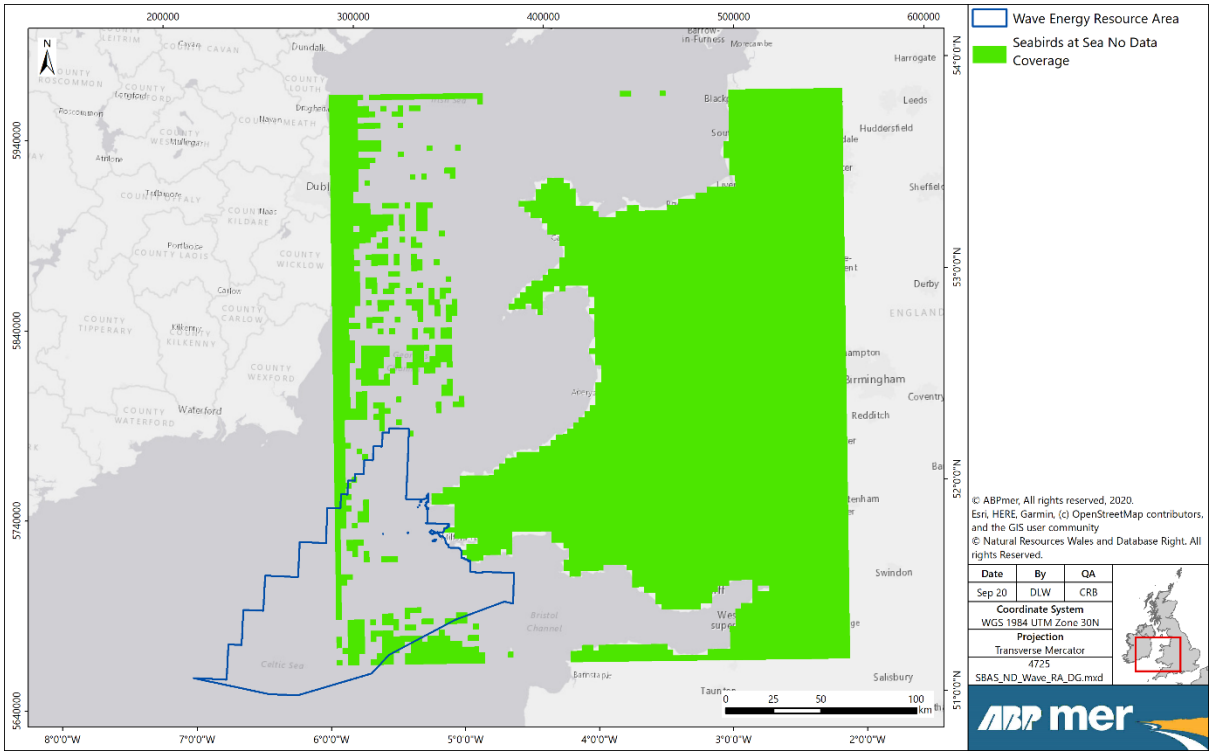

Figure 15. **Indication of those areas where no data exists for the Seabirds at Sea dataset. Wave Energy RA is shown**

Wave Energy RA (wave energy seabed)

The final outputs for seabed technology (see Figure 16) showed a similar pattern to that of surface technology.

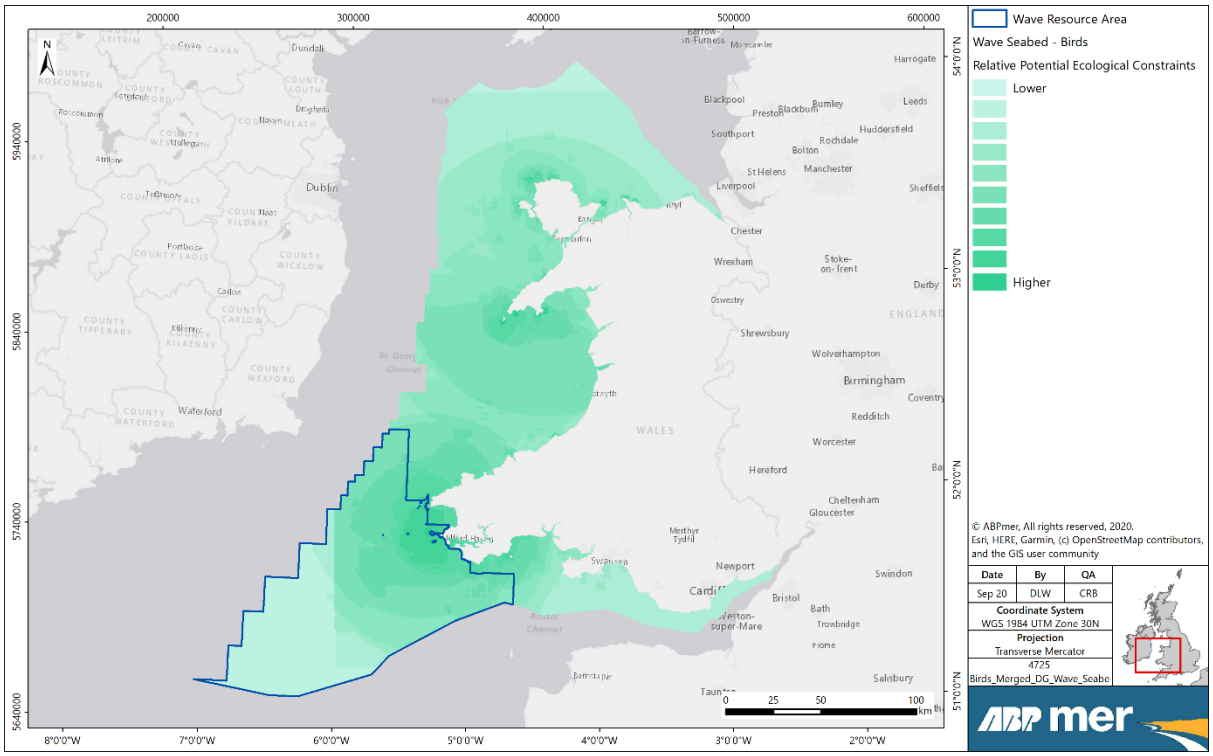

Figure 16. **Relative potential ecological constraints in relation to birds for wave energy seabed technology**

Although hotspots of constraints are not so clearly defined as indicated by the surface technology output, the relatively higher bird constraints are in the same locations. This is close inshore to the west coast of Pembrokeshire, in particular around Skomer, Skokholm and Grassholm, and then off the coast of St David's Head, around Ramsey Island.

Appreciating that only deep diving birds are likely to be exposed to seabed technologies, the complexity adjustment value discriminated these bird species (Table 4). In terms of the outputs, this did not result in any significant changes in the contributions of the selected datasets within the RAs from that indicated by the surface water technology outputs. Hence, inshore it is the multiple overlaps of foraging areas from diving birds that contribute most to the potential constraints. Beyond the influence of the colonies and the foraging ranges of many species, the density distribution of seabirds (as indicated by the seabirds at sea dataset) is the greatest contributor. The fall to minimal relative constraints towards the far south west, is caused by the lack of Seabirds at Sea data available covering this area (see Figure 15). At the distances where no density distribution data was available from the Seabirds at Sea dataset and beyond, there are fewer bird species which have a mean foraging range >80 km, these being generally limited to surface feeding birds such as Fulmar, Kittiwake and Manx Shearwater, all of which have important populations off the coast of Pembrokeshire.

5.2.3 Marine mammals

Welsh waters

In relation to marine mammals, very close inshore the areas of relatively higher constraint are a result of grey seal haul out and pupping locations, especially where these overlap with SACs which have marine mammals as a qualifying feature (e.g. around Anglesey; Bardsey, Cardigan Bay and Milford Haven) and the MCZ at Skomer (see Figure 17). Slightly further offshore the key contributors to a relatively higher constraints score tend to be cetacean and grey seal distribution and the presence of designated sites. Inshore, along the mid Wales coastline in particular, but also to the east of Anglesey, the distribution of the coastal bottlenose dolphin ecotype also contributes heavily to the overall constraints.

From the southern coast of Pembrokeshire to the Severn Estuary, comparatively low constraints were indicated, particularly east from the Mumbles. With the exception of harbour porpoise, cetacean density distribution is indicated as low in this area, with no important seal haul out sites and no SAC with marine mammals as qualifying features east of the Bristol Channels Approaches SAC.

Given the available evidence, it was considered that there was no potential for significantly different levels of exposure to marine mammals form the varied wave energy technologies (seabed, surface). Hence, the finalised mapping output was relevant to all wave energy technologies.

Wave energy RA

Around Pembrokeshire, especially along the north coastline and off the west coast, are many important seal haul-out and pupping sites. Very close inshore, the relatively high constraints are mainly indicative of the multiple seal haul out sites around Ramsey Island and Skomer Island. There are also multiple European designated sites that overlap with the RA (i.e. Pembrokeshire Marine SAC; West Wales Marine SAC;) and nationally designated sites (e.g. Skomer MCZ; Skomer Island and Middleholm SSSI; St David's Peninsula Coast SSSI etc.). Offshore, it is the density distribution of cetaceans such as bottlenose dolphin, minke whale, Risso's dolphin and common dolphin which are the main contributors to the relative constraints, along with the presence of the two SACs. Beyond the extent of the SACs the main influence on the constraints are cetacean and grey seal distribution, which even at distances >50 km from the coast indicate the relative importance of these southwestern waters for marine mammals. However, in offshore waters to the south and southeast the constraints are notably lower, reflective of the lower

cetacean densities in these areas, with the exception of harbour porpoise, and lower usage by grey seal indicated by the datasets (see Figure 17).

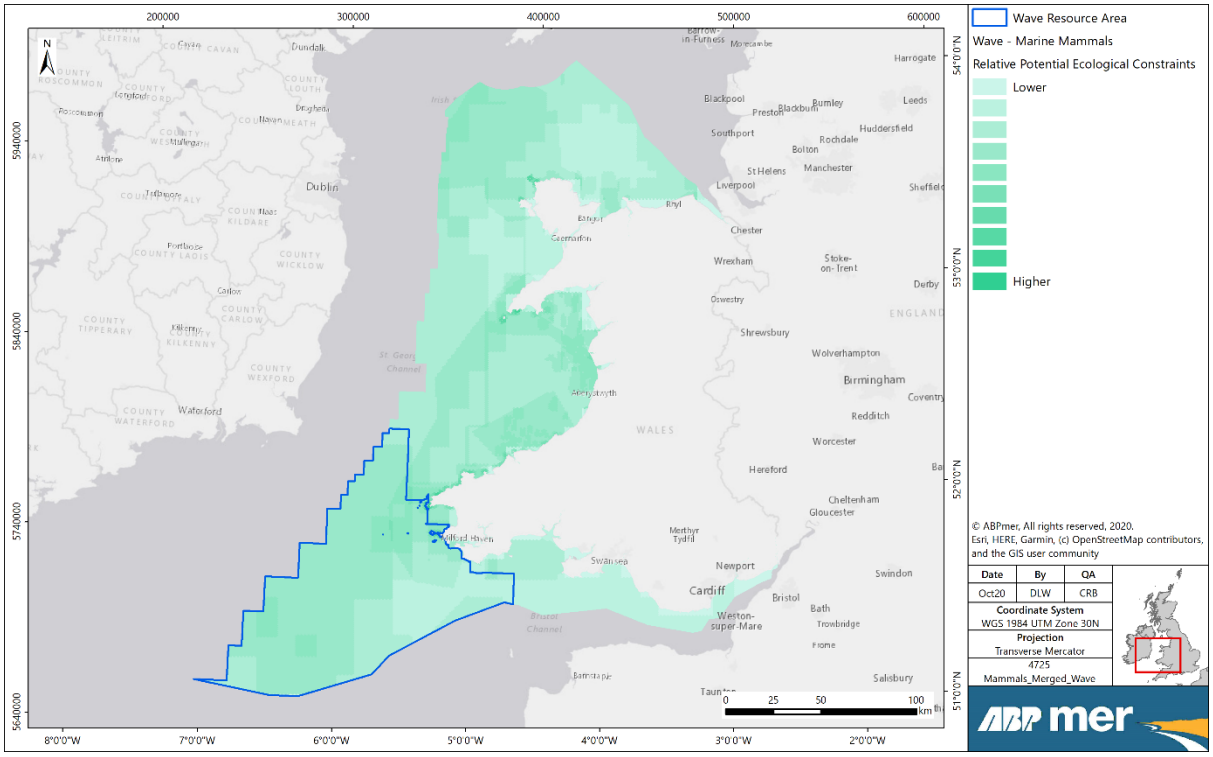

Figure 17. Relative potential ecological constraints in relation to marine mammals for wave energy technology

5.2.4 Fish

Welsh waters

The relative constraints in relation to fish are largely a result of overlaps with spawning and nursery grounds (see Ellis *et al.*, 2012). The spatial data layers from this dataset are very broad, subsequently resulting in the broad patterning visualised by the mapping outputs.

Along the north coast of wales, coincidence with the Dee Estuary Ramsar and SAC, important migratory fish routes and fish spawning areas to the north of Rhyl, result in relatively high constraints (see Figure 18). Across the top of Anglesey, the presence of nursery and spawning grounds contribute most to the constraint; although the overall indication is comparably lower constraints than to the east of Anglesey. Close inshore, at the mouths of estuaries along the mid-wales coastline, constraints are indicated as a result of migratory fish corridors.

Offshore, the main contributing factors to the constraints are the presence of fish spawning areas and the Cardigan Bay SAC to the south. Around the Pembrokeshire coastline there are multiple designated sites which, along with fish nursery grounds, contribute to the constraints. Spawning and nursery grounds for multiple fish species are found offshore to the south of Pembrokeshire. To the east of the Bristol Channel the overall constraints indicated are comparatively lower than many other areas of Welsh waters. However, the constraints increase again heading into the Severn Estuary signifying the importance of this area for migratory fish and the presence of designated sites for fish (e.g. Severn Estuary SAC; Severn Estuary Ramsar).

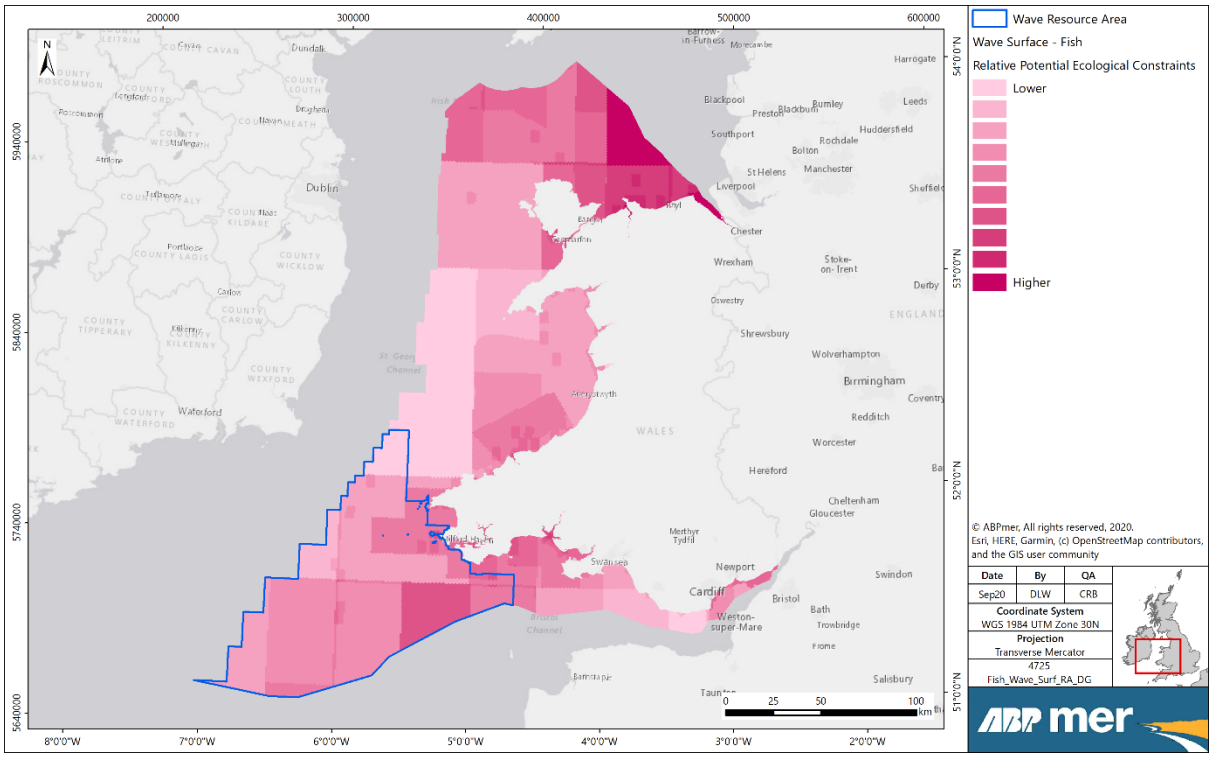

Figure 18. Relative potential ecological constraints in relation to fish for wave energy surface technology

Wave Energy RA (surface)

Just off the west coast of Pembrokeshire, it is the presence of a number of fish nursery grounds and to a lesser extent spawning grounds, in addition to overlap with the European designated site (Pembrokeshire Marine SAC) and, at a more localised level, the Skomer MCZ, which lead to some of the highest constraints indicated within the wave energy resource area (see Figure 18). However, the highest relative constraints in relation to fish are indicated more than 20 km to the south of Milford Haven; a consequence of overlap with spawning grounds for multiple fish species (e.g. cod, sandeel, plaice, sole etc.). Further offshore, to the southwest, the overlap with a number of spawning and nursery grounds (e.g. mackerel, sole and cod) continued to contribute most to the constraints.

Wave Energy RA (seabed)

The final outputs relevant to seabed technology (see Figure 19), showed an almost identical pattern to that of surface technology, hence the text above remains relevant. Minor changes in the outputs are reflective of the differing complexity adjustment values assigned to cod and herring features against the two wave energy technologies. However, these differences did not alter the overall pattern of constraint outputs within the RA from that indicated for surface water technology.

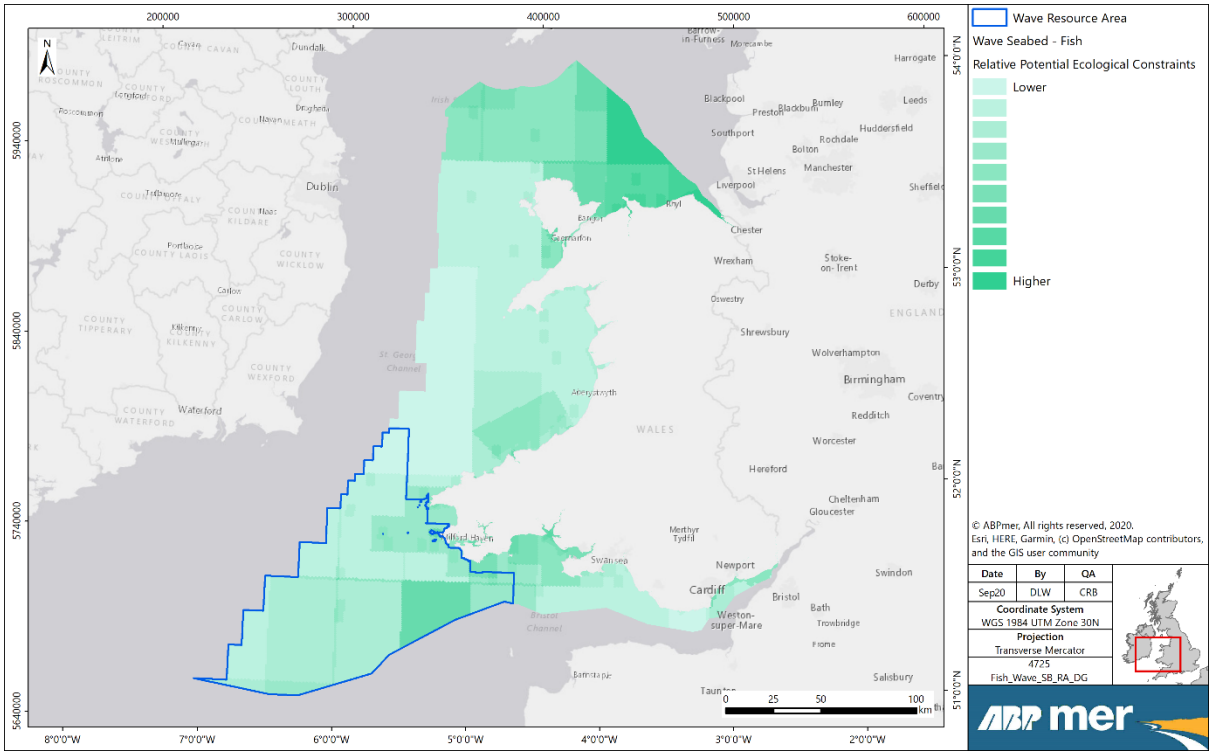

Figure 19. Relative potential ecological constraints in relation to fish for wave energy seabed technology

5.2.5 Habitats

Welsh waters

Inshore along the Welsh coastline, the relative constraints are notably higher than offshore environments (see Figure 20), noting that data gaps are more prevalent in offshore locations (see below). More than 10-20 km offshore are extensive areas identified as being of relatively low constraints based on current data availability, such as to the east and far north of Anglesey, to the west of mid Wales, and in the south west. Offshore, the pattern of constraints is largely indicative of mixed muddy sediment or reef habitats. Within estuaries the constraints are elevated and the result of multiple Section 7 and/or Article 17 features being present.

Designated sites have a strong influence on the constraints e.g. Llyn Peninsula and the Sarnau SAC, Cardigan Bay SAC and Pembrokeshire Marine SAC. The pattern of constraints is also indicative to the presence of reef and estuarine features, both of which are Article 17 features encompassing a variety of other designated (Article 17, Section 7, OSPAR) habitats and species.

The habitat datasets (i.e. Article 17/Annex I features; Section 7/OSPAR habitats; Section 7/OSPAR species) represent the amalgamation of data collected during numerous and varied benthic surveys over a number of years. Much of the habitat mapping to form these datasets is based on the interpretation of various multibeam (or other remote sensing) outputs supported by a range of groundtruthing. An indication of where data gaps exist is not simply derived through the absence of Section 7/OSPAR/Annex I data, as this does not mean there is no habitat data at all in these locations, as features may be present (as derived from survey effort) that are not recognised through these designations. Such limitations with the habitat datasets are highlighted in the Study as it should not be assumed, particularly in offshore waters, that areas absent of Section 7/OSPAR/Annex I features have survey data adequate to indicate that no features relevant to the constraints analysis exist.

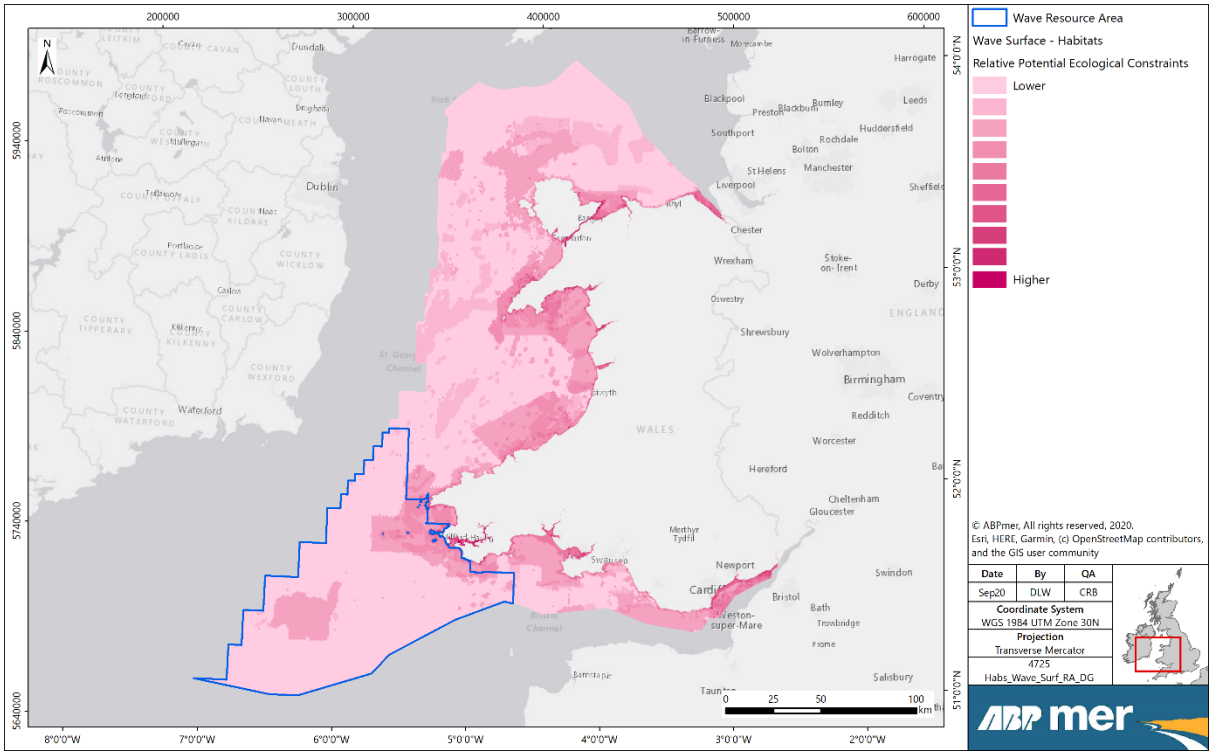

Figure 20. **Relative potential ecological constraints in relation to habitats for wave energy surface technology**

Wave Energy RA (surface)

Within the RA, the highest habitats constraints were indicated close inshore, along the west coast of Pembrokeshire (see Figure 20). The comparatively higher constraints were the result of overlaps with Article 17 (subtidal and to a lesser extent intertidal reefs; sea caves around Ramsey and Skomer Island; sandbanks to the west and south of Milford Haven) and Section 7/OSPAR (e.g. fragile sponge and anthozoan communities, mixed muddy sediments) features. In addition, the presence of the Pembrokeshire Marine SAC which encompasses much of the RA and at a localised level numerous nationally designated sites (e.g. Skomer MCZ; Ramsey SSSI; St David's Peninsula Coast SSSI; Grassholm SSSI; Skomer Island and Middleholm SSSI etc.) also represent relatively higher levels of constraint.

Further offshore, the pattern of higher constraints is indicative of the Pembrokeshire Marine SAC which extends some way offshore and is designated for Annex I reef. Beyond the extent of the SAC, most of the area was indicated as having constraints comparatively lower than elsewhere in Welsh waters; however, in the far southwest a large area of notably higher constraints was shown. Contributing to these higher constraints were Section 7 and OSPAR habitats, specifically the presence of 'mixed muddy sediments' but also 'mud habitats in deep water' and 'seapens and burrowing megafauna' communities.

Just inshore of the RA the output indicated areas of particularly high relative constraint, such as in the Milford Haven, due to presence of many Article 17 and Section 7/OSPAR features (e.g. reef, maerl, mixed muddy sediments, tide swept channels etc.) and around south Pembrokeshire, due to presence of intertidal and subtidal reef, many sea caves and also overlap with the Pembrokeshire Marine SAC and SSSIs (e.g. Castlemartin Range SSSI).

Wave Energy RA (seabed)

The final outputs relevant to seabed technology (see Figure 21), showed an almost identical pattern to that of surface technology, hence the text above remains relevant. Despite minor differences in the constraints score, reflective of differing complexity adjustment values assigned against some features, these differences did not alter the overall pattern of constraint outputs within the RA from that indicated for surface water technology, with the key contributors to a relative constraint in a grid cell largely remaining the same.

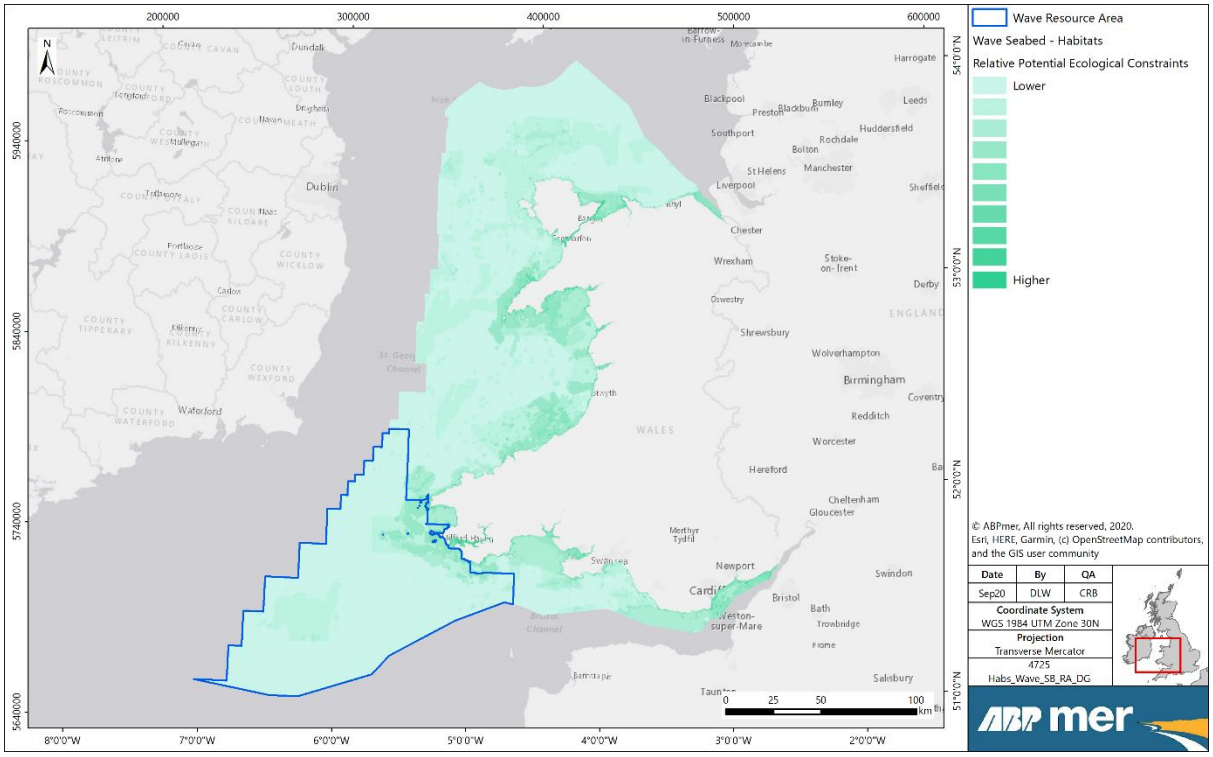

Figure 21. Relative potential ecological constraints in relation to habitats for wave energy seabed technology

5.3 Aquaculture

Following application of the methodology, five discrete mapping outputs were generated (see Step 5) encompassing the BIFs. Aquaculture was divided into two major activity types, bivalve and seaweed, as these have the potential for quite different levels of exposure to specific BIFs (see Scope and assumptions).

5.3.1 General narrative

Within the WNMP, the cultivation of bivalve shellfish and seaweed were identified as having considerable potential for commercial development in Welsh waters. Research suggests there is considerable marine space offering potential for the development of aquaculture, in particular, in relation to shellfish[30]. While potential near-shore areas are limited compared to offshore areas, further viability assessment work is needed to support the identification of specific opportunities and constraints[31].

30 www.gov.wales/assessment-potential-aquaculture

31 https://gov.wales/sites/default/files/publications/2019-11/welsh-national-marine-plan-document_0.pdf

The RAs for aquaculture cover much of the waters within the 12 nm limit, with a few exceptions such as the north of Anglesey, along the northern part of the mid-wales coastline, part of Carmarthen Bay and around the eastern extent of the Bristol Channel (see Figure 22).

As the RAs cover much of Welsh waters they have been broadly divided into north, mid and south groupings and are defined as follows:

- North - from the Dee Estuary to the north coast of Llyn Peninsula;
- Mid - from far west coast of Llyn Peninsula to Strumble Head; and
- South – from Strumble Head to the Severn Estuary.

It should be acknowledged that the environments within each of these areas vary greatly and the groupings are simply a practicable means of presenting the evidence which could be further refined in the future, as required.

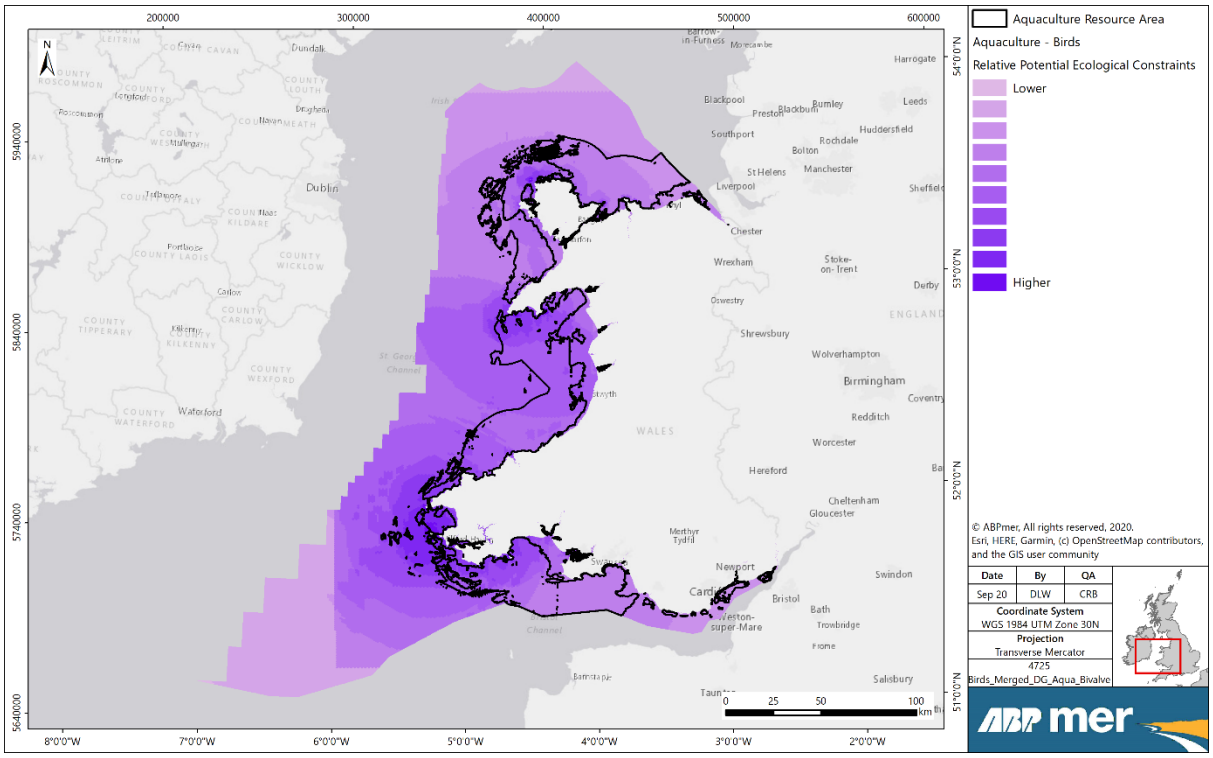

Figure 22. Relative potential ecological constraints in relation to birds for aquaculture

5.3.2 Birds

Welsh waters

In relation to birds, the areas of relatively higher constraint in Welsh waters are generally a result of seabird colonies and the foraging ranges of resident populations, especially where these overlap with SPAs (e.g. around Anglesey; Bardsey, and Milford Haven). At a localised level the higher constraints along the coastline are largely representative of bird colonies and foraging areas (see Figure 22). Moving offshore, the relatively higher constraints are largely a result of mean foraging distances from colonies overlapping with offshore waters. The Seabirds at Sea dataset indicated greater relative density distribution of seabirds near colonies. Away from the coastline, for example, in the Bristol Channel, to the south and south east of Llyn Peninsula, to the west and north west of Anglesey and along the north coast of Wales, the main contributor towards constraints was from the Seabirds at Sea dataset and thus the relative density of seabirds from the rationalised list (see Table 5).

It was considered that there was no potential for significantly different levels of exposure to seabirds from the varied aquaculture activities (seaweed, bivalve). Hence, the finalised mapping output for birds was relevant to either of these activities.

Aquaculture (north)

Around the mouth of the Dee it is the relative density of seabird distribution and the overlapping designated sites that contribute most to the constraints (see Figure 23).

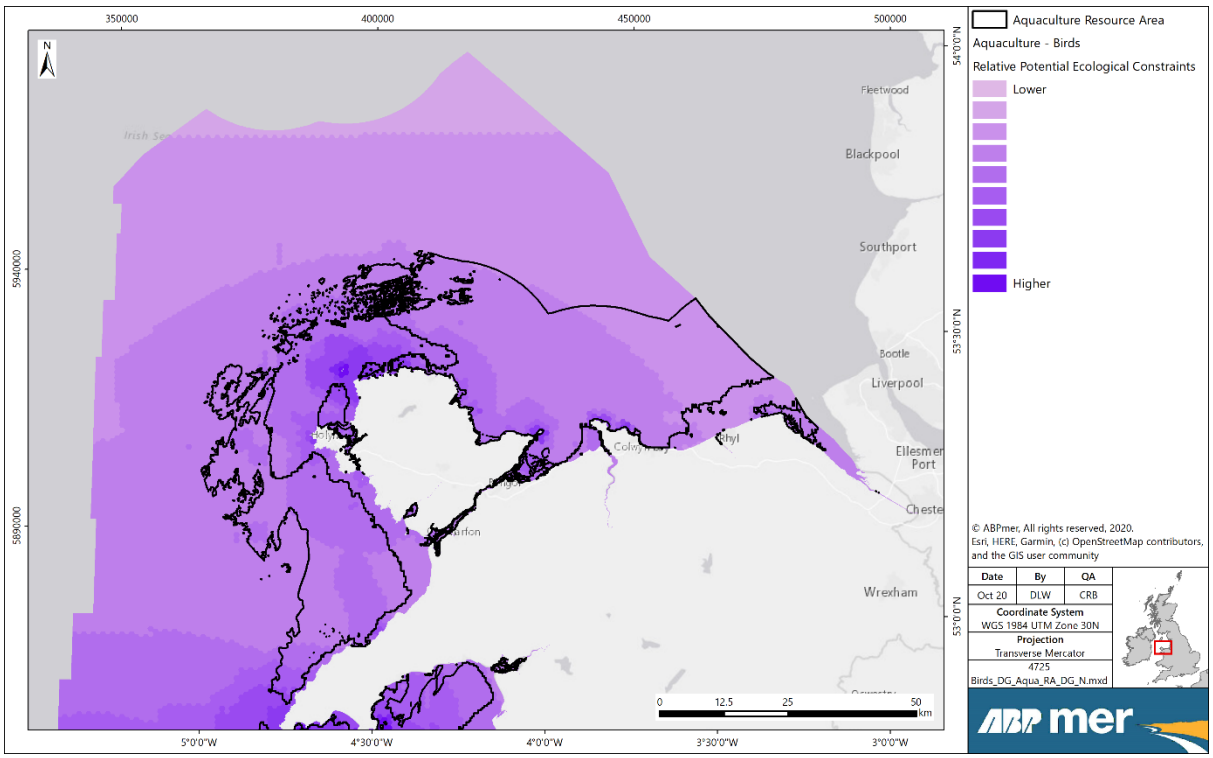

Figure 23. Relative potential ecological constraints in relation to birds for aquaculture in north RA grouping

Close inshore, from Little Orme round to the west coast of Anglesey, the constraint hotspots are a result of the seabird colonies (e.g. Little Orme, Great Orme, Puffin Island, Middle Mouse, Cemlyn, The Skerries etc.) leading to the greater bird densities and the importance of these inshore waters for loafing and foraging activities. There is also an overlap with the Liverpool SPA and Anglesey Terns SPA. Close inshore to Holy Island, the RSPB dataset indicates an important foraging area for Guillemots and Razorbill; however, there is only minimal overlap with the multiple RAs for aquaculture. Offshore, away from the colonies, the constraints are notably lower with seabird density distribution and foraging areas contributing most to those constraints indicated.

North of the Llyn Peninsula the constraints are comparatively low with the main influence on the overall constraints being the seabird colony at Carreg y Llam and the usage of these waters by Guillemots, as the RSPB utilisation data indicated.

The relative constraints increase as the RA approaches the western tip of the peninsula. Here the waters overlap with a combination of important foraging areas for birds from colonies such as Bardsey Island and Ynysoedd Gwylan, as well as the Aberdaron Coast and Bardsey Island SPA.

Aquaculture (mid)

From Bardsey Island around the south coast of the Llyn Peninsula are several hotspots, reflective of the bird colonies at Bardsey, Ynysoedd Gwylan and Saint Tudwal's Islands. High constraints extend approximately 10 km offshore due to the importance of foraging areas and the density distribution of seabirds (see Figure 24). Towards Tremadoc Bay, the constraints lessen, and are relatively low within Morfa Harlech despite overlap with the Morfa Harlech SSSI. Likewise, at Barmouth, constraints are also low within the Mawddach Estuary. However, constraints are relatively higher at Dyfi Estuary due to a greater overlap with foraging areas and also the Dyfi SSSI.

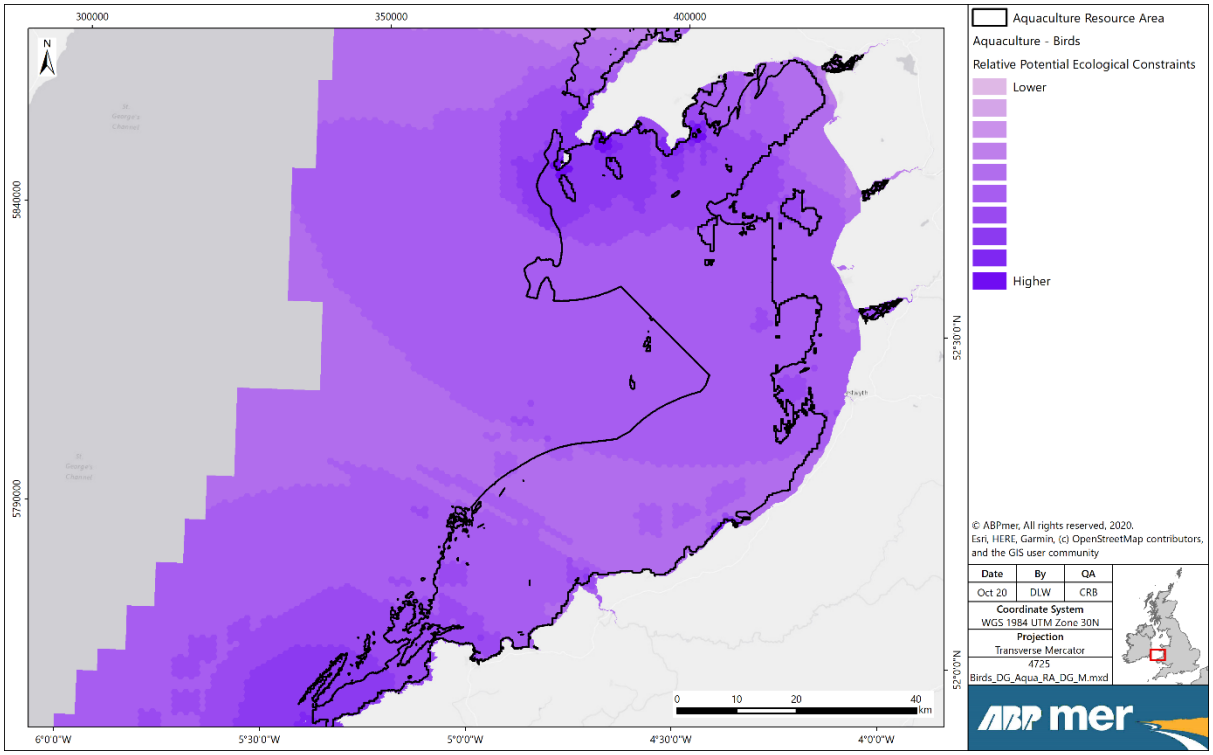

Figure 24. Relative potential ecological constraints in relation to birds for aquaculture in mid RA grouping

Generally, the constraints are relatively low across the mid RAs, especially in the more offshore areas. To the south, it is the presence of the bird colonies at New Quay Head and Cardigan Island which result in the constraint hotspots indicated. Between these two colonies are areas of comparably lower constraint, which fall outside key identified foraging waters.

As the RA begins to overlap with foraging areas (including those defined within the RSPB dataset) the relative constraints increased, there also being an increased density distribution of seabirds around Fishguard Bay and Strumble Head.

Aquaculture (south)

From Strumble Head and around the coast of Pembrokeshire the constraints are comparatively higher than elsewhere in Welsh waters (see Figure 25). Contributing to the higher scores here is the Skomer, Skokholm and the seas off Pembrokeshire SPA, and the multiple bird colonies along the north coast, and especially at Ramsey Island, Bishops and Clerks, Skomer, Grassholm, and Skokholm. Many of the seabirds at these colonies have mean foraging ranges of >50 km (e.g. Gannet, Puffin, Fulmar). The RSPB dataset also indicates hotspots for utilisation of these waters by Guillemot, Shag and Razorbill. Seabird

density distribution is also high in this area. Into the Bristol Channel and to the east seabird density distribution decreases, although it is generally the main contributor to the constraint output indicated within the inshore and offshore areas.

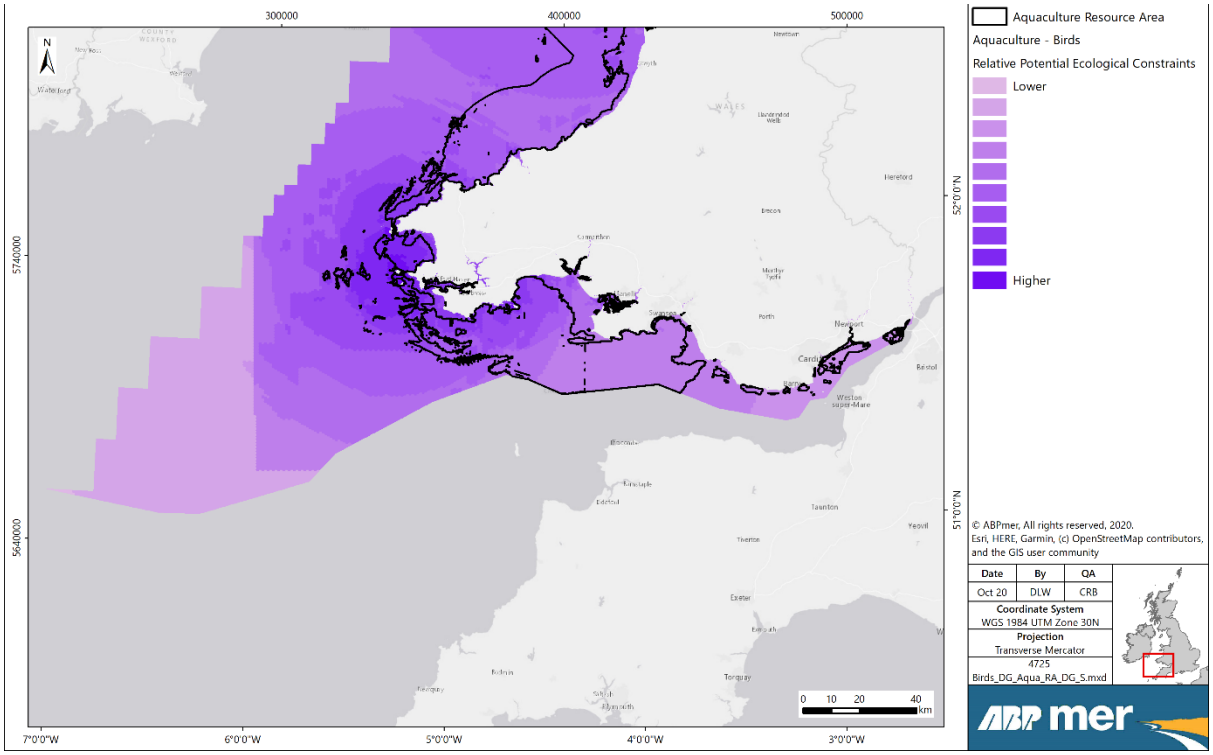

Figure 25. Relative potential ecological constraints in relation to birds for aquaculture in south RA grouping

Within this region the bird constraints in the RAs are relatively low when compared to RAs elsewhere. Into the Severn Estuary there are slightly higher constraints along the Welsh coastline where there is an overlap with the Severn Estuary Ramsar and SPA sites. The only seabird colony in the area is at Flatholm which has a population of Lesser Black Backed Gull. The mean foraging range of this species (43 km) contributes to the constraint score within this range from Flatholm.

5.3.3 Marine mammals

Welsh waters

In relation to marine mammals, very close inshore the areas of relatively higher constraint are a result of grey seal haul out and pupping locations, especially where these overlap with SACs which have marine mammals as a qualifying feature (e.g. around Anglesey; Bardsey Island, Ramsey Island, Cardigan Bay, Milford Haven) and the MCZ at Skomer (see Figure 26). Slightly further offshore the key contributors to a relatively higher constraints score tend to be cetacean and grey seal distribution and the presence of designated sites. Inshore, along the mid Wales coastline in particular, but also to the east of Anglesey, the distribution of the coastal bottlenose dolphin ecotype also contributes heavily to the overall constraints.

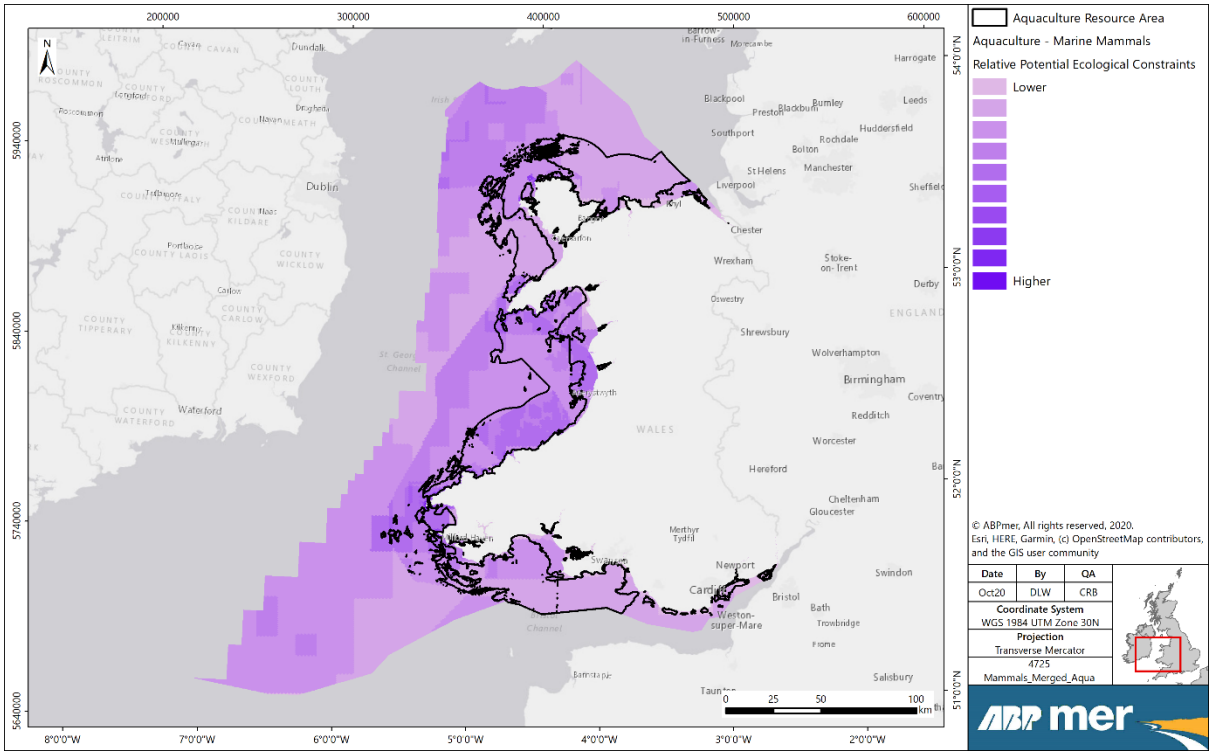

Figure 26. Relative potential ecological constraints in relation to marine mammals for aquaculture

From the southern coast of Pembrokeshire to the Severn Estuary, comparatively low constraints were indicated, particularly east from the Mumbles. With the exception of harbour porpoise, cetacean density distribution is indicated as low in this area, with no important seal haul out sites and no SAC with marine mammals as qualifying features east of the Bristol Channels Approaches SAC.

Given the available evidence, it was considered that there was no potential for significantly different levels of exposure to marine mammals or their responses to the varied aquaculture activities (seaweed, bivalve). Hence, the finalised mapping output for mammals was relevant to either of these activities.

Aquaculture (north)

At the mouth of the Dee Estuary the increase in relative constraint is a result of overlap with the Dee Estuary Ramsar site and the increased utilisation of these waters by harbour porpoise and grey seal. Comparatively, much of the area to the east of Anglesey is lower in constraint with minimal overlap with designated sites (see Figure 27).

Around the north coast of Anglesey the RAs are quite close inshore, with notable increases in the constraints off Llanbadrig Head (a consequence of relative increase in bottlenose dolphin activity) and to the north east of Carmel Head (resulting from multiple seal haul out sites in the vicinity). The presence of seal haul out sites along the north coast of Holy Island also leads to the increased constraints identified. Offshore, to the west of Holy Island, constraints are lower and tend to decrease heading south, once beyond the extent of the North Anglesey Marine SAC.

The increase in constraints indicated just off the north coast of Lleyn Peninsula results from the density distribution of cetaceans, grey seal usage and the overlap with the Lleyn Peninsula and the Sarnau SAC.

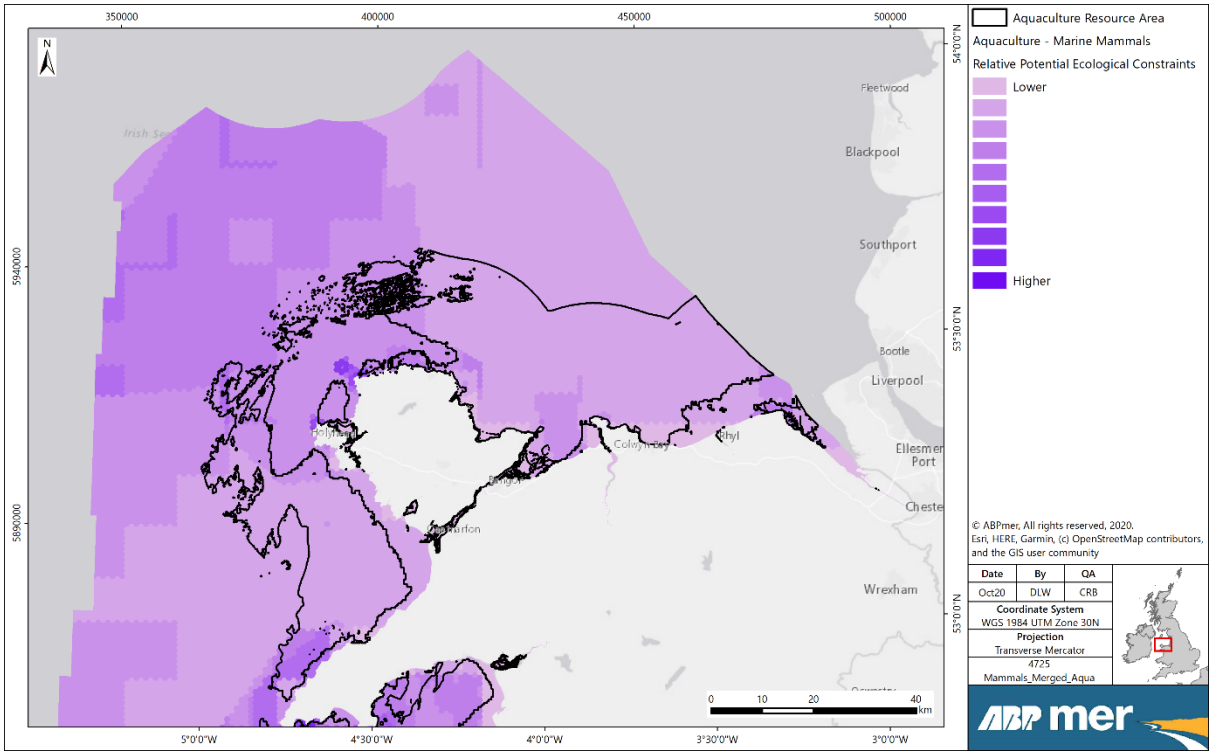

Figure 27. **Relative potential ecological constraints in relation to marine mammals for aquaculture in north RA grouping**

Aquaculture (mid)

Around Bardsey Island and close inshore to the southern coast of the Lleyn Peninsula, the presence of multiple seal haul outs leads to the areas of greatest constraint (see Figure 28).

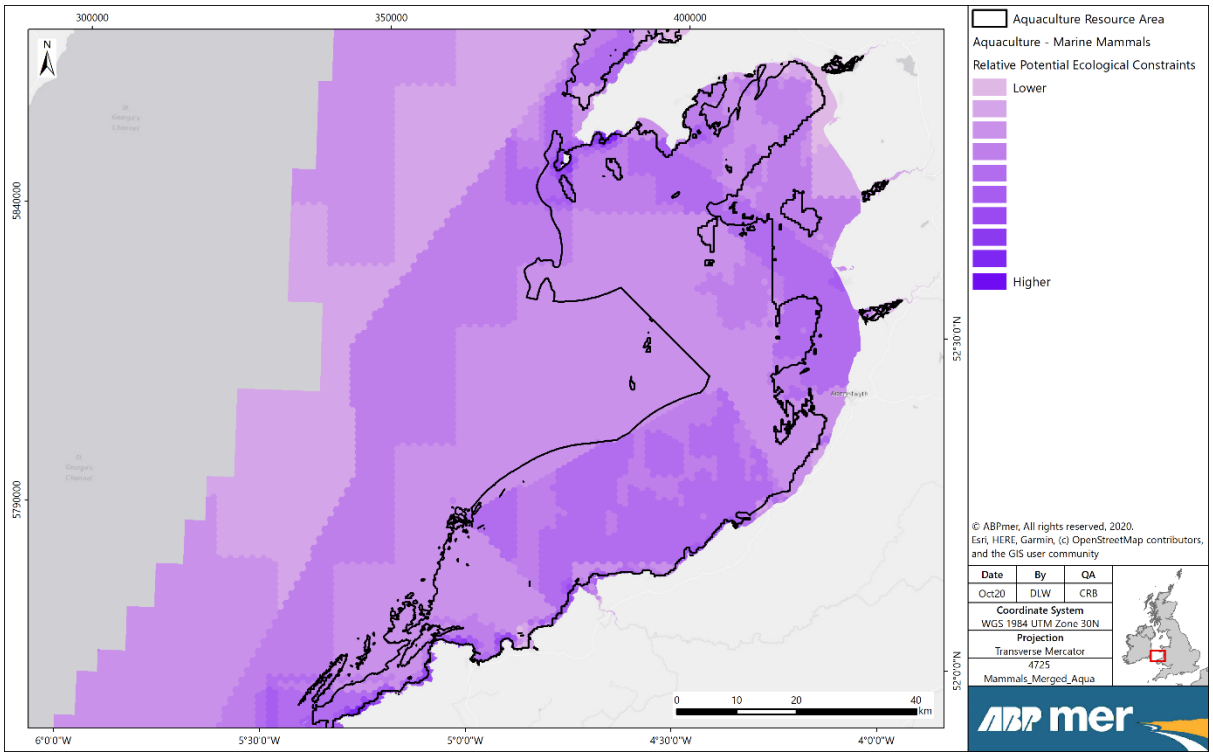

Figure 28. **Relative potential ecological constraints in relation to marine mammals for aquaculture in mid RA grouping**

The boundary of the Lleyn Peninsula and the Sarnau SAC and West Wales Marine SAC can be observed in the outputs, showing the influence of these sites. The overlap of these sites with increased occurrence of bottlenose dolphin and increased density distribution of harbour porpoise lead to areas of elevated constraints.

The estuaries at Morfa Harlech and Barmouth are comparatively low in constraints as compared to the Dyfi Estuary, due to increased harbour porpoise activity here.

Clear increases in constraints result from the overlap with the Cardigan Bay SAC and areas of relative increases in bottlenose dolphin presence, harbour porpoise density and grey seal usage. Very close inshore, towards Strumble Head, there are numerous seal haul-out areas, which result in areas of higher levels of constraint.

Aquaculture (south)

From Strumble Head and around the west coast of Pembrokeshire, along the inshore margins of the RAs the marine mammals constraints are comparatively higher than elsewhere in Welsh waters (see Figure 29). This is due to the numerous seal haul out and pupping areas that are found along the coastline and on the islands (of Ramsey and Skomer). This part of the Welsh coastline also overlaps with the West Wales Marine SAC and Pembrokeshire Marine SAC, in addition to the Skomer MCZ and nationally designated sites (e.g. Skomer MCZ; Skomer Island and Middleholm SSSI; St David's Peninsula Coast SSSI etc.) at a localised level.

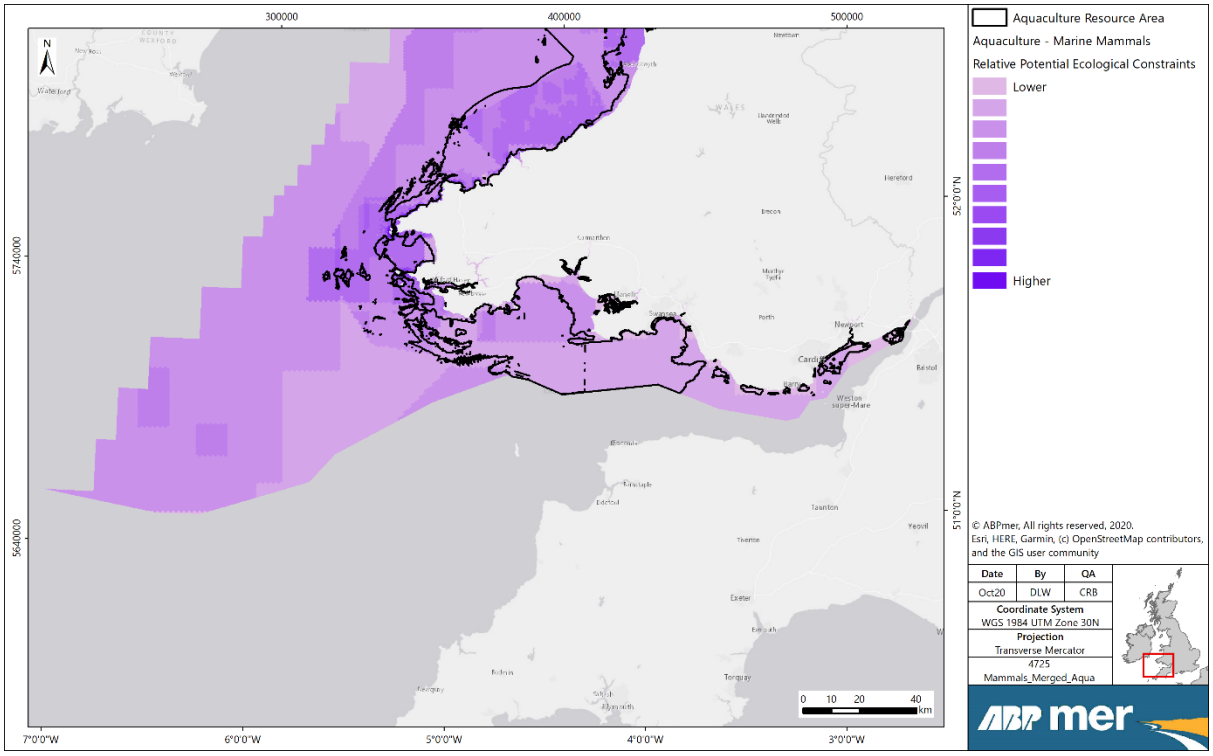

Figure 29. Relative potential ecological constraints in relation to marine mammals for aquaculture in south RA grouping

Within offshore parts of the RAs around the Pembrokeshire coastline, it is the density distribution of cetaceans such as bottlenose dolphin, minke whale, Risso's dolphin and common dolphin which are the main contributors to the relative constraints, along with the presence of the two SACs. The results of which keep the relative constraints elevated in this area.

Into the Bristol Channel the constraints are largely a result of the Pembrokeshire Marine SAC and Bristol Channel Approaches SAC (designated for harbour porpoise). Where these two SACs overlap with each other off the coast near Tenby, the sites and the increased densities of harbour porpoise contribute heavily to the elevated constraints indicated.

The relative constraints are quite low within the RAs around Afon Taf and Burry Port, however, seaward of these areas, outside of the RAs, an increased constraint is indicated, this being a result of overlap with the Bristol Channel Approaches SAC and increased densities of harbour porpoise. East of Carmarthen Bay, within the Bristol Channel and also close inshore, the relative constraints are indicated as lower than elsewhere in Welsh waters.

This pattern of low constraints continues towards and into the Severn Channel. There are no important seal haul out sites in the area, nor overlapping or adjacent SAC or SSSI sites with marine mammals as features. Along the most inshore regions of the RA the main contributor to the relative constraints reflect grey seal usage of these waters, while the presence of harbour porpoise is the main influence on those constraints indicated within the remainder of the RA.

5.3.4 Fish

Welsh waters

The relative constraints in relation to fish are largely a result of overlaps with spawning and nursery grounds (see Ellis *et al.*, 2012). The spatial data layers from this dataset are very broad, subsequently resulting in the broad patterning visualised by the mapping outputs.

Along the north coast of wales, coincidence with the Dee Estuary Ramsar and SAC, important migratory fish routes and fish spawning areas to the north of Rhyl, result in the most extensive area of high constraints indicated in Welsh waters (see Figure 30).

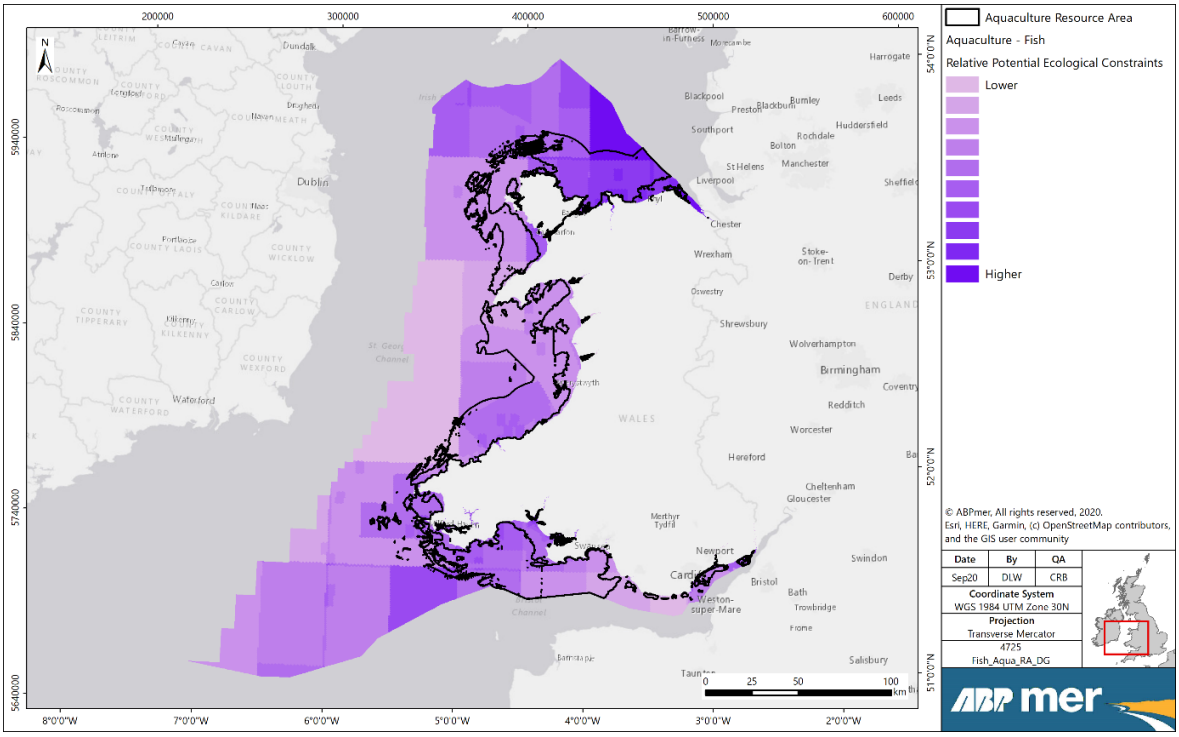

Figure 30. Relative potential ecological constraints in relation to fish for aquaculture

Across the top of Anglesey, the presence of nursery and spawning grounds contribute most to the constraints; although the overall indication is comparably lower than constraints to the east of Anglesey. Close inshore, at the mouths of estuaries along the mid-wales coastline, constraints are a result of overlap with migratory fish corridors in addition to spawning and nursery grounds. Offshore, the main contributing factors to the constraints were the presence of fish spawning areas and the Cardigan Bay SAC to the south. Around the Pembrokeshire coastline there are multiple designated sites which, along with fish nursery grounds, contribute to the constraints. Spawning and nursery grounds for multiple fish species are found offshore to the south of Pembrokeshire. To the east of the Bristol Channel the overall constraints indicated are comparatively lower than many other areas of Welsh waters. However, the constraints increase again heading into the Severn Estuary signifying the importance of this area for migratory fish and the presence of designated sites for fish (e.g. Severn Estuary SAC; Severn Estuary Ramsar).

It was considered that there was no potential for significantly different levels of exposure to fish or their responses to the varied aquaculture activities (seaweed, bivalve). Hence, the finalised mapping output for fish was relevant to either of these activities.

Aquaculture (north)

Notably high relative constraints were indicated across much of the RAs to the east of Anglesey (see Figure 31).

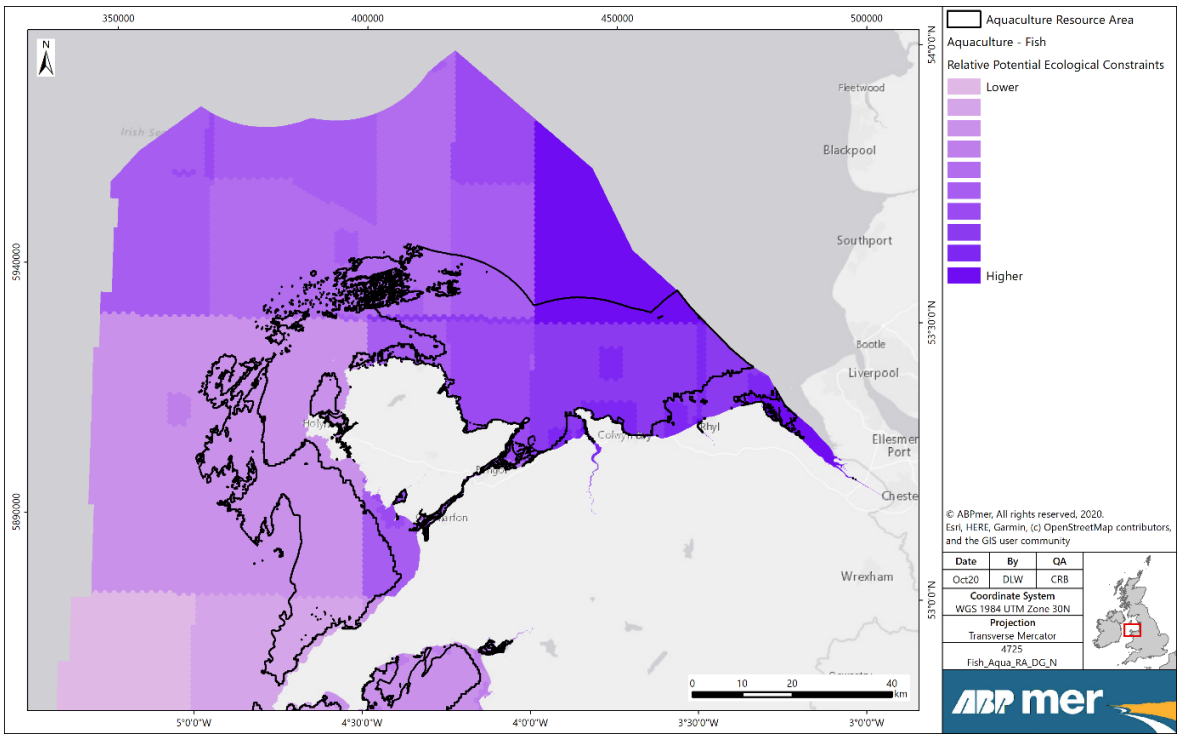

Figure 31. Relative potential ecological constraints in relation to fish for aquaculture in north RA groupings

The overlap with important nursery and spawning grounds for multiple fish species including herring, cod whiting and sandeel, contribute most to the constraints observed. Inshore, around the Dee, there is also an overlap with the Dee Estuary SAC and Ramsar site, and an important migratory corridor. To the west and south of Anglesey, constraints are elevated by the overlap with recognised low intensity spawning and nursery grounds for several fish species including cod, whiting and sandeel. The slight increase in constraints seen in the waters offshore of Trefor are as a result of overlap with high intensity nursery grounds for whiting. Within the Menai Strait, overlap with these nursery and spawning grounds as well as important migratory corridors gives rise to the relatively high constraints near Caernarfon.

Aquaculture (mid)

There are no designated European sites with fish as qualifying features around the Llyn Peninsula, and it is the multiple spawning grounds that provide the main contributor to the constraints indicated off the southern coast of the Llyn Peninsula and in offshore waters to the south (see Figure 32). The relative level of constraints are comparatively low in the estuaries at Morfa Harlech, Barmouth and Dyfi, despite overlapping with migratory fish corridors.

The overlap with an increasing number of nursery and spawning grounds around Cardigan Bay, in addition to the SAC, results in relatively higher constraints although these reduce notably approaching Strumble Head.

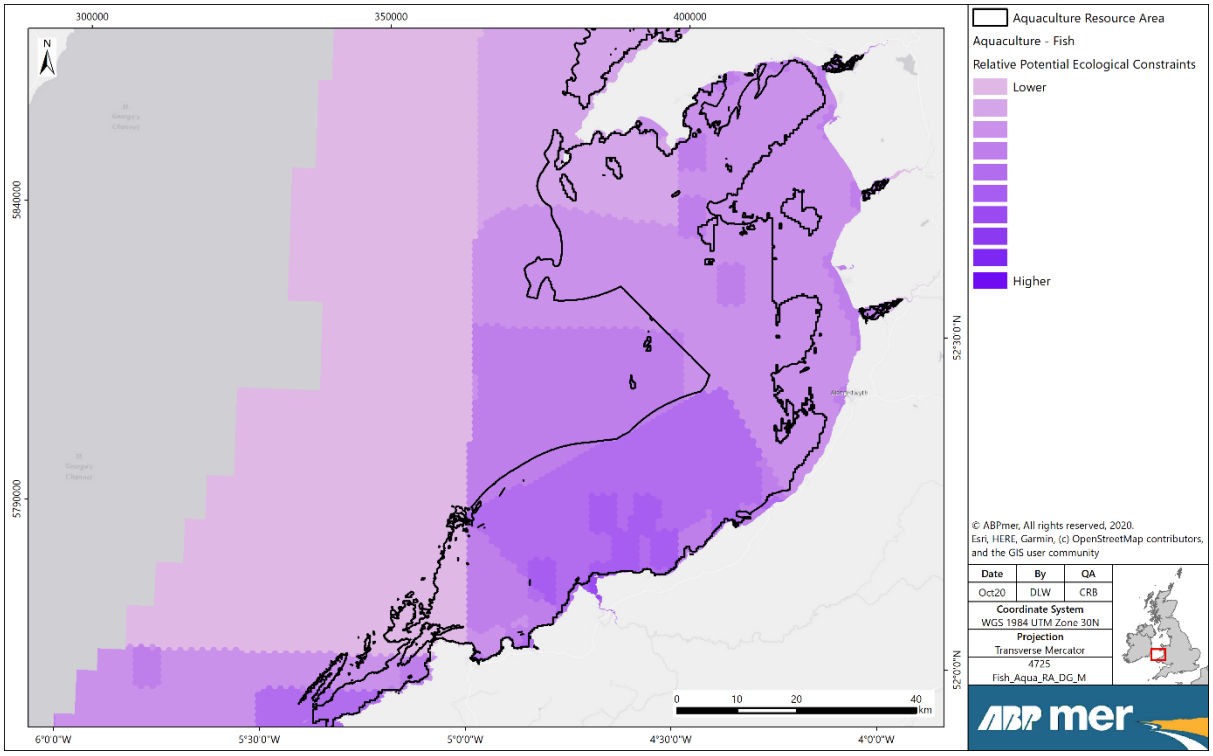

Figure 32. Relative potential ecological constraints in relation to fish for aquaculture in mid RA groupings

Aquaculture (south)

Close inshore, around St Davids Head, Ramsey Island and St Brides Bay, it is the low intensity nursery grounds of species such as whiting and mackerel, high intensity sandeel spawning grounds and in the overlap with the Pembrokeshire Marine SAC that result in relatively high constraints (see Figure 33). At a localised level, these constraints increase close inshore to Skomer due to overlap with multiple designated sites. Similarly, around Milford Haven it is the presence of nursery grounds and overlap with the Pembrokeshire Marine SAC that result in the relatively high constraints.

The presence of high intensity (sandeel and cod) and low intensity (mackerel and whiting) spawning grounds result in the highest relative constraints to the south. Towards the east, through the Bristol Channel, the constraints reduce, reflecting minimal overlap with spawning or nursery grounds. The RAs present off the coast at Aberthaw and Barry Island have minimal constraints, however, approaching and within the Severn Estuary, constraints increase as a result of overlap with the Severn Estuary SAC and Ramsar site. This is also the result of the presence of nursery grounds for plaice and sole along with the importance of this region for migratory fish.

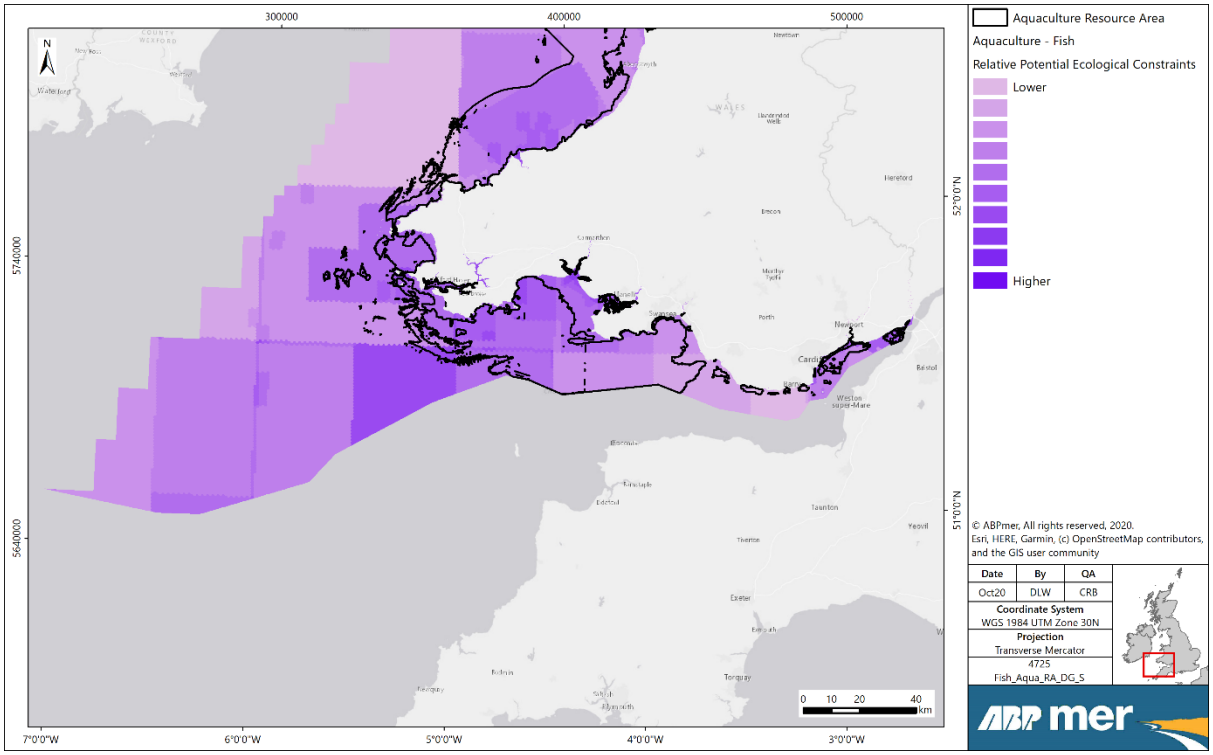

Figure 33. Relative potential ecological constraints in relation to fish for aquaculture in south RA groupings

5.3.5 Habitats

Welsh waters

Inshore along the Welsh coastline, the relative constraints are notably higher than offshore environments (see Figure 34), noting that data gaps are more prevalent in offshore locations (see below). More than 10-20 km offshore are extensive areas identified as being of relatively low constraints based on current data availability, such as to the east and far north of Anglesey, to the west of mid Wales, and in the south west. Offshore, the pattern of constraints is largely indicative of mixed muddy sediment or reef habitats. Within estuaries the constraints are elevated and the result of multiple Section 7 and/or Article 17 features being present.

Designated sites have a strong influence on the constraints e.g. Llyn Peninsula and the Sarnau SAC, Cardigan Bay SAC and Pembrokeshire Marine SAC. The pattern of constraints is also indicative to the presence of reef and estuarine features, both of which are Article 17 features encompassing a variety of other designated (Article 17, Section 7, OSPAR) habitats and species.

The habitat datasets (i.e. Article 17/Annex I features; Section 7/OSPAR habitats; Section 7/OSPAR species) represent the amalgamation of data collected during numerous and varied benthic surveys over a number of years. Much of the habitat mapping to form these datasets is based on the interpretation of various multibeam (or other remote sensing) outputs supported by a range of groundtruthing. An indication of where data gaps exist is not simply derived through the absence of Section 7/OSPAR/Annex I data, as this does not mean there is no habitat data at all in these locations, as features may be present (as derived from survey effort) that are not recognised through these designations. Such limitations with the habitat datasets are highlighted in the Study as it should not be assumed, particularly in offshore waters, that areas absent of Section 7/OSPAR/Annex I features have survey data adequate to indicate that no features relevant to the constraints analysis exist.

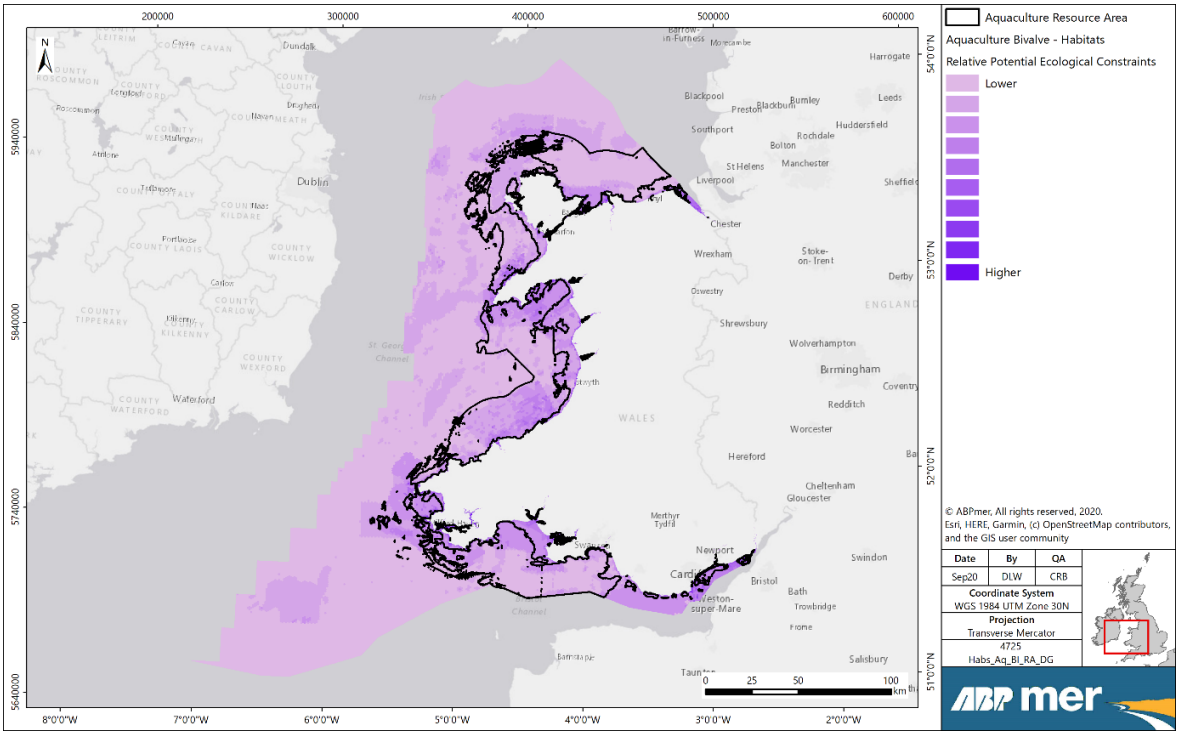

Figure 34. **Relative potential ecological constraints in relation to habitats for bivalve aquaculture**

Habitats (north) (bivalve aquaculture)

Like some of the other Welsh estuaries, very high constraints are indicated in the Dee Estuary where there are multiple Article 17 features (e.g. estuaries, mudflats and sandflats, saltmarsh) and Section 7 /OSPAR features (e.g. intertidal mudflats, saltmarsh) and also overlap with the Dee Estuary SAC and Ramsar site) (see Figure 35).

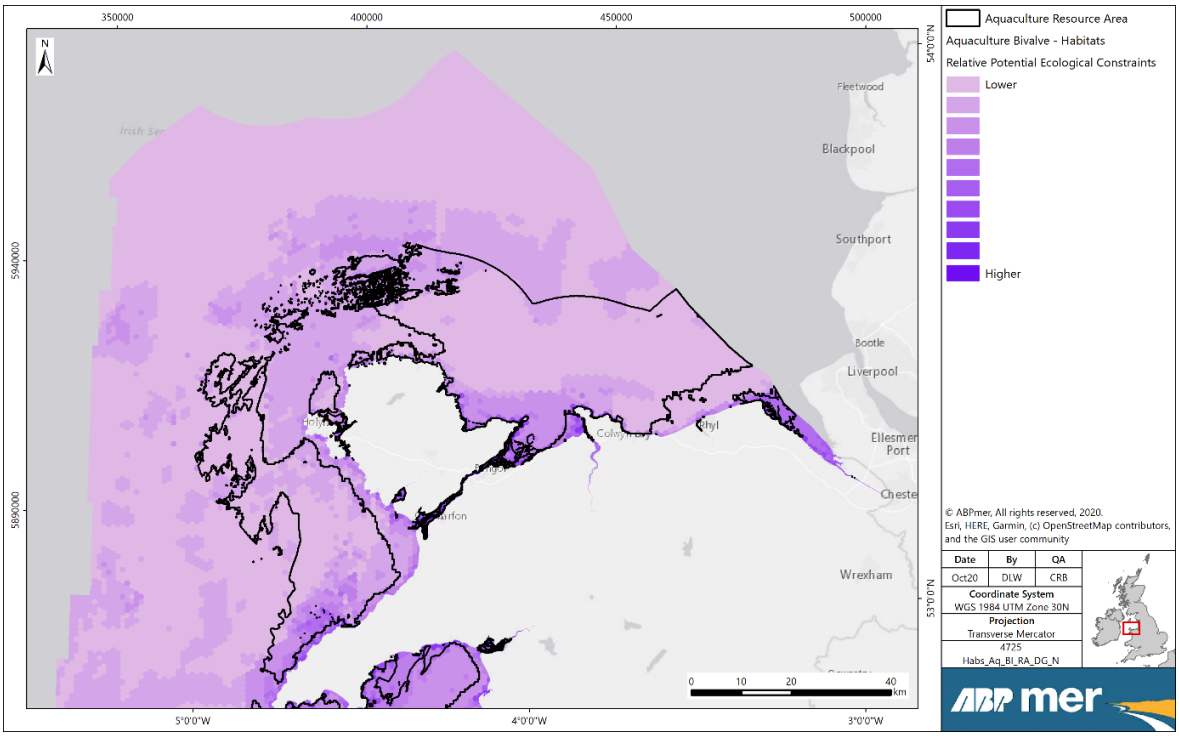

Figure 35. **Relative potential ecological constraints in relation to habitats for bivalve aquaculture in north RA groupings**

Away from the coast there are minimal constraints depicted, with a slight increase shown in the northern extent of the RA here, where there is overlap with the mixed muddy sediment feature (Section 7). Towards Anglesey and the Menai Strait, constraints increase as a result of multiple features such as sand banks and mixed muddy sediments, along with the presence of the Menai Strait SAC. Close inshore, around Puffin Island and along the coastline around Beaumaris, the constraints are particularly high as a consequence of many Article 17 (e.g. reefs, mudflats) and Section 7 features (e.g. tidal swept channels, intertidal reef, mixed muddy sediments).

The presence of intertidal and subtidal reefs along the north coast of Anglesey results in localised areas of relatively high constraints. However, moving offshore these reduce markedly, the occasional increases seen here being the result of subtidal reef features. Near Cemlyn Bay the constraints are indicative of the SSSI. To the west of Anglesey, the RAs are comparatively low in constraints with the slight elevations indicated being the result of subtidal reef.

Towards the Llyn Peninsula, the constraints increase as result of reef presence, including patches of horse mussel bed, mixed muddy sediment and overlap with the Llyn Peninsula and Sarnau SAC.

Habitats (mid) (bivalve aquaculture)

Habitats constraints are relatively high around Bardsey Island, resulting from multiple overlaps with Section 7/OSPAR features (e.g. fragile sponge and anthozoan communities, mixed muddy sediment) Article 17 (reef) and the European (Llyn Peninsula and Sarnau SAC) and nationally designated (Ynys Enlli SSSI) sites (see Figure 36).

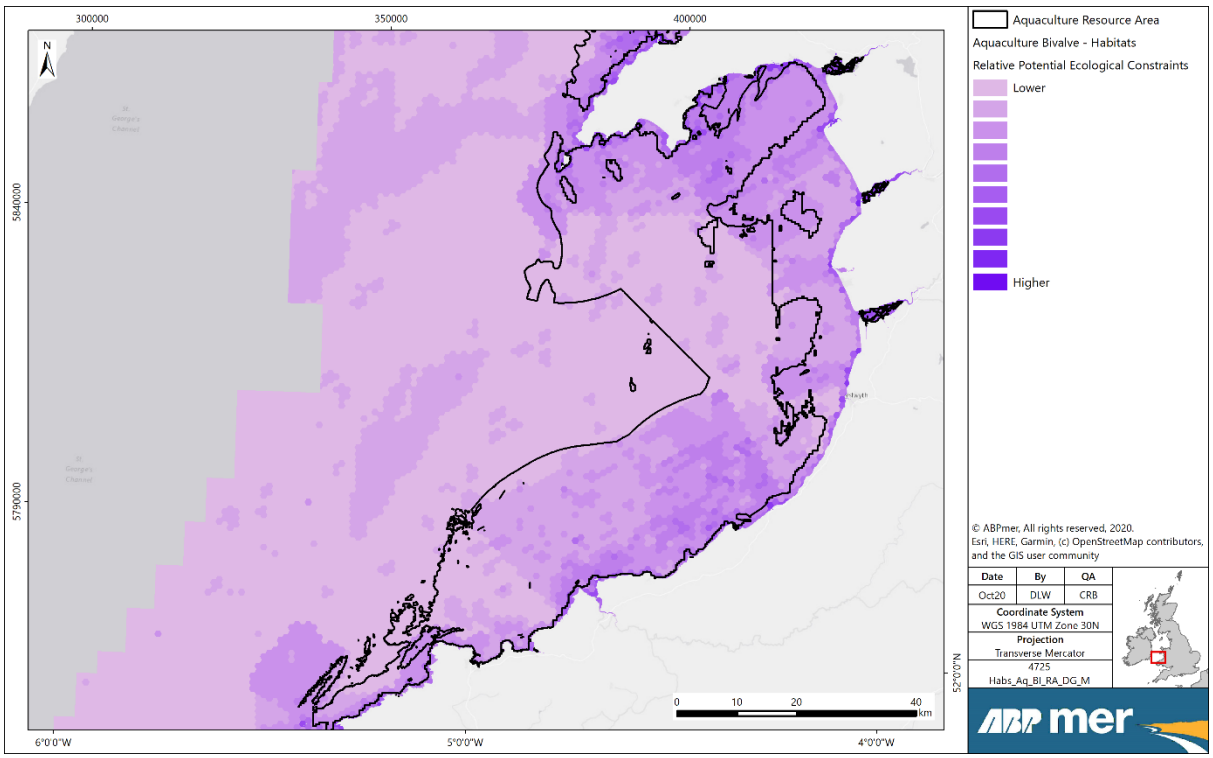

Figure 36. Relative potential ecological constraints in relation to habitats for bivalve aquaculture in mid RA groupings

Where the RAs overlap with near shore areas along the peninsula there are clear increases in constraints, these result from the overlap with SSSIs, and intertidal features such as intertidal reef, sea caves and mudflats. The estuaries at Morfa Harlech, Barmouth and Dyfi are all high in constraints. This tends to

be as a result of the presence of multiple Article 17 features (estuaries, saltmarsh, intertidal reef) and Section 7/OSPAR habitats.

The continuation of the Llyn Peninsula and Sarnau SAC to the south is the main contributor to the relatively low constraints indicated offshore, along with Article 17 subtidal reef. Although the pattern of constraints is largely reflective of very low or minimal constraints offshore, the overlap with Cardigan Bay SAC and mixed muddy sediment feature, increase the relative constraints.

Inshore, as seen elsewhere across the Welsh coastline, the constraints are notably higher where they overlap with intertidal features and SSSIs.

Habitats (south) (bivalve aquaculture)

Around the west coast of Pembrokeshire the highest constraints were indicated close inshore and were the result of overlaps with Article 17 (subtidal and to a lesser extent intertidal reefs; sea caves around Ramsey and Skomer Island; sandbanks to the west and south of Milford Haven) and Section 7/OSPAR (e.g. fragile sponge and anthozoan communities, mixed muddy sediments) features (see Figure 37). In addition to the presence of the Pembrokeshire Marine SAC which encompasses much of the RA here, and at a localised level numerous nationally designated sites (e.g. Skomer MCZ; Ramsey SSSI; St David's Peninsula Coast SSSI; Grassholm SSSI; Skomer Island and Middleholm SSSI etc.).

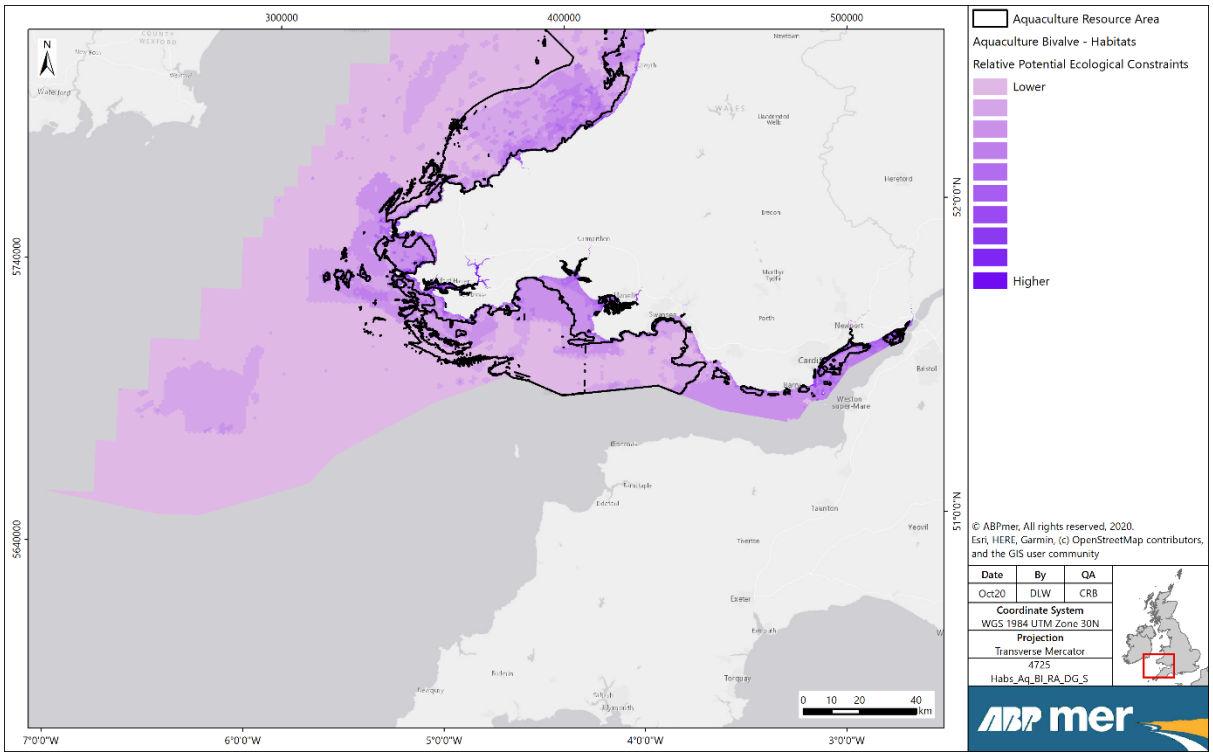

Figure 37. Relative potential ecological constraints in relation to habitats for bivalve aquaculture in south RA groupings

Higher constraints are indicated within the Milford Haven, the multiple Article 17 features (estuaries, reefs, large shallow inlets and bays, mudflats and sandflats) being the main contributor. To the south east and into the Bristol Channel constraints are minimal. However, within Carmarthen Bay and specifically the estuaries at Afon Taf and Burry, the constraints increase with the presence of Article 17 features and, within the estuaries, the presence of SSSIs (e.g. Pembrey Coast SSSI, Taf Estuary SSSI, Burry Inlet and Loughor Estuary SSSI).

The presence of subtidal reef contributes to the constraints off the south coast RAs, for example at Aberthaw and Barry Island. With the presence of Section 7/OSPAR features (e.g. *Sabellaria alveolata* reefs and seagrass) also contributing within localised inshore areas. Heading into the Severn Estuary the constraints are mainly a result of Article 17 features (e.g. estuaries, subtidal reefs, sand banks, mudflats and sandflats) with localised hotspots close inshore also influenced by Section 7/OSPAR habitats and overlap with designated sites (e.g. Severn Estuary Ramsar, SSSI and SAC).

Habitats (seaweed aquaculture)

The final outputs relevant to seaweed aquaculture (see Figure 38 showed a very similar pattern to that of bivalve aquaculture despite a number of the features having slightly lower complexity adjustment factors than assigned for bivalve aquaculture (see Table 15). The minor changes seen in the patterning are largely because of the lower complexity value assigned to the Article 17 features 'mudflats and sandflats' and 'intertidal reef'; however, the text above remains relevant to the outputs within the RAs for seaweed aquaculture.

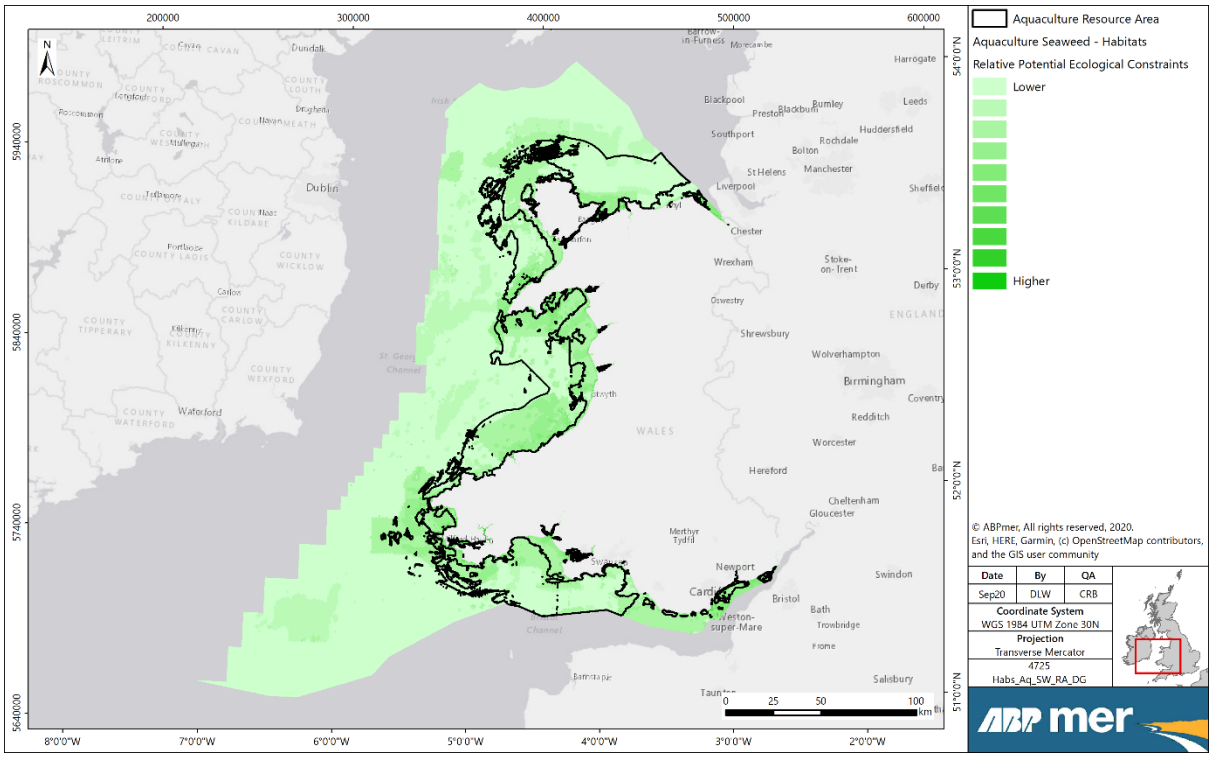

Figure 38. Relative potential ecological constraints in relation to habitats for seaweed aquaculture

6 Discussion

As set out in the WNMP, Welsh Government planning policy is to support the sustainable development of emerging marine sectors such as tidal stream energy, wave energy and aquaculture; whilst ensuring marine ecosystems are protected and enhanced.

Potentially suitable RAs for the focus sectors (tidal stream energy, wave energy, aquaculture) have already been identified in Welsh waters through the provision of RAs, as defined and presented within the WNMP and WMPP. This component of the SMMNR project has focussed on identifying and mapping the relative potential ecological constraints particular to a focus sector within the respective RAs. However, recognising the evolving technology of these marine sectors, the study has not constrained the analysis to the RAs but also provides an indication of the ecological constraints across all Welsh waters. This allows for future proofing of the approach, acknowledging that resource opportunities will likely change, as new technologies emerge, and existing technologies evolve.

For this work, an ecological constraint was defined as an ecological feature's presence which based upon technical expert judgement, could add to the complexity of marine consenting and thus have the potential to increase consenting risk for development of marine sectors, be they focus sectors or otherwise. Hence, understanding where the relatively higher ecological constraints exist within an RA, or elsewhere in Welsh waters, will inform marine spatial planning, affording greater opportunity for development while helping minimise impacts on the marine environment.

In agreement with Welsh Government and NRW, ecological features were divided into birds, fish, marine mammals and habitats; the BIFs. These groupings were considered to be suitably high-level but still meaningful for the purpose of this study. To allow consideration of impact pathways relevant to these features and the focus sectors, early assumptions were required (see Scope and Assumptions), including the decision to limit the pathways to those that could occur during the operational phase, accepting direct habitat loss as an operational rather than construction impact. It was recognised that the risk from impact pathways that occur during construction and decommissioning are largely dependent on the site and project specifics, rather than the uncertainty or unavailability of evidence to support the assessments. Linked to this assumption is scale of the operations, and while it is recognised that these sectors have demonstration type projects of varied but more limited ecological effects, within this study it was assumed that operations would be at a commercial scale.

Thus, the impact pathways and subsequent dataset selection for the analysis were considered against these assumptions. Such limitations to the study indicate why the outputs cannot substitute the requirement for project level assessment, which covers the specifics of the development in question (e.g. scale, duration, construction impacts, cabling, land infrastructure etc.), along with detailed consideration of ecological features within the zone of influence (the area affected by the project activities). It should be acknowledged that this Study represents a first step to work with stakeholders, to refine mapping methodologies. Future iterations will provide the opportunity for further refinements, as required.

While the outputs of this plan level study do not substitute the requirement for project level assessment benefits will be realised from this work at the project level stage. The outputs will complement baseline characterisation, highlighting gaps and/or deficiencies with existing ecological data, as well as indicating areas of potential relative opportunity at a regional level. As an iterative process, it is the Welsh Government's intention that future reviews of the outputs can be updated in line with changes to the evidence base to ensure that the outputs continue to provide benefits and facilitate project development from both a regulatory and developer perspective.

Highlighting potential areas of greater relative constraint and/or areas of relative opportunity will be an important tool to assist the decision-making process and drive future development at a plan level. Regulators will also be better able to understand where research priorities should be directed to fill gaps, reduce assumptions and strengthen confidence in the data being used to determine the relative spatial constraints.

The datasets used to derive the constraints were selected by agreement with NRW and Welsh Government and represent the best available and most suitable datasets to understanding each of the operational impact pathways identified for a given ecological feature (see Risk Screening). The result of this process (see Step 1) was the selection of several datasets (4 or 5) per BIF. The selection of a dataset that provides metadata which covers most, if not all, of Welsh marine waters was essential for the plan level study. However, in some cases this resulted in a reliance on data that was indirectly related to the impact pathway and BIF. For example, presence and distribution of the features was used to infer feature response thresholds against impacts such as collision, displacement and barriers; even though these thresholds are not fully understood for many mobile features.

Part 1 of the SMMNR project, indicated the knowledge gaps that exist in relation to operational impacts from the focus sectors (ABPmer, 2019). In some cases, work is already underway to better understand the sensitivity of the features to such impacts e.g. collision risk of marine mammals to tidal stream turbines. However, the need for empirical data means that full understanding can only be achieved through operational monitoring studies. Furthermore, even if the sensitivity of a feature is established then questions may remain e.g. is the sensitivity applicable across Welsh waters; to all technologies, to all individual species of feature etc.

It is envisaged that a regular review of the selected datasets will prevent the use of data within the methodology if more suitable and available data were to exist. The broad scoring approach allows for addition, removal and replacement of datasets (see Step 3) as scoring across the relevant datasets is applied in an additive fashion; however, the detailed scoring process for the new dataset will need to be considered (i.e. classification, weighting, complexity adjustment) by the custodian.

Along with data recommendations, deficiencies identified with the selected datasets are highlighted within the report (Appendix B) such as the age of the data or reliance on predictive modelling outputs. These also have implications for the confidence assessment (see Step 1 and Appendix C) which should be revisited during the review process and updated accordingly.

In many instances, as additional data becomes available there may be a requirement to amalgamate with a selected dataset. As part of the SMMNR project, a benthic survey programme was carried out in 2019 (ABPmer, 2020b[32]) to fill evidence gaps and provide greater confidence in habitat maps. Additional analysis of the videos was commissioned by NRW and the results have been added to Marine Recorder[33]. It is the intention of Welsh Government that the data will be amalgamated with Article 17 and Section 7/OSPAR habitat datasets in the near future, as appropriate. Once complete, then these updated datasets could replace those used to inform the current habitat outputs (see Step 6) and the models re-run.

Acknowledging the ongoing need for updates to be incorporated, the outputs are best delivered through an online platform. The key product from the SMMNR project is the production of online evidence packages specific to each sector which include interactive mapping outputs for the constraints study[34]. Interaction with the outputs is crucial to enable full benefits to the end user, with the facility to zoom to areas of interest and understand which data is contributing most to the constraints scores.

32 https://gov.wales/sustainable-management-marine-natural-resources
33 https://jncc.gov.uk/our-work/marine-recorder/
34 https://gov.wales/sustainable-management-marine-natural-resources

The fast-evolving nature of the focus sectors, particularly the emerging wet renewable sectors, means it is important that the detailed scoring process and thus the outputs, can evolve as necessary. There is also the need to consider the future proofing of the study and how it may encompass other sectors and expand over time.

Where uncertainty existed within the study then a precautionary approach was taken. For example, during the risk screening process the identification of a relevant impact pathway for a BIF was based against the individual feature(s) within the BIF group which had the greatest sensitivity to the impact, or where the greatest uncertainty remained (see Risk Screening). Similarly, during the scoring process, a low complexity adjustment value was only applied where a consensus existed that consenting complexity from an activity's operation would be minimal in Welsh waters and where this was supported by evidence (Complexity Adjustment).

A precautionary approach was also inherent within the methodology. At a spatial level, due to the individual 1 km^2 cells that made up the constraints grid, conservative outputs were generated from datasets. The spatial distribution datasets for birds, mammals and fish used a lower resolution than 1 km^2 (i.e. >1 km^2) so although there was no loss of data once this was scored and applied to the grid, a more conservative output was generated. This occurred because where an individual cell overlaps with different scores from a single dataset it defaults to the highest constraint score irrespective of the degree of overlap. Therefore, if a 1 km^2 cell was almost fully encompassed by one constraint score it still defaults to another constraint score if the latter is higher. Essentially this means that the areas of higher relative potential constraint visualised on the outputs are likely to represent conservatively larger areas than if they were exactly aligned to the same resolution as the datasets used to derive the outputs.

At the other end of the spectrum, where point datasets (e.g. Section 7/OSPAR species/habitats) were used in a binary fashion to create a constraint layer i.e. classification represented presence, then the whole grid cell (1 km^2) adopted the score for the feature. However, in some instances multiple point data (e.g. sea caves, sea pens and burrowing megafauna) were located within a single grid cell. This also occurred with some polygon data such as intertidal reef and maerl, where 261 and 1,482 polygon features were respectively located in one grid cell. To avoid significant skewing of the constraint output it was necessary to only score the presence of a distinct 'habitat' feature from a given dataset once in a grid cell and exclude scores from the same feature if they occur again within the same grid cell. However, some features were scored twice due to their consideration within different datasets. For example, biogenic reefs fall under the Article 17 reef (subtidal or intertidal) feature but are discriminated by biogenic reef type under Section 7/OSPAR habitats (e.g. blue mussel beds, horse mussel beds etc.).

As outlined above, the processes and rules adopted within the study lead to conservative outputs which are considered necessary within a plan level study which incorporates so many variables and assumptions. It is important that the conservative nature of the work is indicated to interested stakeholders and thus the requirements for project level assessment are continually highlighted.

Although useful to visualise the degree of relative constraints, these are relative to the scores across the mapping output and should be acknowledged as such. It should not be immediately assumed that development in areas of Welsh marine waters that are depicted at the high end of the relative constraint scale within the mapping outputs, would necessarily be subject to significant consenting risks, especially since the outputs are necessarily conservative (see above). There are many additional factors to consider which are beyond the scope of this study such as the specifics of a particular project and the nature of the receiving environment. However, the study does bring potential risks to the attention of interested stakeholders. Conversely, it is intended that areas of minimal ecological constraints within or near to a RA will be flagged for further consideration of the opportunity highlighted. To fully understand the viability to focus sector development, these areas of opportunity will require additional investigation of the ecological character and detailed consideration against wider constraints e.g. shipping, grid

connectivity, cabling, flood risk, seascape etc. alongside socio-economic considerations. Additional work, beyond the scope of this project will consider potential social and economic opportunities and constraints to these sectors.

Furthermore, the finalised output for a sector or a sector technology/activity, relevant to a BIF, is not cross-comparable with any other finalised outputs (sector or sector technology/activity). This results from consideration of 'relative' constraint scores and unavoidable differences between the ecological feature datasets and the detailed scoring mechanisms applied (see Dataset Scoring). Hence, it was not appropriate or beneficial to provide a cumulative output covering all of the BIFs for a sector or sector technology/activity. This is not seen as a limitation to the outputs as even if it were possible to merge all the BIF outputs for an individual sector, the BIF's are not directly comparable in terms of their potential to increase consenting complexity. Greater benefit is achieved through provision of individual outputs for each feature as these can be readily absorbed, the input data easily interrogated, and a clear supporting narrative presented.

The granularity of the mapping outputs differed between BIFs due to the nature of the feature coupled with the nature of the data available. For example, as the broad fish spawning and nursery areas (Ellis *et al*., 2012) resulted in relatively high potential constraints the boundaries of these broad areas are depicted in the final outputs. Similarly, the low resolution of cetacean spatial distribution datasets resulted in a quite different patterning from the concentric circles, representing foraging distances from colonies, seen in the bird outputs.

Whilst the study illustrates the broad constraints in relation to a feature and sector it is not possible to capture localised constraints within the outputs. Thus, there may be instances where a feature in a geographical area may represent a much greater consenting risk than elsewhere in Welsh waters. Although broad areas of particular importance to a BIF will generally be encompassed by consideration of the relevant designated sites, certain areas may not fully acknowledge highly localised constraints. This might include, for example, the presence of Roseate terns along the north coast of Anglesey, or particularly important seal haul-out and pupping sites. Presence of such features may increase consenting complexity and would need to be acknowledged within project level assessment; however, there is scope for recognition of such features within the online evidence packages[35] and future iterations of the outputs could flag such potential constraints to align with current thinking and advice.

During application of the methodology careful consideration was given to the potential problem of illustrating an area of opportunity due to the absence of data, rather than data being available and indicating a low constraint score. The datasets selected can be considered as absolute (e.g. designated site boundaries; seal haul-out locations), observational (Seabirds at Sea; Atlas of Marine Mammals) or a combination of modelling informed by survey records (e.g. cetacean distribution; Article 17 habitats). The absolute and modelled data were acknowledged for this study as covering all Welsh marine waters, the exception was the cetacean distribution data which does not cover bottlenose dolphin distribution within 30 km of the Welsh coastline. However, this 'gap' was picked up through the Atlas of Marine Mammal data for bottlenose dolphin which covers the relevant region of Welsh waters and thus supplemented the cetacean distribution dataset. Whereas, within the Seabirds at Sea dataset spatial gaps were identified most notably within the wave energy RA which extended beyond the limits of the surveys used to inform Seabirds at Sea and also contained a number of data gaps more than 25 km offshore (see Figure 15). A few data gaps relevant to the tidal stream RAs existed but these were limited to the offshore RAs west of Llyn Peninsula. No specific data gaps existed which were relevant to aquaculture RAs.

[35] https://gov.wales/sustainable-management-marine-natural-resources

To understand potential constraints in relation to fish, much reliance was given to the comparatively old nursery and spawning datasets (Ellis *et al*., 2012). There are many other limitations to the data used to inform the nursery and spawning datasets such as gear type used, seasonality of surveys and lack of detailed coverage within close inshore coastal areas (see Section 4.3.2 and Appendix B). Indeed, the surveys used to inform the work by Ellis *et al*. (2012) did not cover the Severn Estuary and the eastern end of the Bristol Channel; however, the datasets produced infer nursery grounds for plaice and sole overlap with these areas. The lack of data on migratory fish movements in marine waters was flagged (see Appendix B), leading to important areas for migratory fish being inferred through a 1 km seaward extension of Welsh estuaries. Future studies, such as tagging of migratory fish species, may hopefully provide a clearer understanding of migratory fish pathways in Welsh waters, allowing further refinement of this Study.

Particular caution was highlighted around the Section 7/OSPAR/Article 17 datasets used to indicate potential constraints in relation to habitats. Although these datasets represent the best available and most complete data of these marine features across Welsh waters, they are the amalgamation of numerous survey programmes (see Section 4.1.2 and 5), the majority of which cover coastal inshore environments. Further work is required to review these surveys and provide an indication of where gaps exist or data is deemed insufficient to give meaningful habitat maps. Yet, with such knowledge, full certainty is never completely achieved unless coincident with the location of a groundtruthed station. Even so, mobile sediment features and ephemeral biogenic aggregations (e.g. *Sabellaria* sp. reefs, blue mussel beds) may be present only in the short term. Such considerations once again highlight the requirement for project level assessment and benthic surveys to support sustainable development of the sectors.

It should also be acknowledged that the outputs do not address 'cumulative' or 'in-combination' effects between the focus sectors or other marine activities. The lack of long-term datasets and scientific studies to inform operational effects on features means the potential for cumulative effects or potential 'in-combination' effects will require case by case consideration at the time of application. Therefore, during discussions with NRW and Welsh Government in 2019, it was agreed that consideration of cumulative effects, between the focus sectors or other marine activities, would not be taken forward within the Study due to so many uncertainties.

It is envisaged that the constraint outputs would be used as a first step in the planning process, allowing broad consideration of where ecological constraints might exist and where there are potential opportunities for development. However, it is just one step in a much wider marine planning process which requires detailed stakeholder engagement and statutory consultation, regional locational guidance, sustainability appraisal and consideration against national (WNMP) and regional policies. Throughout the ecological constraints study, communication with stakeholders has been carried out to provide progress updates and to present early mapping outputs to elicit feedback. In 2020 example mapping outputs were presented at Expert Panel meetings and a Consenting Strategy Action Group (CSAG) meeting, with an interactive PDF sent out to stakeholders. Feedback from stakeholders on the mapping outputs were then discussed with Welsh Government in August 2020 and acknowledged accordingly within final development of the outputs.

As mentioned above, the mapping outputs are also located within an online platform[36], as evidence packages, to allow full functionality and therefore maximum benefit to the user. The evidence package relating to each of the focus sectors which, along with the mapping outputs, provide easily accessible information relevant to the sector covering areas such as consenting, guidance and policy, with links to related websites, dataset sources and studies.

[36] https://gov.wales/sustainable-management-marine-natural-resources

Alongside stakeholder input, the outputs from this study will assist developers and regulators; recognising that while the outputs do not substitute the requirement for project level assessment, they do provide a valuable supplementary tool to understanding the potential risks and evidence needs.

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8 Abbreviations/Acronyms

AONB	Areas of Outstanding Natural Beauty
Aq	Aquaculture
BI	Bivalve
BIF	Broad Interest Features
BoCCW3	Birds of Conservation Concern for Wales
BTO	British Trust for Ornithology
CCW	Countryside Council for Wales
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CI	Confidence Interval
cSAC	candidate Special Area of Conservation
CSAG	Consenting Strategy Action Group
DECC	Department of Energy and Climate Change
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
EMFF	European Maritime and Fisheries Fund for Welsh Government
ESAS	European Seabirds at Sea
EU	European Union
GIS	Geographic Information Systems
GW	Gigawatt
HabMap	Habitat Mapping for Conservation and Management of the Southern Irish Sea
HRA	Habitats Regulations Assessment
IAMMWG	Inter-Agency Marine Mammal Working Group
INNS	Invasive Non-native Species
JNCC	Joint Nature Conservation Committee
MARESA	Marine Evidence-Based Sensitivity Assessment
MCS	Marine Conservation Society
MCZ	Marine Conservation Zone
MLWS	Mean Low Water Springs
MPA	Marine Protected Area
MW	Mid-Water
NBN	National Biodiversity Network
NIRAS	NIRAS Consulting Ltd
NRW	Natural Resources Wales
ORJIP	Offshore Renewables Joint Industry Programme
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic (OS – Oslo, PAR – Paris)
PAD	Pressures-Activities Database
PDF	Portable Document Format
QA	Quality Assurance
RA	Resource Area
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SB	Seabed
SeaMap2	Broad-scale Physical Habitat Map for European Seas
SMMNR	Sustainable Management of Marine Natural Resources
SMP	Seabird Monitoring Programme
SMRU	Sea Mammal Research Unit

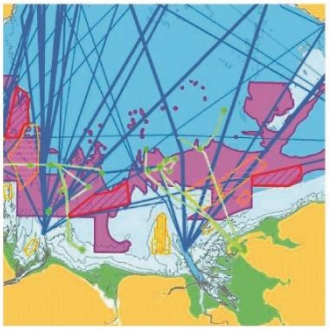
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
St	Saint
SU	Surface
SW	Seaweed
TS	Tidal Stream
UD	Utilisation Distribution
UK	United Kingdom
UTM	Universal Transverse Mercator
Wave	Wave Energy
WebGIS	Geographic Information Systems Resource
WeBS	Wetland Bird Survey
WeBS	Wetland Bird Survey
WG	Welsh Government
WGS	World Geodetic System
WMPP	Welsh Marine Planning Portal
WNMP	Welsh National Marine Plan
WOS	Welsh Ornithological Society
WP	Work Package
WWT	Wildfowl and Wetlands Trust

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Appendices




Innovative Thinking - Sustainable Solutions

ABP mer

A Sensitivity Assessment

Table A1. Sensitivity matrix for operational impacts of a commercial tidal stream energy development

Ref No.	Impact Pathway	Habitats	Birds	Marine Mammals	Fish
1	Development footprint leading to permanent loss/changes to seabed, foraging or nursery/spawning areas				
2	Presence of structures leading to permanent loss/gain of habitat resulting in changes to mobile species distribution/abundance	n/a			
3	Presence of structures/vessels resulting in temporary/permanent changes to habitat from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes		n/a	n/a	n/a
4	Presence of structures/vessels resulting in temporary/permanent changes to foraging or nursery/spawning areas from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	n/a			
5	Presence of structures/vessels resulting in physical damage (or mortality) to species from collision, entanglement or disorientation	n/a			
6	Presence of structures causing barrier to movement, migratory pathways and/or access to feeding grounds	n/a			
7	Operational activities resulting in noise disturbance to mobile species	n/a			
8	Operational activities resulting in visual disturbance (e.g. lighting) to mobile species	n/a			
9	Electromagnetic Fields (EMF) and thermal emissions from power cables interfering with prey location, mate detection and/or creating barriers to migration for sensitive species		n/a		
10	Introduced structures resulting in exclusion/displacement of mobile species from an area				
11	Spillage of fluids, fuels during maintenance/operation leading to reduction in water quality				
12	Structures on the seabed providing new substratum that facilitates the colonisation and ingress of invasive non-native species		n/a	n/a	n/a
13	Introduction of invasive non-native species as biofouling species on the surfaces of vessels or cultivated species		n/a	n/a	n/a
14	Operational activities resulting in an increase of suspended sediments and turbidity, leading to displacement of mobile species	n/a			

No distinction was made between tidal stream energy technologies (see Scope and Assumptions). Shaded cells indicated where there is potential for a significant impact (as previously defined) to occur on a broad interest feature. Unshaded cells indicate that a pathway may exist but a significant impact (as previously defined) is unlikely to occur on a broad interest feature. Where a pathway is not specifically relevant to a broad interest feature it is denoted by 'n/a'.

Table A2. Sensitivity matrix for operational impacts of a commercial wave energy development

Ref No.	Impact Pathway	Habitats	Birds	Marine Mammals	Fish
1	Development footprint leading to permanent loss/changes to seabed, foraging or nursery/spawning areas				
2	Presence of structures leading to permanent loss/gain of habitat resulting in changes to mobile species distribution/abundance	n/a			
3	Presence of structures/vessels resulting in temporary/permanent changes to seabed from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes		n/a	n/a	n/a
4	Presence of structures/vessels resulting in temporary/permanent changes to foraging or nursery/spawning areas from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	n/a			
5	Presence of structures/vessels resulting in physical damage (or mortality) to species from collision, entanglement or disorientation	n/a			
6	Presence of structures causing barrier to movement, migratory pathways and/or access to feeding grounds	n/a			
7	Operational activities resulting in noise disturbance to mobile species	n/a			
8	Operational activities resulting in visual disturbance (e.g. lighting) to mobile species	n/a			
9	Electromagnetic Fields (EMF) and thermal emissions from power cables interfering with prey location, mate detection and/or creating barriers to migration for sensitive species		n/a		
10	Introduced structures resulting in exclusion/displacement of mobile species from an area				
11	Spillage of fluids, fuels during maintenance/operation leading to reduction in water quality				
12	Structures on the seabed providing new substratum that facilitates the colonisation and ingress of invasive non-native species		n/a	n/a	n/a
13	Introduction of invasive non-native species as biofouling species on the surfaces of vessels or cultivated species		n/a	n/a	n/a
14	Operational activities resulting in an increase of suspended sediments and turbidity, leading to displacement of mobile species	n/a			
No distinction is made between wave energy technologies. (see Scope) Shaded cells indicate where there is potential for a significant impact (as previously defined) to occur on a broad interest feature. Where a pathway is not specifically relevant to a broad interest feature it is denoted by 'n/a'					

Table A3. Sensitivity matrix for operational impacts of bivalve aquaculture

Ref No.	Impact Pathway	Habitats	Birds	Marine Mammals	Fish
1	Development footprint leading to permanent loss/ changes to seabed, foraging or nursery/spawning areas				
2	Presence of structures leading to permanent loss/gain of habitat resulting in changes to mobile species distribution/abundance	n/a			
3	Presence of structures/vessels resulting in temporary/ permanent changes to seabed from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes		n/a	n/a	n/a
4	Presence of structures/vessels resulting in temporary/permanent changes to foraging or nursery/spawning areas from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	n/a			
5	Presence of structures/vessels resulting in physical damage (or mortality) to species from collision, entanglement or disorientation	n/a			
6	Presence of structures causing barrier to movement, migratory pathways and/or access to feeding grounds	n/a			
7	Operational activities resulting in noise disturbance to mobile species	n/a			
8	Operational activities resulting in visual disturbance (e.g. lighting) to mobile species	n/a			
10	Introduced structures resulting in exclusion/displacement of mobile species from an area				
11	Spillage of fluids, fuels during maintenance/operation leading to reduction in water quality				
12	Structures on the seabed providing new substratum that facilitates the colonisation and ingress of invasive non-native species		n/a	n/a	n/a
13	Introduction of invasive non-native species as biofouling species on the surfaces of vessels or cultivated species		n/a	n/a	n/a
14	Operational activities resulting in an increase of suspended sediments and turbidity, leading to displacement of mobile species	n/a			
15	Operational activities resulting in increased sedimentation with damage or loss of seabed features		n/a	n/a	n/a
16	Introduction of litter leading to smothering, entanglement or ingestion				
17	Release of synthetic compounds associated with species cultivation e.g. pesticides, pharmaceuticals etc.		n/a	n/a	
18	Biological disturbance to native species from interactions with cultivated species		n/a	n/a	
19	The import or rearing of cultivated stock leading to introduction of microbial pathogens		n/a	n/a	
20	Operational activities leading to increased organic enrichment or deoxygenation of substrata		n/a	n/a	n/a

No distinction is made between bivalve species, inshore/offshore or seabed/water column activities; with a precautionary approach taking forward a worst-case (see Scope). Shaded cells indicate where there is potential for a significant impact (as previously defined) to occur on a broad interest feature. Where a pathway is not specifically relevant to a broad interest feature it is denoted by 'n/a'.

Table A4. Sensitivity matrix for operational impacts of seaweed aquaculture

Ref No.	Impact Pathway	Habitats	Birds	Marine Mammals	Fish
1	Development footprint leading to permanent loss/changes to seabed, foraging or nursery/spawning areas				
2	Presence of structures leading to permanent loss/gain of habitat resulting in changes to mobile species distribution/abundance	n/a			
3	Presence of structures/vessels resulting in temporary/permanent changes to habitat from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes		n/a	n/a	n/a
4	Presence of structures/vessels resulting in temporary/permanent changes to foraging or nursery/spawning areas from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	n/a			
5	Presence of structures/vessels resulting in physical damage (or mortality) to species from collision, entanglement or disorientation	n/a			
6	Presence of structures causing barrier to movement, migratory pathways and/or access to feeding grounds	n/a			
7	Operational activities resulting in noise disturbance to mobile species	n/a			
8	Operational activities resulting in visual disturbance (e.g. lighting) to mobile species	n/a			
10	Introduced structures resulting in exclusion/displacement of mobile species from an area				
11	Spillage of fluids, fuels during maintenance/operation leading to reduction in water quality				
12	Structures on the seabed providing new substratum that facilitates the colonisation and ingress of invasive non-native species		n/a	n/a	n/a
13	Introduction of invasive non-native species as biofouling species on the surfaces of vessels or cultivated species		n/a	n/a	n/a
14	Operational activities resulting in an increase of suspended sediments and turbidity, leading to displacement of mobile species	n/a			
15	Operational activities resulting in increased sedimentation with damage or loss of seabed features		n/a	n/a	n/a
16	Introduction of litter leading to smothering, entanglement or ingestion				
17	Release of synthetic compounds associated with species cultivation e.g. pesticides, pharmaceuticals etc.		n/a	n/a	
18	Biological disturbance to native species from interactions with cultivated species		n/a	n/a	
19	The import or rearing of cultivated stock leading to introduction of microbial pathogens		n/a	n/a	
20	Operational activities leading to increased organic enrichment or deoxygenation of substrata		n/a	n/a	n/a
No distinction is made between farmed species or inshore/offshore activities; with a precautionary approach taking forward a worst-case (see Scope). Shaded cells indicate where there is potential for a significant impact (as previously defined) to occur on a broad interest feature. Where a pathway is not specifically relevant to a broad interest feature it is denoted by 'n/a'.					

B Datasets Selected

Table B1. Datasets selected for tidal stream based upon best available for understanding impact pathways identified in Table A1 (Appendix A)

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
1	Development footprint leading to permanent loss/changes to seabed, foraging or nursery/ spawning areas	H	Loss of benthic habitat and communities Changes to distribution of benthic habitat and associated communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Wider monitoring to address gaps in spatial mapping extent. Review of datasets to understand underlying coverage of survey extent, predictive mapping and gaps in spatial data. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time. EU SeaMap2, provides modelled broadscale mapping but ground-truthing of the data would be required to provide fine resolution data for development level constraints analysis.

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
		B	Loss of foraging areas Changes to foraging areas	Indication of bird density (wintering and breeding) provides low resolution foraging areas. Bird colonies tend to be close to important foraging areas. Many important colonies are designated sites. Water immediately around seabird colonies often important for loafing. Knowledge of foraging range allows consideration of potential foraging areas.	▪ Seabirds at Sea evidence database – composite of ESAS and WWT (bird distribution and density) (NRW) ▪ RSPB utilisation/foraging maps (Kittiwake, Shag, Guillemot, Razorbill) ▪ Seabird colonies and population counts (Seabird Monitoring Programme) ▪ JNCC maintenance extensions ▪ Mean foraging ranges (Woodward *et al*., 2019) ▪ Designated conservation sites	Data on bird distribution old. Some spatial gaps exist in Seabirds at Sea dataset. RSPB utilisation maps only available for four species. Bird foraging areas move; however, seabird colonies generally tend to be close to good foraging areas. Population counts at seabird colonies varies in age and can be several years old depending on the last monitoring programme at the colony.	The seabirds at sea evidence database spans to 2009, it therefore needs updating to provide a more accurate assessment of seabird distribution. The data is also highly skewed by observer effort with clear evidence of shipping routes. Correction for effort, and a wider survey area is needed to provide representative coverage. Wider range of species maps for seabird utilisation and foraging required – e.g. Storm petrel, Gulls, Manx Shearwater, Fulmar, Gannet. Aerial surveys of seabird distribution in Welsh waters
		F	Loss of foraging areas/ Changes to foraging areas Loss of nursery/ spawning areas/ Changes to nursery/spawnin g areas	Foraging areas vast and varied. Constraints better understood through consideration of nursery/spawning areas. Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk.	▪ ▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Designated conservation sites	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy. Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al.* (1998) for Herring data Assumes key spawning/nursery areas are as previously described Ellis *et al* (2012) data covers restricted species and not all species of conservation importance. Basking shark data ranges from 1987 to 2006 and is therefore old.	Herring were identified as an important fish species for Welsh planning, however herring maps have not been updated since 1998. No data on Angel shark. Mapping or evidence of this species would be useful to inform constraints analysis. The majority of the nursery and spawning area surveys were carried out in summer. However, some fish show seasonal patterns of migration therefore any temporal changes in distribution may be missing. Surveys across the

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
							year would help monitor this change. Basking shark distribution survey covering Welsh waters recommended.
3	Presence of structures/ vessels resulting in temporary/ permanent changes to seabed from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	H	Loss of benthic habitat and communities Changes to distribution of benthic habitat and associated communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Wider monitoring to address gaps in spatial mapping extent. Review of datasets to understand underlying coverage of survey extent, predictive mapping and gaps in spatial data. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time. EU SeaMap2, provides modelled broadscale mapping but ground-truthing of the data would be required to provide fine resolution data for development level constraints analysis.

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
4	Presence of structures/ vessels resulting in temporary/ permanent changes to foraging or nursery/ spawning areas from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	F	Loss of foraging areas Changes to foraging areas Loss of nursery/spawning areas Changes to nursery/spawning areas	Foraging areas vast and varied. Constraints better understood through consideration of nursery/spawning areas. Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk.	▪ ▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Designated conservation sites	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy. Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data. Assumes key spawning/nursery areas are as previously described. Ellis *et al* (2012) data covers restricted species and not all conservationally important species. Basking shark data ranges from 1987 to 2006 and is therefore old.	Herring were identified as an important fish species for Welsh planning, however herring maps have not been updated since 1998. No data on Angel shark. Mapping or evidence of this species would be useful to inform constraints analysis. The majority of the nursery and spawning area surveys were carried out in summer. However, some fish show seasonal patterns of migration therefore any temporal changes in distribution may be missing. Surveys across the year would help monitor this change. Basking shark distribution survey covering Welsh waters recommended.
5	Presence of structures/ vessels resulting in physical damage (or mortality) to species from collision, entanglement or disorientation	B	Physical damage inc. mortality from collision with turbines or associated structures	Higher density of birds results in greater chance of collision. Juveniles potentially more susceptible to collision. Risk of collision inferred from bird density distribution. Proximity to seabird colonies infers increased collision risk. Understand utilisation of area by birds at greatest risk (diving birds)	▪ Seabirds at Sea evidence database – composite of ESAS and WWT (bird distribution and density) (NRW) ▪ RSPB utilisation/foraging maps (Kittiwake, Shag, Guillemot, Razorbill) ▪ Seabird colonies and population counts (Seabird Monitoring Programme) ▪ JNCC maintenance extensions ▪ Mean foraging ranges (Woodward *et al*., 2019)	Data on bird distribution old. Some spatial gaps exist in Seabirds at Sea dataset. RSPB utilisation maps only available for four species. Bird foraging areas move; however, seabird colonies generally tend to be close to good foraging areas. Inferred collision risk from density distribution.	The seabirds at sea evidence database spans to 2009, it therefore needs updating to provide a more accurate assessment of seabird distribution. The data is also highly skewed by observer effort with clear evidence of shipping routes. Correction for effort, and a wider survey area is needed to provide representative coverage. Wider range of species maps for seabird utilisation and

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
					▪ Designated conservation sites	Population counts at seabird colonies varies in age and can be several years old depending on the last monitoring programme at the colony.	foraging required – e.g. Storm petrel, Gulls, Manx Shearwater, Fulmar, Gannet. Surveys to assess collision risk of bird species with tidal stream devices to more accurately understand what proportion of each seabird population may be at risk. Aerial surveys of seabird distribution in Welsh waters.
		M		Indication of marine mammal density allows understanding of utilisation. Higher density of marine mammals results in greater chance of collision. Juveniles potentially more susceptible to collision. Risk of collision inferred from marine mammal density distribution. Proximity to seal pupping haul out sites infers increased risk of collision Close proximity to haul out sites will increase consenting risk.	▪ Grey seal at sea (Russell *et al*., 2017) ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al*., 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al*., 1995; Westcott and Stringell 2004; Strong *et al*., 2006; Clarke *et al*., 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old. Inferred collision risk from density distribution.	Data on seal pupping and haul out sites has been collated from four different studies to provide national (Wales) coverage. However, these data have been collected in different years. One, Wales wide survey would help improve reliably of the data and remove any temporal discrepancies. Improved data on risk of collision for marine mammals and tidal devices, e.g. avoidance rates or each species, and likely interaction based on device design, is required to understand collision risk to marine mammal species. Aerial survey(s) of marine mammal distribution in Welsh waters.

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
		F		Foraging areas vast and varied. Constraints better understood through consideration of nursery/spawning areas. Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk. Migratory fish routes through activity site may increase chances of collision, entanglement or disorientation. Important migratory fish marine pathways inferred through seaward boundary of Article 17 Estuaries 1 km extension.	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Boundary of riverine SACs (Art 17 Estuaries) ▪ Designated conservation sites	Fish nursery/spawning site data old (reliant on 2010 surveys) and patchy Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data. Assumes key spawning/nursery areas are as previously described. Limited to demersal and benthic species. Pelagic species not full Wales coverage (SW only). Ellis *et al* (2012) data covers restricted species and not all species of conservation importance. Basking shark data ranges from 1987 to 2006 and is therefore old. Diurnal or seasonal movement and migration of mobile fish species could cause changes to occurrence and density in area. Lack of empirical data for migratory routes/migratory fish distribution in marine waters. Inferred collision risk from density distribution.	Spawning and nursery data focuses mainly on species of commercial interest and does not assess the distribution of wider fish populations which will also be impacted by collisions with tidal stream devices. An updated survey to assess nursery and spawning data will also help assess current collision risk. The latest available data is from 2010. The majority of the nursery and spawning area surveys were carried out in summer. However, some fish show seasonal patterns of migration therefore any temporal changes in distribution may be missing. Surveys across the year would help monitor this change. Additional data, for example tagging records of elasmobranch species and migratory fish is recommended Improved data on risk of collision fish and tidal devices, e.g. avoidance rates or each species, and likely interaction based on device design, diurnal movement etc. is required to understand collision risk to fish species.

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
							Demersal species will be less impacted by risk of collision therefore updating the data to provide Welsh coverage of pelagic species is key. Basking shark distribution survey covering Welsh waters recommended. Lack of data on fish migratory pathways (e.g. salmonid migration routes). Currently acknowledged that there is not suitable data for migratory species: *Alosa alosa* Allis shad, *Alosa fallax* Twaite shad, *Anguilla anguilla* European eel, *Lampetra fluviatilis* River lamprey, *Petromyzon marinus* Sea lamprey, *Salmo salar* Atlantic salmon, *Osmerus eperlanus* European Smelt.
6	Presence of structures causing barrier to movement, migratory pathways and/ or access to feeding grounds	M	Barriers to movement resulting in displacement, behaviour changes	Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of displacement effects. Close proximity to haul out sites will increase consenting risk. Need to understand location of devices in relation to areas designated for marine mammal interest features.	▪ Grey seal at sea (Russell *et al*., 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al*., 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al*., 1995; Westcott and Stringell 2004; Strong *et al*., 2006; Clarke *et al*., 2020)	Some mammal distribution data (i.e. Baines and Evans, 2012) old. Inferred displacement from density distribution. Need to establish buffer for seal haul-out locations and increase resolution.	Data on seal pupping and haul out sites has been collated from four different studies to provide national (Wales) coverage. However, these data have been collected in different years. One, Wales wide survey would help improve reliably of the data and remove any temporal discrepancies. Atlas of Marine Mammals of Wales data is relatively old and

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
					▪ Designated conservation sites		could be updated to provide more current distribution of marine mammals. However, Waggitt *et al*. 2019 does provide an updated source for some marine mammal distributions. Aerial survey(s) of marine mammal distribution in Welsh waters.
		F		Foraging areas vast and varied. Constraints better understood through consideration of nursery/spawning areas. Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk. Migratory species routes and/or presence in area raise the likelihood of encounter. Important migratory fish marine pathways inferred through seaward boundary of Article 17 Estuaries 1 km extension.	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Boundary of riverine SACs (Art 17 Estuaries) ▪ Designated conservation sites	Fish nursery/spawning site data old (reliant on 2010 surveys) and patchy Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data Limited to demersal and benthic species. Pelagic species not full Wales coverage (SW only) Ellis *et al* (2012) data covers restricted species and not all conservationally important species Basking shark data ranges from 1987 to 2006 and is therefore old. Lack of empirical data on fish migratory pathways (e.g. salmonid migration routes) Diurnal or seasonal movement and migration of mobile fish species could cause changes	The majority of the nursery and spawning area surveys were carried out in summer. However, some fish show seasonal patterns of migration therefore any temporal changes in distribution may be missing. Surveys across the year would help monitor this change. Lack of data on fish migratory pathways (e.g. salmonid migration routes). Currently acknowledged that there is not suitable data for migratory species: *Alosa alosa* Allis shad, *Alosa fallax* Twaite shad, *Anguilla anguilla* European eel, *Lampetra fluviatilis* River lamprey, *Petromyzon marinus* Sea lamprey, *Salmo salar* Atlantic salmon, *Osmerus eperlanus* European Smelt. Additional data, for example tagging records of

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
						to occurrence and density in area.	elasmobranch species and migratory fish Updated data or increase survey effort to provide Wales level coverage for distributions of pelagic species. The majority of the nursery and spawning area surveys have been carried out in summer. However, some fish show seasonal patterns of migration/ movement therefore any temporal changes in distribution, diurnal seasonal may be missing. Updates surveys as varying times of day and year would help fill this gap. Basking shark distribution survey covering Welsh waters recommended.
7	Operational activities resulting in noise disturbance to mobile species	M	Noise disturbance leading to changes in behaviour	Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of disturbance impacts. Close proximity to seal haul-out sites will increase consenting risk. Need to understand location of devices in relation to areas designated for marine mammal interest features.	▪ Grey seal at sea (Russell *et al*., 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al*., 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al*., 1995; Westcott and Stringell 2004; Strong *et al*., 2006; Clarke *et al*., 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old. Inferred disturbance from density distribution. Need to establish buffer for seal haul-out locations and increase resolution.	Data on seal pupping and haul out sites has been collated from four different studies to provide national (Wales) coverage. However, these data have been collected in different years. One, Wales wide survey would help improve reliably of the data and remove any temporal discrepancies. Atlas of Marine Mammals of Wales data is relatively old and could be updated to provide more current distribution of

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
							marine mammals. However, Waggitt *et al.* 2019 does provide an updated source for some marine mammal distributions. Aerial survey(s) of marine mammal distribution in Welsh waters.
		F		A number of fish species have high sensitivity to noise. Assumed that distribution may change for species affected. These could be demersal species (e.g. cod) or pelagic schooling fish (e.g. herring). Occurrence and abundance of potential sensitive fish species linked to data from fisheries independent research trawl surveys. Important migratory fish marine pathways inferred through seaward boundary of Article 17 Estuaries 1 km extension.	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Boundary of riverine SACs (Art 17 Estuaries) ▪ Designated conservation sites	Fish nursery/spawning site data old (reliant on 2010 surveys) and patchy Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data. Limited to demersal and benthic species. Pelagic species not full Wales coverage (SW only). Lack of empirical data on fish migratory pathways (e.g. salmonid migration routes). Diurnal or seasonal movement and migration of mobile fish species could cause changes to occurrence and density in area.	Lack of data on fish migratory pathways (e.g. salmonid migration routes). Additional data, for example tagging records of elasmobranch species and migratory fish. In particular, for shad species as clupeids are highly sensitive to noise. Updated data or increase survey effort to provide Wales level coverage for distributions of pelagic species.
8	Operational activities resulting in visual disturbance (e.g. lighting) to mobile species	B	Visual disturbance leading to changes in behaviour	Higher density of birds results in greater chance of disturbance effects occurring. Risk of disturbance inferred from bird density distribution. Proximity to seabird colonies	▪ Seabirds at Sea evidence database – composite of ESAS and WWT (bird distribution and density) (NRW) ▪ RSPB utilisation/foraging maps (Kittiwake, Shag, Guillemot, Razorbill)	Data on bird distribution old. Some spatial gaps exist in Seabirds at Sea dataset. RSPB utilisation maps only available for four species.	The seabirds at sea evidence database spans to 2009, it therefore needs updating to provide a more accurate assessment of seabird distribution. The data is also high skewed by observer effort with clear evidence of shipping

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
				infers increased disturbance risk.	▪ Seabird colonies and population counts (Seabird Monitoring Programme) ▪ JNCC maintenance extensions ▪ Mean foraging ranges (Woodward *et al.*, 2019) ▪ Designated conservation sites	Bird foraging areas move; however, seabird colonies generally tend to be close to good foraging areas. Inferred disturbance from density distribution. Population counts at seabird colonies varies in age and can be several years old depending on the last monitoring programme at the colony.	routes. Correction for effort, and a wider survey area is needed to provide representative coverage. Wider range of species maps for seabird utilisation and foraging required – e.g. Storm petrel, Gulls, Manx Shearwater, Fulmar, Gannet. Aerial surveys of seabird distribution in Welsh waters.
		M		Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of disturbance impacts. Close proximity to seal haul-out sites will increase consenting risk. Need to understand location of devices in relation to areas designated for marine mammal interest features	▪ Grey seal at sea (Russell *et al.*, 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al.*, 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al.*, 1995; Westcott and Stringell 2004; Strong *et al.*, 2006; Clarke *et al.*, 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old. Inferred disturbance from density distribution. Need to establish buffer for seal haul-out locations and increase resolution.	Assessment of the wider area used by seals surrounding haul out sites could inform wider area of conflict/ disturbance. Atlas of Marine Mammals of Wales data is relatively old (2009) and could be updated to provide more current distribution of marine mammals. Waggitt *et al.* 2019 does provide an updated source for some marine mammal distributions and provides some correction for observer effort. Aerial survey(s) of marine mammal distribution in Welsh waters.
10	Introduced structures resulting in exclusion/ displacement of	B	Displacement of species	Higher density of birds results in greater chance of disturbance effects occurring.	▪ Seabirds at Sea evidence database – composite of ESAS and WWT (bird distribution and density) (NRW)	Data on bird distribution old. Some spatial gaps exist in Seabirds at Sea dataset.	The seabirds at sea evidence database spans to 2009, it therefore needs updating to provide a more accurate assessment of seabird

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
	mobile species from an area			Risk of displacement inferred from bird density distribution. Proximity to seabird colonies infers increased risk.	▪ RSPB utilisation/foraging maps (Kittiwake, Shag, Guillemot, Razorbill) ▪ Seabird colonies and population counts (Seabird Monitoring Programme) ▪ JNCC maintenance extensions ▪ Mean foraging ranges (Woodward *et al*., 2019) ▪ Designated conservation sites	RSPB utilisation maps only available for four species. Bird foraging areas move; however, seabird colonies generally tend to be close to good foraging areas. Inferred displacement from density distribution. Population counts at seabird colonies varies in age and can be several years old depending on the last monitoring programme at the colony.	distribution. The data is also high skewed by observer effort with clear evidence of shipping routes. Correction for effort, and a wider survey area is needed to provide representative coverage. Wider range of species maps for seabird utilisation and foraging required – e.g. Storm petrel, Gulls, Manx Shearwater, Fulmar, Gannet. Aerial surveys of seabird distribution in Welsh waters.
		M		Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of displacement effects. Close proximity to seal haul-out sites will increase consenting risk. Need to understand location of devices in relation to areas designated for marine mammal interest features.	▪ Grey seal at sea (Russell *et al*., 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al*., 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al*., 1995; Westcott and Stringell 2004; Strong *et al*., 2006; Clarke *et al*., 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old. Inferred displacement from density distribution. Need to establish buffer for seal haul-out locations and increase resolution.	A single, Wales wide survey of seal pupping and haul out would help remove any temporal discrepancies in current seals data. Additionally, assessment of the wider area used by seals surrounding haul out sites could inform constraints analysis. Atlas of Marine Mammals of Wales data is relatively old and could be updated to provide more current distribution of marine mammals and is skewed by observer effort to shipping routes, more even coverage would be useful. Waggitt *et al*. 2019 does provide an updated source for some marine mammal

Ref No.	Impact Summary	Feature Affected	Potential Effect	Dataset Considerations	Best Available Datasets	Data Gaps/Issues	Data Recommendations
							distributions and provides some correction for observer effort. Aerial survey(s) of marine mammal distribution in Welsh waters.
Reference number corresponds to pathway number in Table A1. Broad interest features denoted as H (habitats), B (birds), F (fish), M (marine mammals)							

Table B2. Datasets selected for wave energy based upon best available for understanding impact pathways identified in Table A2

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
1	Development footprint leading to permanent loss/ changes to seabed, foraging or nursery/ spawning areas	H	Loss of benthic habitat and communities Changes to distribution of benthic habitat and associated communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Wider monitoring to address gaps in spatial mapping extent. Review of datasets to understand underlying coverage of survey extent, predictive mapping and gaps in spatial data. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time. EU SeaMap2, provides modelled broadscale mapping but ground-truthing of the data would be required to provide fine resolution data for development level constraints analysis.
		B	Loss of foraging areas	Indication of bird density (wintering and breeding)	▪ Seabirds at Sea evidence database – composite of ESAS and WWT (bird	Data on bird distribution old. Some spatial gaps exist in Seabirds at Sea dataset.	The seabirds at sea evidence database spans to 2009, it therefore needs updating to

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
			Changes to foraging areas	provides low resolution foraging areas. Bird colonies tend to be close to important foraging areas. Many important colonies are designated sites. Water immediately around seabird colonies often important for loafing. Knowledge of foraging range allows consideration of potential foraging areas.	distribution and density) (NRW) ▪ RSPB utilisation/ foraging maps (Kittiwake, Shag, Guillemot, Razobill) ▪ Seabird colonies and population counts (Seabird Monitoring Programme) ▪ JNCC maintenance extensions ▪ Mean foraging ranges (Woodward *et al*., 2019) ▪ Designated conservation sites	RSPB utilisation maps only available for four species. Bird foraging areas move; however, seabird colonies generally tend to be close to good foraging areas. Population counts at seabird colonies varies in age and can be several years old depending on the last monitoring programme at the colony.	provide a more accurate assessment of seabird distribution. The data is also highly skewed by observer effort with clear evidence of shipping routes. Correction for effort, and a wider survey area is needed to provide representative coverage. Wider range of species maps for seabird utilisation and foraging required – e.g. Storm petrel, Gulls, Manx Shearwater, Fulmar, Gannet. Aerial surveys of seabird distribution in Welsh waters.
		F	Loss of foraging areas/ Changes to foraging areas Loss of nursery/ spawning areas/ Changes to nursery/ spawning areas	Foraging areas vast and varied. Constraints better understood through consideration of nursery/ spawning areas. Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk.	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Designated conservation sites ▪	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy. Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data. Assumes key spawning/ nursery areas are as previously described. Ellis *et al* (2012) data covers restricted species and not all species of conservation importance. Basking shark data ranges from 1987 to 2006 and is therefore old.	Herring were identified as an important fish species for Welsh planning, however herring maps have not been updated since 1998. No data on Angel shark. Mapping or evidence of this species would be useful to inform constraints analysis. The majority of the nursery and spawning area surveys were carried out in summer. However, some fish show seasonal patterns of migration therefore any temporal changes in distribution may be missing. Surveys across the

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
							year would help monitor this change. Basking shark distribution survey covering Welsh waters recommended.
3	Presence of structures/ vessels resulting in temporary/ permanent changes to seabed from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	H	Loss of benthic habitat and communities Changes to distribution of benthic habitat and associated communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the UK Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Wider monitoring to address gaps in spatial mapping extent. Review of datasets to understand underlying coverage of survey extent, predictive mapping and gaps in spatial data. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time. EU SeaMap2, provides modelled broadscale mapping but ground-truthing of the data would be required to provide fine resolution data for development level constraints analysis.

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
4	Presence of structures/ vessels resulting in temporary/ permanent changes to foraging or nursery/ spawning areas from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	F	Loss of foraging areas Changes to foraging areas Loss of nursery/ spawning areas Changes to nursery/ spawning areas	Foraging areas vast and varied. Constraints better understood through consideration of nursery/ spawning areas. Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk.	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Designated conservation sites	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy. Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data. Assumes key spawning/ nursery areas are as previously described. Ellis *et al* (2012) data covers restricted species and not all species of conservation importance. Basking shark data ranges from 1987 to 2006 and is therefore old.	Herring were identified as an important fish species for Welsh planning, however herring maps have not been updated since 1998. No data on Angel shark. Mapping or evidence of this species would be useful to inform constraints analysis. The majority of the nursery and spawning area surveys were carried out in summer. However, some fish show seasonal patterns of migration therefore any temporal changes in distribution may be missing. Surveys across the year would help monitor this change. Basking shark distribution survey covering Welsh waters recommended.
5	Presence of structures/ vessels resulting in physical damage (or mortality) to species from collision, entanglement or disorientation	B	Physical damage inc. mortality from collision with structures	Higher density of birds results in greater chance of collision. Juveniles potentially more susceptible to collision. Risk of collision inferred from bird density distribution. Proximity to seabird colonies infers increased collision risk. Understand utilisation of area by birds at greatest risk (diving birds).	▪ Seabirds at Sea evidence database – composite of ESAS and WWT (bird distribution and density) (NRW) ▪ RSPB utilisation/ foraging maps (Kittiwake, Shag, Guillemot, Razorbill) ▪ Seabird colonies and population counts (Seabird Monitoring Programme) ▪ JNCC maintenance extensions	Data on bird distribution old. Some spatial gaps exist in Seabirds at Sea dataset. RSPB utilisation maps only available for four species. Bird foraging areas move; however, seabird colonies generally tend to be close to good foraging areas.	The seabirds at sea evidence database spans to 2009, it therefore needs updating to provide a more accurate assessment of seabird distribution. The data is also highly skewed by observer effort with clear evidence of shipping routes. Correction for effort, and a wider survey area is needed to provide representative coverage.

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
					▪ Mean foraging ranges (Woodward *et al.*, 2019) ▪ Designated conservation sites	Inferred collision risk from density distribution. Population counts at seabird colonies varies in age and can be several years old depending on the last monitoring programme at the colony.	Wider range of species maps for seabird utilisation and foraging required – e.g. Storm petrel, Gulls, Manx Shearwater, Fulmar, Gannet. Surveys to assess collision risk of bird species with wave energy devices to more accurately understand what proportion of each seabird population may be at risk. Aerial surveys of seabird distribution in Welsh waters.
		M		Indication of marine mammal density allows understanding of utilisation. Higher density of marine mammals results in greater chance of collision. Juveniles potentially more susceptible to collision. Risk of collision inferred from marine mammal density distribution. Proximity to seal pupping haul out sites infers increased risk of collision Close proximity to haul out sites will increase consenting risk.	▪ Grey seal at sea (Russell *et al.*, 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al.*, 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al.*, 1995; Westcott and Stringell 2004; Strong *et al.*, 2006; Clarke *et al.*, 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old Inferred collision risk from density distribution	Data on seal pupping and haul out sites has been collated from four different studies to provide national (Wales) coverage. However, these data have been collected in different years. One, Wales wide survey would help improve reliably of the data and remove any temporal discrepancies. Improved data on risk of collision for marine mammals and tidal devices, e.g. avoidance rates or each species, and likely interaction based on device design, is required to understand collision risk to marine mammal species.

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
							Aerial survey(s) of marine mammal distribution in Welsh waters.
		F		Foraging areas vast and varied. Constraints better understood through consideration of nursery/ spawning areas. Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk. Migratory fish routes through activity site may increase chances of collision, entanglement or disorientation. Important migratory fish marine pathways inferred through seaward boundary of Article 17 Estuaries.	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Boundary of riverine SACs (Art 17 Estuaries) ▪ Designated conservation sites	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data Assumes key spawning/ nursery areas are as previously described Limited to demersal and benthic species. Pelagic species not full Wales coverage (SW only) Ellis *et al* (2012) data covers restricted species and not all conservationally important species Basking shark data ranges from 1987 to 2006 and is therefore old. Diurnal or seasonal movement and migration of mobile fish species could cause changes to occurrence and density in area. Lack of empirical data for migratory routes/ migratory	Spawning and nursery data focuses mainly on species of commercial interest and does not assess the distribution of wider fish populations which will also be impacted by collisions with wave energy devices. An updated survey to assess nursery and spawning data will also help assess current collision risk. The latest available data is from 2010. Additional data, for example tagging records of elasmobranch and migratory species. Improved data on risk of collision fish and wave energy devices, e.g. avoidance rates or each species, and likely interaction based on device design, diurnal movement etc. is required to understand collision risk to fish species. Demersal species will be less impacted by risk of collision therefore updating the data to provide Welsh coverage of pelagic species is key. Basking shark distribution survey covering Welsh waters recommended.

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
						fish distribution in marine waters Inferred collision risk from density distribution	Lack of data on fish migratory pathways (e.g. salmonid migration routes). Currently acknowledged that there is not suitable data for migratory species: *Alosa alosa* Allis shad, *Alosa fallax* Twaite shad, *Anguilla anguilla* European eel, *Lampetra fluviatilis* River lamprey, *Petromyzon marinus* Sea lamprey, *Salmo salar* Atlantic salmon, *Osmerus eperlanus* European Smelt.
6	Presence of structures causing barrier to movement, migratory pathways and/ or access to feeding grounds	M	Barriers to movement resulting in displacement, behaviour changes	Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of displacement effects. Close proximity to haul out sites will increase consenting risk. Need to understand location of devices in relation to areas designated for marine mammal interest features.	▪ Grey seal at sea (Russell *et al*., 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al*., 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al*., 1995; Westcott and Stringell 2004; Strong *et al*., 2006; Clarke *et al*., 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old Inferred displacement from density distribution Need to establish buffer for seal haul-out locations and increase resolution	Data on seal pupping and haul out sites has been collated from four different studies to provide national (Wales) coverage. However, these data have been collected in different years. One, Wales wide survey would help improve reliably of the data and remove any temporal discrepancies. Atlas of Marine Mammals of Wales data is relatively old and could be updated to provide more current distribution of marine mammals. However, Waggitt *et al*. 2019 does provide an updated source for some marine mammal distributions.

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
							Aerial survey(s) of marine mammal distribution in Welsh waters.
		F		Foraging areas vast and varied. Constraints better understood through consideration of nursery/ spawning areas. Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk. Migratory species routes and/ or presence in area raise the likelihood of encounter. Important migratory fish marine pathways inferred through seaward boundary of Article 17 Estuaries 1 km extension.	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Boundary of riverine SACs (Art 17 Estuaries) ▪ Designated conservation sites	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data. Limited to demersal and benthic species. Pelagic species not full Wales coverage (SW only). Ellis *et al* (2012) data covers restricted species and not all conservationally important species. Basking shark data ranges from 1987 to 2006 and is therefore old. Lack of empirical data on fish migratory pathways (e.g. salmonid migration routes). Diurnal or seasonal movement and migration of mobile fish species could cause changes to occurrence and density in area.	The majority of the nursery and spawning area surveys were carried out in summer. However, some fish show seasonal patterns of migration therefore any temporal changes in distribution may be missing. Surveys across the year would help monitor this change. Lack of data on fish migratory pathways (e.g. salmonid migration routes). Currently acknowledged that there is not suitable data for migratory species: *Alosa alosa* Allis shad, *Alosa fallax* Twaite shad, *Anguilla anguilla* European eel, *Lampetra fluviatilis* River lamprey, *Petromyzon marinus* Sea lamprey, *Salmo salar* Atlantic salmon, *Osmerus eperlanus* European Smelt. Updated data or increase survey effort to provide Wales level coverage for distributions of pelagic species. Knowledge of herring distribution (nursery/

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
							spawning areas) acknowledged as important consideration for marine planning; however, much of the data on herring nursery and spawning grounds has not been updated since 1998. The majority of the nursery and spawning area surveys have been carried out in summer. However, some fish show seasonal patterns of migration/movement therefore any temporal changes in distribution, diurnal seasonal may be missing. Updates surveys as varying times of day and year would help fill this gap. Basking shark distribution survey covering Welsh waters recommended.
7	Operational activities resulting in noise disturbance to mobile species	M	Noise disturbance leading to changes in behaviour	Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of disturbance impacts. Close proximity to seal haul-out sites will increase consenting risk. Need to understand location of devices in relation to areas	▪ Grey seal at sea (Russell *et al*., 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al*., 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al*., 1995; Westcott and Stringell 2004; Strong *et al*., 2006; Clarke *et al*., 2020)	Some mammal distribution data (i.e. Baines and Evans, 2012) old Inferred disturbance from density distribution Need to establish buffer for seal haul-out locations and increase resolution	Data on seal pupping and haul out sites has been collated from four different studies to provide national (Wales) coverage. However, these data have been collected in different years. One, Wales wide survey would help improve reliably of the data and remove any temporal discrepancies. Atlas of Marine Mammals of Wales data is relatively old and

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
				designated for marine mammal interest features.	▪ Designated conservation sites		could be updated to provide more current distribution of marine mammals. However, Waggitt *et al*. 2019 does provide an updated source for some marine mammal distributions. Aerial survey(s) of marine mammal distribution in Welsh waters.
		F		A number of fish species have high sensitivity to noise. Assumed that distribution may change for species affected. These could be demersal species (e.g. cod) or pelagic schooling fish (e.g. herring). Occurrence and abundance of potential sensitive fish species linked to data from fisheries independent research trawl surveys. Important migratory fish marine pathways inferred through seaward boundary of Article 17 Estuaries	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Boundary of riverine SACs (Art 17 Estuaries) ▪ Designated conservation sites	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data Limited to demersal and benthic species. Pelagic species not full Wales coverage (SW only) Lack of empirical data on fish migratory pathways (e.g. salmonid migration routes) Diurnal or seasonal movement and migration of mobile fish species could cause changes to occurrence and density in area.	Lack of data on fish migratory pathways (e.g. salmonid migration routes). .Additional data, for example tagging records of shad, which is highly sensitive to noise, would be useful. Updated data or increase survey effort to provide Wales level coverage for distributions of pelagic species.
8	Operational activities resulting in visual	B	Visual disturbance leading to	Higher density of birds results in greater chance of disturbance effects occurring.	▪ Seabirds at Sea evidence database – composite of ESAS and WWT (bird	Data on bird distribution old. Some spatial gaps exist in Seabirds at Sea dataset.	The seabirds at sea evidence database spans to 2009, it therefore needs updating to provide a more accurate

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
	disturbance (e.g. lighting) to mobile species		changes in behaviour	Risk of disturbance inferred from bird density distribution. Proximity to seabird colonies infers increased disturbance risk.	distribution and density) (NRW) ▪ RSPB utilisation/ foraging maps (Kittiwake, Shag, Guillemot, Razorbill) ▪ Seabird colonies and population counts (Seabird Monitoring Programme) ▪ JNCC maintenance extensions ▪ Mean foraging ranges (Woodward *et al.*, 2019) ▪ Designated conservation sites	RSPB utilisation maps only available for four species. Bird foraging areas move; however, seabird colonies generally tend to be close to good foraging areas. Inferred disturbance from density distribution. Population counts at seabird colonies varies in age and can be several years old depending on the last monitoring programme at the colony.	assessment of seabird distribution. The data is also high skewed by observer effort with clear evidence of shipping routes. Correction for effort, and a wider survey area is needed to provide representative coverage. Wider range of species maps for seabird utilisation and foraging required – e.g. Storm petrel, Gulls, Manx Shearwater, Fulmar, Gannet Aerial surveys of seabird distribution in Welsh waters.
		M		Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of disturbance impacts. Close proximity to seal haul-out sites will increase consenting risk. Need to understand location of devices in relation to areas designated for marine mammal interest features.	▪ Grey seal at sea (Russell *et al.*, 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al.*, 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al.*, 1995; Westcott and Stringell 2004; Strong *et al.*, 2006; Clarke *et al.*, 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old. Inferred disturbance from density distribution. Need to establish buffer for seal haul-out locations and increase resolution.	Assessment of the wider area used by seals surrounding haul out sites could inform wider area of conflict/ disturbance. Atlas of Marine Mammals of Wales data is relatively old (2009) and could be updated to provide more current distribution of marine mammals. Waggitt *et al.* 2019 does provide an updated source for some marine mammal distributions and provides some correction for observer effort. Aerial survey(s) of marine mammal distribution in Welsh waters.

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
10	Introduced structures resulting in exclusion/ displacement of mobile species from an area	M		Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of displacement effects. Close proximity to seal haul-out sites will increase consenting risk. Need to understand location of devices in relation to areas designated for marine mammal interest features.	▪ Grey seal at sea (Russell *et al*., 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al*., 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al*., 1995; Westcott and Stringell 2004; Strong *et al*., 2006; Clarke *et al*., 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old. Inferred displacement from density distribution. Need to establish buffer for seal haul-out locations and increase resolution.	A single, Wales wide survey of seal pupping and haul out would help remove any temporal discrepancies in current seals data. Additionally, assessment of the wider area used by seals surrounding haul out sites could inform constraints analysis. Atlas of Marine Mammals of Wales data is relatively old and could be updated to provide more current distribution of marine mammals and is skewed by observer effort to shipping routes, more even coverage would be useful. Waggitt *et al*. 2019 does provide an updated source for some marine mammal distributions and provides some correction for observer effort. Aerial survey(s) of marine mammal distribution in Welsh waters.
Reference number corresponds to pathway number in Table A2. Broad interest features denoted as H (habitats), B (birds), F (fish), M (marine mammals)							

Table B3. Datasets selected for bivalve aquaculture based upon best available for understanding impact pathways identified in Table A3

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
1	Development footprint leading to permanent loss/ changes to seabed, foraging or nursery/ spawning areas	H	Loss of benthic habitat and communities Changes to distribution of benthic habitat and associated communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Wider monitoring to address gaps in spatial mapping extent. Review of datasets to understand underlying coverage of survey extent, predictive mapping and gaps in spatial data. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time. EU SeaMap2, provides modelled broadscale mapping but ground-truthing of the data would be required to provide fine resolution data for development level constraints analysis.
		F	Loss of foraging areas/ Changes to foraging areas	Foraging areas vast and varied. Constraints better understood through	▪ Fish spawning and nursery areas (Ellis *et al*., 2012)	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy. Ellis *et al* (2012) needs to be	The majority of spawning/ nursery survey data was collected from water depths of greater than 20 m.

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
			Loss of nursery/ spawning areas/ Changes to nursery/ spawning areas	consideration of nursery/ spawning areas. Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk.	▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Designated conservation sites	supplemented by the even older Coull *et al*. (1998) for Herring data. Assumes key spawning/ nursery areas are as previously described. Ellis *et al* (2012) data covers restricted species and not all species of conservation importance. Basking shark data ranges from 1987 to 2006 and is therefore old.	Therefore, coastal and estuarine environments, often key for nursery and spawning grounds, are underrepresented. Further monitoring of inshore areas would address this gap. An updated survey to assess nursery and spawning data required. The latest available data is from 2010. Additionally, current data focuses mainly on species of commercial interest and does not provide full coverage of pelagic species distribution. Updated surveys are required to address this gap. The majority of the nursery and spawning area surveys were carried out in summer. However, some fish show seasonal patterns of migration therefore any temporal changes in distribution may be missing. Surveys across the year would help monitor this change. No data on Angel shark. Mapping or evidence of this species would be useful to inform constraints analysis.

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
							Basking shark distribution survey covering Welsh waters recommended.
3	Presence of structures/ vessels resulting in temporary/ permanent changes to seabed from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	H	Loss of benthic habitat and communities Changes to distribution of benthic habitat and associated communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Wider monitoring to address gaps in spatial mapping extent. Review of datasets to understand underlying coverage of survey extent, predictive mapping and gaps in spatial data. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time. EU SeaMap2, provides modelled broadscale mapping but ground-truthing of the data would be required to provide fine resolution data for development level constraints analysis.

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
7	Operational activities resulting in noise disturbance to mobile species	B	Noise disturbance leading to changes in behaviour	Higher density of birds results in greater chance of disturbance effects occurring. Risk of disturbance inferred from bird density distribution. Proximity to seabird colonies infers increased disturbance risk.	▪ Seabirds at Sea evidence database – composite of ESAS and WWT (bird distribution and density) (NRW) ▪ RSPB utilisation/ foraging maps (Kittiwake, Shag, Guillemot, Razorbill) ▪ Seabird colonies and population counts (Seabird Monitoring Programme) ▪ JNCC maintenance extensions ▪ Mean foraging ranges (Woodward *et al.*, 2019) ▪ Designated conservation sites	Data on bird distribution old. Some spatial gaps exist in Seabirds at Sea dataset. RSPB utilisation maps only available for four species. Bird foraging areas move; however, seabird colonies generally tend to be close to good foraging areas. Inferred disturbance from density distribution. Population counts at seabird colonies varies in age and can be several years old depending on the last monitoring programme at the colony.	The seabirds at sea evidence database spans to 2009, it therefore needs updating to provide a more accurate assessment of seabird distribution. The data is also high skewed by observer effort with clear evidence of shipping routes. Correction for effort, and a wider survey area is needed to provide representative coverage. Wider range of species maps for seabird utilisation and foraging required – e.g. Storm petrel, Gulls, Manx Shearwater, Fulmar, Gannet. Aerial surveys of seabird distribution in Welsh waters.
		M		Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of disturbance impacts. Close proximity to seal haul-out sites will increase consenting risk. Need to understand location of devices in relation to areas designated for marine mammal interest features.	▪ Grey seal at sea (Russell *et al.*, 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al.*, 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al.*, 1995; Westcott and Stringell 2004; Strong *et al.*, 2006; Clarke *et al.*, 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old. Inferred disturbance from density distribution. Need to establish buffer for seal haul-out locations and increase resolution.	Data on seal pupping and haul out sites has been collated from four different studies to provide national (Wales) coverage. However, these data have been collected in different years. One, Wales wide survey would help improve reliably of the data and remove any temporal discrepancies. Atlas of Marine Mammals of Wales data is relatively old and could be updated to provide more current

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
							distribution of marine mammals. However, Waggitt *et al*. 2019 does provide an updated source for some marine mammal distributions. Aerial survey(s) of marine mammal distribution in Welsh waters.
		F		A number of fish species have high sensitivity to noise. Assumed that distribution may change for species affected. These could be demersal species (e.g. cod) or pelagic schooling fish (e.g. herring). Occurrence and abundance of potential sensitive fish species linked to data from fisheries independent research trawl surveys. Important migratory fish marine pathways inferred through seaward boundary of Article 17 Estuaries.	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998) ▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Boundary of riverine SACs (Art 17 Estuaries) ▪ Designated conservation sites	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy Ellis *et al* (2012) needs to be supplemented by the even older Coull *et al*. (1998) for Herring data. Limited to demersal and benthic species. Pelagic species not full Wales coverage (SW only). Lack of empirical data on fish migratory pathways (e.g. salmonid migration routes). Diurnal or seasonal movement and migration of mobile fish species could cause changes to occurrence and density in area.	Lack of data on fish migratory pathways (e.g. salmonid migration routes). Additional data, for example tagging records of shad species, which are highly sensitive to noise. Updated data or increase survey effort to provide Wales level coverage for distributions of pelagic species.
8	Operational activities resulting in visual disturbance (e.g. lighting)	B	Visual disturbance leading to changes in behaviour	Higher density of birds results in greater chance of disturbance effects occurring. Risk of disturbance inferred from bird density distribution.	▪ Seabirds at Sea evidence database – composite of ESAS and WWT (bird distribution and density) (NRW)	Data on bird distribution old. Some spatial gaps exist in Seabirds at Sea dataset. RSPB utilisation maps only available for four species.	The seabirds at sea evidence database spans to 2009, it therefore needs updating to provide a more accurate assessment of seabird distribution. The data is also

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
	to mobile species			Proximity to seabird colonies infers increased disturbance risk.	▪ RSPB utilisation/ foraging maps (Kittiwake, Shag, Guillemot, Razorbill) ▪ Seabird colonies and population counts (Seabird Monitoring Programme) ▪ JNCC maintenance extensions ▪ Mean foraging ranges (Woodward *et al*., 2019) ▪ Designated conservation sites	Bird foraging areas move; however, seabird colonies generally tend to be close to good foraging areas. Inferred disturbance from density distribution. Population counts at seabird colonies varies in age and can be several years old depending on the last monitoring programme at the colony.	high skewed by observer effort with clear evidence of shipping routes. Correction for effort, and a wider survey area is needed to provide representative coverage. Wider range of species maps for seabird utilisation and foraging required – e.g. Storm petrel, Gulls, Manx Shearwater, Fulmar, Gannet. Aerial surveys of seabird distribution in Welsh waters.
		M		Indication of marine mammal density allows understanding of utilisation. Proximity to seal pupping haul out sites infers increased risk of disturbance impacts. Close proximity to seal haul-out sites will increase consenting risk. Need to understand location of devices in relation to areas designated for marine mammal interest features.	▪ Grey seal at sea (Russell *et al*., 2017). ▪ Atlas of Marine Mammals of Wales (Baines & Evans, 2012) ▪ Cetacean distribution (Waggitt *et al*., 2019) ▪ Seal pupping and haul out sites (amalgam of four datasets: Baines *et al*., 1995; Westcott and Stringell 2004; Strong *et al*., 2006; Clarke *et al*., 2020) ▪ Designated conservation sites	Some mammal distribution data (i.e. Baines and Evans, 2012) old Inferred disturbance from density distribution Need to establish buffer for seal haul-out locations and increase resolution	Assessment of the wider area used by seals surrounding haul out sites could inform wider area of conflict/ disturbance. Atlas of Marine Mammals of Wales data is relatively old (2009) and could be updated to provide more current distribution of marine mammals. Waggitt *et al*. 2019 does provide an updated source for some marine mammal distributions and provides some correction for observer effort. Aerial survey(s) of marine mammal distribution in Welsh waters

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
12	Structures on the seabed providing new substratum that facilitates the colonisation and ingress of invasive non-native species	H	Changes to benthic communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Assessment of presence and distribution of non-native species in Welsh waters required to address the likelihood of spread or introduction of INNS. Fine resolution data of the distribution of Section 7 habitats required to understand areas of vulnerability to INNS. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time.
15	Operational activities resulting in increased sedimentation	H	Changes to benthic communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species	Gaps in spatial mapping of habitat features including large areas with predicted features.	Updated assessment of the distribution of habitats susceptible to sedimentation.

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
	with damage or loss of seabed features			conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Designated conservation sites	Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Fine resolution data of the distribution of Section 7 or Article 17 features to understand areas of vulnerability to habitat change. Updated analysis of Article 17 data also required to assess the validity of historic records.
19	The import or rearing of cultivated stock leading to introduction of microbial pathogens	H	Changes to benthic communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020	Updated assessment of the distribution of habitats e.g. Section 7 or Article 17 features to impacts of microbial pathogens.

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
				area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.		will be amalgamated within relevant habitat datasets in future iterations of this work.	
20	Operational activities leading to increased organic enrichment or deoxygenation of substrata	H	Changes to benthic communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Updated assessment of the distribution of habitats e.g. Section 7 or Article 17 features to impacts of increased organic enrichment or subsequent impacts from algal blooms or other associated water quality changes.

Ref No.	Impact summary	Broad interest feature affected	Potential effect	Dataset rationale	Best available datasets	Data gaps/ issues	Data recommendations
				Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.			
Reference number corresponds to pathway number in Table A3. Broad interest features denoted as H (habitats), B (birds), F (fish), M (marine mammals)							

Table B4. Datasets selected for seaweed aquaculture based upon best available for understanding impact pathways identified in Table A4

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
1	Development footprint leading to permanent loss/ changes to seabed, foraging or nursery/ spawning areas	H	Loss of benthic habitat and communities Changes to distribution of benthic habitat and associated communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Wider monitoring to address gaps in spatial mapping extent. Review of datasets to understand underlying coverage of survey extent, predictive mapping and gaps in spatial data. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time. EU SeaMap2, provides modelled broadscale mapping but ground-truthing of the data would be required to provide fine resolution data for development level constraints analysis.
		F	Loss of foraging areas/ Changes to foraging areas	Foraging areas vast and varied. Constraints better understood through consideration of nursery/ spawning areas.	▪ Fish spawning and nursery areas (Ellis *et al*., 2012) ▪ Fisheries sensitivity maps in British waters – (Coull *et al*., 1998)	Fish nursery/ spawning site data old (reliant on 2010 surveys) and patchy. Ellis *et al* (2012) needs to be supplemented by the even	The majority of spawning/ nursery survey data was collected from water depths of greater than 20 m. Therefore, coastal and

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
			Loss of nursery/ spawning areas/ Changes to nursery/ spawning areas	Areas identified as relatively greater importance for fish include known spawning or nursery areas. Overlap with these defined areas would increase consenting risk.	▪ Basking shark distribution (Bloomfield and Solandt, 2010) ▪ Designated conservation sites	older Coull *et al*. (1998) for Herring data. Assumes key spawning/ nursery areas are as previously described. Ellis *et al* (2012) data covers restricted species and not all species of conservation importance. Basking shark data ranges from 1987 to 2006 and is therefore old.	estuarine environments, often key for nursery and spawning grounds, are underrepresented. Further monitoring of inshore areas would address this gap. An updated survey to assess nursery and spawning data required. The latest available data is from 2010. Additionally, current data focuses mainly on species of commercial interest and does not provide full coverage of pelagic species distribution. Updated surveys are required to address this gap. The majority of the nursery and spawning area surveys were carried out in summer. However, some fish show seasonal patterns of migration therefore any temporal changes in distribution may be missing. Surveys across the year would help monitor this change. No data on Angel shark. Mapping or evidence of this species would be useful to inform constraints analysis. Basking shark distribution survey covering Welsh waters recommended.

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
3	Presence of structures/ vessels resulting in temporary/ permanent changes to seabed from scour (including vessels, anchors, jack-up legs) or hydrodynamic changes	H	Loss of benthic habitat and communities Changes to distribution of benthic habitat and associated communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Wider monitoring to address gaps in spatial mapping extent. Review of datasets to understand underlying coverage of survey extent, predictive mapping and gaps in spatial data. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time. EU SeaMap2, provides modelled broadscale mapping but ground-truthing of the data would be required to provide fine resolution data for development level constraints analysis.
12	Structures on the seabed providing new substratum that facilitates the colonisation	H	Changes to benthic communities	Reporting under Article 17 of the EU Habitats Directive requires member states to report on progress towards achieving favourable conservation status for habitats and species of	▪ Article 17 features ▪ Section 7 and OSPAR habitats ▪ Section 7 and OSPAR species ▪ Designated conservation sites	Gaps in spatial mapping of habitat features including large areas with predicted features. Updates/ improvements to habitat layers through	Assessment of presence and distribution of non-native species in Welsh waters required to address the likelihood of spread or introduction of INNS.

Ref No.	Impact Summary	Broad Interest Feature Affected	Potential Effect	Dataset Rationale	Best Available Datasets	Data Gaps/ Issues	Data Recommendations
	and ingress of invasive non-native species			Community Importance. The assessment of conservation status does not only relate to that component of the habitat area or species population to be found in Special Areas of Conservation, but to the totality of the habitats and species throughout the United Kingdom. Section 7 and OSPAR habitats are those of 'principle importance' in Wales. Relative increased consenting complexity where present. Similarly, this is true for Section 7 and OSPAR species. Some habitats have greater importance/ value than others. Important to understand the type of habitat(s) that would be lost under the footprint.		focussed survey work ongoing. Data outputs from survey work carried out in 2019 and interpreted in 2020 will be amalgamated within relevant habitat datasets in future iterations of this work.	Fine resolution data of the distribution of Section 7 habitats required to understand areas of vulnerability to INNS. Article 17 data range from 1899. Analysis is required to reassess the validity of historic records as spatial distribution and extent is likely to change over time.
Reference number corresponds to pathway number in Table A3. Broad interest features denoted as H (habitats), B (birds), F (fish), M (marine mammals)							

C Confidence Assessment

Table C1. provides the results of the confidence assessment undertaken on each of the datasets considered as the best available data. The confidence assessment was conducted in-line with the methodology applied within WP1 (ABPmer, 2019). However, the criteria for assessing 'Appropriateness' has been amended to acknowledge the datasets applicability for constraints and opportunity analysis for development within Welsh waters.

It should be noted that some datasets have been derived from more than one core dataset. Where data have been derived from more than one dataset, each core dataset has been assessed separately. Where these datasets have resulted in different overall values, then the average of the datasets has been used to apply the overall confidence assessment.

Table C1 Results of the confidence assessment undertaken on each of the datasets considered as the best available data

Derived dataset	Core Datasets	Relevant Sector	Assessment Criteria				Overall Confidence Assessment
			Appropriateness	Methodology	Timeliness	Accuracy/ Ground Truthing	
All features							
Designated sites	cSACs SACs SPAs MCZs SSSIs Ramsar	All	3 National (Wales) level data. Provides mapped information on location, extent and condition of designated sites considered directly relevant for constraints analysis.	3 Digital boundaries of designated sites in Wales, defined from paper maps during SAC Moderation Project in 2000.	3 2019	3 The datasets are provided with excellent details on quality assurance.	High (12)
Seabirds							
Seabird foraging	Seabird colony locations – Seabird Monitoring Programme[37]	All	3 National (Wales) level data. Provides information on the location of seabird colonies.	2 Data from direct observation. Binary data only of colony locations.	3 Colony location data provided in 2019 through SMP.	1 No QA method provided and no evidence of ground-truthing undertaken. However, colony locations supported by NRW specialists.	**Average: High (9)** High (9)

[37] https://app.bto.org/seabirds/public/data.jsp

Derived dataset	Core Datasets	Relevant Sector	Assessment Criteria				Overall Confidence Assessment
			Appropriateness	Methodology	Timeliness	Accuracy/ Ground Truthing	
	Seabird Colony population counts – Seabird Monitoring Programme (various years)		3 National (Wales) level data. Provides information on density and location of seabird populations.	2 Data collected using a defined, best practice methodology, however, uses publicly submitted data which cannot be validated.	3 Dataset ranges from 1998 to 2019.	1 The dataset is provided with details on quality assurance methods and analysis methods clearly stated. However, due to public nature of the monitoring limited validation can be undertaken.	High (10)
	Mean foraging range – Woodward *et al*. 2019		3 National (Wales) level data.	2 Data not collected by study but where possible uses 'direct' data to inform assessment, uses best available methods and builds upon previous work.	3 2018	2 The dataset (methodology) provided with good details on quality assurance and data analysis techniques and provides a confidence assessment.	High (9)
Seabird loafing	Seabird colony locations – Seabird Monitoring Programme	All	3 National (Wales) level data. Provides information on the location of seabird colonies.	2 Data from direct observation. Binary data only of colony locations.	3 Colony location data provided in 2019 through SMP.	1 No QA method provided and no evidence of ground-truthing undertaken. However, colony locations supported by NRW specialists	**Average: High (9)** High (9)
	JNCC maintenance extensions[38]		3 National (Wales) level data. Provides information on the wider use of sea areas surrounding seabird colonies.	3 Data collected using a defined, best practice methodology.	1 Assessment is based on data collected prior to 2003.	2 The dataset is provided with good details on quality assurance and analysis methods.	High (9)

38 http://archive.jncc.gov.uk/pdf/SAS_Identification_of_generic_maintenance_extensions_to_seabird_colonies_2.pdf

Derived dataset	Core Datasets	Relevant Sector	Assessment Criteria				Overall Confidence Assessment
			Appropriateness	Methodology	Timeliness	Accuracy/ Ground Truthing	
RSPB seabird utilisation distributions	RSPB – Cleasby *et al.*, 2018	All	3 Data collected at UK wide level, providing mapped information on the distribution and behaviour of four seabird species. Considered directly relevant for constraints analysis.	2 Data collected using a defined, best practice methodology. Hotspot mapping undertaken using two analysis techniques.	3 Dataset ranges from 2010 to 2015.	2 The dataset is provided with good details on quality assurance methods and methods for hotspot mapping are transparent and repeatable.	High (10)
Seabirds at Sea	JNCC European seabirds at Sea and Wildfowl and Wetlands (Consulting) Ltd marine aerial surveys database	All	3 Data collected at national (Wales) level, data is high resolution and provides mapped information on location, extent and condition of feature considered directly relevant for spatial planning.	2 Collated seabird distribution and abundance data in Welsh waters from JNCC ESAS and WWT.	1 Datasets range from 1998 to 2009.	2 The dataset is provided with good details on quality assurance methods and the data sources are clearly stated for modelled and collated datasets.	Medium (8)
Marine Mammals							
Grey Seal at Sea*[39]	Russell *et al.*, 2017	All	3 Data collected at UK wide level, providing mapped information on the location of grey seals, considered directly relevant for constraints analysis.	3 Data collected using a defined, best practice methodology.	2 Dataset ranges from 1991 to 2016.	3 The dataset is provided with excellent details on quality assurance methods, data sources and collection methods are clearly stated.	High (11)
Atlas of Marine Mammals of Wales	Baines and Evans, 2012	All	3 Data collected at national (Wales) level, data is high resolution and provides	3 Data collected using a defined, best practice methodology.	1 Dataset ranges from 1990 to 2009.	2 The dataset is provided with good details on quality assurance methods and	High (9)

[39] Available at https://data.marine.gov.scot/dataset/estimated-sea-distribution-grey-and-harbour-seals-updated-maps-2017

Derived dataset	Core Datasets	Relevant Sector	Assessment Criteria				Overall Confidence Assessment
			Appropriateness	Methodology	Timeliness	Accuracy/ Ground Truthing	
			mapped information on location, extent marine mammals, a feature considered directly relevant for constraints analysis.			collection methods clearly stated. Data standardised based on survey effort.	
Cetacean distribution*[40]	Waggitt *et al.*, 2019	All	3 Data collected at national (Wales) level, data is high resolution and provides mapped information on location and extent marine mammals. Considered directly relevant for constraints analysis.	2 Collated marine mammal and seabird distribution and abundance data in Welsh waters and standardised using detection functions to estimate variation in the surface area covered (km^2).	3 Dataset ranges from 1980 to 2018.	3 The dataset is provided with good details on quality assurance methods and collection methods clearly stated. Data standardisation and modelling methods clearly stated.	High (11)
Seal pupping and haul out sites	Baines *et al.*, 1995	All	2 West Wales coverage from Caldey Island in the southeast and Aberystwyth in mid Cardigan Bay.	3 Data collected using a defined, best practice methodology.	1 Dataset ranges from 1992 to 1994.	2 The dataset is provided with details on quality assurance methods and analysis methods clearly stated	**Average: Medium (8)** Medium (8)
	Westcott and Stringell, 2004		2 Data collected from North Wales, Llyn Peninsular and Anglesey, therefore not National coverage.	3 Data collected using a defined, best practice methodology.	1 Dataset ranges from 2002 to 2003	2 The dataset is provided with details on quality assurance methods and analysis methods clearly stated.	Medium (8)
	Strong *et al.*, 2006		2 Data collected from Ramsey Island and North	3 Data collected using a defined, best practice	1 Data collected in 2005 – but adds to	2 The dataset is provided with details on quality	Medium (8)

[40] Available at https://datadryad.org/stash/dataset/doi:10.5061/dryad.mw6m905sz

Derived dataset	Core Datasets	Relevant Sector	Assessment Criteria				Overall Confidence Assessment
			Appropriateness	Methodology	Timeliness	Accuracy/ Ground Truthing	
			Pembrokeshire therefore not National coverage.	methodology, following methods used in previous monitoring in the area.	previous data, from 1995-97 (Strong, 1998) and 1992-94 (Baines *et al.*, 1995)	assurance methods and analysis methods clearly stated.	
	Clarke *et al.*, 2020		2 Data collected from North Wales and Anglesey therefore not National coverage.	3 Data collected using a defined, best practice methodology, following methods used in previous monitoring in the area.	3 Data collected in 2017	2 The dataset is provided with details on quality assurance methods and analysis methods clearly stated.	High (9)
Fish							
Nursery areas	Ellis *et al.*, 2012	All	3 Data collected at UK wide level, providing mapped information on the location of fish nursery and spawning grounds. Considered directly relevant for constraints analysis.	2 Data collected using a defined, best practice methodology and has been analyses to provide polygon data. No further interpretation required.	2 Dataset ranges from 1998 to 2012.	1 Metadata does not provide details on the QA process undertaken on the data assessment or methods used to account for sampling effort	Medium (8)
Spawning grounds	Coull *et al.*, 1998; Ellis *et al.*, 2012	All					Medium (8)
Basking Sharks	MCS – Bloomfield and Solandt, 2010	All	2 Data collected at UK wide level, providing mapped information on the location of basking sharks. However, the data relates to sightings of sharks at the surface and does not allow for a full assessment of the population dynamics of the species. Despite this it is considered the best	2 Data collected using a defined, best practice methodology, however, uses public sightings data which cannot be validated.	1 Dataset ranges from 1987 to 2006.	1 Limited QA undertaken due to public nature of the monitoring. Data collects surface sighting data only and is therefore only suitable for relatively limited. No account of effort or area/ regional bias or 'double counting' by multiple recorders.	Medium (6)

Derived dataset	Core Datasets	Relevant Sector	Assessment Criteria				Overall Confidence Assessment
			Appropriateness	Methodology	Timeliness	Accuracy/ Ground Truthing	
			available data to assess this constraint.				
Migratory fish transitional waters	Boundary of riverine SACs - Article 17 Estuaries	All	2 National (Wales) level data. Provides mapped information on location, extent and condition of designated sites. Considered relevant for constraints analysis. However, strong reliance required on implied presence rather than certainty – due to poor information on migratory fish in marine waters	2 Digital boundaries of Article 17 Estuaries. However, no inference on specific use for fish migration.	3 2019	2 The datasets are provided with details on quality assurance. However arbitrary buffer added to account for seaward extent of use by migratory fish.	High (9)
Habitats							
Article 17 features (Annex I habitats)	Marine Article 17 Reporting Habitat Features	All	2 Data collected at national (Wales) level, data is high resolution and provides mapped information on location, extent and condition of Annex I habitats considered directly relevant for constraints analysis. However, indication of spatial gaps in data coverage are required.	2 Collated habitat distribution data for Welsh waters from numerous surveys and monitoring programmes.	3 Dataset ranges from 1899 to 2018 (updated every 6 years).	1 Metadata does not provide details on the QA process undertaken on the data and does not specifically list the data sources. No understanding of data standardisation.	Medium (8)
Section 7 and OSPAR features	Section 7 and OSPAR habitats	All	2 Data collected at national (Wales) level, data is high resolution and provides mapped information on location and extent of	2 Collated habitat distribution data for Welsh waters from Marine Recorder, Phase 1	3 Dataset ranges from 2008 to 2019.	2 QA process clearly described, and each layer is accompanied by processing notes detailing data sources and all decision	High (9)

Derived dataset	Core Datasets	Relevant Sector	Assessment Criteria				Overall Confidence Assessment
			Appropriateness	Methodology	Timeliness	Accuracy/ Ground Truthing	
			Section 7 and OSPAR features. Layers produced as both polygon and point data, some interpretation required. Indication of spatial gaps in data coverage are required.	Intertidal, HabMap and Marine Monitoring Data.		made in creating the layers. However, data layers within this dataset are updated at different times, therefore, not all standardised.	
	Section 7 and OSPAR species		2 Data collected at national (Wales) level, data is high resolution and provides mapped information on location and extent of Section 7 and OSPAR features. Layers produced as point data. Indication of spatial gaps in data coverage are required	2 Collated species distribution data for Welsh waters from Marine Recorder, Phase 1 Intertidal, HabMap and Marine Monitoring Data	3 Dataset ranges from 2008 to 2020	2 QA process clearly described, and each layer is accompanied by processing notes detailing data sources and all decision made in creating the layers. However, data layers within this dataset are updated at different times, therefore, not all standardised.	High (9)

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