

Review of Information Sources to Support Connectivity Assessments under the Habitats Regulations

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1 Executive Summary

A working group was convened by The Crown Estate to focus on exploring routes to refine the consenting process for marine renewable energy sites under 3MW. One proposal considered the development of a tool to facilitate the assessment of connectivity between small marine renewable energy project sites and the features of designated European marine sites, or the 'Natura 2000' network^{1,2}. To clarify understanding of available tools, The Crown Estate commissioned a review of existing resources which could have the potential to contribute to the assessment of connectivity under the Habitats Regulations.

The following report documents the review process. Overall the review identified a comprehensive set of resources in the form of sensitivity analysis tools, interactive GIS databases, site information tools, guidance and policy documents, and reports. In total, twenty three resources (including two categories of clustered resources) were reviewed for their potential application in assessing connectivity.

Each tool was individually analysed, primarily through available online content, and also through discussions with relevant points of contact. Each resource was categorised on the basis of its format, and described in terms of its content, coverage, management, year of development, update frequency (where known) and likely contribution to the assessment of connectivity. To meaningfully assess how each tool could input into the connectivity assessment, a basic decision-making process was set out to identify the specific points where each tool could input into the process. The three decision points were:

- Identify the spatial range of a project influence / impact;
- Identification and characterisation of designated European sites; and
- The application of spatial ecological data to determine potential overlap.

Approximately eight interactive maps tools were identified (two unavailable to the public), which linked to associated site information resources. The site information resources were generally uniform in content and provided general information on designated European sites in the marine environment (four 'site information' tools were identified), including qualifying features. The GIS databases varied in sophistication from basic interfaces to extensive interactive tools with an expansive database of additional ecological data layers. Two of the interactive map sites were unavailable to the public, however both of these tools integrated a weighting / scoring system to data layers which were considered to have some future potential in refining connectivity assessments. All of the tools had potential to input into the identification and characterisation of designated European sites at varying levels.

Three 'Sensitivity Analysis Tools' were assessed. The basic concept behind these tools is to enable a user to query an activity against a receptor to generate a risk assessment or analysis of sensitivity of the receptor to a particular pressure. Whilst these resources were considered of most value later in the Habitats Regulations Appraisal (HRA) process, for example in the determination of Likely Significant

¹ A network of nature protection areas within the European Union, comprising Special Areas of Conservation, Special Protection Areas and Ramsar sites.

² The study does not specifically focus on onshore sites which have qualifying features that have the potential to use the marine environment, other than diadromous fish; however, some of the resources assessed in the study include tools and methodologies that address potential connectivity of onshore sites with developments in the marine environment.

Effect (LSE), one tool developed by Natural England had potential to feed into connectivity assessments via the application of certain 'benchmark criteria' to define a range of a project impact.

Four Guidance and Policy documents were identified. Of these, only two were assessed to have a direct input into connectivity assessment. Guidance published by Scottish Natural Heritage (SNH) - 'Assessing Connectivity with Special Protection Areas' - represented the only dedicated guidance document addressing a methodology to assess connectivity. The methodology describes the use of radial foraging ranges for mainly terrestrial breeding and some non-breeding birds. SNH also uses similar guidance for seabirds, but this information is currently unpublished. A report published by the Joint Nature Conservation Committee (JNCC); 'Management Units for Cetaceans in UK Waters', has been adopted both at plan level HRA and by individual Statutory Nature Conservation Bodies (SNCBs) to assess connectivity for harbour porpoises and bottlenose dolphins.

Two reports were reviewed; both authored by consultants ABPmer for plan level HRAs. The reports identified methodologies to define the spatial range of a project impact, through the application of tidal excursion areas and wave shadows to determine indirect hydrodynamic change. The reports also applied other assessment criteria for qualifying features including harbour porpoise, bottlenose dolphin, Atlantic salmon and otter.

A number of additional resources were identified which were classified into the category of 'Resource Portals' due to the similar nature of the tools. These sites are generally repositories for data generated elsewhere and include a range of resources including baseline, and post construction monitoring reports for marine developments, individual chapters for Environmental Impact Assessments (EIAs), research papers, raw monitoring data, and literature reviews, amongst others.

Finally, two examples of 'Open Software Tools' were provided to illustrate an alternative concept for refining connectivity assessments in the future. The aim of these software tools is to support predictive habitat and species modelling which could, in the future, be utilised to refine predictions of some species movements outside a designated European site.

Overall the review identified a range of tools which had the potential to contribute to different points or stages in the assessment of connectivity. In addition, technological platforms were identified through numerous interactive GIS map sites to display data layers. These layers could include, for example, central point foraging ranges for breeding seabirds, migratory routes for migratory fish, otter movement buffers, and JNCC Management Units for bottlenose dolphins and harbour porpoises. Future, more refined functionality options include incorporating weighting of data layers or software modelling to refine species distribution.

A number of challenges were identified in specifying a future tool; formal guidance to assess the concept of connectivity exists for only a limited number of qualifying species, and could be limited in application. Individual SNCBs regularly apply connectivity assessments through a number of ways which are not captured within formal guidance documents. Sharing practice and formalising methodologies for determining connectivity could generate efficiencies in methodology development and ensure a more consistent approach across the UK.

2 Background

A working group was convened by The Crown Estate to investigate consenting routes for marine renewable energy sites under 3MW, whilst ensuring that the requirements of the Habitat Directive are met. The group discussed the value in The Crown Estate developing an approach or tools, to inform The Crown Estate's own views about whether, and when, the need for a plan-level HRA might be triggered, as well as help to deliver a more strategic approach to planning for the future development of the wave and tidal current sectors. As a result of these discussions, the work group identified a potential need for a tool to facilitate the assessment of connectivity between small marine renewable energy project sites and marine designated European sites, primarily those sites contributing to the marine Natura 2000 network. Evidence suggests, however, that there are numerous existing data sources currently available, or under development, that could potentially fulfil all or part of this decision-making process.

To inform the discussions, The Crown Estate commissioned a review of existing information sources that have the potential to contribute to the process of assessing connectivity between small scale wave and tidal sites with sites designated under the Birds Directive (Directive 2009/147/EC on the conservation of wild birds), the Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) and the Ramsar Convention. These tools range from policy and guidance documents, databases, reports and resource portals to expansive Global Information System (GIS) platforms of public domain data. This report reviews the range and scope of information sources suggested by the working group, extends the review to other known datasets and resources, and assesses the potential usefulness of each in contributing to the decision-making process for assessing connectivity under the Habitats Regulations.

The report is structured the following sections:

- Context;
- Methodology;
- Review of Resources;
- Summary; and
- Conclusions.

3 Context

3.1 Legislation and Terminology

The European Union has implemented two directives as the basis of Europe's conservation policy for the protection of wild birds, habitats and animal and plant species. These are the Habitats Directive (Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora) and the Birds Directive (Council Directive 2009/147/EC on the conservation of wild birds). These Directives are transposed into domestic UK legislation through various statutory instruments and are collectively referred in this report as the 'Habitats Regulations'.

The designated Natura 2000 sites to which the Habitats Regulations apply are Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). Ramsar sites designated under the International Convention on Wetlands of International Importance (the Ramsar Convention) are also treated as if they were Natura 2000 sites in accordance with Government policy. Furthermore, in the UK, the same protection is extended to sites that are proposed for designation, or in the process of being classified. These include: potential SPAs (pSPAs), candidate SACs (cSACs), possible SACs (pSACs),

and Sites of Community Importance (SCIs)³. Throughout this review, designated sites protected by law under the Habitats Regulations, sites in the process of being designated or classified (including extensions), and Ramsar sites are referred to throughout this review as ‘designated European sites’.

3.2 The Concept of Connectivity

The Habitats Regulations set out a consenting procedure requiring all competent authorities to carry out an appropriate assessment of a plan or project, if the plan or project is likely to have a significant effect on a Natura site. The regulations can apply to plans or projects outside the boundary of designated European sites if there are implications for the interest protected within that site. If a proposal is not directly connected with the management of the site, the competent authority then has to establish whether the proposal is likely to have a significant effect on the site, either individually, or in combination with other plans and projects. Deciding if an aspect of a plan or project is likely to have a significant effect on a Natura site acts as a screening stage, removing those aspects of a plan or project which clearly have no ecological connectivity to a sites qualifying interest, or those where it is clear that whilst connected, the conservation objectives for a sites qualifying features will not be undermined.

At the most basic level, assessing connectivity between development proposals and designated European sites is understanding whether a species originating in a designated European site has the potential to be present on a project site⁴. Connectivity can also extend outside a development site through direct effects, for example the extent to which construction noise may travel, and also via indirect effects through, for example, hydrodynamic change or sediment transport. The latter has the potential to influence non-mobile qualifying features, such as habitats.

Methods that establish geographic overlap provide a reasonably suitable and straightforward method of identifying connectivity. To date, this stage has been determined most prominently through the application of foraging ranges for mobile species. This initial step enables a competent authority to quickly remove qualifying features from further assessment on the basis that there are no potential physical or ecological pathways with activities associated with the development. Once connectivity is established, the next stage involves assessing project activities, undertaking site surveys, establishing impact pathways, and evaluating the sensitivity of a species to potential impacts to determine Likely Significant Effects (LSE). The use of this methodology enables an efficient approach to a Habitats Regulations Appraisal (HRA), enabling efforts to be focused on those qualifying features for which the proposal is likely to have a significant effect.

4 Methodology

The working group identified an initial suite of fourteen information sources which were considered to have potential utility in assessing connectivity. This initial suite was expanded with further interrogation of related public sector websites, discussions with contacts within various organisations, and a general investigation of other GIS datasets.

³ Potential SPA (pSPA) - a site that has been approved for consultation but is not yet classified; candidate SACs (cSAC) - site that has been submitted to the European Commission, but not yet formally adopted; possible SAC (pSAC) - site that has been approved for consultation but has yet to be submitted to the European Commission; and Sites of Community Importance (SCIs) – sites that have been adopted by the European Commission but not yet formally designated by the government of each country.

⁴ Note, a project site for a wave and tidal development will include all aspects of the project, including an operation and maintenance (O&M) base, transit routes for O&M, cable route, cable landing point and other electrical infrastructure.

Each tool was reviewed individually on the basis of its format, content, coverage, management, year of development, update frequency (where available) and potential contribution to connectivity assessments. Where necessary, discussions with key points of contact via email or telephone were carried out to clarify further detail on the dataset, for example, future or current modifications. Each tool was categorised according to the following format types:

- Interactive Maps;
- Sensitivity Analysis Tools;
- Policy and Guidance;
- Site Information;
- Reports;
- Grouped resources.

To assess the potential contribution of each tool to connectivity assessments, three defined stages were identified where a tool could input to the process. It was not the primary purpose of the review to analyse and present existing practice with respect to assessing connectivity. However, in order to appropriately identify tools that could materially contribute to the decision-making process for connectivity, and to meaningfully assess the level and type of contribution of each tool in the process, it was necessary to define a basic structure for the assessment process. Three distinct areas were identified which characterise the connectivity assessment and assist in classifying where a tool can materially input into the process. These were condensed into assessment criteria as outlined in Table 1. Each tool was collated into a Main Summary Table (Section 7, Table 3).

Table 1 Summary of stages in assessing connectivity, as applied in the final analysis Main Summary Table.

Decision Point	Title	Description
A	Identify project and project ranges of influence.	Project boundaries may not reflect the ecological impacts associated with the development. Direct effects, such as noise, and indirect effects, such as hydrodynamic changes and sediment generation, may extend to well outside a development boundary (including ancillary infrastructure such as cable routes, operation and maintenance base etc.).
B	Identification and characterisation of Natura 2000 sites.	It is necessary to identify the physical site boundaries and accompanying details of the qualifying features within the sites and their relationship to a project boundary
C	Application of spatial data.	Foraging distances, dispersal ranges, migratory routes or other discrete spatial information is applied to identify initial pathways for interactions between project sites and designated European sites.

In addition, a colour coding system described in Table 2 was assigned to the Main Summary Table (Section 7, Table 3) to illustrate the relative importance of each resource to connectivity assessments.

Table 2 Description of colour coding references.

Colour Code	Explanation
Green	Resource currently has a direct application in assessing connectivity.
Yellow	Resource currently has some potential to input into connectivity assessments, however application may be limited in application due to overlap with other better quality resources or has potential to indirectly contribute to connectivity assessments.
Orange	Resource currently has no direct applications in assessing connectivity between Natura sites and project sites, but may have some applications at a later stage, i.e. determining Likely Significant Effect or have a potential indirect application (i.e. a methodology).
Grey	Resource currently has no direct application in assessing connectivity between Natura 2000 sites and project sites.
Purple	Information resources, which although unlikely to have a direct contribution to the connectivity decision-making process, represents material may have a potential future application in providing supplementary information or methodologies to support the decision making process.

Over the course of the review a number of additional resources were identified which were considered to have indirect utility in the process. These have been categorised as ‘Grouped Resources’ and include Resource Portals and Open Software tools. Whilst unlikely to have a direct contribution to the decision-making process, the material in these categories was considered worth highlighting to illustrate the range of resources and approaches available, and may have a potential future application.

5 Review of Individual Tools

The following section reports the individual reviews of each tool identified via The Crown Estate Working Group and a further interrogation of existing data sources. Each tool was categorised according to the following format:

- Interactive Maps;
- Sensitivity Analysis Tools;
- Policy and Guidance;
- Site Information;
- Reports; and
- Grouped Resources (Resources Portals and Open Software Tools).

Each tool is fully summarised with corresponding judgement on where it can contribute in the process of the connectivity assessment in the Main Summary Table (Table 3) at the end of this section.

5.1 Interactive Maps

Tool 1: SNH Interactive Map

Scottish Natural Heritage (SNH) has produced an interactive map⁵ to illustrate the boundaries of designated European sites for Scotland. Boundary data for designated European sites can be further interrogated by linking directly through to the SNH SiteLink service (Section 5.4.3), a general database providing detailed information on designated sites in Scotland. Site information includes qualifying features, conservation objectives, pressures, casework, citations and maps to provide the most up to date source of information available. Updates are frequent, with last update dates shown on the site details page. Where designated sites are located further than 12nm from the coastline, the interactive map interface links directly to site information on the Joint Nature Conservation Committee (JNCC) website.

⁵ <http://www.snh.gov.uk/publications-data-and-research/snhi-information-service/map/>

The system provides essential information to identify and characterise designated European sites and their boundaries for coastal and offshore sites, with their corresponding qualifying features and conservation objectives. A straightforward data download and/or Web Management Service (WMS)⁶ option can enable a user to quickly assess SNH information against project boundaries (and project area of influence).

Tool 2: National Marine Plan Interactive (NMPi)

The NMPi⁷ is a publically available interactive GIS platform managed by Marine Scotland (MS), designed to facilitate ongoing national and regional marine planning work within Scotland. The tool is comprehensive in scope, and includes hundreds of layers presenting data across climatic, environmental, socio economic and administrative information sources. The physical boundaries of designated European sites are presented, and link to SNH's SiteLink tool where appropriate, to provide details on conservation objectives, qualifying features and site condition (offshore sites do not appear to currently link to the JNCC site). MS regularly inputs new data, updates, and revises the layers which appear in a separate window on opening the application.

In addition, NMPi provides substantial additional ecological data, notably on abundance, count and distribution data for several seabird species. Data is also available on maximum curvature analysis, seasonal breeding concentrations and predicted feeding distribution for seabirds.

Other example layers for features that are not seabirds include (amongst many others):

- Annual distribution and relative abundance of Bottlenose dolphins;
- Estimated total usage of harbour seals and breeding colonies;
- Population density data for harbour porpoises; and
- Estimated total usage of grey seals across the UK.

These data have potential for further application, for example seal usage maps produced by Sea Mammal Research Unit (SMRU) indicate clear areas that are favoured by grey seals throughout the year. Given that SACs for non-breeding grey seals become less important outside the breeding season (G.Lees *Pers Comm.*), there may be potential to adopt this additional information for connectivity assessments in the future.

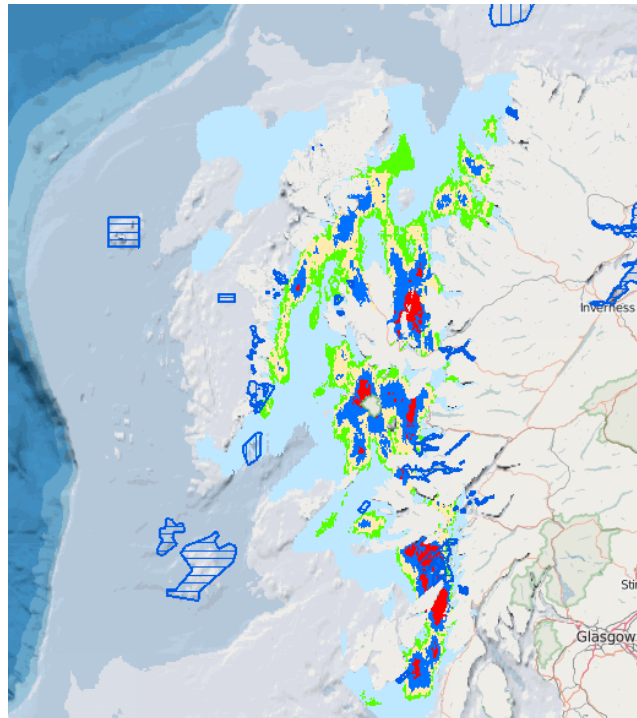


Figure 1 Extract of one NMPi output showing boundaries of SACs contributing to the MPA network and high density areas of harbour porpoise.

NMPi links with the SNH SiteLink resource (Section 5.4.3), and subsequently provides basic information required to characterise designated European sites. NMPi also provides a range of other information which could be integrated at the discretion of a consultant or competent authority, for further habitats regulations assessment (HRA) analysis, for example usage or density data layers may contribute to an

⁶ WMS, in the context of this report, enables a user to have remote access to another organisations geo-database.

⁷ <https://marinescotland.atkinsgeospatial.com/nmpi/>

assessment of the proportion of qualifying features that may use a site. Figure 1 illustrates an example output of a density layer for Harbour porpoise.

Marine Scotland provides a WMS option for users to link directly to the geo-database behind the system to access data on their own GIS platform. This enables immediate comparison of boundaries and provides the option to quickly initiate an HRA assessment.

Tool 3: MAGIC

MAGIC⁸ is a comprehensive interactive mapping system which has been operational since 2002, but relaunched in 2013. It provides a wide range of information about the natural environment across Scotland, England, Wales and Northern Ireland. Natural England manages the service, providing information covering rural, urban, coastal and marine environments.

Natural England, in their Marine Conservation Advice Packages, suggest MAGIC as a starting point when assessing the potential impacts on all designated sites. Designated areas include the complete suite of designated European sites (onshore, coastal waters and offshore). However, querying a marine site generates only limited metadata for marine designated European sites (site name and designation).

In addition to providing basic information on designated European site boundaries, MAGIC also provides other data including marine SPA supporting habitats, where these are known. Figure 2 presents an indicative output showing a SPA boundary with supporting habitat.

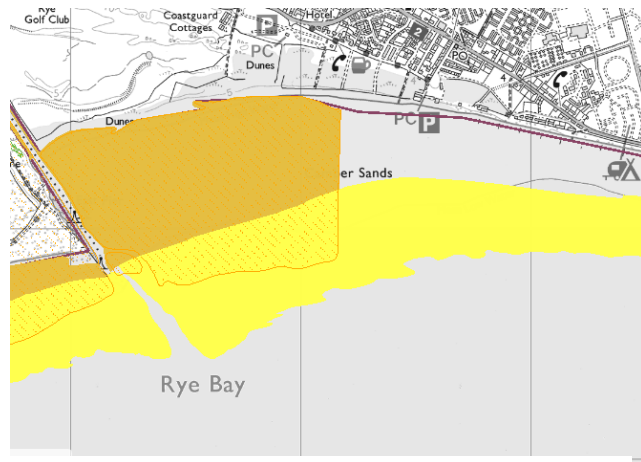


Figure 2 Example output from MAGIC illustrating the boundary for Dungeness to Pett Level SPA (brown diagonal hatch) with SPA supporting habitat (brown - intertidal mud, yellow - intertidal sand and muddy sand).

MAGIC provides an essential tool to identify designated European site boundaries in the marine environment to take them forward for further assessment using Natural England's Designated Sites System and associated gov.uk website (Section 5.4.1). The specific identification of supporting habitats for SPAs provides a direct mechanism to assess connectivity with habitats directly supporting marine SPAs which may be outside the SPA site. However, the evidence base on supporting habitats for SPAs is not complete and so this information is not available for all features of all SPAs.

Tool 4: MaRS

The Marine Resource System (MaRS)⁹ is defined as a 'multi-criteria evaluation and data management tool' (K. Bell *Pers Comm.*) based on a GIS platform and is managed by The Crown Estate. It provides national level resolution data, although this can be applied for refined local scale decision-making processes, depending on data availability. The system is presently under development and is not generally available to the public. However, in the past, it has been made accessible via service agreements and licencing to public agencies such as Marine Scotland and private developers as a

⁸ <http://magic.defra.gov.uk/>

⁹ <http://www.thecrownestate.co.uk/mars-portal-notice/>

service. Figure 3 shows an example output of MaRS, which in this case is a technical resource model output for commercial scale wave energy. The model incorporates a small number of constraints including bathymetry data and wave mean power density threshold of 20Kw/m. In this figure the blue colour indicates areas with greatest levels of wave resource.

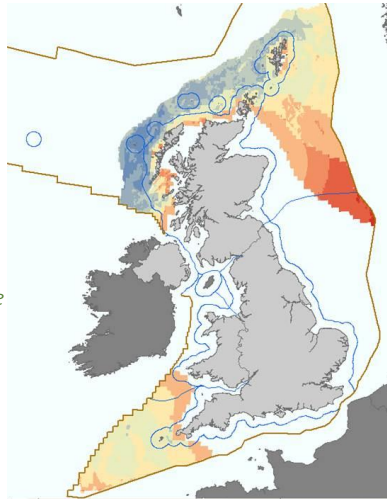


Figure 3 Example model.

Whilst based on a GIS system, MaRS differs from other similar tools by integrating decision-making criteria into layers to define how important, or how much weighting they should receive. Following the application of a weighting / scoring criteria to each layer, the system builds up a model which can apply different levels of importance. The system contains hundreds of layers of GIS data and enables opportunity and constraint analysis through consideration of technical conditions, external interests, sensitivities and in addition to other users of the marine environment (K. Bell *Pers Comm.*).

It has not been possible to directly review this tool; however, in terms of connectivity, the data layers are unlikely to provide the specific ecological spatial data requirements required to assess connectivity. In addition, the lack of availability in the short to medium term for public usage restricts the overall potential of the tool (although service agreements with public and private entities have been achieved in the past). However, the technique of weighting / scoring data layers adds another dimension to decision-making processes, and is particularly useful where there may be uncertainty in data, or known differences in the distribution of importance (e.g. core and maximum foraging ranges). The methodology developed by The Crown Estate may merit further consideration in the specification of a future tool to capture subtler aspects to data display.

Tool 5: Joint Nature Conservation Committee (JNCC) Marine Protected Area Mapper

The JNCC Marine Protected Area Mapper¹⁰ is a combined interactive map / site information tool containing information on all the MPAs designated in UK waters including SPAs, SACs and SCI's. The JNCC manages the site, which provides information on site boundaries, as well as key metadata including lat/long and site area. Data are collated from multiple sources with an associated summary of each of the mapping products that are collated, with information on the last update and update period.

An information summary of each designated site is available through querying the site boundary which generates a link to additional site information including details of qualifying features and the standard designation forms submitted to the EC. A number of other layers are available within the interactive map interface including SAC site specific survey maps, covering still images and grab sample data.

The site, similar to many other interactive map products summarised in this review, provides an essential, accessible option to review designated site boundaries and gather initial basic information on the qualifying features. The site also includes a WMS feature, enabling GIS competent users to link directly with the data layers on their own GIS platform.

Tool 6: Welsh Marine Planning Portal

The Welsh resources are currently under a substantial review and development, due to consolidation of resources from legacy agencies and the imminent release of the Wales National Marine Plan. A central repository of data and evidence (Lle, assessed under Tool 6.1.1) is currently being populated

¹⁰ <http://jncc.defra.gov.uk/page-5201>

with information and continuously updated. Ongoing development of the Marine Planning Portal will draw on evidence collated within Lle repository.

The Welsh Marine Planning Portal¹¹ has recently been launched to support the introduction and implementation of Wales’ first National Marine Plan and the marine planning process by:

- Raising awareness and understanding of the marine data that is readily available for Welsh seas;
- Providing an understanding of the marine planning evidence base currently available;
- Providing interested parties with the opportunity to comment on the evidence base and the need or availability of further spatial evidence.

. The Marine Planning Portal has been developed and managed by the Welsh Government and Natural Resources Wales (NRW). An online interactive map interface allows the user to view maps showing the distribution of human activities and natural resources in Welsh seas (Figure 4 shows an example output). The Portal is a work in progress and the Welsh Government is continually adding new layers and refreshing existing data layers.

The intention is for the system to become comprehensive, providing access to all key data. However, currently the Portal does not allow for the download of data, although this can be achieved for some NRW datasets through Lle (refer to the ‘Other Resources’ section below). The Marine Planning portal currently includes the key outputs from the MRESF (Section 5.1.8) and in the longer term, will incorporate many of the key datasets within the MRESF, so they can be viewed alongside other datasets (K.Smith *Pers. Comm.*).

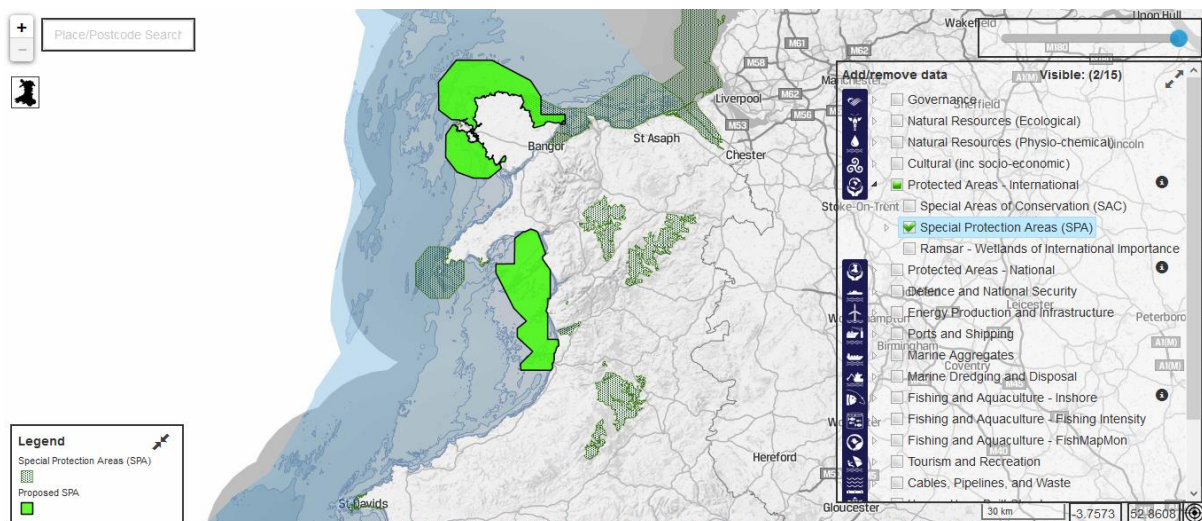


Figure 4 Example output showing the interface of the Welsh Marine Planning Portal for SPAs and pSPAs

Information on marine Natura 2000 sites is already available within the Planning Portal. Users can query designated sites to generate the name of a site. There is also an option to further investigate specific aspects of each layer within the Portal via an accompanying report: Wales Marine Evidence Report. This report outlines the best available evidence on the state of the marine environment, identifies trends and uses this information to consider the future. Whilst the report is comprehensive in scope, it does not provide direct information on the implementation of the Habitats Regulations or detailed

¹¹ <http://lle.gov.wales/apps/marineportal/#>

information on sites and features to inform assessments of connectivity. However, the tool is currently under development and the website is likely to be updated in the near term.

Tool 7: Northern Ireland Environment Agency

The Northern Ireland Environment Agency (NIEA)¹² has published a basic interactive mapping tool enabling the user to query designated sites including SACs and SPAs for the Northern Ireland area and immediate coastal waters only. Further information regarding specific coastal sites is accessed through a site link directly through to JNCC website. Figure 5 shows an example output of the tool.



Figure 5 Example output for SAC and SPA layer search, for the NIEA interactive mapping tool. Web links refer directly to JNCC Site Information pages.

The site contains basic information suitable for initial analysis of the location and basic characterisation of designated European sites; however, these details duplicate information provided on the JNCC website on a significantly more basic GIS platform with minimal additional functionality. No further spatial information which could contribute to an assessment of connectivity is provided.

Tool 8: Marine Renewable Energy Strategic Framework for Wales

The Marine Renewable Energy Strategic for Wales (MRESF)¹³ was a three stage project initiated by the Welsh Government to investigate the potential of the marine renewable energy resource in Welsh Territorial Waters. The methodology used is similar to other marine spatial planning routes: using energy resource and information on constraints to assess the potential for renewable electricity generation. Although this tool was unavailable to directly assess the content, a review of accompanying documentation indicates that approximately 159 layers of data contribute to the tool, with constraints assigned a score according to the likelihood that they would hinder or prevent development. Only a small number of constraints were ranked so highly that they would preclude marine energy development.

The layers include information covering designated sites (including designated European sites), wave and tidal resource layers and also other socio economic and environmental constraints to wave and tidal development. MRESF outputs included several reports and spatial datasets which provide detailed information on the extent of the wave and tidal stream energy resources, and how much of these

¹² <http://maps.ehsni.gov.uk/naturalheritage/#>

¹³ <http://mresf.rpsgroup.com/>

resources can be exploited once constraints on development have been considered (K. Smith *Pers. Comm.*).

Access to the online ArcGIS tool is currently restricted; data are currently held and managed by consultancy firm, RPS, who developed the MRESF, and are accessible through a password protected ArcGIS Online site. On being granted access, a user can view outputs from the MRESF on an online map interface; however, access to the underlying data is by request to RPS. Data layers are available to the public in PDF format only. Furthermore, a number of the MRESF data sources reviewed had metadata dates ranging from 2007 – 2011, and a number of these are likely to have been superseded.

The Welsh Government is in the process of considering a number of options for the MRESF, including updating the data and incorporating the constraints and energy resource layers into a wider tool (K. Smith *Pers. Comm.*), or into other existing portals such as Lle or the Marine Planning Portal. Some of the data sets within the MRESF, including designated sites, have already been incorporated into these other portals.

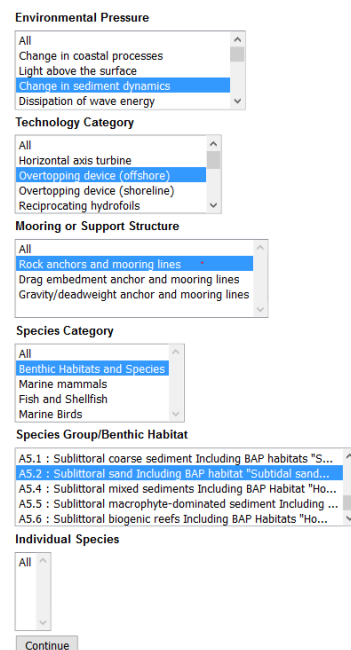
In terms of addressing designated European sites, the framework outlines a methodology of scoring particular constraints based on the physical boundaries of that constraint. However, no accompanying guidance appears to be provided in terms of assessing proximity or connectivity of a designated European Site. Currently, the MRESF is concluded to have limited application in the assessment of connectivity. Although, like The Crown Estate tool, MaRS, the use of weighted data layers may have an application in a future connectivity tool.

5.2 Sensitivity Analysis Tools

Tool 9: IMPACT

IMPACT¹⁴ is a database that has been produced by Orkney-based consultants Aquatera for the Scottish Government, and is available freely on the Scottish Government website. The tool is based on a comprehensive database of agreed potential impacts arising from different wave and tidal technology types, their support structures and specific activities associated with the construction, operation and maintenance of a site on the ecological environment. The scales of impacts are based on a project of 10MW installed capacity. The detailed review of interactions was carried out by a project team that included the Scottish Association of Marine Science (SAMS), the Sea Mammal Research Unit (SMRU), Aberdeen University and others. Where a potential impact is identified, the tool generates a detailed summary of the assessment results and provides recommendations and guidance for monitoring. Figure 6 shows the tool interface and selection criteria for technology types and environmental pressures.

The tool is comprehensive in its detail and outputs, but limited in its application, not covering impacts associated with support vessel activity, subsea cables and other infrastructure, nor accidental events. In addition, the tool was developed during the period 2010-2011, and there may be a need to review the content periodically to ensure that the content remains up to date.



The screenshot displays the IMPACT tool's selection interface. It features several dropdown menus for filtering results:

- Environmental Pressure:** Options include 'All', 'Change in coastal processes', 'Light above the surface', 'Change in sediment dynamics' (highlighted), and 'Dissipation of wave energy'.
- Technology Category:** Options include 'All', 'Horizontal axis turbine', 'Overtopping device (offshore)' (highlighted), 'Overtopping device (shoreline)', and 'Reciprocating hydrofoils'.
- Mooring or Support Structure:** Options include 'All', 'Rock anchors and mooring lines' (highlighted), 'Drag embedment anchor and mooring lines', and 'Gravity/deadweight anchor and mooring lines'.
- Species Category:** Options include 'All', 'Benthic Habitats and Species' (highlighted), 'Marine mammals', 'Fish and Shellfish', and 'Marine Birds'.
- Species Group/Benthic Habitat:** Options include 'A5.1 : Sublittoral coarse sediment Including BAP habitats "S...', 'A5.2 : Sublittoral sand Including BAP habitat "Subtidal sand...', 'A5.4 : Sublittoral mixed sediments Including BAP Habitat "Ho...', 'A5.5 : Sublittoral macrophyte-dominated sediment Including ...', and 'A5.6 : Sublittoral biogenic reefs Including BAP Habitats "Ho...'.
- Individual Species:** Option is 'All'.

A 'Continue' button is located at the bottom of the interface.

Figure 6 IMPACT tool, illustrating combinations of technology, environmental pressures, species and habitat that can be individually interrogated.

In terms of support in assessing connectivity, the tool provides a pre-agreed assessment of impacts which ensure consistent and transparent decision-making in determining whether an effect exists for sites <10MW. Spatial data is not available to demonstrate a physical pathway or presence or absence of a species on a site. The application of IMPACT at this stage of an HRA process is limited; however, it has significant potential for application in the decision-making process for determining if the project has a Likely Significant Effect. For example, identifying impact pathways may lead to certain Natura 2000 features being quickly scoped out of the need for further consideration.

Tool 10: Natural England Marine Conservation Advice Packages

Natural England is in the process of publishing comprehensive conservation advice for all MPAs in England. The timetable of development and publication currently runs from May 2016 to March 2019¹⁵, with some information already completed, published and available within the public domain. The advice is collated into dedicated 'Marine Conservation Advice Packages'¹⁶ (MCAPs) for each designated site. The web based content of each Marine Conservation Advice Package is very detailed, each including the following typical outputs:

¹⁴ <http://www.gov.scot/Topics/marine/Licensing/marine/tool>

¹⁵ Timetable: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/523465/mpa-advice-timetable.pdf

¹⁶ An example Marine Conservation Advice Package for the Alde-Ore Estuary SPA <https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9009112&SiteName=alde-ore&countyCode=&responsiblePerson=>

- Site information, including its designation or classification history, geographic area, feature descriptions and overlapping MPAs;
- Background information and geography;
- Site maps (linked to the MAGIC website (see Table 3; Tool 3);
- High level conservation objectives and supplementary advice;
- Advice on operations, including how an activity can affect a protected site feature on the site;
- Advice on the seasonal sensitivity of features;
- Overlapping features; and
- Condition assessment.

The intention is to provide the information through Natural England’s Designated Sites System (Section 5.4.1) and a ‘Main Collection’ page on an associated gov.uk¹⁷ web page. A change log interface will record updates and modifications to the system (R. Elever *Pers Comm.*)

Within the MCAP, another database in the form of an Excel workbook called ‘Advice on Operations’ (AoO), allows the user to interrogate specific site activities against features (species and supporting habitats). The user can select an industry, and a specific activity associated with that industry, to generate a series of colour coded pressures for each qualifying feature, and an associated rationale for that assessment. Industries included in the assessment include most of the ancillary activities associated with a wave and tidal development including shipping and cabling. Future development plans aim to make this process far more user friendly and provide a more robust evidence base for each output (R. Elever *Pers Comm.*).

The ‘AoO’ output provides an initial assessment of whether the feature is sensitive to the activity and differentiates between breeding and non-breeding birds of the same species. A risk profile score is assigned to each ‘pressure’. Figure 7 illustrates an example output of the AoO for cables.

Advice within the MCAPs is provided outlining how this information can be used for HRA. In terms of assessing connectivity, the guidance states that a user should “use the site information and maps to help determine if your work is in, or near to, the site”¹⁸. This guidance does not outline any specific methodology to assess connectivity, other than a general proximity assessment. However, Natural England has also developed ‘benchmark’ information which has the potential in some cases, to define a distance of an effect associated with a particular activity. For example, querying underwater noise generation for fish generates an output that defines a species indicator level of noise for features that might potentially use an area (V. Copley & R. Elever *Pers. Comm.*). Other example benchmarks include:

- For fish, tidal current, including sediment transport considerations are considered sensitive with a change in peak mean spring tide bed flow velocity of between 0.1 m/s to 0.2 m/s over population areas or 50% of width of a water body for more than one year;
- Birds are considered sensitive to displacement when disruption to greater than 10% of the population of a migratory feature are affected by permanent or temporary lack of continuity of parts of the commuting or migration corridor; and
- A habitat feature would be sensitive to temperature changes representing a decrease or an increase in 5°C for one month, or 2°C for one year.

¹⁷ <https://www.gov.uk/government/collections/conservation-advice-packages-for-marine-protected-areas>

¹⁸ <https://www.gov.uk/guidance/conservation-advice-for-marine-protected-areas-how-to-use-site-advice-packages>

These benchmarks can theoretically be mapped at project characterisation stage to assist in screening out potential qualifying species from further determination of likely significant effect (LSE). However, this approach may be complex to implement and the distinction between determining connectivity and determining LSE becomes unclear.

Operation	Activity	Pressure	Justification	Bird features							
				Breeding Avocet (Recurvirostra avosetta)	Breeding Lesser black-backed gull (Larus fuscus)	Breeding Little tern (Sternula albifrons)	Breeding Marsh harrier (Circus aeruginosus)	Breeding Sandwich tern (Sterna sandvicensis)	Non-breeding Avocet (Recurvirostra avosetta)	Non-breeding Redshank (Tringa totanus)	Non-breeding Ruff (Philomachus pugnax)
CABLES	Telecommunication cable: Laying, burial and protection	Above water noise	33	S	S	S	IE	S	S	S	S
CABLES	Telecommunication cable: Laying, burial and protection	Abrasion/disturbance of the substrate on the surface of the seabed	1484								
CABLES	Telecommunication cable: Laying, burial and protection	Changes in suspended solids (water clarity)	26		S	S		S			
CABLES	Telecommunication cable: Laying, burial and protection	Collision ABOVE water with static or moving objects not naturally found in the marine environment (e.g. boats, machinery, and structures)	1490	S	S	S	S	S	S	S	S

Figure 7. Advice on Operations for telecoms cables, generating specific pressures associating with activities. Each feature is then risk assessed, (S indicates sensitive).

Natural England’s online tool is comprehensive in the level, detail and site specific nature of the information available, combining a detailed sensitivity analysis tool with guidance and links to maps. The industry options in the AoO include shipping, cables and coastal infrastructure, theoretically covering the complete suite of activities associated with a marine renewable energy development. For the purposes of specifically assessing connectivity, the tool does not provide direct spatial approach to determining connectivity, but does provide some information which could theoretically be used to generate spatial information to characterise a project impact.

Tool 11: Feature Activity Sensitivity Tool (FEAST)

FEAST¹⁹ is a database created in 2013, managed by Marine Scotland Compliance, and is described as ‘a starting point for determining potential management requirements for Nature Conservation MPAs and highlights where further discussion with users of the marine environment may be required’.

The system was developed through collaboration with experts and stakeholders, and features bibliographic references in the outputs. A user can query by industry activity, or by ecological pressure to generate a ‘change features sensitivity’, which provides a description of the evidence base for a feature sensitivity and assigns an overall value of sensitivity, based on a combined score of tolerance (resistance) and recovery (resilience). Figure 8 shows an example output of the tool.

The tool is very similar to IMPACT and a subcomponent of Natural England’s online tool ‘Advice on Operations’ database. FEAST differs from IMPACT in that it covers activities beyond the wave and tidal sector such as aquaculture, seaweed extraction and harvesting. Notably in its assessment, it covers ‘additional infrastructure’ for renewable energy extraction (for example, cables). FEAST also appears to be limited in species assessed, focusing on bird species, habitats and physical features. Many

¹⁹ <http://www.marine.scotland.gov.uk/FEAST/>

qualifying features of designated European sites are not available e.g. seals, cetaceans, otters and migratory fish.

The FEAST tool, like IMPACT and AoO, provides a consistent response to ecological pressures generated by an activity and the subsequent impacts that activity may have on a feature. The FEAST tool covers a number of differing industries including ancillary infrastructure and activities associated with wave and tidal energy development. The tool does not provide specific spatial information to allow an initial analysis of impact pathways, nor cover the complete suite of species that are qualifying features in designated European sites, but could contribute to a later stage of HRA, in the assessment of LSE.

<input type="checkbox"/> Change Activity Selection , Selected Activity: Tidal turbine energy production Reset Report			
<input type="checkbox"/> Change Selected Pressures			
Selected Pressures: Death or injury to mobile species by collision			
<input type="checkbox"/> Change Feature Sensitivities , Selected Feature Sensitivities: High, Medium, Low, Sensitive			
Black guillemot, Common skate			
Feature Name: Black guillemot (click here to view feature references)			
Pressure Name	Feature Sensitivity	Association Value	Evidence Base
Death or injury to mobile species by collision	Medium*	Associated	The collision risk with tidal turbines is uncertain - some evidence to assess this through temporal separation of foraging and when tidal turbines are operating due to tidal flow/stack water may limit risk (Furness, R.W. & Wade, H., 2012) . Tolerance to collision with above surface structures is high. Black guillemot dives and swims underwater searching for fish and have been found to collide with ships in low numbers in Greenland (Merkel and Johansen, 2011) and will fly away from approaching boats (Ronconi and Clair, 2002). Tolerance is assessed as medium with medium recovery for areas key to species life cycle.

Figure 8 Example output of FEAST for tidal turbine energy production as activity and ‘death of injury to mobile species by collision’. The tool generates two species (Black guillemot and Common Skate) as having a medium sensitivity.

5.3 Policy and Guidance

Tool 12: Survey Deploy and Monitor Policy Guidance (V2)

The Survey, Deploy and Monitor (SDM) Policy²⁰ is written policy guidance from Marine Scotland intended to provide regulators and developers with a risk-based approach for assessing wave and tidal energy development proposals. It is primarily focused on enabling a proportionate approach to determining survey requirements to inform consenting processes, based on a combined risk assessment of the following criteria:

- Environmental sensitivity of the location;
- Scale of the proposed development; and
- Technology type.

Environmental sensitivity maps from nineteen different datasets provide the basis of environmental sensitivity, and the policy draws on the IMPACT tool to assess technology risk, the third criterion. Overall the tool provides a useful generic benchmarking exercise for interpreting overall environmental risk.

Work is underway to update the tool via the RiCORE project²¹, a European funded project which aims to establish a European-wide risk-based approach to consenting where the level of survey requirement is based on environmental sensitivity of the site. The project completed in June 2016 and made a number of recommendations regarding updates to the SDM policy (P. Smith *Pers. Comm.*). These include updating environmental sensitivity criteria.

Currently, however, the updates to the SDM policy have not been specified in detail. The policy document in its current form does not focus on the level of specific implementation of the Habitats Directives. The policy is primarily a tool to define an appropriate survey approach for marine renewable energy projects, and in this sense would be expected to have limited value in assessing connectivity.

²⁰ <http://www.gov.scot/Topics/marine/Licensing/marine/Applications/SDM>

²¹ <http://ricore-project.eu/wp-content/uploads/2016/06/Final-RiCORE-brochure.pdf>

Tool 13: Ocean Energy Forum

The Ocean Energy Forum (OEF)²² was created by the European Commission, in response to a need to create a European-wide stakeholder forum to steer progress of the wave and tidal energy sector. The OEF has convened an Environmental and Consenting Steering Group²³ (ECSG) whose main objective has been to draft a Strategic Roadmap which covers a series of actions relating to the environment and consenting sector. Within these initiatives are an Environmental and Consenting Plan and Action Plan to de-risk environmental consenting. The initiatives feeding into the OEF include RiCORE (see Survey, Deploy and Monitor Tool 12), and the OEF acts as a repository of information of other ongoing and previous European funded projects.

Whilst there are a range of initiatives being promoted by the OEF that could help direct policy, it is unclear how these would specifically feed into decision-making processes regarding connectivity. Documentation reviewed by the OEF is focused at a strategic level and does not address the detailed implementation of the Birds and Habitats Directives. However, the OEF does set high level objectives that are refined by the Steering Group. Future outputs may have relevance to detailed implementation of the Habitats Directive and potentially have an application in developing connectivity assessments.

Tool 14: SNH Connectivity Maps and Guidance Note

SNH published the third version of a guidance note (2016): 'Assessing Connectivity with Special Protection Areas (SPAs)'²⁴ which provides specific advice, for mainly terrestrial species, based on the use of radial foraging distances for breeding and some non-breeding birds from an SPA to determine potential connectivity. The concept has been developed based on bird behaviour during the breeding season; during the breeding season seabirds are fixed to a single geographical location with an associated foraging range extending out to sea. In most cases, the guidance specifies that it is the core range that should be used in determining connectivity. The use of breeding season foraging ranges is accepted to be a suitable method for assessing geographical overlap, and subsequently connectivity.

Although this guidance is for primarily terrestrial species, a similar concept has been applied to marine bird species, and further guidance has been developed by SNH. Currently, this guidance is used only internally and has not been formally published. It differs from the published guidance note, notably in terms of the foraging metric adopted. The published guidance stresses the use of core foraging ranges, whereas SNH have adopted the mean maximum metric or the mean maximum +1 standard deviation where the value does not exceed the maximum foraging range for seabirds. In addition, the internal guidance specifies levels of theoretical connectivity which can be assessed based on the relative location of a development site within a foraging metric e.g. a site within the mean foraging range is considered to have a 'high' level of theoretical connectivity, whereas a site within the maximum foraging range is considered to have a 'low' level of theoretical connectivity.

The SNH published guidance provides specific spatial advice designed to be applied for the purposes of identifying geographic overlap with project sites based on radial foraging ranges for terrestrial bird species. The tool is designed to screen species in or out of a subsequent HRA. However, the tool is not absolute, and dedicated assessment of renewable sites should be based on the unpublished guidance, and consider the following limitations in the assessment:

- SPA breeding seabird populations are protected at all times and not exclusively during the breeding season; therefore any assessment will require consideration of SPA populations during breeding and non-breeding seasons;

²² <http://www.oceanenergy-europe.eu/policies/ocean-energy-forum>

²³ <https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1036>

²⁴ <http://www.snh.gov.uk/docs/A2015314.pdf>

- An HRA will also need to consider migratory and wintering species;
- The guidance states that core foraging ranges (as opposed to maximum ranges) should be used when determining whether there is connectivity between a proposal and a qualifying interest; however, SNH should be consulted where there is doubt over the use of this figure (e.g. where there is a lack of closer foraging sites).
- For some species, e.g. great black-backed gull, there is little data available on foraging ranges; similarly foraging ranges may change as more is learned regarding species behaviour.

A similar approach is being adopted for grey and harbour seals, with specific maximum movement distances for each species being applied during the breeding season (G. Lees *Pers Comm.*). However, similar issues exist in terms of defining appropriate radial distances for non-breeding grey seals, where SACs become of reduced importance outside the breeding season for this highly mobile species (G. Lees *Pers. Comm.*) and pragmatism should be exercised in applying radial limits. Overall SNH's tool is a key resource dedicated to addressing connectivity based on spatial data and corresponding geographic overlap with breeding and some non-breeding bird qualifying species.

Tool 15: JNCC Cetacean Management Units

The JNCC published the report "Management Units for Cetaceans in UK Waters, Report No.547"²⁵ in 2015 which details the final agreed Management Units (MUs) for the seven most common cetacean species in the UK, including harbour porpoises and bottlenose dolphins. The Inter Agency Marine Mammal Working Group (IAMMWG) comprising of representatives from all the UK SCNBs provided input to the report and the findings have already been integrated into the Population Consequences of Disturbance (PCoD) interim model for assessing the impacts of marine renewable energy developments on marine mammals. The MUs are expected to be formally reviewed every five years.

The MUs provide an indication of the geographical range of populations for each of the seven species detailed. They are designed to provide an indication of the spatial scales at which impacts of plans and projects alone, cumulatively, and in-combination, need to be assessed for the key cetacean species in UK waters. The areas are based on an understanding of the geographical range of populations and subpopulations, to provide an indication of the spatial scale at which impacts can be assessed consistently across the UK.

Further guidance was due to follow the papers outlining how SNCBs should interpret the MUs, however, this has not been published as yet. The intention is that the guidance will inform the assessment processes for plans and projects with the potential to affect cetacean features of SACs and other European Protected Species (EPS).

Currently SNCBs are using the existing management units to inform their advice for the purposes of HRA (K. Smith *Pers Comm.*), and MUs have already been adopted to define connectivity for The Crown Estate's Further Leasing Plan HRA (Section 5.5.2). This guidance note defines geographic units identified to facilitate management, and subsequent development work is likely to generate further information of value to identifying connectivity between qualifying features (Bottlenose dolphin and Harbour porpoise).

²⁵ http://jncc.defra.gov.uk/pdf/Report_547_webv2.pdf

5.4 Site Information

Tool 16: Natural England's Designated Sites System

Natural England's Designated Sites System (DSS)²⁶ provides detailed site information through a database format developed by Natural England. The site enables a user to search for designated site information (including European designated sites) and accompanying information. The tool generates detailed information including site conservation objectives, information on qualifying species, maps and management plans.

The development date of the tool is unknown; however, the system is currently in the process of being updated with links to Marine Conservation Advice Packages (Section 5.2.2) under an ongoing development process. Overall the site provides essential information to assist in characterising a designated European site.

Tool 17: Natural Resources Wales Designated Sites Search

Natural Resources Wales (NRW) Designated Site Search²⁷ provides site information through a database developed by NRW. The site enables a user to search for designated site information (including European designated sites) through a basic search function similar to the Natural England and SNH site information tools (Tools 10, 16 and 18). The tool generates detailed information including;

- Site information, including its designation or classification history, geographic area, feature descriptions;
- Background information and geography;
- Site maps;
- Conservation objectives and supplementary advice; and
- Advice on operations, including how an activity can affect a protected site feature on the site.

The system can be used in conjunction with data download features from the Lle Geo Portal to identify and characterise designated European sites.

As with a number of the Welsh resources, NRW's designated sites search is currently under development as part of an ongoing process to update and improve NRW's website and collate data and information previously held by the legacy management bodies for Wales (Countryside Council for Wales, Environment Agency Wales and Forestry Commission Wales). The associated content and timetable for development of the website is currently unclear, but NRW plans to update the designated sites information, including on marine Natura 2000 sites by the end of 2016. This will improve access to designated sites information, ensuring that it is much more accessible. The longer term intention will be to ensure that other portals such as Lle and The Marine Planning Portal provide signposting to this updated information. (K.Smith *Pers. Comm.*).

At the moment, the system provides a search functionality that can be used in combination with other tools to generate essential basic information regarding designated European sites. However further information contributing to the decision making process regarding connectivity is currently unavailable.

Tool 18: Scottish Natural Heritage SiteLink

The SNH SiteLink²⁸ information service sits within the wider SNH information service (SNHi) and links to a number of other interactive map interfaces (NMPi and SNH Interactive Map). A search can be carried out based on an SNH area, designation and local authority. Information generated includes qualifying

²⁶ <https://designatedsites.naturalengland.org.uk/>

²⁷ <https://naturalresources.wales/conservation-biodiversity-and-wildlife/find-protected-areas-of-land-and-seas/designated-sites-search/?lang=en>

²⁸ <https://gateway.snh.gov.uk/sitelink/>

interests' conservation objectives, and site condition. Further casework information can also be accessed. Where offshore sites are queried, the site links directly to the JNCC portal for further information. Overall the site provides essential information to assist in characterising a designated European site.

Tool 19: European Nature Information System (EUNIS)

EUNIS²⁹ collates data from three European databases into a site information database divided into sites, species and habitat types. The main objective is to assist reporting and provide assistance to the Natura 2000 process. The database includes:

- European threat status;
- EU Conservation Status and IUCN Red List Status;
- Listing of all international legal instruments and agreements that protect the species;
- Lists the sites under which they are protected, and an interactive map providing basic information; and
- Information on species, habitat types and designated sites mentioned in relevant international conventions and in the IUCN Red Lists.

The EUNIS database provides comprehensive general information regarding species and habitats, and is a good general reference point for further information on designated European sites and species. However, data that could potentially be used in an assessment of connectivity is not immediately apparent. Information on overall national condition and level of the population is available, although it is likely that this will be available within the SNCBs at a finer resolution, and more up to date than reporting to the European Environment Agency. The data may have utility in supporting developers identify transnational sites that may be screened into an assessment; however, this is likely to be relevant only for commercial scale wave and tidal developments.

²⁹ <http://eunis.eea.europa.eu/index.jsp>

5.5 Reports

Tool 20: Scottish Government Regional Locational Guidance / Draft Sectoral Marine Plan

The Regional Locational Guidance (RLG)³⁰ was developed to facilitate the development of offshore wind, wave and tidal energy in Scottish Waters by the Scottish Government. The guidance uses detailed environmental, technical and socioeconomic and planning information to refine 'Areas of Search' identified in both the 2012 Scoping Report for Wave Energy Developments and the 2012 Scoping Report for Tidal Energy Development. The information is presented in a written format, systematically working through national / regional scale data on physical, technical, human, and environmental constraints to provide the basis of zoning 'Areas of Search'. The evidence base is presented across five separate volumes relating to specific regions in Scotland.

The RLG (which is still published as 'Draft' form) was published in 2012 and has not been updated since then, instead forming part of an ongoing Sectoral Marine Planning process which sets out the proposed spatial policy for the development of commercial scale (>30MW) renewable energy in Scotland. The draft Sectoral Marine Plan (SMP) was published in July 2013³¹ and includes the RLG outputs, incorporating the results of pre-consultation, Strategic Environmental Assessment and HRA. The final SMP has not yet been published. The RLG zones, as updated by the SMP, are also available through GIS layers on NMPi, and an extract of the SMP is provided in Figure 9.

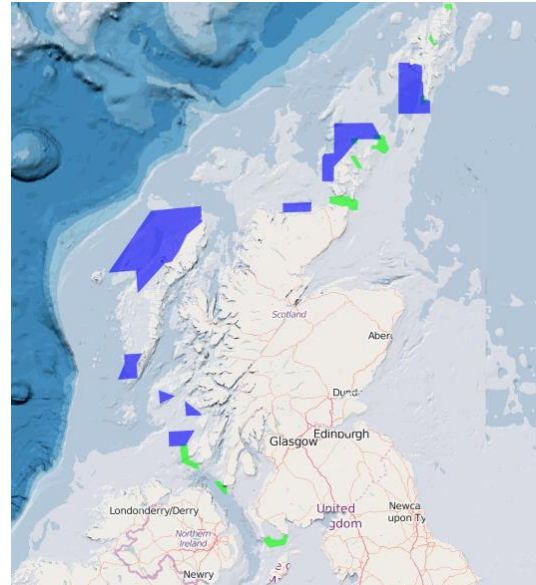


Figure 9 Sectoral Marine Plan - draft plan options for wave and tide

The RLG contains prescriptive geographic layers of data and does not include further spatial ecological information which could be incorporated into an assessment of connectivity. However, the Draft SMP has been subject to an HRA, which includes a relatively high level assessment on connectivity.

The methodology for the HRA is outlined in the 'Habitats Regulations Appraisal of the Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters: Draft Pre-Screening Report' by ABPmer³² (published in 2013) and describes a process to identify relevant designated European sites and features for which there is a potential for LSE, or where LSE cannot be excluded. A 100km screening buffer zone was applied around each draft plan option, identifying all European sites. Following a screening process, a methodology was set out to outline connectivity for the various marine interests. The general approach is summarised below:

- Coastal, intertidal and subtidal habitats and associated species: screen in sites with spatial overlap with plan options and potential ancillary infrastructure, apply hydrodynamic model data to determine distance covered by one tidal excursion (tidal ellipse) to define a potential zone of effect for indirect impacts;
- Birds: screen in specific species based on a review of foraging behaviour;

³⁰ <http://www.gov.scot/Topics/marine/marineenergy/Planning/waverlg>

³¹ <http://www.gov.scot/resource/0042/00428016.pdf>

³² <http://www.gov.scot/Topics/marine/marineenergy/Planning/drafthra>

- Anadromous fish and freshwater pearl mussel: use the latest information regarding fish migratory patterns to assess potential influence of option areas along migration routes of these species. Adopt tidal excursion methodology for further assessment of spatial overlap; and
- Otters: adopt a 10km boundary to represent appropriate buffer distances.

The approach adopted by ABPmer offers an initial high-level methodology that could be potentially applied in the development of a tool for marine habitats and associated species. Although the methodology for birds and marine mammals has since been developed and superseded by new guidance in some places (See 'JNCC Cetacean Management Unit Advice' and the report 'Wave and Tidal Further Leasing Plan HRA', in Sections 5.5.1 and 5.5.3).

Overall, the RLG and associated marine spatial planning documentation provides two important points of information. Firstly, it identified specific preferred zones for marine renewables, which have been subject to a high level HRA, including an initial screening process. Secondly, the associated HRA provides a high level methodology for screening connectivity at a national scale resolution. The RLG and associated SMP documentation are considered to have a potential application in assessing connectivity for wave and tidal sites, although aspects of the approach have since been superseded by other resources.

Tool 21: Wave and Tidal Further Leasing Plan HRA

The Wave and Tidal Further Leasing Plan HRA (ABPmer, 2014) was commissioned by The Crown Estate to assess the effects that the proposal to run a series of managed 'demonstration zones' for wave and tidal energy projects across the UK would have on protected nature conservation interests (designated European sites). The approach builds on the methodology developed for the Sectoral Marine Plan process taken forward by the Scottish Government. The report outlines a range of approaches that could be applied for assessing site specific connectivity assessments. Key approaches are summarised below:

- Screen in designated European sites where there is potential for indirect effects arising from physical or water quality changes because the distance between a designated European site and a proposed development is less than that of one locally defined tidal excursion;
- Screen out designated sites supporting long distance marine foraging species that have a landmass greater than 50km between them and demonstration sites because seabirds are unlikely to travel over large tracts of land when foraging;
- Screen in all designated European sites that have qualifying bottlenose dolphin interest features within the JNCC Cetacean Management Units (Tool 15);
- Screen in all designated European sites that have qualifying harbour porpoise interest features that lie within the appropriate management units defined for this species by the UK IAMMWG;
- Screen in all designated European sites that have qualifying migratory fish and freshwater pearl mussel interest features where the demonstration zones lie along the approach routes by which migratory fish species are known to, or are most likely to approach the UK from the Atlantic; and
- Screen in all designated European sites that have qualifying otter interest features where they lie at distances of less than 10km from the demonstration zones.

The methodology outlined in the report formalises a range of approaches to undertake a connectivity assessment, which are not otherwise published in specific guidance documents. It also builds on, and develops the methodology previously implemented in the Sectoral Marine Planning reports. The report is assessed by this review to indirectly provide approaches which could be adapted to provide ecological spatial data to assist in defining connectivity for specific qualifying features.

6 Other Resources

6.1 Resource Portals

A number of additional resources have been identified that operate as repositories for data generated elsewhere. These tools provide a range of resources including baseline, and post construction monitoring reports for marine developments, individual chapters for Environmental Impact Assessments, research papers, raw monitoring data and literature reviews, amongst others.

Whilst these portals alone are unlikely to specify the detailed tools and guidance needed to generate the information required to make an assessment of connectivity, the contents may assist in defining a 'connectivity case'; for example, primary research papers published on the effects of noise on a range of qualifying features or defining migratory routes. It is acknowledged that whilst there are many other repositories and databases that may also theoretically fulfil this requirement, the specific focus of these tools on the wave, tidal and general marine sector are considered to justify inclusion in the review.

6.1.1 Lle Geo Portal

Wales' Geo Portal Lle³³ is a web-based resource catalogue currently under development by the Welsh Government and NRW. There are approximately 150 data sources contained within the catalogue comprising spatial data, website links, applications, services and publications. The Welsh resources are currently under a substantial review and development, due to consolidation of resources from legacy agencies and the imminent release of the Wales National Marine Plan. Lle is currently being populated with information and continuously updated, which will in turn feed into the Marine Planning Portal tool.

The spatial data sources include digitised boundaries of designated European sites; users can directly download data layers or directly access the data via a WMS in the future. Some additional marine data layers are also available including National Biodiversity Network (NBN) data (Section 6.1.6) and habitat mapping layers. In future, the intention is to provide access to documents detailing the Conservation Objectives for SACs, SPAs and Ramsar sites within the geo portal (K.Smith *Pers. Comm.*), via a link to the information on NRW's website (see corresponding notes under Tool 17). This information is not currently linked to the digitised boundary data, but the intention is that it will be available by late 2016 or early 2017.

6.1.2 Wave and Tidal Knowledge Network

The Wave and Tidal Knowledge Network³⁴ was originally developed by The Crown Estate to facilitate data exchange within the wave and tidal sector. The network is now managed by the Offshore Renewable Energy Catapult. It is a resource catalogue in the form of a searchable database that contains in excess of 2,000 resources on a range of reports and datasets relevant to wave and tidal energy. Data can be downloaded directly, or is signposted should there be a commercial aspect to the data.

6.1.3 Marine Data Exchange

The Marine Data Exchange (MDE)³⁵ is managed by The Crown Estate and provides access to survey data and reports collated during the planning, building and operating of offshore renewable energy projects. It also incorporates all of the data that was submitted to the COWRIE (Collaborative Offshore Wind Research into the Environment) database, which the MDE system replaces.

³³ <http://lle.gov.wales/home>

³⁴ <http://www.waveandtidalknowledgenetwork.com/>

³⁵ <http://www.marinedataexchange.co.uk/>

The MDE also operates as a repository of information from The Crown Estate leasing processes; a clause in most offshore lease agreements requiring developers to submit data gathered as part of site development activities to The Crown Estate. Not all of this data is publically available. However, the system will provide further signposting to the data owner, should a data source be commercially sensitive or is considered to have a financial value associated. In future, the repository of data from information in the MDE will be transferred to the Marine Environmental Data and Information Network (MEDIN).

6.1.4 Marine Environmental Data and Information Network (MEDIN)

MEDIN³⁶ is a resource catalogue which aims to promote sharing of, and access to, marine data held by UK private and public sector organisations. Data is submitted with an agreed common standard of metadata, data format and content, supported by guidelines and software tools to ensure best practice data management. Data has been submitted from a range of marine data holders including DASSH (Section 6.1.7); The Archive for Marine Species and Habitats Data, CEFAS and Marine Scotland. Data can be searched through an interactive map or through submitting a 'theme' through a query tool. The range of data available is extensive and includes bird monitoring data from private sector.

6.1.5 Annex IV Knowledge Base: Tethys

Tethys³⁷ was developed by the Pacific Northwest National Laboratory to support the US Department of Energy's wind and water power technologies office. The system aims to facilitate the exchange of information and data on the environmental impact of wind and marine renewable energy technologies. The system is contributed to by a range of international partners and includes public and private data sources. The programme has also recently published the second State of the Science Report, which collates the evidence base on key environmental issues and impacts relating to marine energy developments³⁸. This is a key source of information which should help inform assessments of connectivity, though not necessarily directly.

The Annex IV programme has recently been awarded funding for a further 4 years and one of the areas of focus will be on developing science summaries on key issues. These may help to address issues relating to assessing connectivity between projects and protected sites and features.

6.1.6 National Biodiversity Network (NBN)

The NBN³⁹ Gateway is a UK repository of conservation and occurrence data recorded by over 150 formal biological recording groups / initiatives across the country, including groups such as the Marine Biological Association and Sea Search Surveys. The Gateway includes interactive maps which can be queried by searching by species or habitat, with data presented as 1km records. A search for 'harbour porpoise' for example, lists 33 different datasets contributing to that group.

6.1.7 The Archive for Marine Species and Habitats Data (DASSH)

DASSH⁴⁰ is the UK data archive for marine biodiversity data for both species and habitats. The system is managed by the Marine Biological Association and core funded by the Department for Environment, Food and Rural Affairs (Defra), the Scottish Government and is part of the MEDIN partnership. DASSH specialises in archiving and curating marine biodiversity data and information. Its data includes habitat survey data, species lists, habitat or biotope lists, species or habitat distribution maps, figures, images,

³⁶ <http://www.oceannet.org/>

³⁷ <http://tethys.pnnl.gov/map-viewer>

³⁸ <https://tethys.pnnl.gov/publications/state-of-the-science-2016>

³⁹ <https://data.nbn.org.uk/>

⁴⁰ <http://www.dassh.ac.uk/>

video clips and other relevant information. Data examples include trawling or dredging surveys, grab sampling or sedimentary cores, diver surveys and volunteer or amateur naturalist surveys and sightings.

6.1.8 Marine Scotland Information

Marine Scotland Information⁴¹ has recently been introduced by the Scottish Government as a general information portal, providing access to important contextual information for the data and resources made available by Marine Scotland online.

The resource combines information from NMPi (Tool 2), the Marine Scotland data portal and the geospatial data previously hosted on Marine Scotland Interactive (MSi). Content includes general information (text and background organised into themes), maps (spatial data available as interactive or downloadable map sources) and data (datasets, statistics, downloadable documents and links to other websites).

6.2 Open Source Software Tools

With the development of new statistical techniques and GIS tools, the use of predictive habitat distribution models has rapidly increased in ecology. A wide range of models have been developed to cover aspects as diverse as biogeography, conservation biology, climate change research, and habitat or species management. Over the course of this review many other open source tools were identified, and also highlighted with discussions with GIS specialists (K. Bell *Pers. Comm.*) which are freely available to undertake species distribution, or predictive habitat distribution modelling. Whilst the following software packages do not provide the necessary data to assess connectivity, the tools may provide novel approaches to developing a refined approach to modelling connectivity:

- Maxent (Maximum Entropy Distribution)⁴² – This software takes an input as a set of layers or environmental variables (such as elevation, precipitation, etc.), in addition to a set of georeferenced occurrence locations, and produces a geographic model of the range of the given species. The software aims to identify areas within a region which satisfy a species particular ecological niche for the purposes of identifying a ‘potential distribution’. The software operates by using a set of locations representing occurrence data and defines a set of environmental variables associated with that location to generate a probable framework of distribution.
- GARP (Genetic Algorithm for Rule-Set Production)⁴³ - is a software package for biodiversity and ecology research that allows the user to predict and analyse wild species distributions. The system creates an ecological niche model for a species that represents the environmental conditions where that species would be able to maintain populations. GARP uses as input a set of point localities where the species is known to occur and a set of geographic layers representing the environmental parameters that might limit the species' ability to survive.

These tools, and variations of these techniques have been applied specifically to the marine environment. Studies using these techniques have been published extensively in scientific literature and described in various projects. A brief selection of examples is listed below.

- Predicting the distribution of deep sea corals⁴⁴;

⁴¹ <http://marine.gov.scot/>

⁴² See <https://www.cs.princeton.edu/~schapire/maxent/> and http://rob.schapire.net/papers/maxent_icml.pdf

⁴³ <http://www.nhm.ku.edu/desktopgarp/index.html>

⁴⁴ <https://marine-conservation.org/what-we-do/program-areas/coral-conservation/deep-sea-corals/predictive-habitat-modeling/>

- Identifying cetacean habitat preferences based on slope and depth⁴⁵;
- Managing marine areas based on the spatial and temporal distribution of marine mammals ⁴⁶;
- Assessing the distribution and extent of protected deep sea habitats⁴⁷.

7 Summary

The Main Summary Table (Section 6.3, Table 3) collates each individual tool under its format heading and assigns a letter corresponding to the Decision Point criteria outlined in the Methodology (Section 4, Table 1). In addition, each tool is colour coded to provide a general indication of the overall value of the tool in the context of assessing connectivity (see detailed description in Section 4, Methodology).

⁴⁵ <http://www.sciencedirect.com/science/article/pii/S0967063702001231>

⁴⁶ <http://www.sciencedirect.com/science/article/pii/S0964569112001391>

⁴⁷ <http://onlinelibrary.wiley.com.eor.uhi.ac.uk/doi/10.1111/ddi.12010/abstract>

Table 3 Main Summary Table of Tool Review

Tool No.	Tool	Format & Link	Content	Region / Coverage	Management	Connectivity Assessment	Connectivity Decision Point	Year of Development	Update Frequency
Interactive Maps (GIS Databases)									
1	SNH Interactive Map	Interactive Map	Map-based information on the presence and boundaries of European Sites. Qualifying interests, site condition and conservation objectives of European Sites.	Scotland	SNH	Provides essential information to define project boundaries, qualifying features and associated conservation objectives within European sites.	B	No information on website	Specific dates provided for site information. Site frequently updated with last update indicated on site information page.
2	National Marine Plan Interactive (NMPi)	Interactive Map	Map-based information on the presence and boundaries of European Sites. Maximum curvature analysis, Seasonable breeding concentrations, predicted feeding distribution for seabirds. Abundance, count and distribution data for other species.	Scotland	Marine Scotland	Provides essential information to define the boundaries, qualifying features and associated conservation objectives of European sites. Additional ecological data layers may contribute to further connectivity assessment (e.g. seal usage maps).	B	No Information on website, evolved from Scotland's Marine Atlas (2011)	Website frequently updated with recent changes (and dates) highlighted on a notification box on opening the site.
3	MAGIC	Interactive Map	Map-based information on the presence and boundaries of European Sites. Supporting habitats for SPAs	UK	Natural England, under direction of a Steering Group	Provides essential information on European site boundaries, but with limited associated information on each site. Provides some additional ecological data layers e.g. detail on supporting habitats for SPAs.	B	First developed 2002, relaunched 2013	Approximately monthly, with updated datasets listed within the website.

Tool No.	Tool	Format & Link	Content	Region / Coverage	Management	Connectivity Assessment	Connectivity Decision Point	Year of Development	Update Frequency
4	MaRS	Interactive Map – Not publically available	Multi criteria decision-making tool based on a GIS platform. System uses existing data (although some generated by TCE) to present standard GIS layers which can be weighted in importance for decisions which require consideration of multiple variables. Not currently available to the public.	UK	The Crown Estate	The MaRS system is unlikely to provide any new data to contribute to connectivity assessments, however the methodology for weighting and scoring data layers may have direct application in the specification of a future tool to consider connectivity. The scoring / weighting methodology behind the model could be considered for developing the concept of connectivity in the future.	N/A	Not Known	N/A
5	JNCC MPA Mapper	Interactive Map	Interactive map containing information on designated MPAs Map-based information on the presence and boundaries of European sites.	UK	JNCC	Provides essential basic information to define the boundaries, qualifying features and associated conservation objectives of European sites. Additional spatial ecological information may contribute to further connectivity assessments.	B	No information on website	Unknown
6	Welsh Marine Planning Portal	Interactive Map	Map based information on the presence and boundaries of European Sites.	Wales	Natural Resources Wales	Provision of basic boundary information and names of European sites. No download feature currently available and little accompanying site information with European site boundaries. Future developments expected to generate greater functionality in this tool.	B	2015	Under development, ongoing

Tool No.	Tool	Format & Link	Content	Region / Coverage	Management	Connectivity Assessment	Connectivity Decision Point	Year of Development	Update Frequency
7	Northern Ireland Environment Agency Interactive Map	Interactive Map	Boundary and site information data (via JNCC) for designated sites under Natura 2000.	Northern Ireland	Northern Ireland Environment Agency	The site provides basic information including boundary data and links to other tools such as JNCC Marine Mapper.	B	No information on website	Unknown
8	Marine Renewable Energy Strategy Framework Wales (MRESF)	Interactive Map	Three stage process resulting in 'areas of search' for marine renewable sites in Welsh waters based on systematic analysis of resource, environmental and physical constraints. Interactive map available by request to RPS.	Wales	Welsh Government and RPS	The MRESF provides basic information on European sites, but does not provide further information which could potentially support connectivity assessments. MRESF is on a non-updateable format and should not be used to gather basic information on European sites. The future of the MRESF is to be determined; Welsh Government are considering its ongoing value. It's likely that the key data layers will be made available via the Marine Planning Portal and Lle.	N/A	2011	Not updated since publication, under consideration by Welsh Government (under review).
Sensitivity Analysis Tools									
9	IMPACT	Sensitivity Analysis Tool	Database covering general impacts of different technology types on a range of species under different environmental pressure scenarios. Comprehensive outputs summarising environmental risk and recommendation of pre and post monitoring requirements where necessary.	Scotland	Marine Scotland	Extensive outputs focusing on risk assessment and monitoring requirements. Does not provide spatial information on geographic distribution of features outside of European sites. However does provide information of value suited to later stage assessment of HRA (determination of LSE). For example, identifying impact pathways may lead to certain Natura 2000 features being quickly scoped out of the need for further consideration.	N/A	Assessment undertaken 2010-2011	Not specified, as determined by Marine Scotland.

Tool No.	Tool	Format & Link	Content	Region / Coverage	Management	Connectivity Assessment	Connectivity Decision Point	Year of Development	Update Frequency
10	Natural England Marine Conservation Advice Packages (MCAPs)	Sensitivity Analysis Tool, Guidance / Policy and Site Information	Comprehensive suite of guidance, information and databases providing highly detailed information on European sites, qualifying features, conservation objectives, conservation targets and more. Advice on Operation operates as a Sensitivity Analysis Tool, generating risk assessments of activities on each qualifying features of the site.	England	Natural England	Site provides extensive site information, essential for European site characterisation. The tool also provides benchmark criteria for some project activities that could theoretically enable a user to develop a more detailed project 'area of influence' for some features or contribute to the assessment of LSE.	A and B	Ongoing timetable 2016 - 2019	<ul style="list-style-type: none"> • Currently in the process of being updated. • Extensive timetable referenced in text.
11	Feature Activity Sensitivity Tool	Sensitivity Analysis Tool	Database providing the option to search by a range of activity types and pressures to generate a feature sensitivity assessment and evidence base for the analysis.	Scotland	Marine Scotland	Tool provides a methodology to consistently assess whether an activity, and associated pressure has the potential to affect a qualifying feature, therefore more suited to a later stage of HRA.	N/A	2013	Website indicates that the tool will be updated periodically to reflect best evidence.
Guidance and Policy									
12	Survey Deploy and Monitor Policy	Guidance / Policy	A guidance document outlining a risk-based approach to monitoring scenarios for wave and tidal sites based on scale	Scotland	Marine Scotland	Does not provide information providing detail on geographic distribution of features outside of European sites. Potential to provide a basic analysis of overall environmental risk but unlikely to provide the detail necessary for any specific part of a connectivity assessment. Development of	N/A	V2 Issued April 2016	Updates recommended through RiCORE project. No current

Tool No.	Tool	Format & Link	Content	Region / Coverage	Management	Connectivity Assessment	Connectivity Decision Point	Year of Development	Update Frequency
			of development, environmental sensitivity maps and technology assessment.			risk based approaches in the future may provide guidance to enable Natura 2000 sites or features to be scoped out of HRA at an earlier stage.			timetable for updates.
13	Ocean Energy Forum	Guidance / Policy	High-level strategic objectives published via a series of Roadmaps, Vision Paper etc.	Europe	Ocean Energy Forum	The initiatives are defined at strategic level. No apparent action plan to consider detailed implementation of the Habitats Regulations.	N/A	Strategic Roadmap	Strategic objectives – N/A
14	Assessing Connectivity with Special Protection Areas.	Guidance/ Policy	Defined advice with respect to the application of radial foraging distances to determine physical pathways for interaction.	Scotland	Scottish Natural Heritage	Guidance produced specifically to assist users in assessing connectivity between European sites designated for mainly terrestrial birds based on core foraging ranges. Internal guidance, as yet unpublished, presents a methodology for seabirds based on mean maximum foraging ranges and levels of theoretical connectivity.	C	2016	Third version. Appears to be updated when required.
15	JNCC Cetacean Management Units	Policy / Guidance	Guidance outlining geographic Management Units for seven cetacean species as a basis for further guidance including how decisions should be made about what proportion of animals within an MU might be affected by a proposed plan or project.	UK	JNCC	Advice already implemented in defining connectivity for harbour porpoises and bottlenose dolphins by some SCNBs. Methodology also incorporated at plan level HRA (see Tool 21).	C	2015	MUs updated every 5 years.
Site Information									

Tool No.	Tool	Format & Link	Content	Region / Coverage	Management	Connectivity Assessment	Connectivity Decision Point	Year of Development	Update Frequency
16	Natural England Designated Sites View	Site Information	Sites queried by name or searched within counties. Information on qualifying objectives and conservation objectives of European sites	England	Natural England	Provides essential information to define project boundaries, qualifying features and conservation objectives within European sites.	B	Ongoing development	Marine site information currently being updated in parallel with MCAPs.
17	Natural Resources Wales Designated Site Search	Site Information	Designated sites queried by name or searched within counties. Information on qualifying objectives and conservation objectives of European sites	Wales	Natural Resources Wales	Provides essential information to define project boundaries, qualifying features and conservation objectives in European sites.	B	No information on site	Under development
18	SNH SiteLink	Site Information	Designated sites queried by name or searched within regions. Information on qualifying objectives and conservation objectives of European sites	Scotland	SNH	Provides essential information to define project boundaries, qualifying features and conservation objectives in European sites.	B	Unknown	Constant updates in response to new information additions
19	European Nature Information System (EUNIS)	Site Information	Data on European species and habitat types. Data collected via European Environment Agency reporting activities.	Europe	European Environment Agency	EUNIS provides essential basic information on European sites, within a European context. However data presented is likely to be held by reporting countries and national level resolution is unlikely to be able to provide significant input into connectivity assessments.	B	Unknown	Unknown (last updates January 2016)
Reports									

Tool No.	Tool	Format & Link	Content	Region / Coverage	Management	Connectivity Assessment	Connectivity Decision Point	Year of Development	Update Frequency
20	Scottish Government Regional Locational Guidance / Sectoral Marine Planning	Reports	RLG identifies 'Areas of Search' from a systematic analysis of physical, technical, environmental and socio-economic data sets for marine renewables. Spatial datasets available through NMPI. Associated documentation outlines high level connectivity assessments.	Scotland	Marine Scotland	The RLG / Sectoral Marine Plan duplicate historic information on designated sites, and should not be used to gather basic information on European sites. However as part of the marine planning process, an HRA has been carried out on the area options and may provide an indicative methodology for determining connectivity for some qualifying features, although aspects of this methodology have since been superseded.	A and C		RLG and related documents are published documents forming part of marine spatial planning process. Not updated.
21	Wave and Tidal Further Leasing Plan HRA (ABPmer, 2014)	Report (Available through Wave and Tidal Knowledge Exchange Site)	Report on the HRA for The Crown Estate's Further Leasing Process. Includes high level screening criteria for marine European sites.	UK	The Crown Estate	The report outlines approaches to screening in or out European sites i.e. initial connectivity assessment. The methodology formalises the approach an approach to assessing connectivity for some qualifying features.	A and C	2014	Static Report N/A
GROUPED RESOURCES									
	Resource Portals	Various	A range of information sources, generally dedicated to marine renewables sector with specific research papers and data relevant to the sector.	UK and internationally	Various	These portals have the potential to contribute to the development of resources that may contribute to future connectivity assessments e.g. research outputs regarding the migratory routes of Atlantic salmon, and include a repository of different approaches to assessing connectivity both at individual site level and at plan-level assessments.	C		Updated continuously
	Open source species	Various	Open source software tools that	N/A	Various	This group of resources represents technological options which could be used to refine a future connectivity tool.	C		N/A

Tool No.	Tool	Format & Link	Content	Region / Coverage	Management	Connectivity Assessment	Connectivity Decision Point	Year of Development	Update Frequency
	<i>distribution tools</i>		<i>may have some potential in refining</i>						

Overall the review has identified a wide range of interactive GIS databases, guidance and policy documents, sensitivity analysis tools, reports and information sources that are considered to have potential to contribute to the connectivity decision-making process. In total, twenty one primary information sources were assessed, in addition to two additional categories of clustered resources.

The 'Methodology' section outlines the process developed in order to characterise how individual tools could potentially input into the decision making process for assessing connectivity. To reiterate, the process is as follows:

- A: Characterisation of a wave and tidal site is the first step to understand the activities associated with a project, to determine the likely physical boundaries of potential effects arising from the proposals. Characterisation includes defining all associated activities and applying an approximate 'area of influence'; this would include indirect effects associated with an operation and maintenance base, vessel transits, cable route, cable landing point and ancillary infrastructure;
- B: The next stage is gathering information on European designated sites, using a combination of interactive map tools to define site boundaries, and investigating the relevant qualifying features present; and
- C: The final step is the systematic application of ecological spatial information to determine theoretical overlap between the qualifying features of European designated sites and any aspect of the proposed wave and tidal project.

To provide context in terms of how the tools may be used in an assessment of connectivity, Figure 10 outlines the broad decision-making process of assessing potential connectivity between project sites and a European designated sites, and the types of tools which are generally appropriate at each stage.

In considering Figure 10, the suggestions for tools in Stage C are highlighted to indicated where a relevant tool is available for that particular feature. Although the suggested tools are applicable for those particular qualifying features, they may not provide a comprehensive method of assessing connectivity. For example, Tool 14 has been suggested as a tool to support the connectivity assessment of birds however, this particular tool is focused on terrestrial species, the tool is also focused on core foraging ranges during the breeding season and does not cover many non –breeding species, finally the tool was developed for Scotland and may not cover the range of UK qualifying bird species.

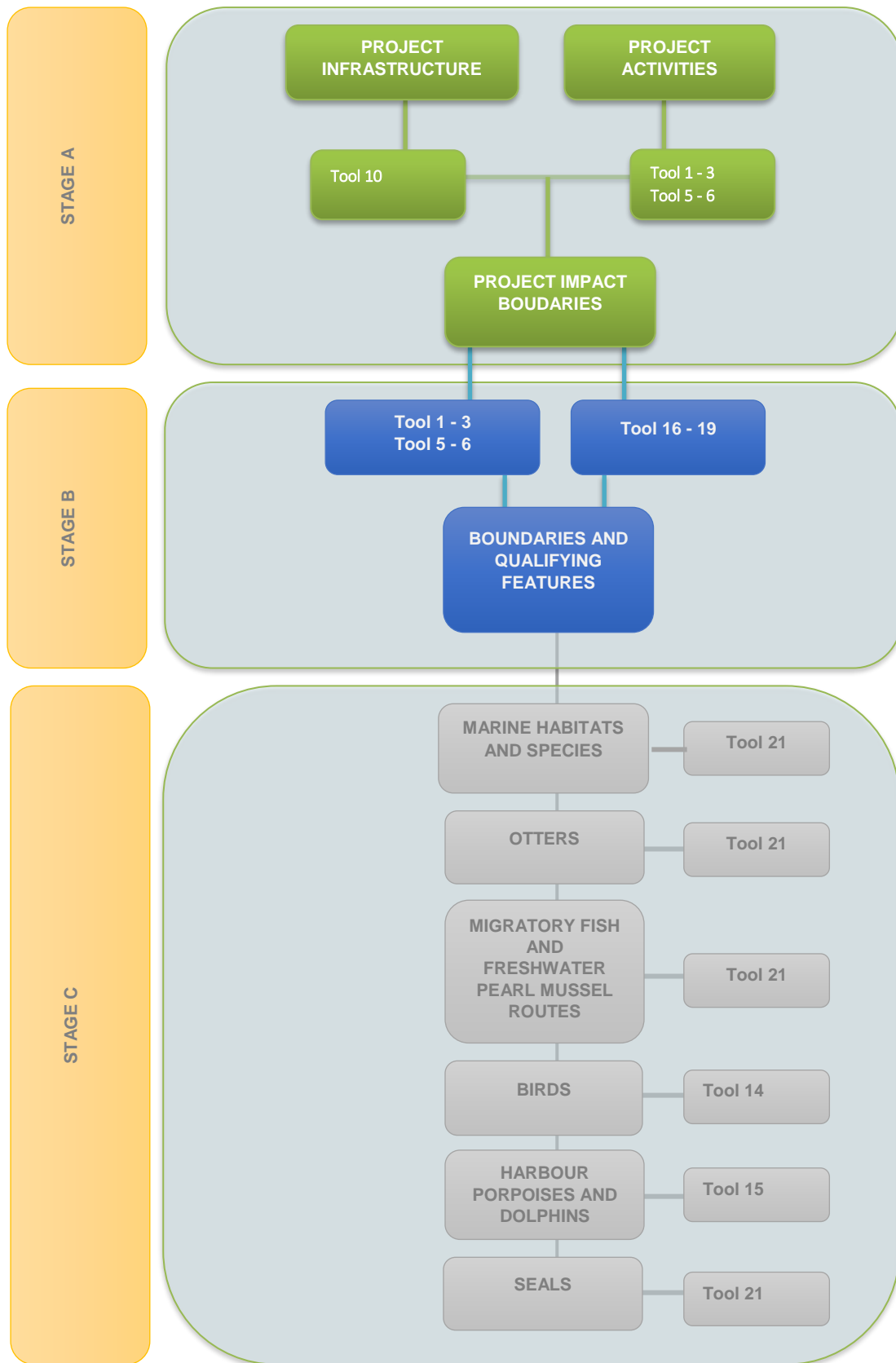


Figure 10 Flowchart showing the broad decision-making process and how specific tools can feed into the assessment.

The following section briefly summarises the range of tools and describes the potential application in connectivity assessments, based on the potential to input into the categories above.

7.1 Interactive Map Sites

Eight resources were defined as interactive maps; six of these provide direct information regarding designated European site boundaries, enabling a visual assessment of the proximity of a designated European site to a proposed project boundary. Many include data download options and WMS functionality, allowing a user to directly link to the geodatabase through their own GIS. The resources are as follows:

- National Marine Plan Interactive (NMPi);
- SNH SiteLink;
- MAGIC;
- JNCC Marine Mapper;
- Welsh Marine Planning Portal;
- MaRS;
- Welsh Marine Renewable Energy Strategic Framework; and
- Northern Ireland Environment Agency Interactive Map.

Querying a European site within its boundaries usually provided further information - at the very least the name of the site - which could then be further investigated by other tools. Some systems provide direct links to additional information on the qualifying features and conservation objectives.

Figure 11 summarises these resources with information on the associated coverage of each tool in terms of the UK, and its devolved administrations. Several tools cover the UK in its entirety; however, many authorities have created their own tools / resources of varying standards. All of the tools overlap through presenting map-based information (including designated European site boundaries) on an interactive map interface; however, they do differ markedly in the volume and quality of associated information, and directly queried data from each tool. Some of this additional information could potentially be used to further refine connectivity or contribute to the later stage of an HRA assessment, for example, additional abundance, count and usage maps, such as those published on NMPi.

The organisation of legislative responsibility for protection in the marine environment is devolved to national SNCBs for marine designated European sites within 12 nm. Outwith this limit, the JNCC has specific responsibilities for offshore marine nature conservation which are set out in the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007, the Marine and Coastal Access Act 2009, and a number of Regulations that relate to the activities of the offshore oil and gas sector. For all the tools available for direct review, with the exception of the NIEA interactive mapper, information was presented information on both the devolved and UK wide designated European sites.

Two of the tools are unavailable to the general public; MaRS is an internal system to The Crown Estate and the MSREF for Wales is not currently available to the public; however, some of the MSREF layers are available via another Welsh resource, Lle. Both of these tools incorporate decision-making criteria embedded within GIS layers to assign levels of importance. Whilst these tools were unavailable for this review, the concept of applying a weighting system to spatial data could provide a further approach in displaying and interpreting spatial information to be used in connectivity mapping.

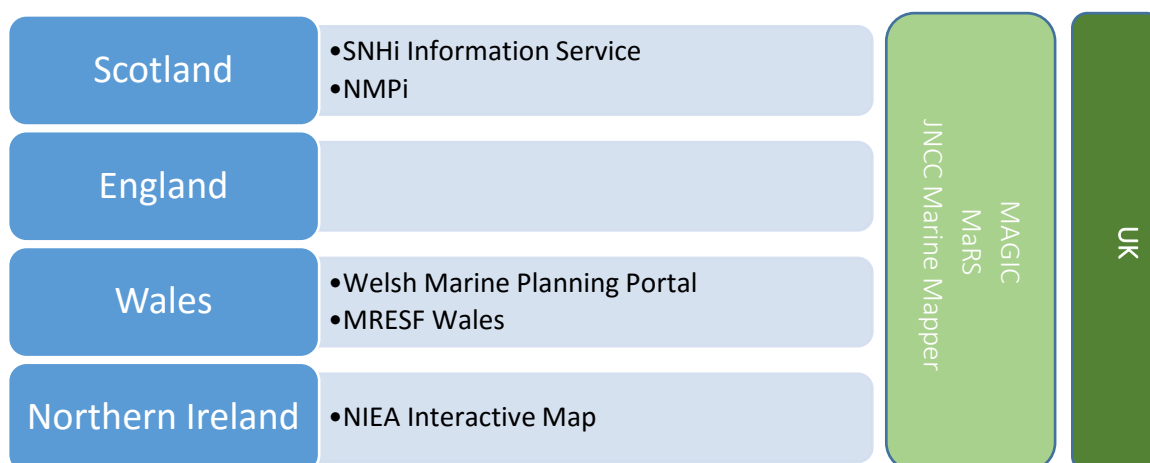


Figure 1 Summary of the spatial coverage of interactive map sites, sites in green refer to UK wide coverage.

Most of the interactive tools assessed, with the exception of the tools which are not publicly available and NIEA (due to the format of the tool), have the potential to integrate spatial information data layers illustrating specific connectivity. They all materially contribute to the assessment of connectivity through, at the very minimum, defining designated European site boundaries, to assist in characterising designated European sites for the information gathering phase.

7.2 Sensitivity Analysis Tools

Three sensitivity analysis tools were identified. These tools could be queried to a highly detailed level based on a site activity and species and generated a form of risk or sensitivity assessment. The tools are summarised below:

- IMPACT (Marine Scotland);
- Feature Activity Sensitivity Tool (Marine Scotland); and
- Marine Conservation Advice Packages - Advice on Operations (Natural England).

Although similar in concept, each tool differed in focus and objective. One of the most comprehensive of the databases was the Advice on Operations (AoO) spreadsheet, produced by Natural England. Natural England is in the process of developing a separate AoO tool for each Marine Protected Area in England (including designated European sites). The tool covers a range of industries and activities; generating sensitivity analysis for individual qualifying features with an associated evidence base for the assessment. The AoO also provides benchmark criteria enabling a user to define relatively detailed areas of influence for some specific project activities. Triggering a benchmark criterion would result in the species group being assessed as 'sensitive'. Application of the tool could be used upfront for some activities to understand if the project would exceed benchmark criteria in the first instance, or alternatively support an assessment of LSE at a later stage of HRA.

IMPACT and FEAST are similar in their ability to query activities and features; however, IMPACT is significantly more detailed in both the options that can be queried and outputs generated. Furthermore IMPACT is also dedicated specifically to assessing the impact of wave and tidal energy. IMPACT also, in addition to detailed assessment outputs, generates advice on the type and nature of desk-based assessment, baseline characterisation surveys and monitoring activity for demonstration arrays (<10MW). FEAST covers a range of different marine activities, and covers breeding and non-breeding features to generate an evidence base for feature sensitivity.

Although similar in concept, the three analysis tools differ markedly in output and content. The AoO has potential to support detailed definitions of project 'areas of influence' in addition to contributing to the detailed assessment of LSE. However, the usefulness of IMPACT and FEAST are restricted towards the later stages of HRA, particularly the assessment of LSE.

7.3 Site Information

Typically associated with the interactive map resources are information sites which provide detailed associated information on the qualifying features (habitats and species) and their conservation objectives for European sites. In many cases significant additional detail was provided. Generally, these were managed by the SNCBs:

- SiteLink (SNH);
- Natural England's Designated Site System (NE DDS);
- Marine Conservation Advice Packages (MCAP - Natural England);
- Wales Designated Site System (NRW); and
- EUNIS.

SNH's Sitelink and Natural England's DSS could be queried using a basic tool to generate information on specific designated sites including qualifying features and conservation objectives. The Marine Conservation Advice Packages are currently being transferred over to the Natural England DSS and are subject to a long-term timetable of defining content of each MCAP, upgrading the web interface and transitioning to the Natural England DDS view. Specific site information was not immediately apparent on a national basis for Northern Ireland; however, much of the necessary information for Northern Ireland could be queried via the UK wide JNCC or MAGIC tools. The Welsh Designated Site System Tool is similar in format to the Natural England's DDS. Finally, EUNIS collates data on European sites at a European level from the SCNBs. Accessing this site may be necessary to identify sites that may be subject to transboundary impacts.

Working in parallel with the interactive map sites, these tools provide essential detail on the qualifying features of the European sites, and are therefore a necessary part of the decision-making process during the information gathering phase.

7.4 Guidance and Policy

A total of five tools categorised as 'Guidance and Policy' were reviewed, these included:

- Survey, Deploy and Monitor (Marine Scotland);
- Ocean Energy Forum Initiatives;
- Marine Conservation Advice Packages (Natural England);
- Guidance on Assessing Connectivity with SPAs (SNH); and
- Management Units for Cetaceans in UK Waters (JNCC).

The Survey, Deploy and Monitor policy is a tool to undertake a general risk assessment of a site; for the purposes of defining appropriate monitoring strategies. A recent project to update the policy has resulted in a series of recommendations to expand the guidance and refine the methodology. However, these have yet to be developed further, and the high level nature of the policy and accompanying focus on monitoring is unlikely to generate specific detail on the assessment of connectivity as part of the Habitats Regulations.

The Ocean Energy Forum was created by the European Commission in response to the trade association for marine energy, Ocean Energy Europe, calling for a stakeholder led forum. A draft strategic roadmap

was published outlining a series of measures to de-risk environmental consenting. The review concluded that measures were high-level and strategic in nature, and did not immediately provide information or methodologies that would support detailed connectivity assessments. However, outputs arising from any projects delivered as part of the roadmap may be of future value. Furthermore, the OEF could potentially provide a future route to lobby for, develop and deliver work packages to improve the decision-making process for connectivity.

Marine Conservation Advice Packages (MCAPs), published by Natural England, provide very detailed information on European sites and their associated qualifying features. The accompanying guidance for assessing proximity to European sites is based on an arbitrary proximity assessment, with guidance outlining a process to determine connectivity based on a licensable activity taking place 'within or near' a European site. However, further guidance within each MCAP in the 'Advice on Operations' provides specific benchmark criteria for assessing the potential impacts of specific activities on features. These benchmarks could assist in defining a detailed 'area of influence' for some project activities.

SNH's connectivity guidance is the only formally published guidance to address a specific methodology for establishing connectivity. The SNH guidance provides specific instructions based on the use of radial foraging distances for breeding and non-breeding birds from a designated site boundary. Discussions with other SCNBs suggest that the foraging ranges developed by Thaxter *et al* 2012⁴⁸ are implemented in other agencies (K.Smith *Pers Comm.*); however, these approaches have not been formalised in specific guidance and there may be differences in how the information in Thaxter *et al* is applied. For example, SNH guidance is based on the core foraging ranges, whereas NRW tends to use the mean / maximum foraging ranges in their advice.

The Management Units for Cetaceans in UK Waters guidance published by the JNCC provides the basis for managing specific populations of cetaceans within geographic units. Guidance is due to follow this report outlining details how the Management Units can be implemented in practice. Guiding principles will be developed on how 'local' impacts on this proportion might be placed in the context of wider regional implications. Despite the unavailability of associated guidance on the implementation of MUs as geographic units, the concept of MUs to address connectivity has already been adopted both at plan level (see Section 7.5) and site specific level (K.Smith *Pers Comm.*).

7.5 Reports

Two resources, classified as 'reports' were reviewed:

- Regional Locational Guidance and associated Marine Sectoral Planning reports (ABPmer for the Scottish Government)
- Wave and Tidal Further Leasing Plan (ABPmer for The Crown Estate, 2014)

The Scottish Government's RLG guidance comprises of a detailed assessment of data layers to define appropriate areas for the development of marine renewables. These locations were subject to a number of sustainability assessments, including an HRA for the proposed areas of search. The RLG itself was concluded to have minimum utility in assessing connectivity; however, the associated documentation within the marine spatial planning process included ABPmer's methodology for undertaking a plan-level HRA for the draft plan options, and was considered to propose a useful approach for some aspects of connectivity. The report outlines methodologies to determine connectivity, including defining a project area of influence based on tidal ellipses for assessing indirect impacts. Although not strictly a tool, it was concluded that this methodology may have some use in the

⁴⁸ Thaxter, CB, Lascelles B, Sugar K and Burton, N. 2012. Seabird Foraging Ranges as a Preliminary Tool for Identifying Candidate Marine Protected Areas. *Biological Conservation*. 156.

consideration of connectivity at a site level, although this has since been superseded by the Further Leasing Plan report undertaken for The Crown Estate.

The HRA undertaken by the same authors for The Crown Estate's Further Leasing Plan built on the approaches initially reported in the Marine Sectoral Planning process described above. Approaches were developed for a site 'area of influence' to include wave shadow in addition to tidal ellipses. The use of the JNCC Cetacean Management Units (Tool 15) was also suggested for bottlenose dolphins and harbour porpoise, a methodology already in use within some SCNBs (K.Smith *Pers Comm.*).

Over the course of the review, other plan level HRA's were identified that could potentially highlight other methodologies for determining connectivity. An example was highlighted, comparing the Wave and Tidal Leasing Plans described above with the plan-level HRA developed for the marine aggregates sector (K.Smith *Pers Comm.*). Considering the methodologies for assessing connectivity across sectors, from individual project level HRA approaches to plan-level HRA may provide useful insights in terms of how assessments of connectivity can be consistently applied.

7.6 Resource Portals

Other information sources were reviewed that had the potential to contribute to a range of aspects related to connectivity assessments. These included the following:

- Lle Geoportal;
- Wave and Tidal Knowledge Network;
- Marine Data Exchange;
- Marine Environmental Data and Information Network (MEDIN);
- National Biodiversity Network Gateway;
- Annex IV Knowledge Base: Tethys;
- DASSH; and
- Marine Scotland Information.

Whilst the nature of these portals is similar to many other scientific databases, the dedicated nature of these portals with regards to the wave and tidal sector, or the marine environment, were considered in the review to increase the value of the datasets contained within them. It was concluded that these portals could provide information which could assist in developing a case for providing information which could contribute to spatial information of use within a connectivity assessment; for example, in the refinement of migratory routes for species such as Atlantic salmon.

7.7 Habitat Mapping Software

Other open source software 'tools' were identified that have potential application in supporting or refining assessments in connectivity have been highlighted as part of the review. Two examples were provided to illustrate the concept of the software. Overall the main aim of these software tools are to support predictive habitat modelling which could, in the future, be utilised to refine relatively basic radial foraging ranges to include for example or predictions of likely habitat usage outside a European site.

8 Conclusions

The aim of the review was to undertake an assessment of existing tools which could contribute to the assessment of connectivity with the HRA process. Twenty three resources (including two grouped resource categories) were assessed for their potential application in assessing connectivity.

The review identified a need to define an 'area of influence' for a project site, which can potentially be agreed across industry, The Crown Estate, regulators and advisors. Administrative project boundaries did not always reflect the range of potential impacts that might be generated by a development. No specific guidance or tool was identified focusing on this specific aspect, however high level approaches were identified in the RLG / Sectoral Marine Spatial Planning Process reporting process and developed by the same authors (ABPmer) in the Wave and Tidal Further Leasing Plan HRA, published by The Crown Estate. The authors applied hydrodynamic modelling to define tidal excursion areas (or ellipses) to identify designated European sites that could be affected indirectly by hydrodynamic changes. Similarly, designated European sites that were within a defined wave shadow area were also considered to have connectivity with a plan area. At a more specific level, Natural England provides benchmark criteria for specific project activities through an Advice on Operations tool located within each site Marine Conservation Advice Package. Some of these benchmark criteria could be used to generate spatial data to define detailed areas of influence for specific features, although others are more suitable for defining LSE.

Overall there is a comprehensive set of publically available datasets providing interactive GIS mapping tools for the whole of UK. Individual SCNBs and Governments have also taken the initiative to generate national databases or resources to meet specific objectives, for example in marine planning. In terms of the assessment of connectivity there is no shortage of these resources to identify (and download) European site boundaries and gather general site information (qualifying features and conservation objectives). These resources enable a basic assessment of connectivity based on locations overlapping to, or in close proximity to European Sites. Most of these resources would be a suitable platform to integrate spatial ecological data for connectivity mapping.

Finally, the application of ecological spatial data (foraging, dispersal or population movement) was identified as the final stage of the assessment required to identify areas of overlap between the relevant site qualifying objectives and a project / project area of influence. Formalised guidance exists for defining connectivity based on breeding seabird foraging ranges and is commonly practiced for other species such as seals. However despite SNCBs commonly applying a range of specific decision making criteria to determine connectivity to a range of qualifying features, very little of this practice appears to be captured in formal guidance. Formalising practice would assist in specifying a future tool. Similarly, to understand current practice in terms of the criteria applied for different qualifying species, a review of existing practice based on a detailed assessment of approaches by SNCBs, plan-level approaches and methodologies generated by developers may be of value in the future.

Existing technological platforms are available through the numerous interactive GIS map sites outlined in this report to display spatial ecological data. Additional functionality could be implemented relatively easily via the integration of associated data layers for each designated European site. These could include central point foraging ranges for breeding seabirds and species migratory routes for migratory fish, otter movement buffers, and JNCC Management Units for bottlenose dolphin and harbour porpoise. These represent relatively straightforward GIS data layers or functionality that can be integrated relatively easily to an existing interactive map interface.

However, defining project 'areas of influence' may present a greater challenge. Methodologies identified in this report would require, for example, a basic hydrodynamic functionality to generate an associated tidal ellipse. Similarly, integration of some of the benchmark criteria outlined in Natural England's Advice on Operations has the potential to be complex and highly project specific, and will differ between each receptor and qualifying feature.

The review identified some complexities in the application of basic ecological spatial data layers; they do not necessarily take into account more subtle aspects of the data e.g. uncertainty (fish migratory routes), potential changes of use (e.g. core versus maximum foraging ranges, breeding versus non-breeding distribution ranges) and known behaviours around specific foraging activities or movements. Nor does this application capture uncertainty (e.g. migratory routes). In this respect, the availability of other tools, for example, The Crown Estate's multi criteria analysis methodology (also applied within the Welsh MRESF) may have potential utility to capture and present these other, more subtle aspects to the data through weighting and scoring specific layers to present additional, and more refined data layers. Similarly, habitat software tools which model species or habitat distributions may be able to further develop and refine existing connectivity mapping in the future.

There are other initiatives across the UK to investigate the potential for developing tools and mechanisms to deliver more proportionate approach to consenting and associated evidence needs. This includes considering how issues might be retired or scoped out at an earlier stage of EIA and HRA. For example, Welsh Government have recognised the opportunity to set policy within the Wales National Marine Plan to drive delivery of these measures. These may therefore, help top deliver tools which in turn will provide steer or guidance for assessing connectivity. The marine planning process was considered an opportunity to improve access to ecological data and further evidence to refine connectivity assessments.

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