Ecological sensitivity analysis of the western Irish Sea to inform future designation of Marine Protected Areas (MPAs)

A report by the Marine Protected Area Advisory Group
for the Department of Housing, Local Government and Heritage

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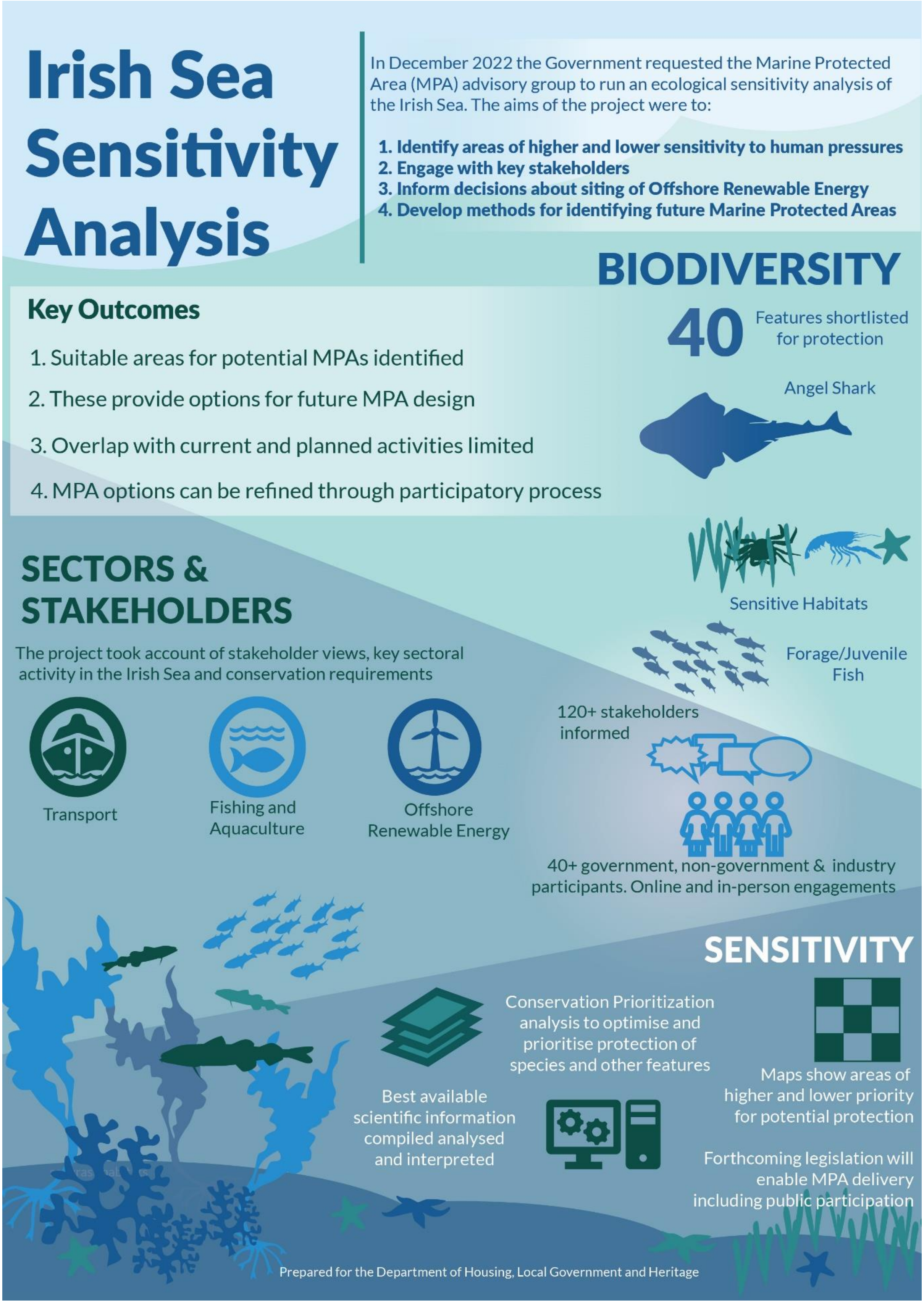

Irish Sea Sensitivity Analysis
In December 2022 the Government requested the Marine Protected Area (MPA) advisory group to run an ecological sensitivity analysis of the Irish Sea. The aims of the project were to:
1. Identify areas of higher and lower sensitivity to human pressures
2. Engage with key stakeholders
3. Inform decisions about siting of Offshore Renewable Energy
4. Develop methods for identifying future Marine Protected Areas
BIODIVERSITY
40
Features shortlisted for protection
Angel Shark
Sensitive Habitats
Forage/Juvenile Fish
Key Outcomes
1. Suitable areas for potential MPAs identified
2. These provide options for future MPA design
3. Overlap with current and planned activities limited
4. MPA options can be refined through participatory process
SECTORS & STAKEHOLDERS
The project took account of stakeholder views, key sectoral activity in the Irish Sea and conservation requirements
Transport
Fishing and Aquaculture
Offshore Renewable Energy
120+ stakeholders informed
40+ government, non-government & industry participants. Online and in-person engagements
SENSITIVITY
Conservation Prioritization analysis to optimise and prioritise protection of species and other features
Best available scientific information compiled analysed and interpreted
Maps show areas of higher and lower priority for potential protection
Forthcoming legislation will enable MPA delivery including public participation
Prepared for the Department of Housing, Local Government and Heritage

Executive summary

Ireland has a legal obligation to protect the marine environment, ensuring that our seas and ocean are clean, healthy, diverse, productive and resilient to the effects of climate change, and that sectoral activities dependent on them are carried out sustainably.

Ireland is currently undergoing several significant changes in relation to maritime activity, its regulation and its planning. This includes provisions for siting and managing the development of Offshore Renewable Energy (ORE) while also taking account of other sectors and other considerations. In this context, the western Irish Sea (i.e., off the eastern seaboard of Ireland) has been identified as suitable for potential ORE development between now and 2030. This includes *Phase 1* wind energy projects referred to in the draft Offshore Renewable Energy Development Plan II (OREDP II).

In parallel with this activity, the forthcoming Marine Protected Areas Bill is at an advanced stage of development. The MPA Bill will enable Ireland to meet its national and international commitments for area-based protection in our seas and ocean, aiming for 30% MPA coverage nationally by 2030.

Given that the MPA legislative process is ongoing, and in order to safeguard areas of environmental sensitivity to the potential effects of ORE development in the near term, a detailed scientific analysis and report on the western Irish Sea was undertaken between December 2022 and April 2023. The aims of this ecological sensitivity and conservation prioritization project were to:

1) identify areas of comparatively higher and lower ecological sensitivity within the western Irish Sea based on the best available evidence;
2) inform planning decisions to be taken about the potential siting of ORE infrastructure, taking account of stakeholder views, conservation requirements and other sectoral activity;
3) establish methods and collate and characterise the evidence base that could be applied to the process of identifying, designating and managing MPAs under the forthcoming legislation.

The project team comprised members of the MPA Advisory Group which provided advice on the expansion of Ireland's MPA network in 2020, working with additional experts and researchers. The team sought to adhere as closely as possible to the principles likely to underpin the forthcoming MPA legislation.

Forty biological and environmental features were identified that could be recommended for spatial protection in the western Irish Sea under the forthcoming MPA legislation, based on criteria aligned with international approaches and the provisions of the General Scheme of the MPA Bill. Selected features included species and habitats classified as threatened or declining on national and/or international lists, species and habitats of recognised ecological importance, areas of high biodiversity and a feature with high potential for restoration.

It should be noted that species or habitats already listed in the EU Birds and Habitats Directives or individually managed under the EU Common Fisheries Policy (CFP) were not included in the project, since legal provisions for their conservation and sustainability are already in place.

For each selected feature, all the data was collated into a single data resource and the evidence was analysed to determine the sensitivity of that feature to the sectoral activities most relevant to the project objectives, i.e., ORE development, shipping, and fishing. Stakeholder engagement was also undertaken by the project team to inform the process and enable information exchange within the project's time constraints.

Based on the available data and evidence, conservation prioritization analysis was carried out to identify areas of high and low priority for protection, considering current and proposed future sectoral activities. Constraints and caveats are outlined in the report’s discussion. It is important to remember that the project had highly specific terms of reference and a particular geographical focus. The scientific and analytical work undertaken was nevertheless rigorous and systematic, and the project’s recommendations are based transparently on the best available evidence and the precautionary principle.

Key outcomes

Suitable areas have been identified from within which an effective network of MPAs could be selected for the species, habitats and other features included in these analyses (Figure 1).

It is important to note that the full extent of these suitable areas would not be required for an effective network of MPAs in the western Irish Sea, and that not all activities would need to be restricted within them.

In identifying these suitable areas, the extent of overlap is limited with areas proposed for Offshore Renewable Energy (ORE) development and areas that are of importance for existing fishing effort (Figure 1).

In addition to the suitable areas identified, there are areas of ecological priority that may need to be considered in the future as part of Ireland’s wider MPA designation process.

Further work under the forthcoming MPA legislation will enable potential MPA network solutions to be refined on the basis of national policy, analyses involving new additional evidence and the participation and input of stakeholders.

It is envisaged that sectoral overlaps would be further reduced during this process, while establishing a coherent effective network for the conservation of the selected species, habitats and other features.

This project report is made up of (1) a main report, and (2) detailed appendices. A full set of key messages and recommendations arising from the project is provided in the Tables below.

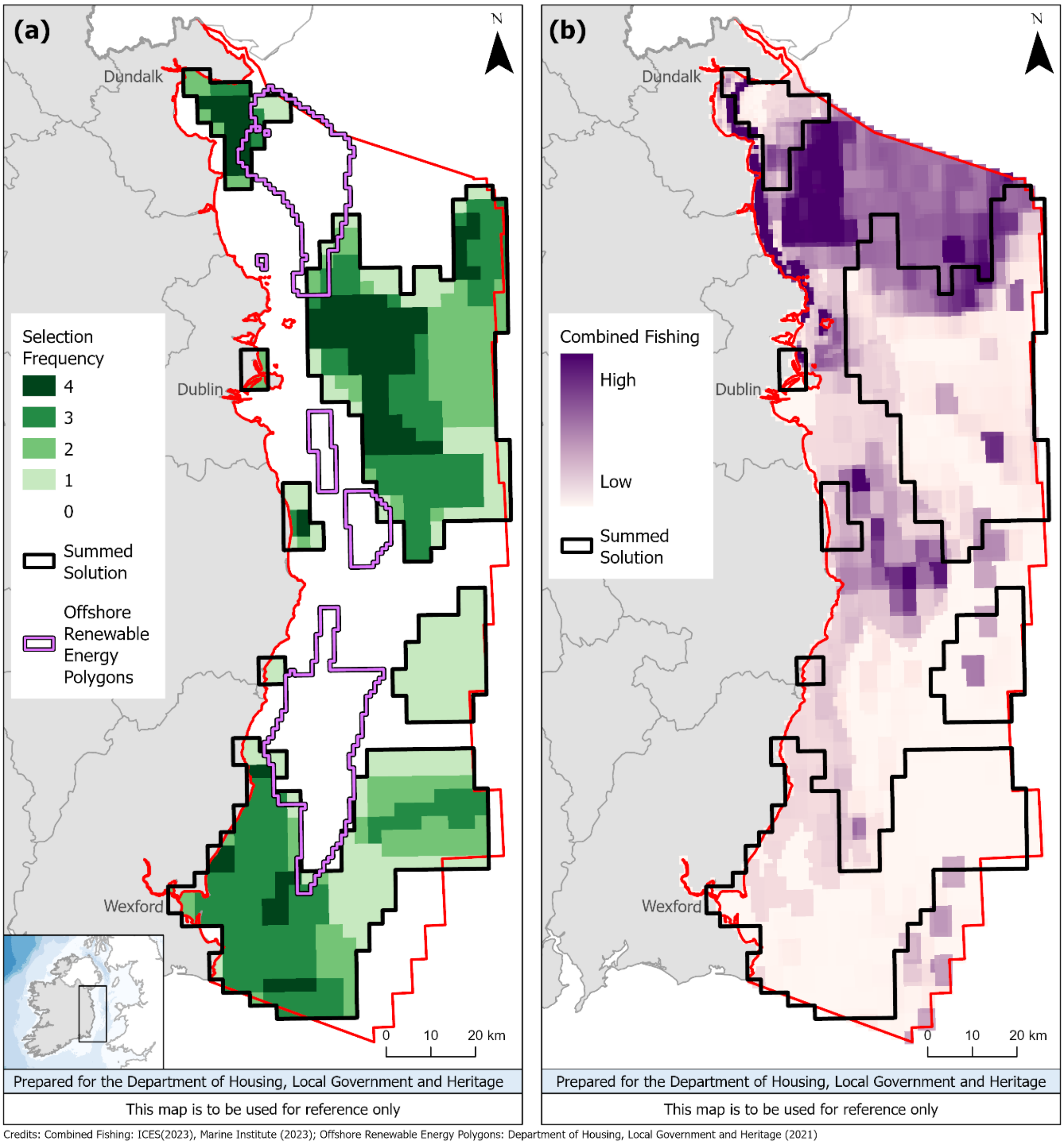

Figure 1. Two-panel presentation of key outcomes from conservation prioritization analyses of the western Irish Sea, completed by the MPA Advisory Group in April 2023.

Panel (a) shows identified areas of comparatively higher priority for potential protection for the selected ecological features (green grid-cells selected in one or more analyses and outlined in black). Suitable areas for potential MPAs could be selected from within these identified areas. Areas of lower priority for potential protection for the selected features are shown in white. Broad areas subject to ORE development applications occur within the pink framed polygons.

Panel (b) shows the same identified areas of comparatively higher priority for potential protection (outlined in black) overlaid with graduated levels of commercial fishing effort in the western Irish Sea, represented by light- to dark-coloured shading of grid-cells (i.e., comparatively lower to higher combined fishing effort).

Further details and discussion are provided in the report (in Sections 3.5.2 and 4.2).

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1 Introduction

1.1 Context and rationale

Ireland has an extensive marine environment that is rich in natural habitats and species, and that also carries a deep cultural significance. It provides a wide range of ecosystem services which underpin health and well-being, regulate climate, and supports inward and outward trade, fisheries, aquaculture, recreation, tourism, and biotechnology, all of which are significant contributors to Ireland's economy and essential to many livelihoods, especially in coastal and island communities. It is also an essential link to the wider world through shipping, and increasingly hosts diverse energy infrastructure. Although much of Ireland's marine environment is generally in good condition, "good environmental status" has not yet been achieved for all 11 qualitative descriptors under the EU Marine Strategy Framework Directive (DHPLG, 2020). Biodiversity loss and ecosystem degradation are of wide concern due to increasing pressures such as over-exploitation, habitat loss, pollution, and climate change (MPA Advisory Group, 2020).

Area-based protection (also known as spatial protection) using Marine Protected Areas (MPAs) and related tools is one of a range of complementary approaches to maintain, conserve and restore coastal and marine ecosystems. In addition to conserving species, habitats, and other natural features, they may also incorporate important cultural, social, and economic considerations. In practice, individual MPAs should form part of a network of sites intended to act synergistically to meet overarching objectives. The definition proposed by the MPA Advisory Group (2020) is as follows:

A geographically defined area of marine character or influence which is protected through legal means for the purpose of conservation of specified species, habitats or ecosystems and their associated ecosystem services and cultural values and managed with the intention of achieving stated objectives over the long term.

Conservation and sustainable management of the marine environment are mandated by several international agreements and legal obligations. Those which include specific requirements for spatial protection include the MSFD, the EU Birds Directive[1] and Habitats Directive[2], the OSPAR Convention[3], the Ramsar Convention[4], the UN Convention on Biological Diversity[5] (CBD) and the UN Sustainable Development Goals[6].

A certain degree of area-based protection of the marine environment is already in place in Ireland, primarily through the Natura 2000 network of sites established under the EU Birds and Habitats Directives. These have been designated by the Irish government and they are managed by the National Parks and Wildlife Service (NPWS). There are, however, some important shortcomings in the status of Ireland's marine environment and in terms of international targets for the total coverage and level of protection for important species and habitats that are threatened or declining, either despite

[1] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. http://data.europa.eu/eli/dir/2009/147/oj

[2] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. http://data.europa.eu/eli/dir/1992/43/oj

[3] Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (1992). http://www.ospar.org/

[4] Ramsar Convention on Wetlands of International Importance (1971). https://www.ramsar.org/

[5] United Nations Convention on Biological Diversity (1992). https://www.cbd.int/convention/

[6] United Nations Sustainable Development Goals (2015). https://sdgs.un.org/goals

protection within the Natura 2000 network or in the absence of spatial protection measures.

MPAs provide benefits not just for the marine environment, but also for society, including through enhancement and resilience of ecosystem service delivery. However, there are also costs. These costs can be broken into establishment costs, management costs and opportunity costs. The socio-economic costs and benefits arising from MPA designation and management vary within and across sectors and stakeholder groups. They can also depend on local socio-cultural contexts and their relationship to socio-political institutions at a variety of scales. As such, care is needed in the identification and management of a network of MPAs to ensure that it provides a maximum net benefit to nature and to society, and that the range of consequences for all aspects of both are given the attention and consideration that is warranted. An MPA network should also be recognised as contributing to a wider ecosystem-based management framework with the aim of achieving Good Environmental Status under the MSFD that combines a range of other environmental objectives, including sustainable fisheries management and favourable food web conditions, as well as resilience to climate change including through enhanced carbon sequestration, and effective Marine Spatial Planning (MSP).

Figure 1.1.1. Some species, habitats, and sectoral activities in the western Irish Sea. Clockwise from top left: *Nephrops norvegicus* (Hans Hillewaert), Rosslare Harbour (Oliver Ó Cadhla), Offshore windfarm (Rob Farrow), Fishing vessel in Howth Harbour (William Murphy), Subtidal rocky reef (Derek Heasley), Basking shark (Greg Skomel).

In this context, over the last three years, Ireland has undertaken a process towards expanding its network of MPAs beyond the current Natura 2000 network of sites established under the EU Birds and Habitats Directives. In December 2019, an expert advisory group was appointed by the then Minister for Housing, Planning and Local Government to summarise relevant information and current thinking about MPAs in an Irish context and to make recommendations for the process of expanding Ireland's network of MPAs. Its final report, which was based on the work of the advisory group and its extensive engagement with stakeholders, was delivered in October 2020.

The MPA Advisory Group report (2020)[7] and its recommendations were then the subjects of a public consultation undertaken by the Department of Housing, Local Government and Heritage (DHLGH) from February to July 2021. The results of this consultation process were independently analysed and published in a separate public consultation report[8]. This analysis indicated widespread support for the expansion of Ireland's MPA network and provided further important considerations and insights. In December 2022, the General Scheme of a Marine Protected Areas Bill was published by DHLGH. It has since undergone pre-legislative scrutiny and the associated Joint Oireachtas Committee report[9] on the General Scheme was published on 1 March 2023. The draft Bill itself is now in preparation and is expected to be tabled in the Oireachtas later this year. At the same time several new Natura 2000 sites or extensions to existing sites under the EU Birds and Habitats Directives are also being considered by NPWS and subsequently designated on a case-by-case basis.

A schematic diagram from the MPA Advisory Group's 2020 report, showing how existing sites (under established legislation) and future sites (under the forthcoming MPA legislation) may be integrated to form a cohesive MPA network, is shown in Figure 1.1.2 below.

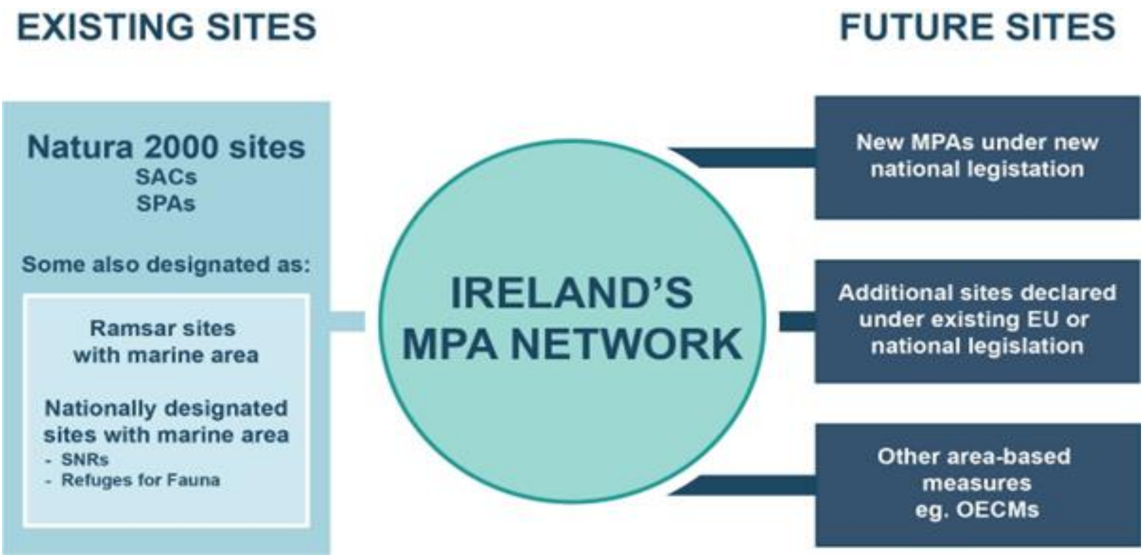

Figure 1.1.2. Existing and proposed new components of Ireland's network of MPAs, from MPA Advisory Group (2020). Note: The work presented in the current Irish Sea report only relates directly to potential 'New MPAs under new national legislation' as outlined above. This work will not lead directly to the selection or designation of MPAs, but it will help provide an informed basis for a national MPA process that will take place after the new MPA legislation comes into force.

In parallel with the MPA process described above, Ireland is currently undergoing several major changes in relation to maritime activity and its spatial planning.

This is not least through provisions and ongoing developments set out in the Maritime Area Planning Act (2021)[10] in addition to plans and policies around the development of offshore renewable energy (ORE), for example. The western Irish Sea is an area that has been identified as suitable for potential ORE development in the near term, i.e.,

[7] https://www.gov.ie/en/publication/135a8-expanding-irelands-marine-protected-area-network/
[8] https://www.gov.ie/en/publication/4acec-independent-analysis-and-report-on-marine-protected-area-mpa-public-consultation-submissions/
[9] https://www.oireachtas.ie/en/committees/33/housing-local-government-and-heritage/documents/
[10] Maritime Area Planning Act (2021). https://www.irishstatutebook.ie/eli/2021/act/50/enacted/en/htmll

during the decade to 2030, and including *Phase 1* wind energy projects. This is based on factors including pre-existing authorisations, international practice and experience, the current state of the industry and technology, as well as demand, logistical and operational factors (e.g., population centres, electricity grid requirements, port facilities, seafloor depth and substrate type).

In light of potentially competing marine interests and space-use priorities for the western Irish Sea within this decade, between (a) ORE development and (b) area-based conservation of biodiversity and other key environmental/cultural resources, the Government of Ireland identified the need to undertake a concise and authoritative review and scientific analysis of features in the western Irish Sea that could identify key areas of ecological importance and thereby also identify potentially suitable and less suitable areas for future MPA designation. In this way, a substantive evidence base for sensitive and vulnerable coastal and marine species and habitats in the Irish Sea can be established prior to the enactment of the MPA Bill, to inform future development and conservation.

The resulting sensitivity analysis project was developed and commissioned by DHLGH in November 2022 and its work began in December. Led by experienced members of the independent MPA Advisory Group established in 2019 and supporting personnel (see Section 2.1), its Terms of Reference are provided in Appendix 1 and its project objectives are provided below. The overall intention is to (a) to provide the best possible evidence base for informing planning decisions to be taken in 2023-24 about the potential locations of ORE infrastructure in the western Irish Sea, and (b) develop methodologies and provide the best available evidence that can be applied to the process of identifying, designating and managing MPAs under the new legislation when it comes into force.

Although this project will not lead directly to the identification and designation of MPAs, its recommendations are intended to feed into that process. As such, it seeks to adhere as closely as possible to the principles likely to underpin the legislation. The definition and key principles for MPAs in Ireland proposed by the MPA Advisory Group report are provided in Appendix 2. Among the key principles that are also reflected in the General Scheme of the MPA Bill (2022), and are of particular relevance to the current project, are that (a) MPAs may be identified through a process of Systematic Conservation Planning, including Conservation Prioritization analysis to identify potential networks of sites to meet specified policy targets, (b) identification, designation and management of MPAs should be based on best available evidence and the precautionary principle, (c) management measures to restrict or prevent harmful activities in MPAs should be tailored to the MPA conservation objectives of each MPA, such that designation of MPAs does not necessarily imply the prevention of all activity within them, and (d) early and sustained stakeholder engagement should be an integral part of the processes of identifying and managing MPAs.

1.2 Objectives and key considerations and constraints

The objectives of the current project are as follows (see also Appendix 1).

Objective 1.

To undertake a comprehensive scientific screening exercise for possible future MPAs in a defined marine region off the east and southeast of Ireland. This will be done through a process and using selection criteria and features that are as consistent as possible with the provisions set out in the forthcoming MPA legislation.

Objective 2.

To facilitate open and constructive engagement with key Government and non-Government stakeholders that have extensive maritime interests in the Irish Sea (e.g., culture/heritage, defence, fisheries, ORE, transport, recreation), to integrate their participation and consider their interests as part of the analysis and mapping processes within the project.

Objective 3.

To ensure that any rationales and recommendations for the potential designation of MPAs in the study area, as determined by the work of the reconstituted MPA Advisory Group, will be up to date and in time for active consideration by DHLGH when the MPA legislation comes into force.

Objective 4.

To facilitate potential future identification by the Government of viable “go-to-areas” for offshore energy projects in the Irish Sea, in view of any biodiversity/environmental/cultural/other sectoral constraints that are concluded via the project.

The project began in mid-December 2022, with a tight deadline for delivery of its final report by the end of April 2023. As such, it was necessary to maintain a close focus on the specific objectives above and to make some strategic decisions to enable the project to deliver the most relevant and informative report possible within this timeframe.

As specified in the objectives, the focus of the work is the western Irish Sea. The area of interest is demarcated in detail in Section 2.1 below and extends to the edge of Ireland’s Exclusive Economic Zone (EEZ) in the western Irish Sea. As such, the project focussed only on features (i.e., species, habitats, and other aspects of the environment) that occur in the western Irish Sea, and it only collated data and undertook analyses for the specified area of interest. Subsequent work will be required to enable informed decisions to be made for Ireland’s wider maritime area and to consider, for example, transboundary considerations and other networks of MPAs in developing a coherent overall framework for conservation and management. This point on transboundary approaches will be considered further in Section 3.

Given the described emphasis on current and future ORE planning and development, this project relates primarily to the main sectors of human activity that occur in waters potentially suitable for ORE. As such its focus is on ORE itself and commercial fisheries and shipping as key sectors. It is important to recognise that a range of other activities also takes place in the Irish Sea, particularly closer to the coast. For example, many people and businesses participate in marine recreation and tourism-related activities such as recreational angling, boating, scuba diving, swimming and wildlife watching. Aquaculture also features in several areas of Ireland’s east coast, such as

Carlingford Lough and Wexford Harbour. Substantial consideration has not been given to these activities in this report, but it is envisaged that they would be considered more fully under the national MPA process that is due to take place once the new MPA legislation comes into force.

It is also important to note that the project and its analyses did not extend in scope to cover species or habitat features that are already covered by requirements or provisions under the EU Birds and Habitats Directives (e.g., Natura 2000 sites). These are already subject to ongoing analyses and site identification processes led by NPWS in accordance with national requirements under those Directives.

Commercial fish and shellfish individually managed under the EU Common Fisheries Policy (CFP) and national fisheries regulations were also excluded (see Appendix 4 for detailed reasoning). Nevertheless, habitats are important to fished species. Commercial species that are not individually managed under fisheries regulations, and some ecologically important species like forage fish and juveniles of some commercial species were included.

Formally protected areas are not the only area-based measures which can deliver positive conservation outcomes. Other Effective area-based Conservation Measures (OECMs) are managed areas in which effective in-situ conservation is achieved but is not the primary objective. Areas managed for renewable energy or to protect cultural heritage sites, or spatial measures to ensure the sustainability of a fishery (e.g., by protecting spawning areas) can also deliver a level of biodiversity protection. For example, the strict protection of historical shipwrecks in Scapa Flow in Orkney also provides a high degree of protection to the benthic ecosystem, allowing maërl beds, flame shell beds, horse mussel reefs and fan shells to thrive (IUCN, 2019).

Aichi Target 11 of the UN Convention on Biological Diversity (CBD) recognises OECMs as valid for inclusion in calculations of total areas under protection (see also Figure 1.1.2). Interpretation of what qualifies as an OECM varies, however. To provide clarification, the 14th COP of the CBD adopted a definition, guiding principles, common characteristics, and criteria for the identification of OECMs (see IUCN, 2019). Nevertheless, individual states are taking different approaches to the recognition of OECMs as part of their networks of MPAs, particularly in relation to ORE developments. This will be an important aspect for Ireland considering the MPA Advisory Group (2020) report and forthcoming MPA Bill, but it is beyond the scope of this project and its Terms of Reference.

The evidence collected and analysed within this report is designed to support different end-users in a range of decision-making contexts. The methods trialled and implemented here could also be applied to the MPA process when new legislation is in force, and could equally be used more generally in spatial conservation planning and in marine spatial planning nationally. To ensure that the process and the results are sufficiently transparent and robust to support planning and conservation decisions and that they are also fully reproducible, considerable effort was spent in documenting the procedures and criteria underpinning the work. A framework for assessing and communicating the quality of data available for each analysis was also developed to ensure transparency in the quality and confidence in the results and the conclusions and recommendations derived from them.

A glossary of terms and a full list of acronyms and abbreviations are provided at the end of the report.

2 Area of interest

The Maritime Area of Ireland includes the internal waters, Territorial Sea, the Exclusive Economic Zone (EEZ), and designated parts of the Continental Shelf (MPA Advisory Group, 2020). This large area is subject to the National Marine Planning Framework (NMPF) and the MSFD. It is worth noting that while most maritime jurisdictional zones are defined from the baseline, which is Mean Low Water (MLW) mark, the Maritime Area under the NMPF will begin at the Mean High Water (MHW) mark. These zones represent the current limits of Ireland's jurisdiction in the sea, which are applicable to the seabed and subsoil only in the extended continental shelf beyond 200 nautical miles (nm). In total, the Maritime Area comprises a surface area nearing 490,000 km^2 in size (see MPA Advisory Group, 2020, for further details).

Given its Terms of Reference (Appendix 1), this project focuses on the ecological sensitivity of the part of the western Irish Sea which falls within Ireland's EEZ (Figure 2.1). Under the United Nations Convention on the Law of the Sea[11] (UNCLOS), a country's EEZ extends up to a maximum distance of 200 nm (370.4 km) from the baseline of its Territorial Sea and includes the contiguous zone shared with neighbouring countries like the United Kingdom. The findings from this study can inform management decisions for the part of the Irish Sea within Ireland's EEZ, where the country has significant agency over natural resources and associated economic activities.

It is important to note that in the case of fish resources, the EEZ area seaward of 12 nm to 200 nm is part of the 'common European pond,' where fish resources are shared with other European states under the CFP.

[11] United Nations Convention on the Law of the Sea (1982). https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf

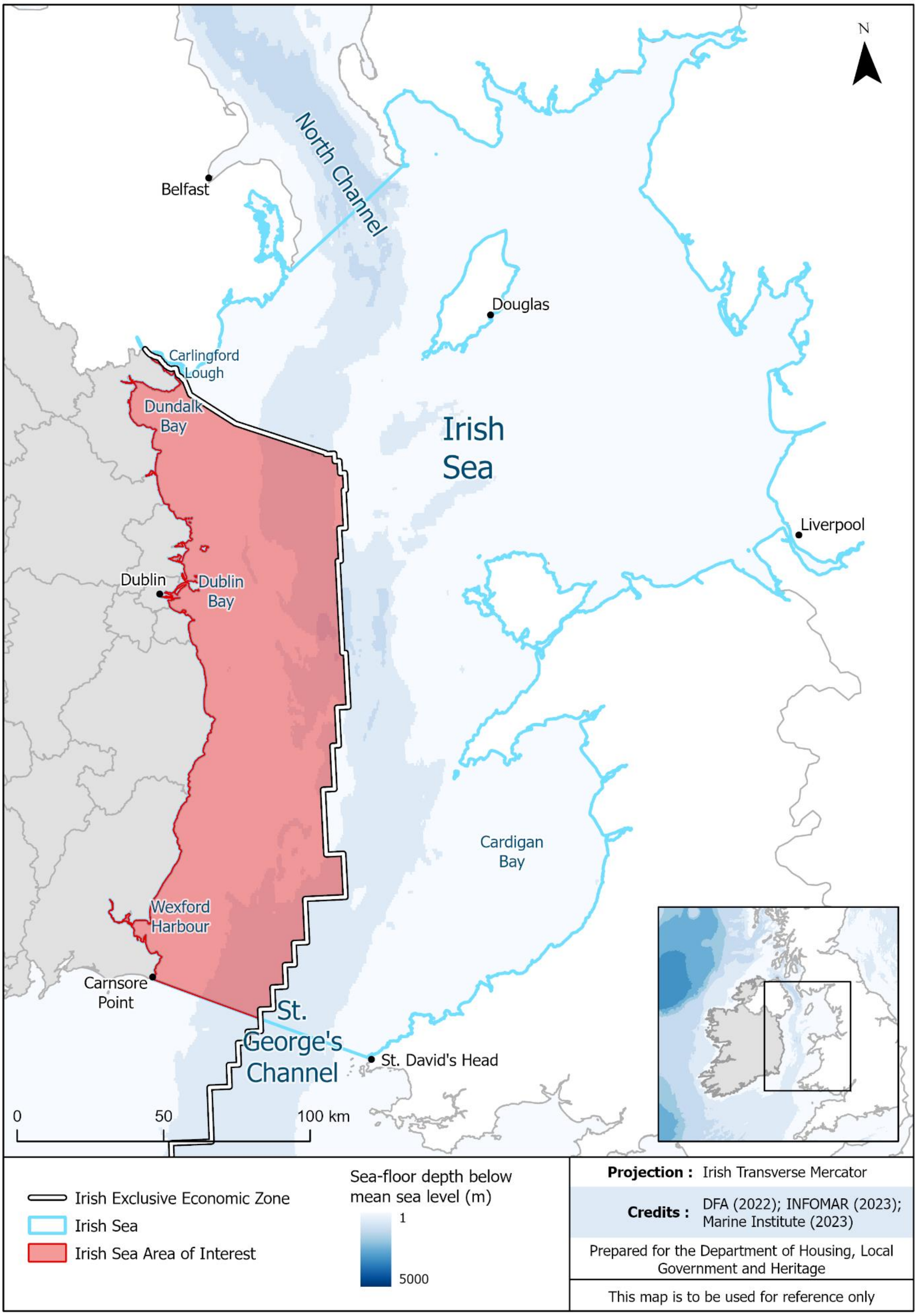

Figure 2.1. Boundaries used to define the area of interest for this project. Eastern boundary - EEZ; Western boundary - mean high-water; Northern boundary - EEZ with extension bisecting Carlingford Lough (indicative only, this boundary is not yet established); Southern boundary – a straight line from Carnsore Point to St. David's Head, Wales.

Figure 2.2. Sediment swirled in the Irish Sea. The flow of water from Ireland (to the west) and England and Wales (to the east) brings large amounts of sediment into the Irish Sea, especially after heavy storms or during spring rains. The Irish Sea bottom is covered by a thick layer of mobile sediment of various types, from pebbles and cobbles to thick mud. The eastern Irish Sea and the area under the gyre in the western Irish Sea are low energy depositional areas as is visible east and west of the Isle of Man. (true-colour image captured by the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite; credit Jeff Schmaltz).

2.1 Biodiversity in the area of interest

2.1.1 Current habitats and biota

The Irish Sea today is home to a substantial diversity of species and habitats that are ecologically, culturally and economically important.

In terms of its seabed habitats, the western Irish Sea is characterised by a series of north-south trending linear sandbanks where the water is seldom more than 20m deep (Figure 2.1.1). Examples of such banks include the Dundalk, Kish, Codling, Arklow and Blackwater sandbanks. These habitats support a great diversity of burrowing fauna including worms, crustaceans, molluscs and echinoderms, with one sandbank having over 100 species identified from benthic grab surveys (Roche et al., 2007).

Another important feature of the western Irish Sea is the extensive area of soft, muddy habitat found in the north of the study area (Figure 2.1.1) which is due to low tidal energy and a deep basin. This broad habitat type is home to the Dublin Bay prawn (*Nephrops norvegicus*) for which a hugely important fishery has developed since the 1960s. The prawn fishery off Irish coasts is currently the second most valuable fishery in Ireland (Marine Institute, 2022).

There are also many estuaries and associated tidal mudflats and sandflats that adjoin the western Irish Sea. These host significant numbers of migratory birds, especially during the winter months, such as the Malahide estuary which holds an internationally important population of Brent geese (*Branta bernicla*). These margins between the land and sea also hold ecologically important coastal habitats such as mudflats and sandflats, seagrass (*Zostera* species) beds and salt-marsh habitats, which are of high value in terms of their biodiversity, their capacity to support large populations of overwintering birds, and their provision of important ecosystem services by capturing carbon and storing it within their sedimentary substrates.

Some rare and unusual habitats also occur in the western Irish Sea. For example, the Wicklow Reef is a subtidal reef constructed by the honeycomb worm *Sabellaria alveolata*. This worm normally constructs reefs on intertidal rocks, but off Wicklow it does so at a depth of 12-30m. A very unusual reef occurs around 24km east of Dublin at a depth of 80-100m. It is called a ‘bubbling reef’ or ‘methane mounds’, where bacteria feed on the methane that is leaking through the seafloor and then deposit small amounts of waste carbonate, which form a solid substrate on which reef fauna become established.

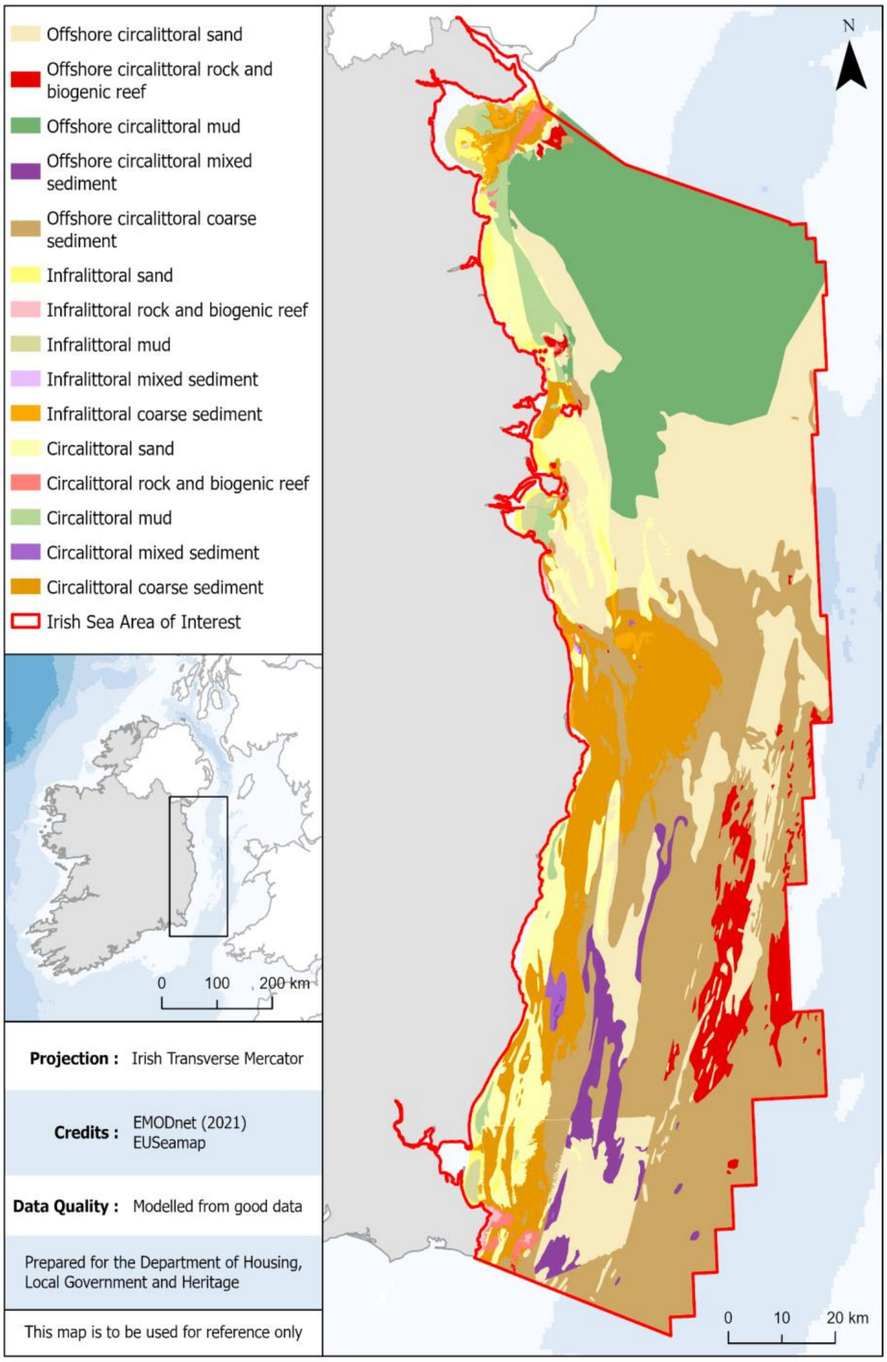

Figure 2.1.1. Broadscale seabed habitat map showing MSFD classifications from the EMODnet EuSeaMap v2021 habitat map for Europe (Vasquez et al., 2021).

It is difficult to estimate the precise number of species that are found in the Irish Sea, but the number must be more than 1,700. For example, 1,030 species of invertebrate were identified on the Welsh side of the Irish Sea from 73 benthic sampling stations in the late 1980s and early 1990s (Mackie et al., 1995). A similar number of invertebrates is likely to be found in the larger western Irish Sea. With such species diversity, it is difficult to single out individual species, but some are clearly worth mentioning as they are highly valued - because they are economically or ecologically important, because they are inspiring and beautiful, or because they contribute to our maritime heritage for example.

The burrowing Dublin Bay prawn (*Nephrops norvegicus*) has an estimated 4 billion burrows in the soft, muddy sediments of the northwestern Irish Sea (Lundy et al., 2019) and its prevalence has enabled the growth of one of Ireland's most lucrative fisheries over recent decades. Culturally and commercially, the herring (*Clupea harengus*) has also been an important commercial species found in the Irish Sea. A highly migratory species that moves between feeding grounds and spawning areas, unusually for a marine fish, its eggs are deposited on the seabed in discrete gravel beds or on flat stone. Within the western Irish Sea, herring only spawn in Dundalk Bay, which is thus a vitally important site for this commercial species in the wider Irish Sea region.

The harbour porpoise (*Phocoena phocoena*), which is the smallest species of cetacean found in Irish waters, is particularly abundant in the Irish Sea with areas of concentrated sightings occurring between Howth Head and Dalkey Island at the northern and southern margins of Dublin Bay. Some of the highest summer counts of porpoises in Ireland have been recorded in these shallow and turbid waters (Berrow et al., 2014). Another key predator within the western Irish Sea is the tope (*Galeorhinus galeus*), a medium-sized shark (up to 1.95m long) that feeds on a variety of fish and invertebrate species. Inland Fisheries Ireland mark-recapture data suggests that individual tope undertake wide migrations between the North Sea, west of Scotland and Ireland, heading south towards the Canary Islands, the Azores, the western Mediterranean and northwest Africa (Fitzmaurice et al., 2003). In the western Irish Sea, juvenile and adult tope (including pregnant females) are caught recreationally across the southeast coast of Ireland, along the Wicklow-Wexford coastline.

Of course, birds are a hugely vital component of the western Irish Sea ecosystem. One species that is really at home in the Irish Sea is the Manx shearwater (*Puffinus puffinus*). The Manx shearwater is a highly migratory seabird that spends most of its life at sea and only comes ashore to breed on certain uninhabited islands of the UK and Ireland, many of which are in the Irish Sea. Aerial survey estimates from the ObSERVE Programme recorded hotspots for the Manx shearwater in the Irish Sea, and model-based estimates of their abundance indicate that more than 31,000 Manx shearwaters are found during the summer months in the western Irish Sea (Rogan et al., 2018). Remarkably, these birds migrate in winter to the South Atlantic, to the Patagonian shelf waters off Argentina (Guilford et al., 2009).

2.1.2 Historical perspective

Far from being a pristine environment, the Irish Sea has a long history of exploitation and human influence. As early as 1806 there was a fear that the oyster beds off Arklow would become exhausted and restrictions on harvesting were recommended (Rees, 2008). In the 1860s boats from England, Wales, France and the Netherlands arrived to dredge the oysters to restock their own depleted beds. Over the next few decades, the Arklow beds became seriously depleted and by 1903 they were gone (Rees, 2008). It is hard to imagine what the Irish Sea was like before the loss of such a large structurally dominant and ecologically important reef off the east coast of Ireland, but today such reefs are known to play hugely important roles in habitat provision and water filtration (Beck et al., 2011).

The advent of steam power in the 1870s led to a great increase in benthic trawling as it freed trawling from the dependency on wind and tide (Roberts, 2007). Amoroso et al. (2018) used Vessel Monitoring System data (VMS-high resolution position data) to estimate the bottom trawl footprint of the world's continental shelves and found that the Irish Sea has one of the highest 'percentages of area' trawled (Amoroso et al., 2018). Such trawling effort dramatically alters the benthic invertebrate and fish communities.

A large expansion of the whitefish fishery in the Irish Sea occurred in the early 1960s (Bentley et al., 2019). This was followed by the development of fisheries for *Nephrops* and industrial fishing for herring in the late 1960s. Herring stocks declined in the 1970s and whitefish landings peaked in the mid-1980s. Steep declines in cod, whiting and sole stocks were evident by the early 1990s. From the mid-1990s shellfish (mainly *Nephrops*) dominated fish landings. A dramatic but short-lived expansion of haddock stocks occurred in the late 1990s and, despite the introduction of a cod recovery plan in the early 2000s, whitefish fisheries collapsed and they remain low to the present day. The lack of recovery despite the reduction or removal of fishing efforts and particularly the continued truncated age structure for some whitefish species remains unexplained.

The scale of the changes is dramatic; for instance, landings of finfish peaked at over 150,000 tonnes in the 1970s with a smaller peak of about 70,000 tonnes in the mid-1980s. In recent years landings, which are significantly constrained by total allowable catches (TACs), which reflect the exceptionally low biomass as assessed by the International Council for the Exploration of the Seas (ICES), have been less than 5,000 tonnes. During this time landings of benthic invertebrates (crustaceans and molluscs) have increased from almost zero in the early 1960s to over 50,000 tonnes in recent years. The removal of cod, which is a significant predator of *Nephrops*, may have led to an increase in *Nephrops* stocks and the capacity to support higher levels of fishing mortality and landings than in the past.

The changes to the Irish Sea ecosystem brought about by fishing or a combination of fishing and environmental changes are complex but today the Irish Sea system is different from the system that existed 40 years ago. In addition to large-scale declines in finfish biomass some species may have been entirely lost; by the late 1970s Brander (1981) reported that overfishing had already brought skate to the brink of extinction in the Irish Sea and that recovery would not be possible if fishing continued.

2.1.3 Areas currently designated for biodiversity

At the national level, Ireland has enacted a comprehensive legal framework to give effect to the EU Habitats Directive and Birds Directive in Irish waters which established the Natura 2000 site network. This network comprises Special Protection Areas (SPAs), designed to protect specific bird species under the EU Birds Directive and Special Areas of Conservation (SACs) established under the Habitats Directive (Figure 2.1.2). SACs are prime wildlife conservation areas in the country, considered to be important on a European scale as well as at a national level. The legal basis on which SACs are selected and designated is the EU Habitats Directive, transposed into Irish law by the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011)[12], as amended. Special Protection Areas (SPAs) are for the protection of listed rare and vulnerable species of birds, regularly occurring migratory species and wetlands, especially those of international importance.

Natural Heritage Areas (NHAs) are areas considered significant for the habitats present or that hold species of plants and animals whose habitat needs protection.

[12] European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011). https://www.irishstatutebook.ie/eli/2011/si/477/made/en/pdf

Under the Wildlife Amendment Act (2000)[13], NHAs are legally protected from damage from the date they are formally proposed for designation (Figure 2.1.2).

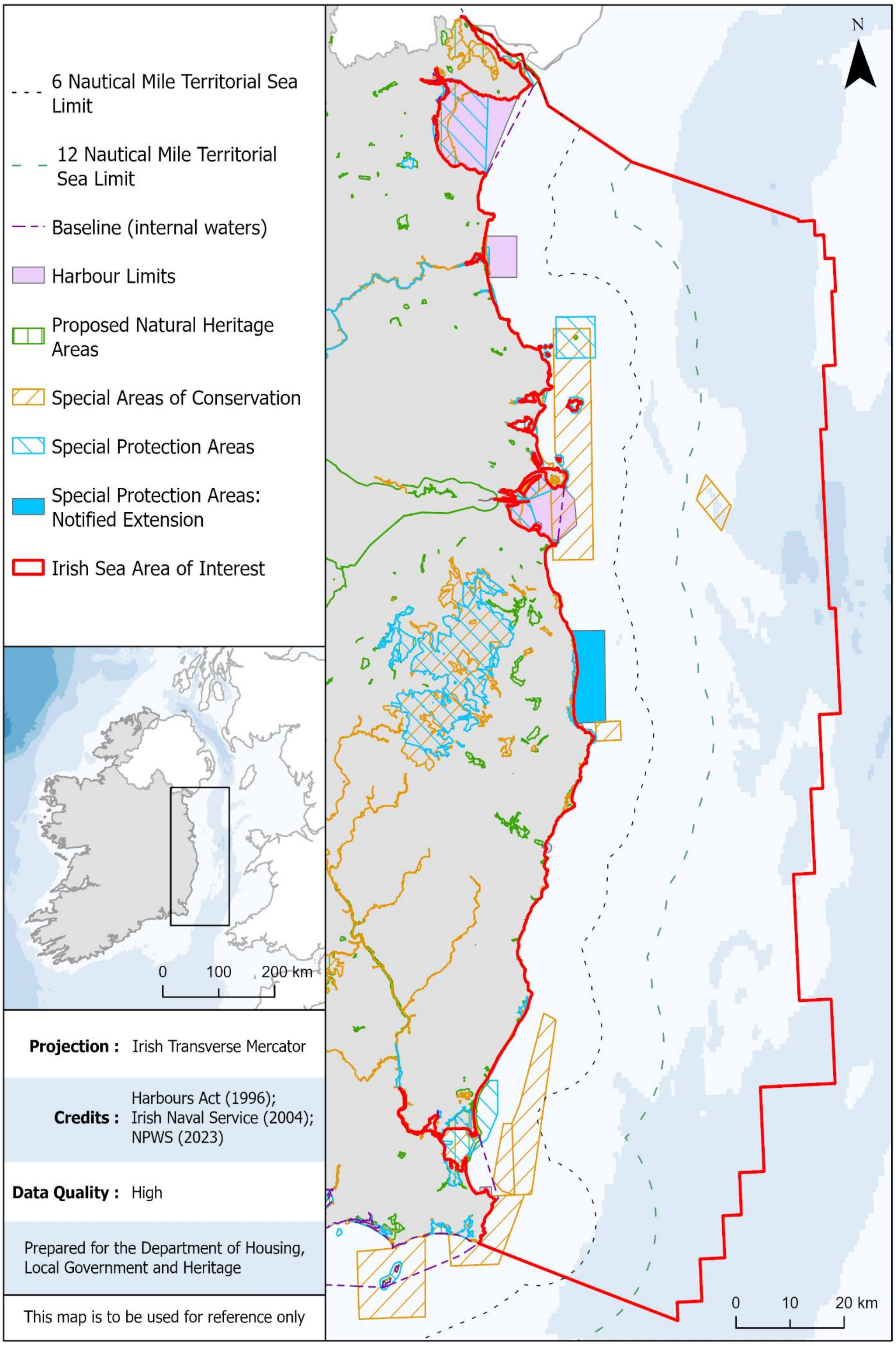

Figure 2.1.2. Existing spatial protection (SACs, SPAs and NHAs), Territorial Sea limits, and harbour limits in the western Irish Sea. The 6nm and 12nm limits are buffered from the coastline and the closing baselines of Dundalk Bay, Dublin Bay and Wexford Bay. Data quality: high.

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[13] Wildlife (Amendment) Act (2000). https://www.irishstatutebook.ie/eli/2000/act/38/enacted/en/pdf

2.1.4 Biocultural diversity

Cultural ecosystem services are the intangible benefits provided to humans by nature. These include recreational use and non-use values and encompass the special relations between people and places, sometimes called biocultural diversity. Understanding how people interact with and depend on the ecosystem can inform management decisions that balance ecological and social considerations.

The Irish Sea is a biocultural hotspot, where maritime cultural identity is intertwined with the biophysical marine environment. Local communities have a deep connection to the sea, with a rich knowledge of its place in their stories, histories, and legends, as well as how it has shaped their conduct and beliefs. Traditional knowledge of the sea, including distinctive grammatical expressions related to fishing and navigation, has been passed down through generations.

The National Monuments Service (NMS) is responsible for identifying and categorising human-built structures, such as lighthouses, historic fishing facilities, areas of religious importance, and ancient human settlements, all of which have contributed to the Irish Sea's cultural heritage. The NMS also maintains an extensive archive of over 18,000 "wrecking events," documenting shipwrecks and other tragedies that dot Ireland's maritime area (Figure 2.1.3). Certain high-profile and historically relevant wrecks, as well as any wrecks older than 100 years, have been designated as "protected", which enables natural habitats to flourish undisturbed by human interference.

Despite the cultural significance of the Irish Sea and the impact of human activities on it, there are few actively managed sites of cultural significance in the area. Additionally, the impact of different pressures on areas of cultural significance is not well-documented. Further engagement and collaboration with the NMS and wider stakeholders should therefore be conducted to ascertain a more precise understanding of the potential impact of different pressures on these culturally significant areas.

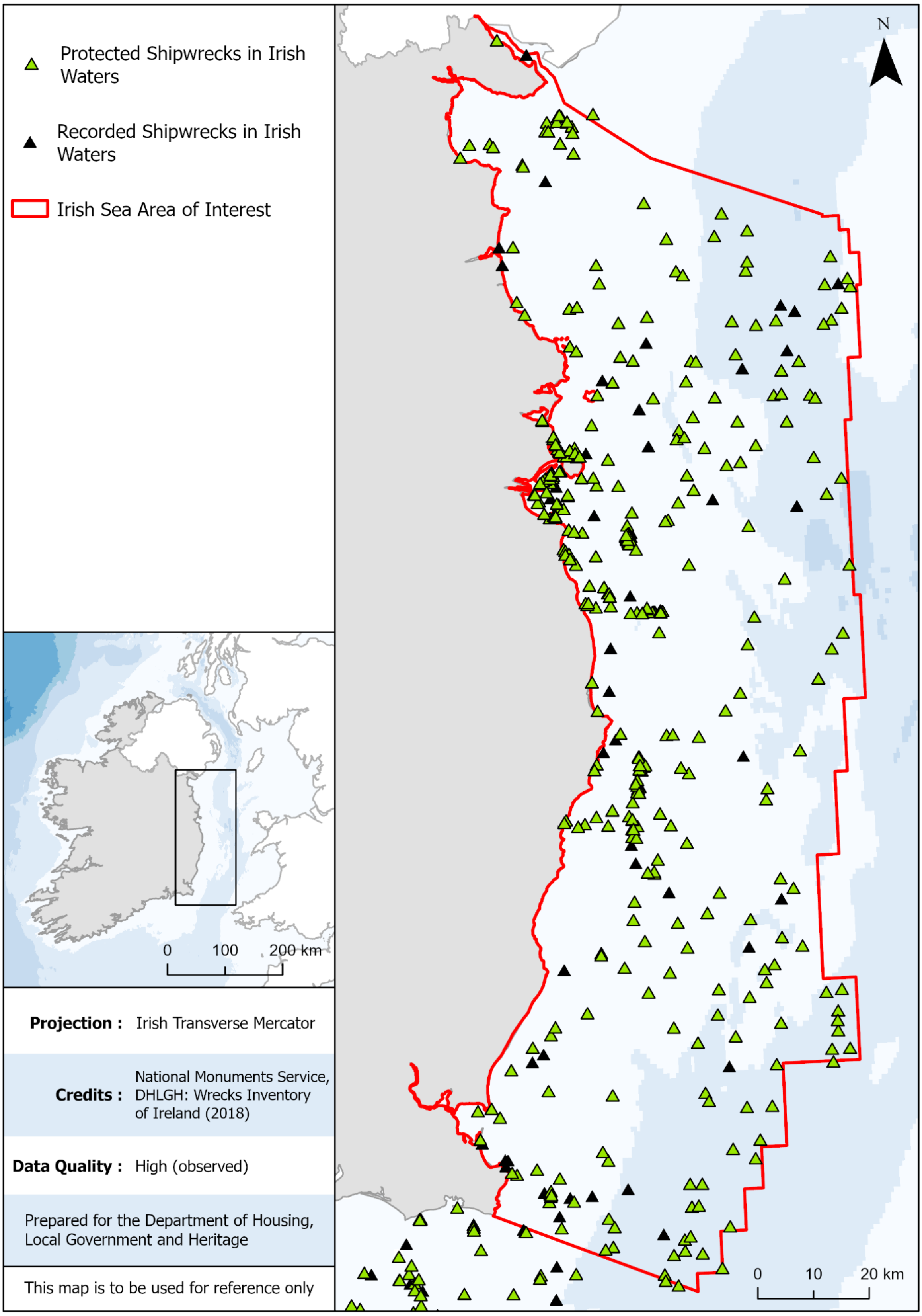


Figure 2.1.3. Shipwrecks in the western Irish Sea, recorded and protected.

2.2 Sectoral activities in the area of interest

The Irish Sea has long been an economic and strategic centre for Ireland, with a vibrant and diverse array of economic activities in different sectors taking place within its waters. As explained in Section 1.2, the sector-related focus of this project is on ORE, commercial fishing, and shipping as key maritime activities within the area of interest.

The area is home to important fisheries and aquaculture operations which support the livelihoods of coastal communities and contribute significantly to Ireland's food production. Shipping is a crucial component of the Irish Sea's economic activity, with major ports and shipping lanes serving as vital conduits for Ireland's trade with the rest of the world. Similarly, ORE projects are expected to become an increasingly important source of electricity for Ireland, with the potential for significant growth in this sector in the coming years.

2.2.1 Commercial fishing

The main fishing activities in the western Irish Sea are characterised in Table A4.1 in Appendix 4 (with further details of management also provided in Appendix 4). Fisheries occur in different areas of the western Irish Sea and reflect the spatial distribution of the target species, which in turn, for shellfish species, reflects the distribution of specific habitats and conditions (e.g., sediments, current speeds).

Most fishing effort in the western Irish Sea is undertaken by Irish vessels. All vessels from Northern Ireland have access to the whole area up to the baseline while France, Belgium and the Netherlands have access to some fisheries up to 6 nm from the baseline. Access and quota arrangements with the UK are under negotiation following the UK withdrawal from the European Union (i.e., Brexit).

The bottom trawl fishery, targeting *Nephrops* and to a lesser extent various species of gadoid fish, occurs on mud and sandy mud in the north-west Irish Sea. In this area, the northwest Irish Sea gyre, a water circulation pattern which develops in summer, retains *Nephrops* larvae and provides regular recruitment of *Nephrops* to the seabed.

Inshore of the trawl fishery, in the north Irish Sea and on coarser sediments, there is a small-scale coastal scallop (*Pecten maximus, Aequipecten opercularis*) fishery conducted by a very limited number of inshore vessels. This fishery also occurs on sandbanks and coarse sediments further south of Wicklow. Larger scallop dredgers may fish these inshore grounds opportunistically.

Closer inshore and up to the low water mark, a dredge fishery for razor clams (*Ensis siliqua*) occurs on muddy sand and mixed sediments in the area from north Dundalk Bay south to Malahide, Co. Dublin. Razor clams are fished in the south Irish Sea from Rosslare Bay north to Curracloe off the east Wexford coast.

Cockles (*Cerastoderma edule*) are fished, using hydraulic dredges, in the intertidal sedimentary habitats of Dundalk Bay. Lobster (*Homarus gammarus*) is fished with creels along coastal reefs, while crab (*Cancer pagurus, Necora puber*) is targeted in various areas, both inshore and offshore, on sedimentary habitats. Small pot fisheries for shrimp (*Palaemon serratus*) may also occur in coastal waters north of Dublin.

In some years (depending on quota availability), there is a pelagic fishery for herring (*Clupea harengus*) off county Down in the western Irish Sea. Sprat (*Sprattus sprattus*) are taken in mid-water trawls all along the coast, but predominantly east of Wexford and Drogheda, Co. Louth.

In the south Irish Sea, currents are stronger and sediments are coarser, so the profile of the fishery is different from that in the north Irish Sea. There is a significant large vessel scallop fishery offshore from Wicklow south to Carnsore Point, which overlaps with a beam trawl fishery for rays and mixed demersal fish. Some bottom trawling also occurs here targeting rays and mixed demersal fish.

Towards the coast, there is an extensive pot fishery for whelk (*Buccinum undatum*) on the landward and seaward slopes of sandbanks. Mussel (*Mytilus edulis*) beds may also be found in small patches at the edge of sand banks and on coarse sediments and rock which are scoured by strong currents. These mussel beds are fished in autumn by large dredging vessels for seed mussels to be relayed for aquaculture.

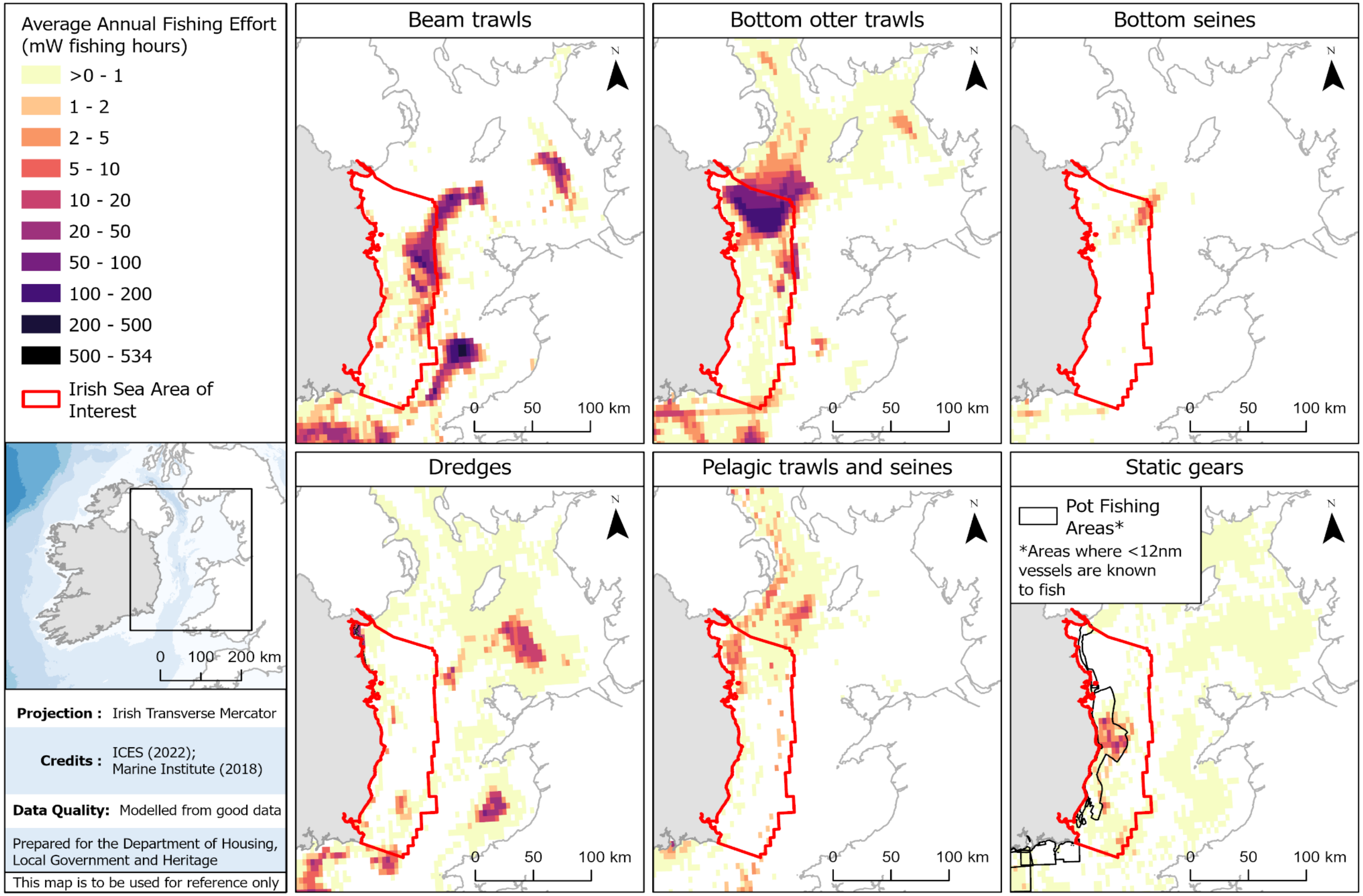


Figure 2.2.1. Average annual total fishing effort (mW fishing hours) for the main commercial fishing gear types used in the Irish Sea. International VMS data is 2018-2021 average. National inshore VMS (iVMS) data is available for certain areas but not visible at this resolution. Static gears include gill nets, trammel nets, traps and lines.

2.2.2 Aquaculture

Aquaculture activity in the Irish Sea is low compared to some areas of the west coast of Ireland (Dennis et al., 2022). It is therefore not included as an activity cost layer in the conservation prioritization analysis undertaken in this project.

Mussels (*Mytilus edulis*) are produced in extensive bottom culture in Wexford Harbour using seed or half-grown mussels sourced from mussel beds in the south Irish Sea. These mussel beds are included in the features list considered for spatial protection in this project. Mussel spat are captured on longlines in a single aquaculture enterprise off the Wicklow coast. On the southern shore of Carlingford Lough, Pacific oysters (*Magallana gigas*) are produced on trestles in intertidal waters.

2.2.3 Shipping and maritime transport

As an island nation, Ireland is heavily reliant on maritime transport and this is reflected in the level of activity of cargo ships, tankers, passenger ferries, cruise liners and pleasure craft in the Irish Sea area. In general, shipping activity is concentrated particularly in the vicinity of ports and shipping lanes. Figure 2.2.2 shows an example of the density of cargo vessel transits. Shipping lanes from south of the Irish Sea to Dublin and UK ports, and from Dublin port to the UK, and from Larne (Northern Ireland) to Great Britain are the main centres of activity.

Data and information on shipping activity were drawn from the European Marine Observation and Data Network (EMODNET) human activities portal, which provides the spatial distribution and intensity of a range of human activities. The information is compiled from a variety of sources, including satellite imagery, Automatic Identification System (AIS) data, and vessel tracking systems. These sources provide detailed and accurate information on vessel movements, including speed, course, and location.

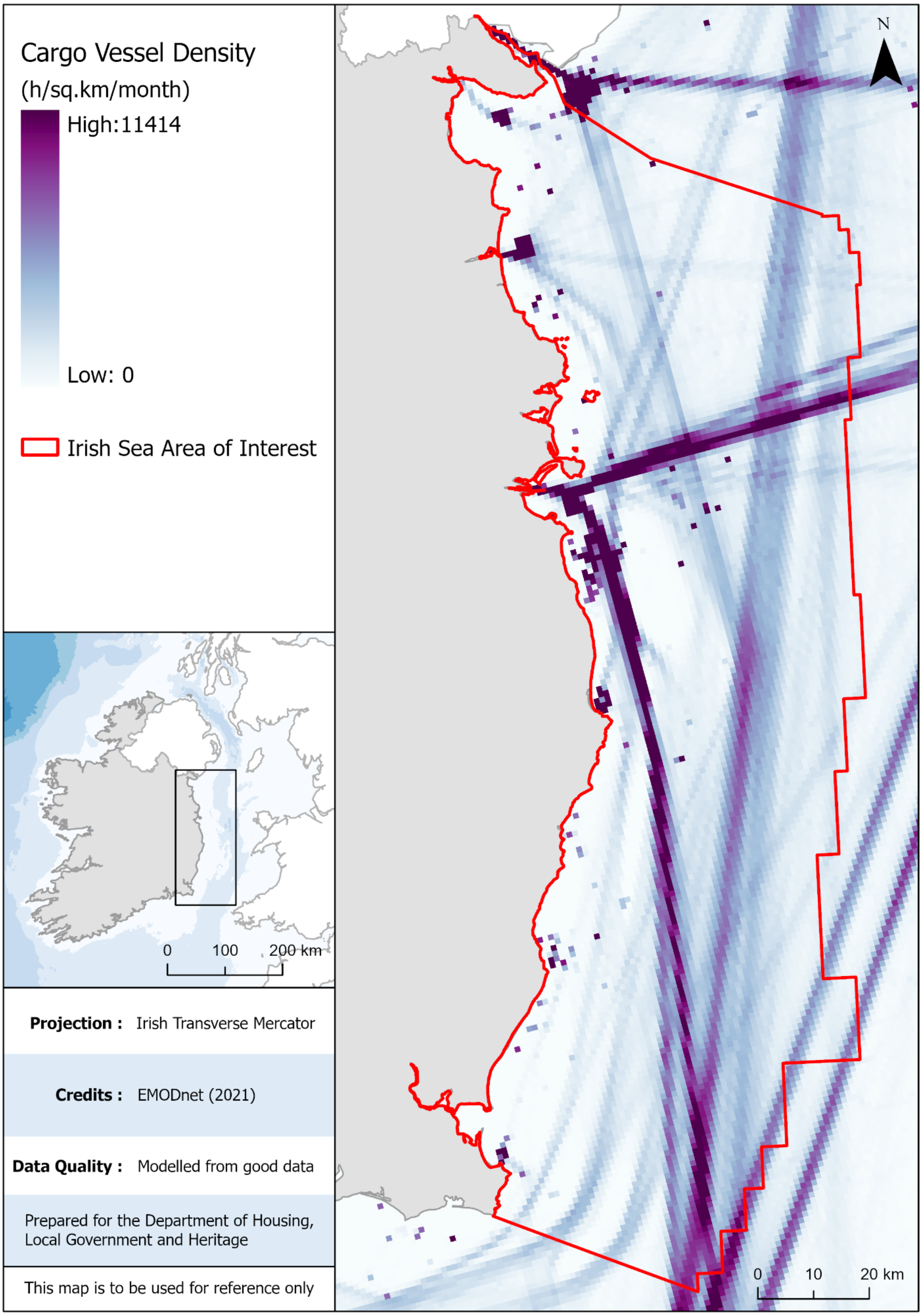


Figure 2.2.2. Density of cargo vessel transits in the western Irish Sea from interpolated AIS pings.

2.2.4 Offshore Renewable Energy

Spatial data for offshore wind energy projects were derived from application information that was officially submitted to the foreshore licensing unit of the Department of Housing, Local Government, and Heritage (DHLGH). These data provide a coarse spatial overview of the areas earmarked for the development of proposed projects (Figure 2.2.3). The spatial footprint of these data is in relation to site investigations, with the indicated areas likely to be much broader than the eventual footprint of future ORE operations.

To supplement this spatial dataset, the advisory group sought further context from ORE projects that had obtained maritime area consent (MAC) status from the Department of the Environment, Climate and Communications (DECC). These MACs were specifically designed to simplify the offshore energy consent regime and expedite the approval process for the most viable offshore wind energy projects that meet Ireland's energy targets, while safeguarding the State's interests in its valuable maritime resource.

In addition to the MAC data, spatial data was also supplied by each ORE project to DECC, including updated cable routes. This data was assessed for inclusion in the sensitivity-cost analysis but ultimately it was deemed inappropriate for inclusion in this study due to its indicative pre-consent nature, and since definitive information was not available within the analytical time frame of this project. However, the available spatial data provided a useful dataset for evaluating the potential impact of offshore wind energy projects on selected ecological features in the western Irish Sea.

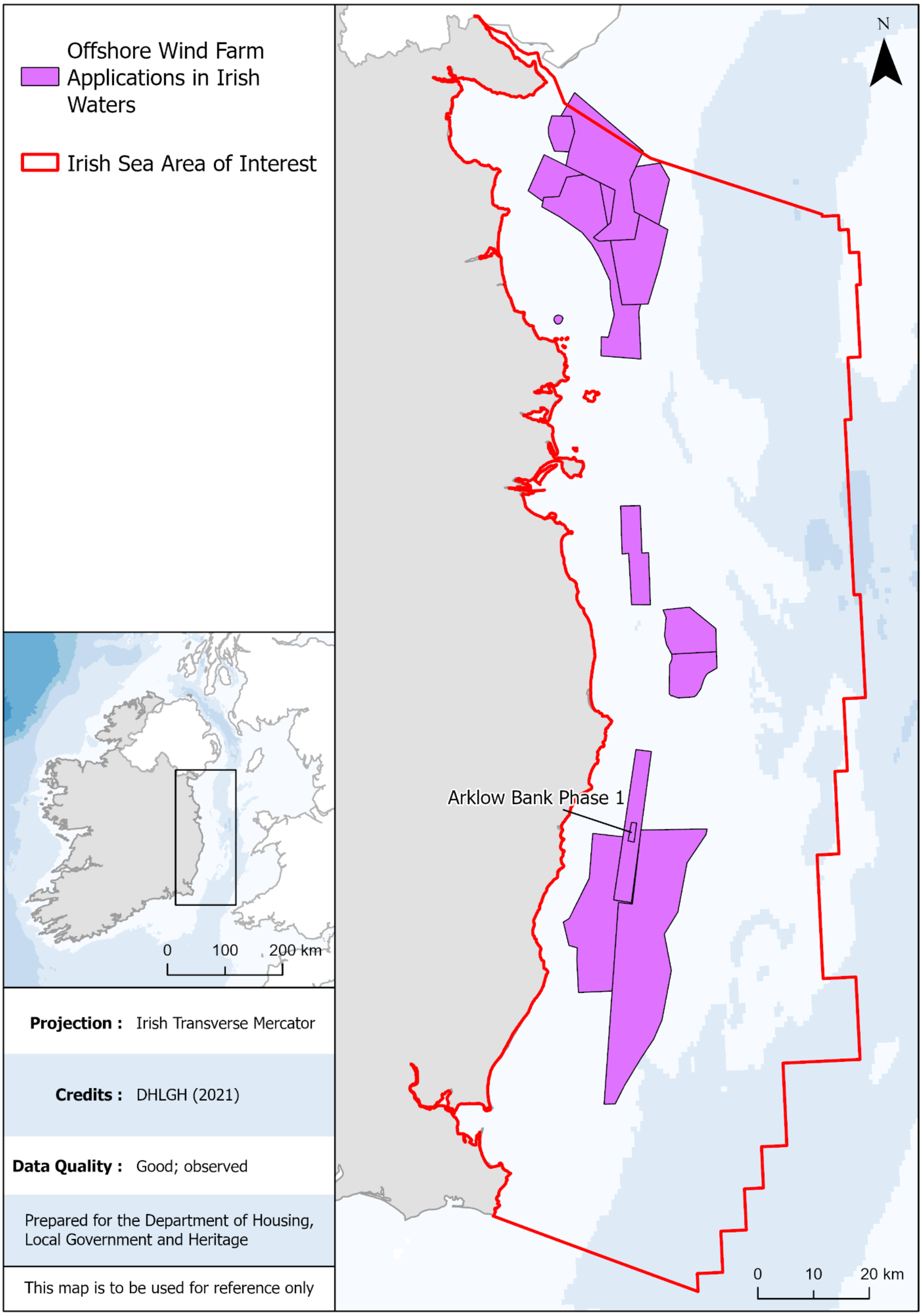


Figure 2.2.3. Outline of ORE application sites in the western Irish Sea.

3 Process and results

To address the objectives of the project within the allocated timeframe, a workflow was developed comprising a series of tasks (Figure 3.1). Each of those tasks will be explained in the sections below. Sub-groups of three to eight team members with relevant expertise were established for each task. Sub-groups worked in between the main project meetings and held sub-group meetings as required. All aspects of the project were also discussed in plenary at the main team meetings and in preparing the report.

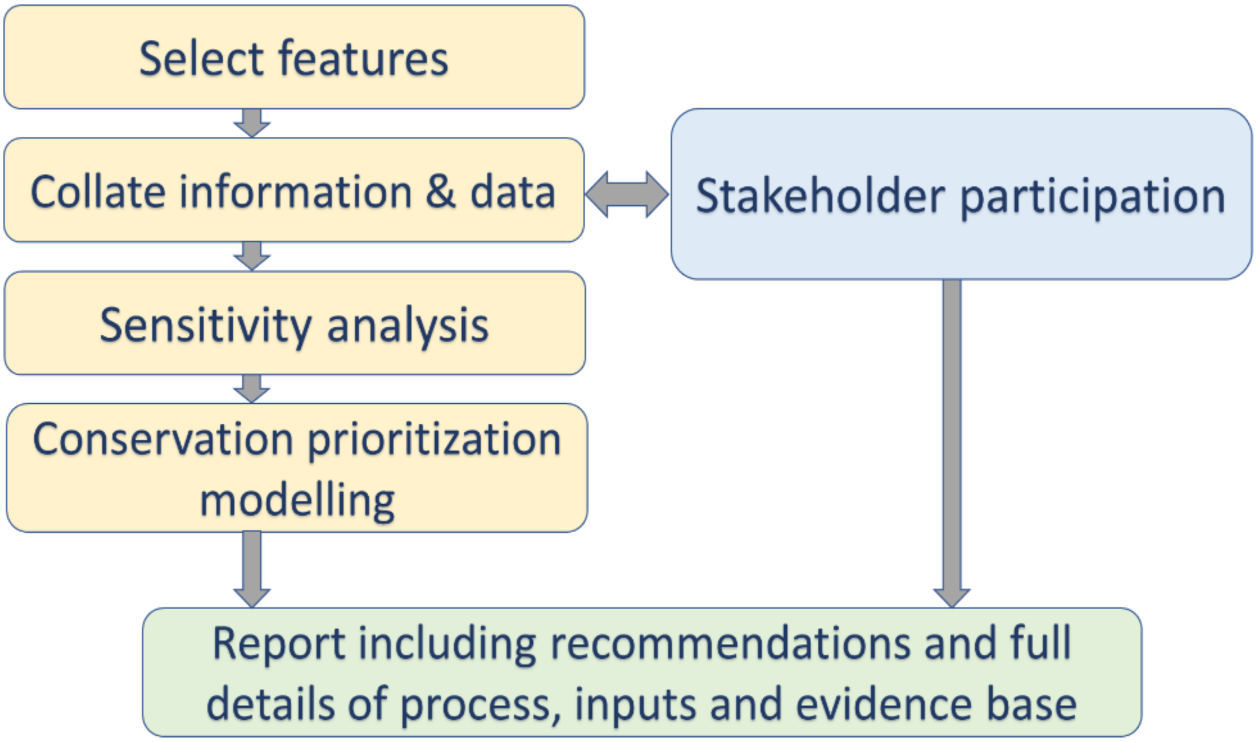


Figure 3.1. The project workflow, indicating each of the main tasks that led to the production of this report. Each of the tasks is explained in the relevant section below.

For key aspects of each task, a detailed repeatable methodology was developed and documented. For each key set of decisions, a set of criteria was established and documented. The text below is intended to succinctly provide sufficient detail for the methodologies and criteria to be understood for each task. Fully detailed descriptions of protocols used can be found in the Appendices. The results of the work are presented in greater detail below, but further information is provided in Appendices and reference lists and will also be provided in a digital repository (except for commercially sensitive information). As such, the basis for the conclusions and recommendations of the project is transparent and defensible.

3.1 Selection of features

In general terms, 'features' are the aspects of nature for which MPAs are selected, that are the focus of conservation objectives in MPAs, and that management measures are designed to protect. They are usually species or habitats but they can be other aspects of the environment, such as ecosystem processes, ecosystem services including cultural ecosystem services or biocultural features for example.

3.1.1 Methodology for selecting features

The full features list for Ireland's national network of MPAs will be developed through a process involving stakeholder engagement and participation under the MPA legislation when it comes into force. Given the time constraints for this project, and the need to establish the focal features at an early stage in the project as they underpin the rest of the work, the advisory group and the wider project team established a practicable, transparent and defensible process for selecting a list of features.

The process for selecting features is summarised in Figure 3.1.1 below. Full details are also available in Appendix 5a.

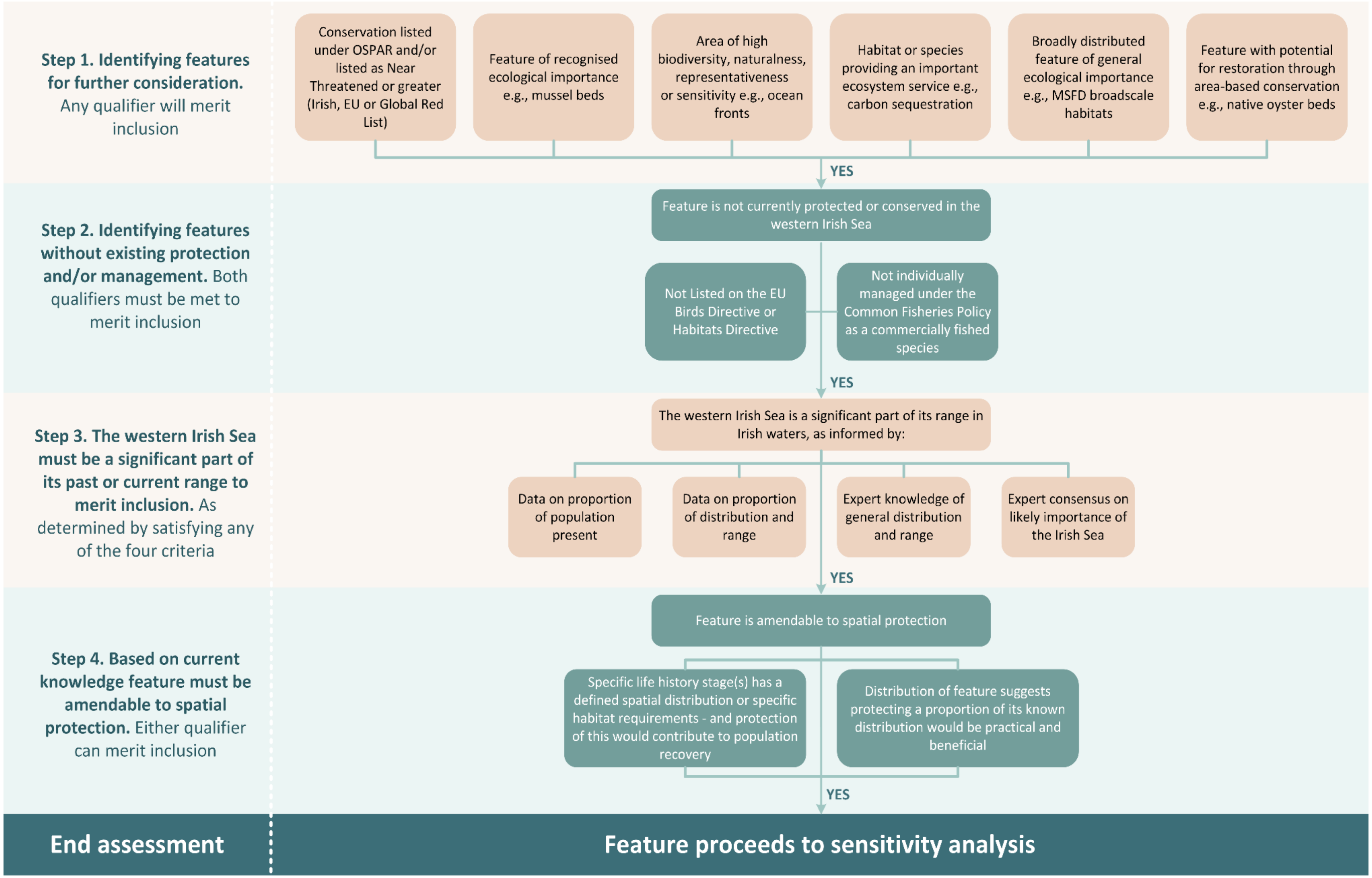


Figure 3.1.1. Criteria for inclusion and exclusion of candidate features for consideration for spatial protection in the current project

3.1.2 Selected features

In total, 40 distinct features met the criteria in Section 2.4 and were included in the further work of the project (Table 3.1.1). For some species, such as blonde ray, separate information was available for adults and juveniles, so they were included as separate sub-features and were analysed separately in conservation prioritization. One of the features, 'Forage/juvenile fish', was an aggregation of eight distinct species, all of which have similar patterns of distribution and were selected for the same ecological rationale. As such, the total number of features including sub-features is 51. Table 3.1.1 provides a brief note on the main rationale for including each feature. Full details are provided in the case reports in Appendix 10.

Eighteen of the features were species listed by OSPAR or on IUCN Red Lists. These included 14 species of fish, including nine elasmobranchs, such as basking shark, angel shark, tope, bull huss and cuckoo ray, and five other fish species, such as American plaice and European eel. Invertebrates included pink sea fan and Icelandic cyprine (ocean quahog). Two of the species, the European eel and angel shark are IUCN red-listed as critically endangered in Ireland, Europe and globally. Tope is critically endangered at a global scale and listed as vulnerable in Ireland and Europe. None of the fish species has an individual Total Allowable Catch (TAC) under the CFP. The ray species are managed under a generic group TAC (see Appendix 4).

Two OSPAR-listed habitats were included: ross worm reefs and sea-pen and burrowing megafauna communities. All the relevant habitats listed as a priority under the MSFD were also included, and muddy habitats modelled as being particularly rich in carbon were included for consideration due to their potential contribution to carbon sequestration. In each case, these habitats are home to a diversity of species and constitute ecosystems which provide a range of ecosystem services and help to maintain productive and healthy seas.

The group identified four features of ecological importance, either because they enhance biodiversity by providing complex habitats for other species (e.g., subtidal mussel beds) or because they provide food for species of commercial or conservation importance (e.g., barrel jelly, forage/juvenile fish).

Two thermohaline frontal systems were also considered areas of high biodiversity, naturalness, representativity or sensitivity. The Western Irish Sea front is of high biodiversity value but, unlike some frontal systems, is not markedly more productive than surrounding seas as nutrient levels are high due to coastal input (see Case Report 39, Appendix 10). The Celtic Sea Front at the southern edge of the area of interest was also considered important, but analysis of its extent revealed that only a small part of it extends into the area of interest. As such, it was excluded, but the group recommends that it is kept under consideration in future decision-making.

After the process of collating data and information on all features that were included, features were divided into three broad groups for their subsequent treatment in the project/report (see Table 3.1.1): CP: Sufficient data of sufficient quality for inclusion in conservation prioritization; ID: Insufficient data for full analysis but areas could be identified to be recommended for protection; ND: Not enough data/knowledge to make recommendations about spatial protection at all. For these features, it is recommended that priority is given to generating new data and knowledge to inform the best approach to conservation.

Table 3.1.1. List of features selected for further analysis that met the criteria for inclusion for spatial protection in this project, as described in Section 3.1.1 and Appendix 5a. A brief rationale is provided for the inclusion of each feature based on Step 1 in Figure 3.1.1. A fully detailed case report is provided in Appendix 10. As described in Section 3.1.2, features either went forward for Conservation Prioritization modelling (CP), had areas recommended for their protection based on limited data (ID) or were deemed to have insufficient data or knowledge to make recommendations for spatial protection at this time (ND). The IUCN column indicates listing on IUCN Red Lists for Ireland (I), Europe (E) and globally (G) as Critically Endangered (CE), Endangered (E), Vulnerable (V) or Near Threatened (NT).

No.	Common name	Latin name	Further analysis	IUCN	OSPAR
		Listed species			
1	American plaice (long rough dab)	*Hippoglossoides platessoides*	CP	G-E	
2	Angel shark	*Squatina squatina*	ID	I-CE, E-CE,G-CE	L
3	Basking shark	*Cetorhinus maximus*	CP	I-E,E-E,G,E	L
4a	Blonde ray adults	*Raja brachyura*	CP	I-NT,E-NT,G-NT	
4b	Blonde ray juveniles	*Raja brachyura*	CP	"	
5	Bull huss	*Scyliorhinus stellaris*	ID	E-NT,G-V	
6a	Cuckoo ray adults	*Leucoraja naevus*	CP	I-V	
6b	Cuckoo ray juveniles	*Leucoraja naevus*	CP	"	
7	Dog whelk	*Nucella lapillus*	ND		L
8	Edible sea urchin	*Echinus esculentus*	ID	G-NT	
9	European eel	*Anguilla anguilla*	CP	I-CE,E-CE,G-CE	L
10	Icelandic cyprine (ocean quahog)	*Arctica islandica*	CP		L
11	Pink sea fan	*Eunicella verrucosa*	ND	G-V	
12	Short snouted seahorse	*Hippocampus hippocampus*	ND	E-DD,G-DD	L
13a	Spotted ray adults	*Raja montagui*	CP		L
13b	Spotted ray juveniles	*Raja montagui*	CP		L
14	Starry smooth-hound	*Mustelus asterias*	ID	E-NT, G-NT	
15a	Thornback ray adults	*Raja clavata*	CP	E-NT,G-NT	L
15b	Thornback ray juveniles	*Raja clavata*	ID	"	L
16	Tope	*Galeorhinus galeus*	ID	I-V, E-V, G-CE	
17	Turbot	*Scophthalmus maximus*	CP	E-V	
18	Witch flounder	*Glyptocephalus cynoglossus*	CP	G-V	
		Listed habitat			
19	Ross worm reefs	*Sabellaria spinulosa*	CP		L
20	Sea-pen and burrowing megafauna communities	*Pennatula phosphorea, Funiculina quadrangulata, Virgularia mirabilis*	CP		L
		Ecological importance			
21	Barrel jelly	*Rhizostoma octopus*	ID		

22	Herring spawning grounds/areas/beds	*Clupea harengus*	CP		
23a	Forage/juvenile fish - European sprat	*Sprattus sprattus*	CP*		
23b	Forage/juvenile fish - Juvenile Cod	*Gadus morhua*	CP*		
23c	Forage/juvenile fish - Juvenile Haddock	*Melanogrammus aeglefinus*	CP*		
23d	Forage/juvenile fish - Sandeel greater	*Hyperoplus lanceolatus*	CP*		
23e	Forage/juvenile fish - Sandeel lesser	*Ammodytes tobianus*	CP*		
23f	Forage/juvenile fish - Juvenile Whiting	*Merlangius merlangus*	CP*		
23g	Forage/juvenile fish - Juvenile Herring	*Clupea harengus*	CP*		
23h	Forage/juvenile fish - Norway pout	*Trisopterus esmarkii*	CP*		
24	Sub-tidal mussel beds	*Mytilus edulis*	CP		
25	Circalittoral coarse sediments		CP		
26	Circalittoral mixed sediments		CP		
27	Circalittoral mud		CP		
28	Circalittoral sand		CP		
29	Infralittoral coarse sediments		CP		
30	Infralittoral mixed sediments		CP		
31	Infralittoral mud		CP		
32	Infralittoral sand		CP		
33	Offshore circalittoral coarse sediments		CP		
34	Offshore circalittoral mixed sediments		CP		
35	Offshore circalittoral mud		CP		
36	Offshore circalittoral sand		CP		
37	Offshore circalittoral rock and biogenic reef		CP		
Ecosystem services					
38	Carbon sequestration		CP		
High biodiversity, naturalness, representativity or sensitivity					
39	Western Irish Sea Front		CP		
Restoration					
40	European flat oyster	*Ostrea edulis*	ND		L

* Grouped with other asterisked features as 'Forage/juvenile fish' for conservation prioritization.

Of the 51 selected features and sub-features, 40 were considered to have sufficient data of a sufficient quality to go forward for conservation prioritization, although in many cases this was marginal and in no case was data of the highest quality available. Some data are available for six of the others (angel shark, bull huss, edible sea urchin, starry smooth-hound, tope, and barrel jelly), such that indicative areas can be recommended for their protection, but the data are not of sufficient quality for inclusion in the main conservation prioritization analyses. Two features that were deemed to merit protection under this project's criteria had so little information that no evidence-based recommendations for spatial protection can be made at this time. A high priority should be given to research to improve knowledge of the distribution and ecology of the features in these latter categories.

In the case of European flat oysters (also referred to as 'native oysters'), they were once widespread and abundant in the western Irish Sea but were fished to extinction. Oysters may be suitable for restoration, however, and were included on the list for that reason.

Appendix 6 lists features that were considered by the group but excluded from further consideration in the current project because they failed to meet one or more of the criteria as set out in Figure 3.1.1. They should nevertheless be considered in future as potentially meriting spatial protection.

3.2 Collation and processing of data

3.2.1 Methodology for collation and processing of data

A structured approach was taken to data discovery, collection, processing and cataloguing in preparation for conservation prioritization. These steps can be seen in the box below and in Figure 3.2.1. A complete description is provided in Appendix 5b.

1. Data Discovery

A comprehensive data discovery process was undertaken that involved exploring various data collection programs in the state archives, ongoing operations, and data from national, regional, and local datasets.

2. Data quality assessment and modelling to estimate distributions over larger areas

A quality filter was applied to each piece of information collected to assess accuracy and reliability (Table 3.2.1). The categorisation of quality for each dataset can be found in Appendix 7.

3. Data Cataloguing

All datasets were catalogued to ensure traceability, transparency and reproducibility. The catalogue includes key information such as the data-owning organisation, metadata records and date range for which the data is available. Full details of the catalogue can be found in Appendix 7.

4. Technical processing

The data used in this study were sourced from various datasets provided in different formats such as CSV, shapefiles, GeoTiffs, and SQL server databases. Data processing involved conversion to spatial file types (where necessary), filtering based on time (age of record) and spatial range (western Irish Sea), creation of summary vector grids, and transformation to GeoTiffs. These steps were applied consistently across all candidate layers. The process of this technical method can be seen in Figure 3.2.1. A 1x1 km^2 grid layer was created and clipped to the Exclusive Economic Zone (EEZ) boundary of Ireland in the Irish Sea for use in the project. More detailed information on the datasets and processing methods can be found in Appendices 5b and 7.

5. Choosing layers for conservation prioritization

In many cases, features had just one or two available sources of data and the decision of which source to use for conservation prioritization was simple. For other features however, particularly those relating to fisheries, there were multiple sources of data available. In such situations, the choice of which dataset to use for conservation prioritization was non-trivial as each had different strengths and limitations. Ideally, all the available evidence for each feature would be included in the analysis by combining data from disparate sources but this was not possible for most features given the time constraints. In most cases, a single best data source was chosen based on coverage, time-series, spatial accuracy, sampling design, sampling intensity, and expert judgement (see Appendix 5b for further discussion of this issue). A full catalogue of data sources used in conservation prioritization is provided in Appendix 8.

Table 3.2.1. Data quality categories to assess the datasets provided. Examples are provided in Appendix 7.

Quality/type	**Description**
High	The ideal dataset for these analyses would be systematically collected without bias, using techniques specific to the feature(s) in question. It would have intensive coverage (e.g., on a 1-3 km grid) and would include repeated observations over several years.
Modelled from good data	Modelled distribution data (based on modelling of systematic design-based observed data). The modelling process enables interpolation to areas not sampled and therefore has high spatial coverage. Uncertainty depends on the predictive power of the model. Examples include survey data used to model the predicted distribution of species, vessel monitoring system (VMS) data, which is extrapolated to a grid, and modelled estimates derived from acoustic data ground-truthed with observed samples.
Modelled from moderate data	Modelled distribution data that may have a spatial bias or provide incomplete information on the potential distribution of the feature. Examples are provided in Appendix 7 and include species distributions from fisheries effort and catch data interpolated or raised to a grid.
Good; observed data	Data acquired systematically which covers a large spatial area, but not the entire area of interest, and preferably with repeated measures over a long time series. These data ideally will provide a good spatial representation of the area but the distance between observations is much larger than the distance between planning units (i.e., grid size). This category also represents data sources which were combined to give a higher spatial coverage of a feature. Examples include observed data acquired from systematic surveys.
Moderate; observed data	Data acquired systematically or opportunistically, but is not modelled and covers only a limited area relative to the potential distribution of the feature. Examples include citizen science data and sea angling data.
Low/ Insufficient for SCP	Data exist in the area of interest but are older than 10 years (for mobile features) or 30 years (for static features) **OR** are anecdotal **OR** are spatially imprecise.
N/A	No data available in the area of interest

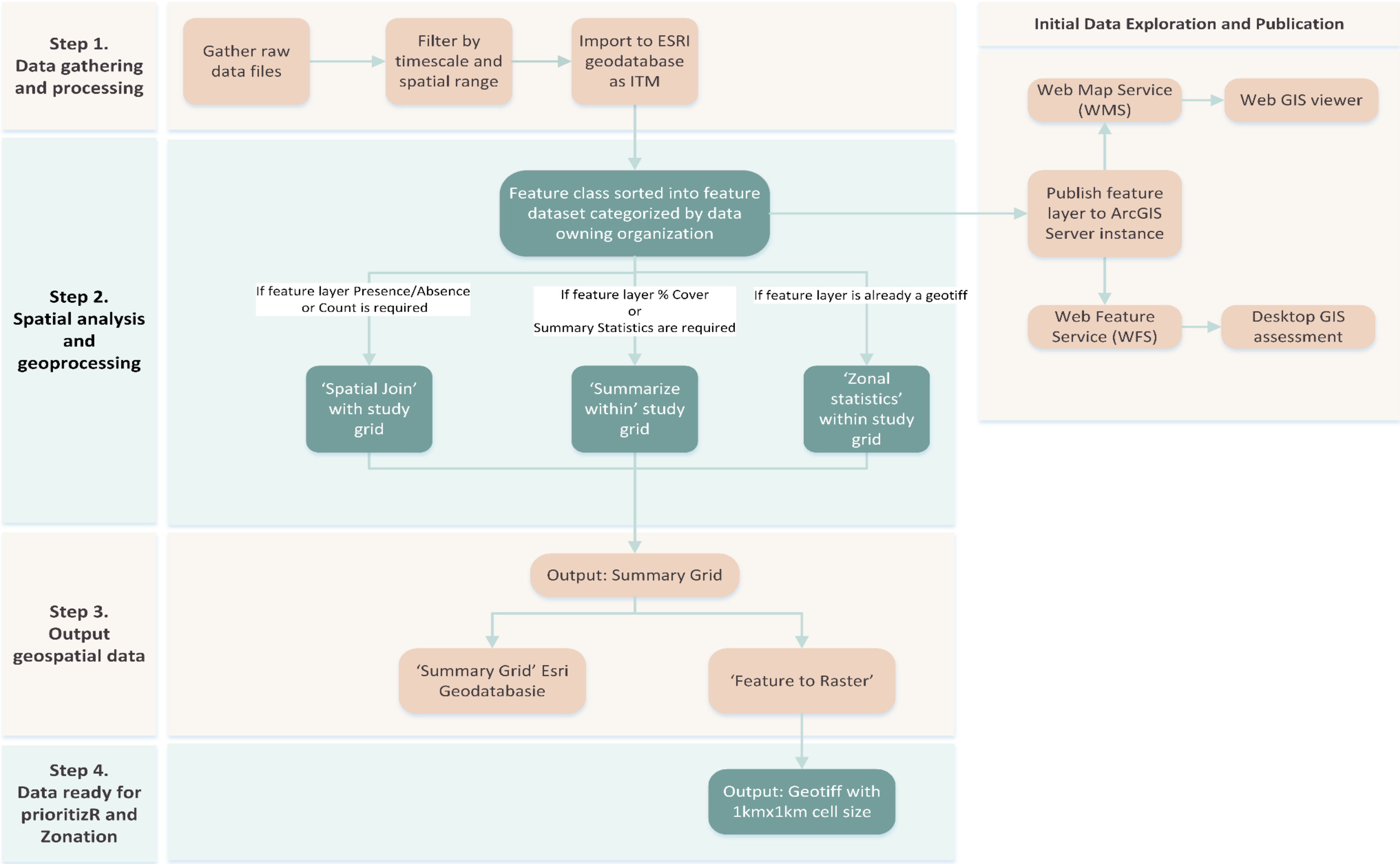


Figure 3.2.1. Process flow of the technical method used to geo-process data in preparation for use in *prioritizr* and Zonation.

3.2.2 Summary of data and visualisations

The compilation of available datasets related to the target features in the western Irish Sea resulted in an extensive file store containing multiple datasets. To ensure data preservation and future usability, these datasets were organised into two distinct file Geo-databases: one containing the raw spatial data and the other with the spatial data gridded. This approach facilitated effective data management beyond the lifetime and scope of the project and supported subsequent analyses as described below. In accordance with the methodology outlined in Section 3.2.1, the datasets identified as suitable for use in the conservation prioritization analysis process were used to create 223 GeoTiffs, each representing an individual feature, using a 1 km x 1 km grid as a reference. An example of one of these outputs can be seen in Figure 3.2.2 below.

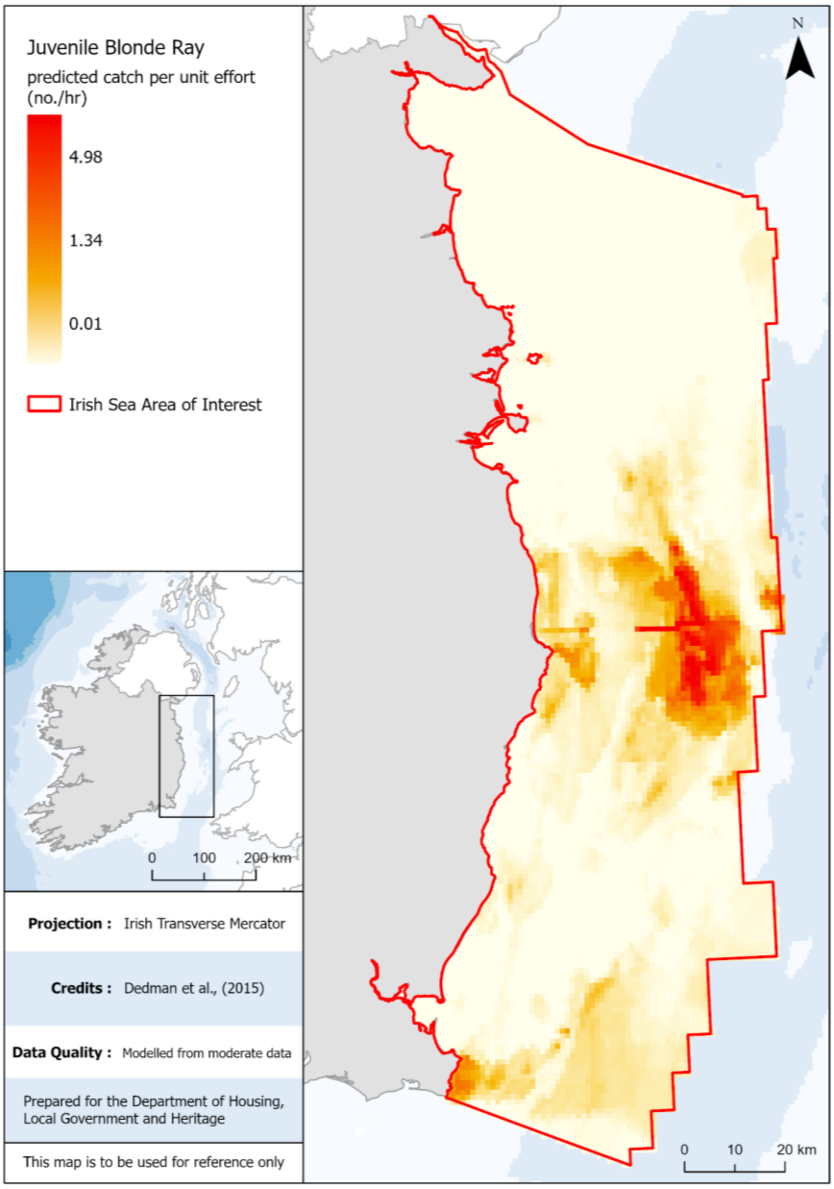


Figure 3.2.2. Illustration of a dataset converted to a GeoTiff using a 1km x 1km grid as a reference. This map shows the predicted catch per unit effort (numbers per hour) for juvenile blonde rays using data from Dedman et al. (2015).

For the purposes of this project, a server-based viewer was developed to enable the team to visualise the data layers during the analysis stages of the project (Figure 3.2.3). This viewer facilitated the creation of a dynamic visual representation of all data layers, which effectively conveyed overlapping patterns and co-location of activities. It is anticipated that a similar viewer would be developed as part of the MPA process in the future so that stakeholders can readily view the assembled data layers in map format.

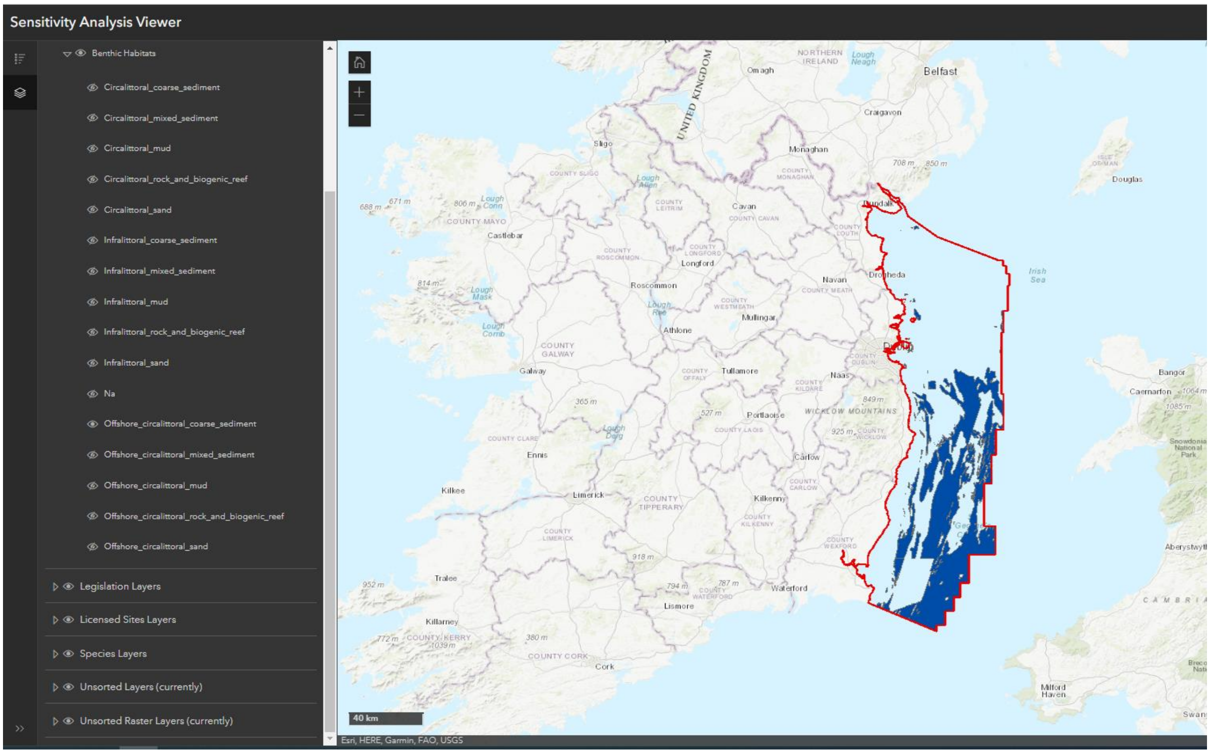


Figure 3.2.3. Image of the web-based map viewer which was used for initial data exploration by the group. It is anticipated that a viewer of this sort will be developed in future to support MPA decision-making and stakeholder engagement.

3.3 Stakeholder engagement and participation

A clear objective of the study was to facilitate open and constructive engagement with key Government and non-Government stakeholders that have extensive maritime interests in the Irish Sea (Section 1.2; Appendix 1). The purpose of this important undertaking was to facilitate the integration and consideration of their interests as part of the group's analyses and mapping processes within the project. Wider considerations and processes outlined in the MPA Advisory Group report (2020) and the General Scheme of the MPA Bill (2022) underline the need for provisions to ensure effective participation and engagement in Ireland's MPA process.

3.3.1 Methodology for stakeholder engagement and participation

A structured and time-bound approach was taken to this aspect of the work, to ensure its delivery on schedule. For this, a stepwise engagement framework was set out and agreed upon by the project team as follows:

Level 1 - Inform:

Goal: To ensure transparency and clarity, inform a wide range of stakeholders, and provide opportunities for comments, questions, and clarifications through an online feedback link.

Tools: An email sent to all identified stakeholders on 25 January 2023.

Level 2 - Involve:

Goal: To involve relevant government departments and agencies, seek input, request data, hear and acknowledge perspectives and potential concerns.

Plan: Four meetings with government and agency groups in February and early March 2023, using a mix of in-person (2 meeting sessions) and online formats (2 meeting sessions).

Level 3 - Engage:

Goal: To engage with key non-governmental stakeholders identified by the Delphi method, hear and discuss perspectives and concerns.

Plan: Key stakeholders identified using the Delphi method. Two days of in-person meetings held with representatives of key stakeholders on 23-24 March 2023.

Level 4 - Disseminate (Inform):

Goal: To ensure transparency and clarity and inform a wide range of stakeholders about the outcomes and results of the project.

Plan: An online webinar in May 2023 (tbc) to disseminate information on the project results. An open invitation to this event will be circulated to all stakeholders identified during the project.

Figure 3.3.1. One of the 'Engage' sessions with non-government and sectoral stakeholders in March 2023. (credit: Elgar Kamjou)

3.3.2 Stakeholder input

3.3.2.1 Results of the 'Inform' level of stakeholder engagement (level 1)

In total, the project team received 10 responses through the designated online feedback link which was opened for submissions up to 24 February 2023. Most respondents that provided input at this initial stage of the project were eNGOs, although some agencies and industries also participated by providing feedback or questions. Groups that took part included the *Ascophyllum nodosum* Processors Group (ANPG), the Fair Seas campaign, the Irish Whale and Dolphin Group, the Irish Seal Sanctuary, and the Irish Farmers' Association (IFA Aquaculture).

Here is a summary of the main topics raised by those that responded through the online feedback link:

1 Participants emphasised the importance of understanding the main databases used in the current project.
2 Participants raised concerns about the lack of specific data, such as acoustic data related to some cetacean species (e.g., Minke whale).
3 Participants requested a full list of features being considered by the project.
4 Concerns were raised about the lack of clear integration of the socio-economic importance of commercial and recreational fisheries in the project's approach.
5 Participants asked about the project's approach regarding existing protected areas, and the impact their size and location might have in identifying further sensitive areas and/or potential MPAs.
6 There were concerns about the potential impact on livelihoods and economic activities arising from the project's outcomes.

Responses were provided by the project team to each query or feedback item identified. In acknowledging the views and concerns expressed by the five responding organisations, the project team committed to the following actions, including provisions in its Terms of Reference, as follows:

1. The team would provide clarity and open data sources unless the data is confidential.
2. The team would use the best available evidence and be explicit about potential uncertainty.
3. The team would provide transparent and objectively defensible processes and conclusions in the report.
4. The team would publish the list of features and the rationale for their inclusion/exclusion in further analyses in the final report.
5. The team would maintain the clear distinction between the work of the current project and the actual identification and designation of MPAs under the legislation enacted in the future.
6. The team would specify the full scope of the project, its aims, and its timeline in its final report.
7. During its engagements, the team would inform stakeholders that the General Scheme of the Marine Protected Areas Bill (2022) has been laid before the Oireachtas and that work has begun on drafting the Bill with the expectation that the legislation will come into force later in 2023.
8. The team would highlight that, under the General Scheme of the Bill, the national MPA process is designed to involve a comprehensive programme of public and stakeholder engagement and participation in the selection, design and delivery of Ireland's MPA network.

3.3.2.2 Results of the 'Involve' level of stakeholder engagement (level 2)

Several key themes emerged from the thematic analysis of the four 'Involve' sessions described above. These themes were used to shape aspects of the current report and to help ensure that the needs and concerns of all stakeholders were considered by the project team. This would also help to inform future discussions and decision-making processes. Overall, seven themes emerged from the data, as seen below:

1. List of features and habitats

During the 'Involve' sessions it became clear to team members, as expected, that the list of features and habitats included in the ecological sensitivity analysis is of great importance to government and agency stakeholders. In addition, participants from multiple groups across government departments and agencies raised some concerns about the exclusion of species listed on the EU Birds and Habitats Directives in the current project (discussed in Section 1.2). Concerns were also raised about other groups of species or features; for instance, how migratory species and transboundary considerations would be dealt with by the Irish Sea project.

As part of its work, the project team carefully included/excluded features based on consistent and transparent criteria for such decisions (Section 3.1.1). Following the initial scope and intentions of the team, while acknowledging such concerns and understanding the importance of relevant discussions and information exchange with stakeholders, the lists of included and excluded features are published in this report along with the selection criteria and notes on their application.

2. Addressing uncertainty

During the 'Involve' sessions, a recurring question revolved around the uncertainties in scientific knowledge and data gaps encountered during the project. Several participants asked: *"How will the group address the lack of data on multiple species?"*

This issue was brought up in every session, highlighting its importance to the government/agency stakeholders alike.

As a group of experts in marine ecology, the project team was and is aware of the existence of data gaps in the Irish marine space. As part of this project, the team has put in significant effort to collect all available data and information. However, there are still areas where evidence and data are scarce or patchy or have not been available or forthcoming. Acknowledging this reality, as part of its work the team has developed and provided a list of these gaps to clarify the available data and clearly define the deficiencies. This list will aid readers and decision-makers in understanding the limitations of the available data and point the way forward for aspects needing further work.

3. Importance of socio-economic integration

The "sectoral trade-off" layer in the conservation prioritization analysis also raised some questions from multiple stakeholders. Queries such as: *"How should different sectoral interests be ranked or weighted?"* are some examples of the questions that were raised during the 'Involve' sessions. Furthermore, there were additional in-session discussions about the absence of spatial data on certain sectoral interests and their activities.

In response, the project team highlighted that including all the sectoral interests in the Irish Sea individually could not fit within the scope and timeline of this project, and thereby further explained the specific purpose of the "sectoral trade-of" layers in the current analysis (Sections 3.2 and 3.5).

4. Impact of the current conserved areas

A recurring topic that government/agency stakeholders raised during the discussions were related to the advisory group's approach towards current protected areas (e.g., Natura 2000 sites: SACs, SPAs). Several participants raised concerns about the adequacy, quality, and extent of existing protections and management or enforcement measures. The discussions largely revolved around whether there had been an assessment of the effectiveness of the existing protected areas.

To address these concerns, the project team provided an explanation of its rationale and approach in Section 1.2.

5. Positive feedback and support

Despite concerns raised by some participants regarding the project's details and limitations, there was a significant amount of positive feedback provided by this set of stakeholders. The project's scientific approach and level of engagement with government and non-government stakeholders appeared to impress many government/agency participants, leading to encouraging comments such as:

"Just a congratulations. This is great, I have to say, delighted to see so much progress done, and having a deadline of April coming. I know it's intense for you guys, and I can see that, so congratulations. So, it's a really really really great progress."

"Impressive work, very interesting and useful work. Using existing models is a wise choice".

These comments, and other similar ones, demonstrate that the team's efforts to establish a systematic and transparent process, based on the best available evidence, were appreciated by stakeholders.

6. The value of this report for Government departments and agencies

Stakeholders in the ‘Involve’ sessions stated that the project’s final report can provide significant benefits to their respective organisations, including using it as a decision-support guide for maritime planning and potential ORE development. However, stakeholders also emphasised that for the report to be effective it must be "easily digestible", "precise" and "transparent."

In response to this perspective, the project team has made several adjustments to the report to make it more user-friendly for different end-user groups. Some of these adjustments include:

- Ensuring the language used in the report is coherent and easy to read.
- Providing the necessary evidence to support decisions made, in a clear and open manner.
- Presenting multiple viable solutions and scenarios and recommendations to enable stakeholders to make informed choices.

7. Additional comments

During the interactive ‘Involve’ sessions, engaging discussions were held on various marine-themed topics with diverse stakeholders. While these discussions may not have been as prominent as the other themes highlighted above, key elements of such discussions included:

a) The extent to which the analysis distinguished between the pressures introduced by ORE development in its construction and its operation phases.

b) Dialogue on potential opportunities for inter-departmental collaborations.

c) Identification of new stakeholders who may have a personal stake in the project and its results.

d) Access to data and information, including discussions on how to obtain and utilise relevant data.

e) Brainstorming ideas on how to present maps effectively and address data deficiencies in the contents of the final report.

Such additional discussions enriched the sessions and provided valuable insights on these important topics.

3.3.2.3 Results of the ‘Engage’ level of stakeholder engagement (level 3): non-government and sectoral stakeholders

As discussed in Appendix 5c, the discussion part of the ‘Engage’ sessions held with non-government and sectoral stakeholders was a facilitator-led process. After a brief introduction, participants were asked to answer a set of questions individually. The questions were designed to lead discussions in a constructive way, to provide the project team with structured responses, and to create a comfortable participatory environment for attendees to share their perspectives. The questions posed to individual stakeholders by the facilitator were as follows:

1. What is your long-term vision for Ireland's marine environment and the Irish Sea within it?
2. What do you like about what you've heard?
3. What are your concerns, including those you represent?
4. How can you help us? (e.g., by providing information, making suggestions)

The results of the 'Engage' sessions were thematically analysed and the results are described below, based on responses received to each of the questions in turn:

1. What is your long-term vision for Ireland's marine environment and the Irish Sea within it?

In response to this question, three main strands of discussion were identified. The first relates to the environmental aspirations of various stakeholders regarding Ireland's marine environment. The second theme highlights concern regarding the future of Ireland's marine environment, while the third discusses other important aspects of the vision of stakeholders, including the significance of cultural and economic factors. The section below discusses each of these themes and their defining sub-themes in further detail:

i) Environmental aspirations:

A range of stakeholders, from eNGOs, fisheries and aquaculture, and energy industry groups shared their long-term vision for Ireland's marine environment, using terms such as "healthy," "biodiverse," "resilient," "restored," and "sustainable" (Figure 3.3.2).

Figure 3.3.2. Word cloud to show words commonly used by non-governmental stakeholders in their individual responses to the question about Ireland's marine environment and the Irish Sea.

The comments made by various groups and sectoral representatives highlighted the significance of a healthy and resilient marine environment, and its continued support of their sectoral activities and key interests, for example. A representative comment which illustrates such a perspective is provided here:

"We need to develop and go beyond simple protection to restoration." (An energy sector representative)

"Even for the aquaculture industry to be sustainable we need to have a healthy marine environment; we can't live without it"
(An aquaculture sector representative)

It was widely communicated across various sectors that MPAs hold substantial promise for the future of Ireland's marine environment. However, stakeholders also stated that their perspectives and voice should be considered to achieve the goals of protection. This sentiment is captured by a representative of Sea Angling Ireland as follows:

"As recreational anglers, we deserve a seat on the table and we deserve a voice [...], we are under declining area, which means that our catch is declining, no doubt about that. [...]. MPAs offer us hope for the future [...], and it will give hope to these people that, yet the future is bright. Because currently, I don't think there is any sector of us, the business of recreational angling, would say that the future is bright."

This viewpoint, like many others, highlights the considered and valued importance of stakeholder involvement and cooperation in seeking to achieve effective MPA designation and management processes. In other words, the view held was that the success of MPAs depends on the involvement and engagement of all relevant stakeholders to ensure that they are developed and managed in a way that acknowledges the needs of all parties involved.

"We certainly have to be continuing something like this [referring to the engage session] in the consultation process, if there could be some kind of constant interaction between ourselves and the scientific community [...] I think it would be a win-win. [...] there are so much mistrust now"
(A fishing sector representative)

Other stakeholders, whose sectors have a greater economic dependency on the Irish Sea, believe that protecting the Irish marine environment should be balanced with the interests of all industry and commercial sectors. They envision a future for the Irish Sea that provides a vibrant environment where sustainable economic activities can coexist with protected species and habitats. To achieve such an environment, the stated emphasis was on the importance of consultation and engagement with stakeholders while building/repairing the trust between the scientific community and sectors.

The consensus on this question among the non-government and sectoral stakeholders underlines the importance of preserving the environment for the benefit of all. It was highlighted that the environment provides vital resources and supports the economic, cultural, recreational, transportation and many other activities of various sectors. The need for sustainable development, which balances economic growth and environmental protection, is therefore considered core in achieving these aspirations.

ii) Challenges:

During discussions on the future vision for Ireland's marine protected areas, some stakeholders raised concerns about current challenges for achieving the protection goals. One of the concerns raised was the fear of exclusion, particularly among stakeholders who feel that although they do not depend on the Irish Sea for their livelihood, they still wish to contribute to its well-being in various ways. These contributions include supporting the tourism industry, participating in citizen science initiatives (such as anglers who catch, tag, and release fish), and providing information on specific species and related changes. More details on this topic are covered under *Concerns related to this project.*

iii) Cultural/economic perspectives:

> *"To appreciate what we have"*
> *(A fishing sector representative)*

There were other trains of thought that were repeatedly emphasised by some stakeholders. These included the cultural and commercial importance of the Irish Sea to the Irish population. For instance, a representative from IFI highlighted the importance of increasing awareness and an appreciation for the Irish Sea and its unique assets among the Irish population. They suggested promoting wider awareness about lesser-known species and resources in the Irish Sea.

While these topics (e.g., education and awareness-raising) may not have been as widely discussed as other sub-themes, they still hold significant value and should not be overlooked. The cultural and commercial significance of the Irish Sea to the Irish population is considered to underscore the need for sustainable management practices that consider not only environmental concerns but also cultural and economic considerations.

2. What do you like about what you have heard?

The responses to question 2 above were found to cluster into three main themes: (i) process-related comments, (ii) appreciation of the significant amount of work being completed within a short timeframe, and (iii) the importance of the project. These themes, along with their related sub-themes, will be further explored below. Overall, the participating stakeholders were optimistic about the project's potential and the positive impact it could have on both the environment and the community.

i) Process-related comments:

Numerous stakeholders from various groups expressed their satisfaction with the methodology employed in this project, describing it as a ***systematic process***. Their positive feedback underscores the robustness of the approach employed, highlighting its effectiveness in addressing the diverse expectations of different stakeholder groups. A representative comment provided by a fishing sector representative stated:

> *"I like the kind of structured and systematic scientific approach [you] are actually taking to do this rather than just looking on a map and going: oh, that's kind of nice there, let's protect that!"*

"[…] collecting data and saying that it will be very transparent, so we be able to drill down how did you come up with, and what pressures did you actually consider safe for offshore wind and so on, I really like that approach."

(An eNGO representative)

A comment from a representative of the fishing industry highlighted the comprehensive and well-organised nature of the methodology, stating that it effectively addressed key concerns and considerations by taking a scientific approach. The KFO representative further expressed appreciation for the collaborative approach taken by the project team in involving stakeholders from distinct groups, which enhanced the transparency and credibility of the overall process.

"taking views into account is valuable"

"Range of stakeholders reached out"

"That all the stakeholders are considered, that's important you know"

Transparency, which is the other sub-theme communicated by stakeholders in answering this question, was highly appreciated by many stakeholders from diverse groups, who commended the advisory team for their clear and transparent approach. The commitment to open communication and availability of data and information was recognised as a key factor in fostering trust and confidence among stakeholders, which is hoped to enable effective collaboration in the future.

The diverse range of stakeholders that participated in the process appeared impressed with the level of engagement and participation that was encouraged throughout. They not only appreciated the scientific approach but also felt that the ***engagement process*** itself was a significant strength of the project. As such, they recommended that this approach should be continued and even further enhanced in future projects. Statements such as "the keyword is involvement and engagement" (Representative from the fishing sector) illustrate such a perspective.

To non-government and sectoral stakeholders, the engagement process signifies a consideration of the project's socio-economic aspects, which are crucial for various sectors.

ii) Appreciation of the amount of work in a short time:

A notable theme that emerged from stakeholders' responses to question 2 was their acknowledgement of the significant amount of data collection, stakeholder participation, analysis and research conducted within a brief period. Stakeholders frequently mentioned the use of multiple data sources to build a comprehensive database. Additionally, a correlation between the use of phrases 'short space of time'/'short time' along with 'sufficient information'/'good data collection', shows that stakeholders recognised the efforts the project team was making to collect the best available data and information. Below is an example of positive responses in this regard:

"I am impressed by how much is being looked at in such a short space of time" (An eNGO representative)

Although most stakeholders appreciated the team's work in conducting a sensitivity analysis of the Irish Sea within a short timeframe, some participants from eNGO groups viewed this as a "double-edged" condition. While acknowledging the project's importance in addressing existing gaps, they expressed concern that ORE may be driving the process instead of policy for MPAs driving the MPA process. One eNGO representative expressed doubts about the framing of the project.

> *"[There is this] fear that ORE is driving the process rather than the MPA driving the MPA process. I have some doubts about the framing of it. Is this project actually about identifying where ORE shouldn't go rather than where MPAs could go"*

The project team responded to such concerns by clearly defining the drivers and objectives of the project (Section 1).

iii) Importance of the project

Representatives from various groups highlighted the significance of this project and considered the mere fact that it had begun as a strength. Several stakeholders emphasised the phrase "*the fact that it's being done.*" Furthermore, one eNGO representative pointed out a crucial aspect of the project that had also been hinted at by a few other participants. This highlighted the need for improved stakeholder engagement and transparency in the designation of protected areas since previous processes may not have been well received due to a lack of involvement of stakeholders and the public. The current project's commitment to engaging with stakeholders and maintaining transparency was seen as a positive step towards rebuilding trust and encouraging public participation in the process.

This perspective is vital to consider as it highlights the importance of inclusivity and transparency in ongoing decision-making processes. By involving a mix of stakeholders, it was considered that this project had the potential to build trust, promote understanding, and ensure that the needs of all parties will be acknowledged. As such, it was considered crucial that future projects and the wider MPA process continue to prioritise transparency and inclusivity throughout their work.

3. What are your concerns related to this project?

Although the overall sentiment towards the Irish Sea project was positive and optimistic, the assembled stakeholders did express several concerns during the 'Engage' stage of this process. Three main themes emerged, regarding: data and analysis, stakeholders' interests, and the level of effectiveness. In response, the project team tried to address most of the concerns that fall within the scope of the project, as detailed in this section of the report.

i) Data and analysis

The primary themes that emerged from stakeholders' responses to the third question related to insufficient data and gaps in data, and the analysis process. Many of the points raised by stakeholders had already been discussed by the expert advisory group itself. However, listening to the stakeholders' perspectives provided the team with valuable insights with which to structure the report, in a way that addresses their concerns as much as possible.

Participants from various representative groups shared their concerns about (i) the lack of data, (ii) the instability of existing information, and (iii) gaps in understanding of the pressures identified in sensitivity analysis.

Some participants stated their concern that the lack of data could be a crucial factor in determining solutions for MPAs in the Irish Sea. Statements like "*Do we have sufficient data?*" and "*Marine data is notably incomplete, particularly around the coastline, which undermines the reasoning behind MPAs*" highlight these concerns. To address these issues, the project team drew a clear distinction between the current ecological analysis process and the national MPA designation process in the future. Through its tasking and the current report, the team has also done substantial work to create an open-access database and to provide recommendations for data collection in areas with insufficient data (Section 3.2).

Stakeholders also enquired about some of the rationales presented by the team around the analysis process. One example was when an eNGO representative expressed their perspective, stating:

> *"(firstly) With the process on excluded areas... SACs, SPAs, or habitats and species listed in the birds and habitats directive are excluded, we haven't really designated enough SPAs, so it is unclear to me how those two will dovetail? And two, on commercial species [...] commercial species are excluded, but some are actually included [...] a bit more clarity on that"*

Among similar concerns, the exclusion of EU Birds and Habitats Directives features was frequently raised. Some stakeholders believed that having two separate processes (i.e., ongoing Natura 2000 site designation and future MPA designations under the forthcoming legislation) leads to confusion. They also expressed concerns about overlaps, management, and the operation of two separate sets of protected areas in Ireland's coastal and marine waters. The team's response to this concern arises in Sections 1.2 and 4.6 of this report, and in the key messages and recommendations.

A few participants raised specific questions about sensitivity analysis and the characterisation of pressures from human activities, especially in cases where insufficient information exists, such as around ORE development. This concern was primarily brought up by eNGO groups and energy industry sectors. For instance, one eNGO representative stated, "*In the Irish Sea, we don't have a lot of ORE at the minute, established, [...], but in the Irish Sea generally, there is a lot of offshore wind (development). [...] Are we taking into account the sensitivity of species to pressures that are also coming from outside of the areas that are part of the Irish Sea?*".

During the meeting, a representative from another eNGO raised a question about the acceptability of the rationales presented by the project team regarding unknown pressures and their weighting in the sensitivity analysis. The representative asked, "What if we disagree with your analysis of pressures?".

Such comments added more depth to the discussions in the meetings. In response the project team, as per previous in-group discussions, has bolstered its efforts to provide as much evidence as possible to support its rationale about the sensitivity of the species to the identified pressures, which are discussed in Section 3.4 and associated appendices. It explained that the analytical processes are intended to be transparent and therefore open to challenge or to changed conclusions in the future, in view of new evidence made available.

ii) Stakeholders' interests

Stakeholders from various groups expressed their concerns about the consideration of their interests in the process of this and future related projects, highlighting three main sub-themes: (i) fear of increasing pressures on their sector, (ii) exclusion of stakeholders' interests, and (iii) unclear meaning (or objectives) of MPAs and of conservation. These sub-themes are discussed in greater detail below.

Several individual stakeholders with economic interests in the Irish Sea raised concerns about "where and when the stakeholders' interests would be integrated into the process?". One of the key drivers behind these questions is the fear among stakeholders of being put out of business or of facing additional pressures because of the MPA designation process. *As expressed by a fisheries* representative: "*I suppose the key concern is how are we taking into account the sectoral interests, and this is happening at the time when the Offshore Renewable Energy (ORE) is coming at us".*

Other stakeholders raised concerns regarding the potential implications of the Irish Sea project and the future designation and management of MPAs when the forthcoming legislation is in place. These stakeholders emphasised the significance of transparency and honesty in communicating the progress and outcomes of such endeavours. They also asserted that it is important to acknowledge that not all stakeholders may ultimately be satisfied and that there may be costs, benefits and conflicts of interest that need to be addressed in the future.

"Be honest about the conflicts that are ahead"
(An eNGO representative)

"Perhaps there is a belief that we can do everything everywhere, all at once and I think there are trade-offs and I think we have to be honest about what those trade-offs would be. Because I don't think we can achieve our targets, and everyone would be happy at the end. Be honest about the conflicts that are ahead"
(Representative from an eNGO)

Such comments made by non-government and sectoral stakeholders alike highlight a necessity for further comprehensive investigation to properly understand the interests of stakeholders, and the associated socio-economic and ecosystem service costs and benefits of designating Marine Protected Areas (MPAs) in the future.

During the discussions, the project team acknowledged that, when it comes to the actual national MPA process under the new legislation, in some or many instances, there may need to be some compromises made by the various stakeholders in Ireland's marine environment. In this regard, the team reflected on provisions for participation and engagement with stakeholders and the wider public, as expressed in the General Scheme of the MPA Bill (2022) and mentioned that further details were currently being drafted as part of the Bill.

iii) Outcome of the report

During the meetings, concerns were raised by some stakeholders regarding the outcome of the project, specifically regarding the effectiveness of the project and what would happen when the group finished its work. It is worth noting that stakeholders expressed concerns about the implementation of MPAs, the management system, and the monitoring process for MPAs in the Irish marine environment. However, these questions, although important, were considered by the project team to be outside the scope of the current Irish Sea ecological sensitivity study (see TORs, Appendix 1). It was concluded that such aspects will be developed and discussed further during the national MPA process itself as underpinned by the forthcoming legislation.

4. How you can help us?

During the stakeholder engagement sessions, the expert advisory group posed a final question to the stakeholders which sought to elicit their input on how they could support the project (and related work in the future), and what further requirements they deemed necessary. This question was intended to create an open and inclusive environment that encouraged stakeholders to explore assumptions about the current project and enabled the expert advisory group to gain a better understanding of the valuable capacities and resources possessed by different stakeholder groups.

Numerous non-government and sectoral stakeholders expressed their willingness to leverage their existing capacities to assist the project team in disseminating the results of this project to a broader audience. They also showed an interest in expanding the list of related stakeholders for future projects. Such an offer was considered by the project team to be highly valuable in increasing awareness among potential stakeholders.

Collaboration with stakeholders can facilitate the integration of diverse perspectives and knowledge, leading to more informed decision-making and effective problem-solving. Engaging a broader group of stakeholders can also help promote awareness and support for the project's objectives, making it more likely to achieve its intended outcomes.

An additional discussion point that emerged during the stakeholder ‘Engage’ meetings was the willingness of stakeholders to participate in data collection efforts, whether that is via the contribution of fisheries data (as is the case) or recreational angling data or through site investigations, new citizen science initiatives or other survey data for example. These efforts currently involve collecting information on various species through observer-based or opportunistic recording, tagging, or voluntary surveys, for example. Acknowledging the potential of such citizen science data and working closely with stakeholders could help to improve its quality, thereby making it more suitable for future analyses. Criteria defined in this project to evaluate the data layers could serve as a starting point for such an approach (Section 3.2 and associated appendices).

While not necessarily prevalent, there were additional lines of discussion that are worth noting. Some stakeholders who represented local authorities emphasised their ability to assist with the MPA management process in the future, when the MPA legislation has been enacted. Additionally, eNGO representatives discussed creating opportunities for transboundary connections and integrating MPA networks on wider regional or international scales.

The second part of question 4 aimed to provide a platform for stakeholders to share their recommendations and requirements. Two distinct sub-themes emerged from the stakeholders’ responses. The first sub-theme relates to the stakeholders' suggestion for the continuation and expansion of the engagement processes in future. Almost all stakeholders emphasised the significance of continued and effective stakeholder engagement and recommended that the team would schedule more frequent meetings and discussions with relevant stakeholders “to hear the stakeholders’ voice”. They stressed that such a process can enhance trust between different sectors and the scientific community, leading to a more comprehensive understanding of the stakeholders' concerns, needs, interests, and requirements. In their view, an interactive process of MPA designation could facilitate successful implementation, management, and monitoring in the future.

The second sub-theme around the ‘requirements’ topic was stakeholders' expectations for and desired outcomes from the advisory group’s final report on the Irish Sea analysis. Stakeholders emphasised the importance of clarity and transparency in the report. They often used words such as "clear," "concise," and "transparent" to describe what they hoped to see in the report. Stakeholders highlighted several key areas of interest, including (i) the list of features (including species and habitats) included in the sensitivity analysis, (ii) a clear definition of what MPAs entail, and (iii) identification of any deficiencies encountered in the current project.

To address these expectations, the advisory group and project team have structured this report in a way that provides detailed information about the decisions made, the scientific evidence and reasoning behind them, and clear recommendations emerging from this work. The report includes specific sections that highlight what the project is and what it isn't, as well as any limitations or shortcomings identified within the scope of the study. The team has also striven to ensure that the report is structured in a logical manner, with all information presented in a clear and as concise a manner as possible.

3.4 Sensitivity analysis

Ecological sensitivity analysis is used to determine the degree to which a species, habitat or other feature is affected by specific pressures resulting from human activities. Sensitivity is determined by the capacity of the feature to remain unchanged under the influence of the pressure (termed 'resistance') and, if changed, the amount of time needed for a full recovery once the activity has stopped (termed 'resilience') (Vincent et al., 2004; Tyler-Walters et al., 2018). A species that is easily damaged by a pressure has low resistance to it and if it takes a long time to recover, has low resilience.

If a feature is not sensitive to the pressures associated with an activity, that activity is not incompatible with the conservation of that feature; if there is a high degree of sensitivity of a feature to an activity in an area designated for that feature, management measures are needed to prevent damage by that activity to the feature.

3.4.1 Methodology for sensitivity analysis

The aim of the sensitivity assessment protocol was to follow a fully reproducible, well-evidenced approach that could be updated when new evidence is published. Where available, existing assessments were extracted from tried and tested international sources including Marine Evidence-based Sensitivity Assessment (MarESA), the Feature Activity Sensitivity Tool (FeAST), and older Marine Life Information Network (MarLIN) group assessments (See Appendix 5d).

For features with no existing assessment, an adapted MaRESA approach was followed, which involved seven key steps as follows:

Step 1. Conduct a systematic search of the literature to identify available evidence on species-specific sector-pressure interactions. Searches were conducted using the Web of Science and the review of the evidence was limited to two days.

Step 2. Define the key elements of a feature (e.g., key characterising species of a habitat, or the life history of a given species).

Step 3. Assess the resistance of the selected feature against the MarESA pressure benchmark

Step 4. Assess the resilience of the feature based on its ecology.

Step 5. Determine the overall sensitivity of a feature. Sensitivity is derived from the resistance and resilience scores. Sensitivity scoring for habitats, species assemblages and grouped features was based on the resistance/resilience of the most sensitive species.

Step 6. Characterise confidence in the evidence base used to make the assessment. Confidence was derived from three evidence scores: (i) the quality of evidence, (ii) the degree to which the evidence applies to the assessment, and (iii) the degree of concordance (agreement) between the evidence sources. An overall confidence scoring for the sector-pressure assessment was based on combinations of the above, resulting in either a low, medium, or high scoring.

Step 7. Document the evidence used and considerations around its application.

Full details of this methodology are presented in Appendix 5d, including a matrix linking specific pressures to each of the focal sectors and sub-sectors of the project and explanations of how sensitivity scores were determined and how confidence in them was assessed.

As a combined output from the process of selecting features and the sensitivity analysis, and drawing on the collated data and information and the input of stakeholders, an individual case report was produced for each feature, providing details of the feature, the rationale for its inclusion in the project, its sensitivity and distribution and an indication of data availability and research needs. Examples are provided in Section 3.4.2; the full set of case reports is available in Appendix 10.

3.4.2 Sensitivity of the selected features

Full sensitivity analyses for all features are presented in Appendix 11, along with formal assessments of the quality, concordance and applicability of the evidence underpinning them. Narrative synopses of key sensitivities for each feature are included in the case reports in Appendix 10.

The following features were concluded to have medium or high sensitivity to all aspects of ORE and all sub-sectors of fishing (Table 3.4.1): American plaice, angel shark, basking shark (but no evidence in relation to ORE cables), blonde ray, bull huss, Icelandic cyprine, pink sea fan, short-snouted seahorse, starry smooth hound, thornback ray, turbot, witch flounder, ross worm reefs, sea-pen and burrowing megafauna communities, herring spawning beds, forage and juvenile fish, sub-tidal mussel beds, all MSFD priority habitats, European flat oyster.

Cuckoo ray, spotted ray and thornback ray have medium sensitivity to all sub-sectors of fishing and to ORE construction, but low sensitivity to operation of ORE cables and turbines. Tope has high sensitivity to all sub-sectors of fishing, but low sensitivity to all aspects of ORE, though confidence in the latter is low due to the limited evidence base (Table 3.4.1).

Edible sea urchins have low sensitivity to pelagic fishing and to fishing with static gear, but high sensitivity to aspects of ORE and to bottom trawling and dredging/beam trawling.

Barrel jelly has low sensitivity to ORE, fishing, and shipping (Table 3.4.1). While the barrel jellyfish scored a low sensitivity for all pressures, there is much more nuance to these scores (as there was for many other species). For example, in terms of resistance to the removal of target species or removal of non-target species, the barrel jellyfish was considered to have a medium resistance. For example, Elliot et al. (2017) stated that during a low abundance year, the extraction of 4.3 tonnes of jellyfish by the fishery (normal fishing levels), combined with the foraging requirements of two leatherback turtles would be enough to completely deplete the population. However, barrel jellyfish have a benthic polyp stage in addition to the pelagic medusa stage. The benthic polyp stage confers some resistance (and resilience) to the species as polyps continuously release new medusae year after year. So provided there is a healthy benthic polyp population, the jellyfish phase can withstand a certain level of exploitation (removal of target species).

Sensitivity to shipping is much more variable among features than sensitivity to ORE and fishing (Table 3.4.1). The following features have medium or high sensitivity to shipping-related pressures: basking shark, pink sea fan, short snouted sea horse, herring spawning beds, subtidal mussel beds, European flat oyster, and most of the MSFD habitats (all of those for which evidence is available). It is important to note, however, that for the benthic or demersal features (all but the basking shark), the sensitivity relates to pressures arising in and around ports rather than in shipping lanes in deeper water. Basking sharks are sensitive to vessel collisions.

The following features have low or no sensitivity to shipping: cuckoo ray, edible sea urchin, European eel, spotted ray and Ross worm reefs. For a range of features, there was insufficient evidence to make an assessment: American plaice, angel shark, blonde ray, bull huss, starry smooth-hound, tope, turbot, witch flounder, sea pen and burrowing megafauna communities, forage and juvenile fish, offshore circalittoral coarse sediments, offshore circalittoral mixed sediment.

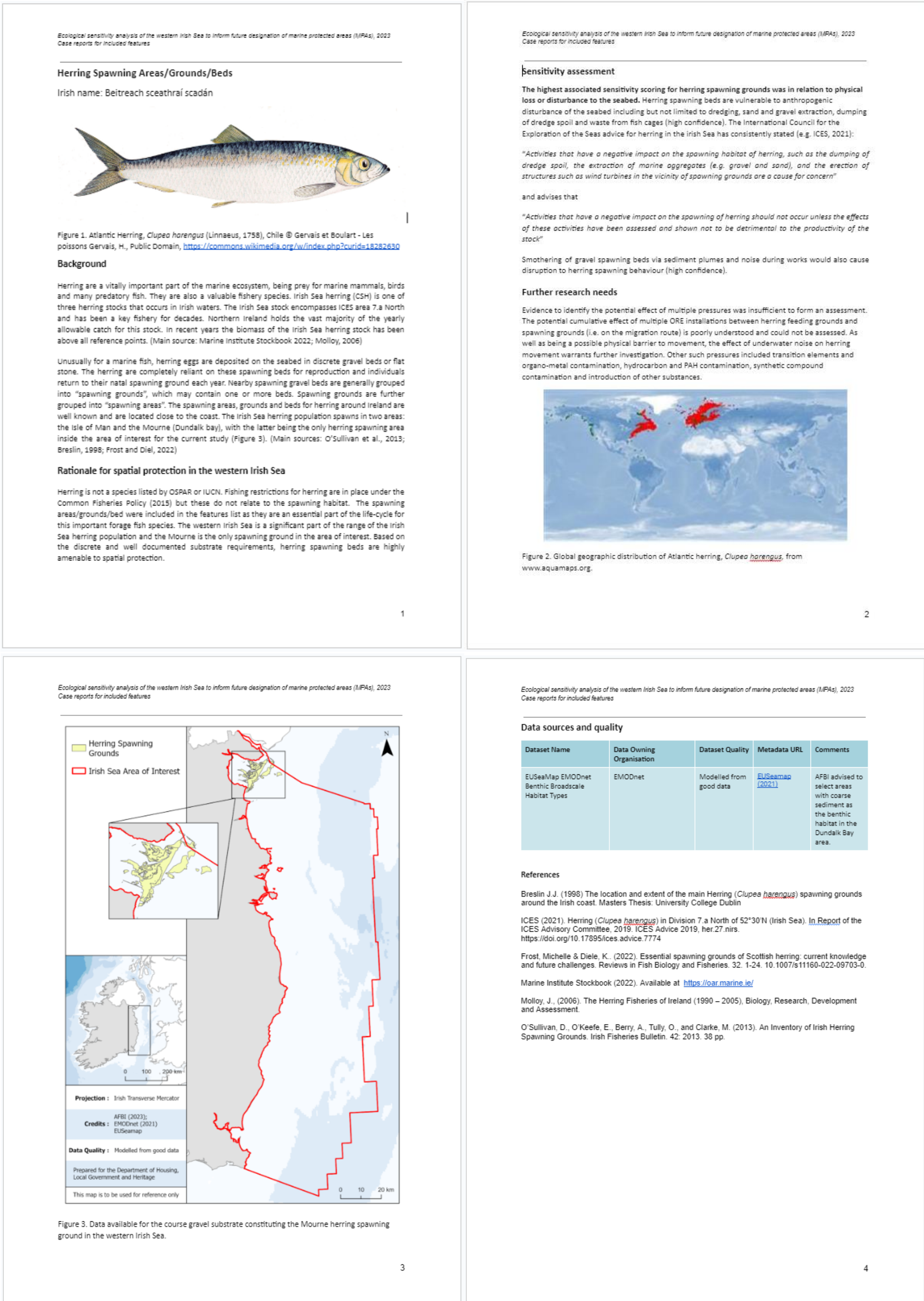
In general, evidence was of sufficient quality, applicability and concordance to enable a high level of confidence in 35% of the sectoral sensitivity assessments above. However, evidence is lacking about sensitivity to quite a few of the pressures for a considerable proportion of features and sectors, with low confidence for 24% of the assessments and insufficient evidence to make an assessment in 9% of assessments. Particularly notable is the general lack of evidence about the impacts of various aspects of ORE and the lack of evidence about the sensitivity of several features that are endangered or critically endangered, such as the angel shark and tope. The sensitivity of carbon sequestration as an ecosystem feature remains difficult to assess as processes causing carbon to either be released to the atmosphere after being suspended into the water column or to re-settle and be sequestered again on the sea floor remain poorly understood (see Case Report 38, Appendix 10). The research needs that arise from these deficiencies of knowledge are discussed in Section 4.5.

Table 3.4.1. Summary of sensitivity scores for each feature on a sector-by-sector basis. Sensitivity is assessed on a pressure-by-pressure basis in relation to each feature (Section 3.4.1, Appendix 5d). The scores below are the scores associated with the pressure linked to each sector to which each feature was most sensitive. The letters in brackets indicate confidence based on the quality, applicability, and concordance of the evidence: H = high confidence, M = medium confidence, L = low confidence (see Appendix 5d). Full individual sensitivity tables for each feature are available in Appendix 11, including a detailed assessment of confidence in the evidence base for each assessment. No sensitivity analysis was done for Dogwhelks, so they are not included in this Table. NS =not sensitive; NR = not relevant; NEv = insufficient evidence of sufficient quality to make an assessment.

	ORE construction	ORE operation (cables)	ORE operation (turbines)	Fishing: bottom trawling	Fishing: dredging/ beam	Fishing: pelagic	Fishing: static gear	Shipping
American plaice (long rough dab)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	NEv
Angel shark	Medium (L)	Medium (L)	Medium (L)	High (H)	High (H)	High (H)	High (H)	NEv
Basking shark	Medium (L)	NEv	Medium (L)	High (L)	High (L)	High (L)	High (L)	Medium (L)
Blonde ray	Medium (L)	Medium (L)	Medium (L)	High (H)	High (H)	High (H)	High (H)	NEv
Bull huss	Medium (L)	Medium (L)	Medium (L)	High (L)	High (L)	High (L)	High (L)	NEv
Cuckoo ray	Medium (L)	Low (L)	Low (L)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	NS (L)
Edible sea urchin	High (L)	High (L)	High (L)	High (L)	High (L)	Low (M)	Low (M)	Low (M)
European eel	Low (L)	High (H)	High (H)	High (H)	High (H)	High (H)	High (H)	Low (L)
Icelandic cyprine (ocean quahog)	High (H)	High (H)	High (H)	High (H)	High (H)	High (M)	High (M)	NR
Pink sea fan	High (H)	High (H)	High (H)	High (H)	High (H)	High (L)	High (L)	Medium (M)
Short snouted seahorse	Medium (M)	Medium (L)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (L)

Table 3.4.1 (contd.)	**ORE construction**	**ORE operation (cables)**	**ORE operation (turbines)**	**Fishing: bottom trawling**	**Fishing: dredging/ beam**	**Fishing: pelagic**	**Fishing: static gear**	**Shipping**
Spotted ray	Medium (L)	Low (L)	Low (L)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	NS (L)
Starry smooth hound	Medium (H)	Medium (H)	Medium (H)	High (H)	High (H)	High (H)	High (H)	NEv
Thornback ray	Medium (L)	Low (L)	Low (L)	Medium (L)	Medium (L)	Medium (L)	Medium (L)	Low (L)
Tope	Low (L)	Low (L)	Low (L)	High (H)	High (H)	High (H)	High (H)	NEv
Turbot	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	NEv
Witch flounder	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	NEv
Ross worm reefs	High (L)	High (L)	High (L)	High (L)	High (L)	Medium (L)	Medium (L)	NS (L)
Sea-pen and burrowing megafauna	High (H)	High (H)	High (H)	High (H)	High (H)	Medium (L)	Medium (L)	NEv
Barrel jelly	Low (M)	Low (M)	Low (H)	Low (H)	Low (H)	Low (H)	Low (M)	Low (M)
Herring spawning beds	High (H)	High (H)	High (H)	High (H)	High (H)	Medium (H)	Medium (H)	Medium (M)
Forage and juvenile fish	High	High	High	High	High	High	High	NEv
Sub-tidal mussel beds	High (M)	High (M)	High (M)	High(M)	High (M)	High (M)	High (M)	High(M)
Circalittoral coarse sediments	High (H)	High (M)	High (M)	High (M)	High (M)	High (M)	High (M)	High (M)
Circalittoral mixed sediments	High (H)	High (M)	High (M)	High (L)	High (L)	High (L)	High (L)	Medium (H)

Table 3.4.1 (contd.)	**ORE construction**	**ORE operation (cables)**	**ORE operation (turbines)**	**Fishing: bottom trawling**	**Fishing: dredging/ beam**	**Fishing: pelagic**	**Fishing: static gear**	**Shipping**
Circalittoral mud	High (H)	High (M)	High (M)	High (M)	High (M)	High (L)	High (L)	Medium (H)
Circalittoral sand	High (H)	Medium (L)	Medium (L)	Medium (L)	Medium (L)	Medium (L)	Medium (L)	Medium (L)
Infralittoral coarse sediment	High (H)	Medium (M)	Medium (H)	Medium (H)	Medium (H)	Medium (H)	Medium (H)	Medium (H)
Infralittoral mixed sediments	High (H)	Medium (M)	Medium (H)	Medium (H)	Medium (H)	Medium (H)	Medium (H)	Medium (H)
Infralittoral mud	High (H)	Medium (M)	Medium (H)	Medium (H)	Medium (H)	Medium (H)	Medium (H)	Medium (H)
Infralittoral sand	High (H)	Medium (L)	Medium (H)	Medium (H)	Medium (H)	Medium (H)	Medium (H)	Medium (H)
Offshore circalittoral coarse sediments	High (H)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	NEv
Offshore circalittoral mixed sediment	High (H)	High (L)	High (L)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	NEv
Offshore circalittoral mud	High (H)	High (M)	High (M)	High (M)	High(M)	High (L)	High (L)	Medium (H)
Offshore circalittoral sand	High (H)	Medium (L)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)	Medium (M)
Offshore circalittoral rock & biogenic reef	High (H)	High (M)	High (M)	High (M)	High (M)	High (L)	High (L)	Medium (H)
Carbon sequestration	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NR
Western Irish Sea Front	NR	NR	NS (L)	NR	NR	NR	NR	NR
European flat oyster	High (H)	High (H)	High (H)	High (H)	High (H)	High (M)	High (M)	High (M)



Ecological sensitivity analysis of the western Irish Sea to inform future designation of marine protected areas (MPAs), 2023
Case reports for included features

Herring Spawning Areas/Grounds/Beds

Irish name: Beitreach sceathraí scadán

Figure 1. Atlantic Herring, *Clupea harengus* (Linnaeus, 1758), Chile © Gervais et Boulart - Les poissons Gervais, H., Public Domain, https://commons.wikimedia.org/w/index.php?curid=18282630

Background

Herring are a vitally important part of the marine ecosystem, being prey for marine mammals, birds and many predatory fish. They are also a valuable fishery species. Irish Sea herring (CSH) is one of three herring stocks that occurs in Irish waters. The Irish Sea stock encompasses ICES area 7.a North and has been a key fishery for decades. Northern Ireland holds the vast majority of the yearly allowable catch for this stock. In recent years the biomass of the Irish Sea herring stock has been above all reference points. (Main source: Marine Institute Stockbook 2022; Molloy, 2006)

Unusually for a marine fish, herring eggs are deposited on the seabed in discrete gravel beds or flat stone. The herring are completely reliant on these spawning beds for reproduction and individuals return to their natal spawning ground each year. Nearby spawning gravel beds are generally grouped into "spawning grounds", which may contain one or more beds. Spawning grounds are further grouped into "spawning areas". The spawning areas, grounds and beds for herring around Ireland are well known and are located close to the coast. The Irish Sea herring population spawns in two areas: the Isle of Man and the Mourne (Dundalk bay), with the latter being the only herring spawning area inside the area of interest for the current study (Figure 3). (Main sources: O'Sullivan et al., 2013; Breslin, 1998; Frost and Diel, 2022)

Rationale for spatial protection in the western Irish Sea

Herring is not a species listed by OSPAR or IUCN. Fishing restrictions for herring are in place under the Common Fisheries Policy (2015) but these do not relate to the spawning habitat. The spawning areas/grounds/bed were included in the features list as they are an essential part of the life-cycle for this important forage fish species. The western Irish Sea is a significant part of the range of the Irish Sea herring population and the Mourne is the only spawning ground in the area of interest. Based on the discrete and well documented substrate requirements, herring spawning beds are highly amenable to spatial protection.

1

Ecological sensitivity analysis of the western Irish Sea to inform future designation of marine protected areas (MPAs), 2023
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Sensitivity assessment

The highest associated sensitivity scoring for herring spawning grounds was in relation to physical loss or disturbance to the seabed. Herring spawning beds are vulnerable to anthropogenic disturbance of the seabed including but not limited to dredging, sand and gravel extraction, dumping of dredge spoil and waste from fish cages (high confidence). The International Council for the Exploration of the Seas advice for herring in the irish Sea has consistently stated (e.g. ICES, 2021):

"Activities that have a negative impact on the spawning habitat of herring, such as the dumping of dredge spoil, the extraction of marine aggregates (e.g. gravel and sand), and the erection of structures such as wind turbines in the vicinity of spawning grounds are a cause for concern"

and advises that

"Activities that have a negative impact on the spawning of herring should not occur unless the effects of these activities have been assessed and shown not to be detrimental to the productivity of the stock"

Smothering of gravel spawning beds via sediment plumes and noise during works would also cause disruption to herring spawning behaviour (high confidence).

Further research needs

Evidence to identify the potential effect of multiple pressures was insufficient to form an assessment. The potential cumulative effect of multiple ORE installations between herring feeding grounds and spawning grounds (i.e. on the migration route) is poorly understood and could not be assessed. As well as being a possible physical barrier to movement, the effect of underwater noise on herring movement warrants further investigation. Other such pressures included transition elements and organo-metal contamination, hydrocarbon and PAH contamination, synthetic compound contamination and introduction of other substances.

Figure 2. Global geographic distribution of Atlantic herring, *Clupea harengus*, from www.aquamaps.org.

2

Ecological sensitivity analysis of the western Irish Sea to inform future designation of marine protected areas (MPAs), 2023
Case reports for included features

Figure 3. Data available for the course gravel substrate constituting the Mourne herring spawning ground in the western Irish Sea.

3

Ecological sensitivity analysis of the western Irish Sea to inform future designation of marine protected areas (MPAs), 2023
Case reports for included features

Data sources and quality

Dataset Name	Data Owning Organisation	Dataset Quality	Metadata URL	Comments
EUSeaMap EMODnet Benthic Broadscale Habitat Types	EMODnet	Modelled from good data	EUSeamap (2021)	AFBI advised to select areas with coarse sediment as the benthic habitat in the Dundalk Bay area.

References

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Frost, Michelle & Diele, K.. (2022). Essential spawning grounds of Scottish herring: current knowledge and future challenges. Reviews in Fish Biology and Fisheries. 32. 1-24. 10.1007/s11160-022-09703-0.

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4

Figure 3.4.1. Example of a case report: Herring Spawning Grounds. Case reports for all features are presented in Appendix 10.

3.5 Conservation prioritization

Conservation prioritization is the process of identifying areas which should be a priority for the protection of selected features (Wilson et al., 2009). Knowledge of the distribution of sectoral activity and the sensitivity of features to those sectors can inform sectoral trade-offs in the design of MPA networks. Software packages provide decision support for this process.

3.5.1 Methodology for conservation prioritization

In this project, two packages, Zonation and *prioritizr,* were used. Both take a set of conservation features extending across a gridded spatial area as input, and each generates an output which informs the conservation prioritization process.

What does Zonation do?

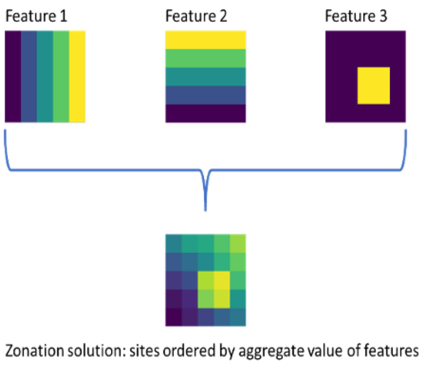


Figure 3.5.1. Schematic representation of Zonation cell ranking.

Zonation generates a priority ranking of locations based on the proportion of conservation features that are found at each location or grid cell. Zonation assigns the highest ranking to cells of the highest conservation priority. Figure 3.5.1 illustrates three conservation features on a 5 x 5 grid, in which brighter colours indicate where more of the feature is present. Zonation captures the gradients in Features 1 and 2, at the same time as emphasising the importance of the four cells where Feature 3 is at its high density.

What does *prioritizr* do?

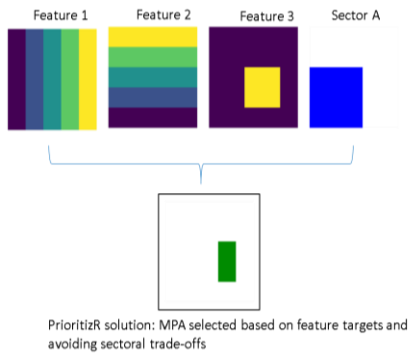


Figure 3.5.2. Schematic representation of *prioritizr* MPA network solution.

prioritizr generates a network of MPAs containing set proportions of features of conservation interest while minimising the selection of cells that are important to sectoral activities. Hence networks generated in *prioritizr* meet conservation objectives and consider the needs of stakeholders. Figure 3.5.2 illustrates the same features as in Figure 3.5.1 and an area important to sector A (marked in blue). *prioritizr* optimises the MPA design to capture set proportions of the three features while minimising MPA network overlaps with the activities of Sector A.

In summary

Zonation highlights areas of high conservation value, while *prioritizr* generates a practical solution showing how conservation objectives can be met while minimising overlap of MPAs with areas important to sectoral activities (see Appendix 5e for full details of the methodology used).

3.5.2 Conservation prioritization results

3.5.2.1 Zonation

The basic ranking of features with sufficient spatial data shows cells with conservation values throughout the region (Figure 3.5.3). There are several coherent areas of high conservation value (ranking towards 1, brighter colours) in the north of the region, along with scattered patches elsewhere. Pixels along the coastline are darker: indicating low priority. This of course reflects the absence of coastal species from the analysis, due in part to the feature selection process and in part due to data deficiencies. There were fewer features in the south of the region, where the brighter offshore patches highlight areas of offshore circalittoral rock and mixed sediment, habitats that are otherwise not widely distributed. In contrast, offshore circalittoral coarse sediment is broadly distributed, meaning that individual cells with this habitat contain less of the regional total and are therefore ranked as a lower priority (darker areas in the south and southeast).

The information for six further features (angel shark, bull huss, edible sea urchin, starry smooth-hound, tope, barrel jelly) did not suggest that critical areas for these species had been missed (Figure 3.5.4). The extra species are examples where there is some information on where the species is found, but this is not sufficient to be confident that the distribution of important locations is fully or mostly captured. This lack of confidence makes the species unsuitable for *prioritzr* analyses (as it is not clear what is captured by a target proportion of the distribution). However, the data might indicate if some key areas have been overlooked with the set of higher confidence feature maps. There was a strong positive correlation (0.91) between ranks in Figure 3.5.3 and Figure 3.5.4. However, it is important to recall that for these extra species (and for some other features), the survey effort and confidence may not be uniform over the region, so a lack of data could still leave some major areas unidentified.

Different features can be weighted by their sensitivity to explore whether there are cells that may be more impacted by specific sectors. Highly ranked cells for a particular sector indicate locations where the management of impacts should be prioritized for the conservation of the selected features. This approach incorporates the information from the sensitivity analysis (Table 3.4.1). In this project, highly sensitive features were weighted three times as heavily as low-sensitivity features. Except for shipping, weighting by sensitivity did not greatly alter the priority ranking of sites (Figure 3.5.5).

In general, deeper, offshore species and habitats are less impacted by shipping, so the Zonation mapping of sensitivity-weighted features for shipping places less emphasis on locations away from the coast. The correlations between the shipping sensitivity map and the maps for other sectors ranged between 0.61 and 0.65. Many features had either medium or high sensitivity to both fishing and ORE sectors. This results in similar ranking maps. ORE operations and bottom trawl rankings weighted for similarity in Figure 3.5.5 are clearly remarkably similar (correlation 0.99). Overall, the correlations among sensitivity-weighted ranking maps for the ORE sectors (construction, cabling, and turbine operation) and the fishing sectors (static, pelagic, bottom trawl and dredge/beam trawl) were high, ranging between 0.98 and 1. It should be noted that the overall sensitivity to each sector may be based on different pressures associated with them. As such, further consideration is needed to underpin potential management measures in the future (see Discussion).

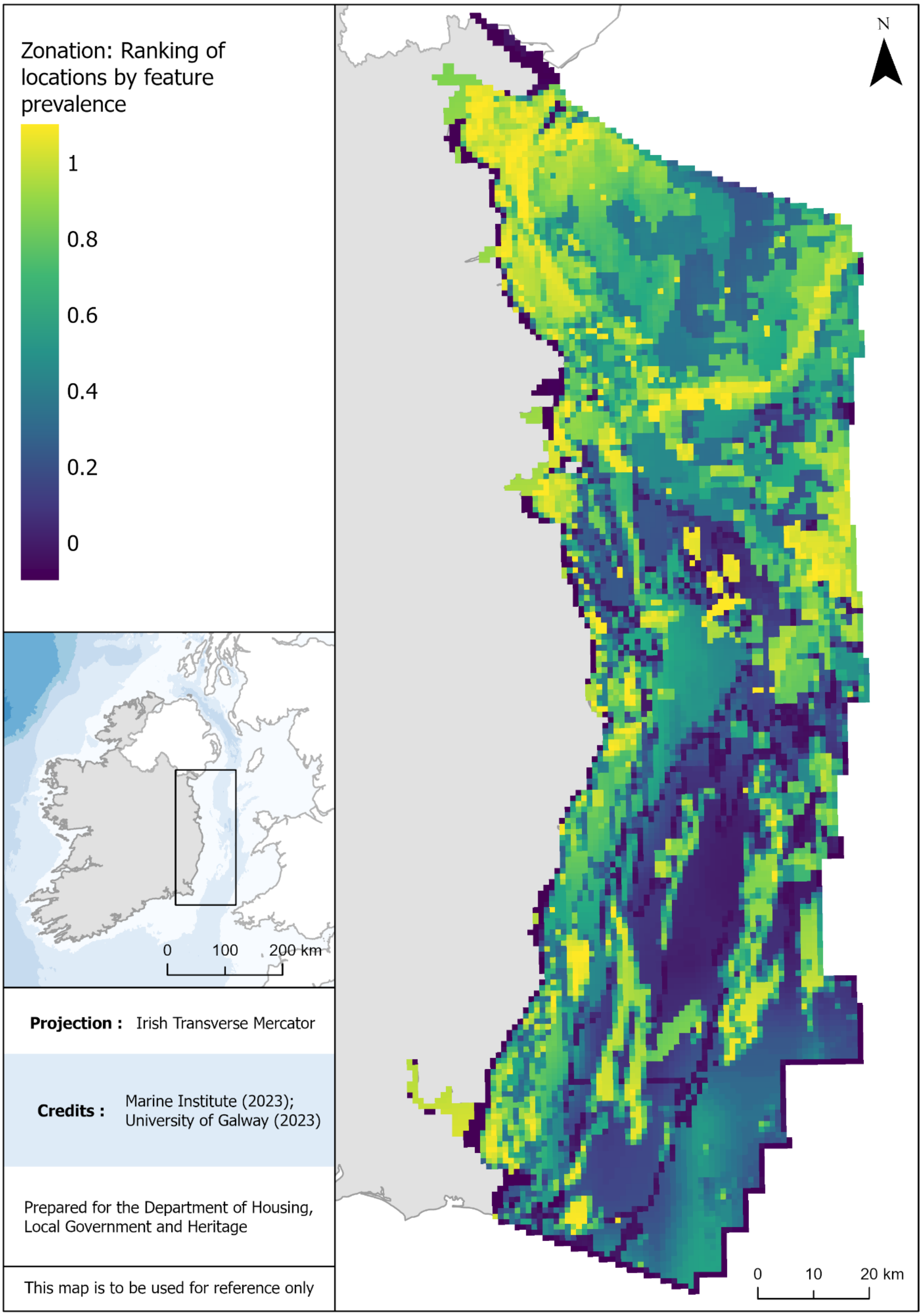


Figure 3.5.3. Ranking using Zonation of conservation value for 1km^2 locations, based on the 33 feature layers where data were suitable for analysis. Feature layers were weighted equally.

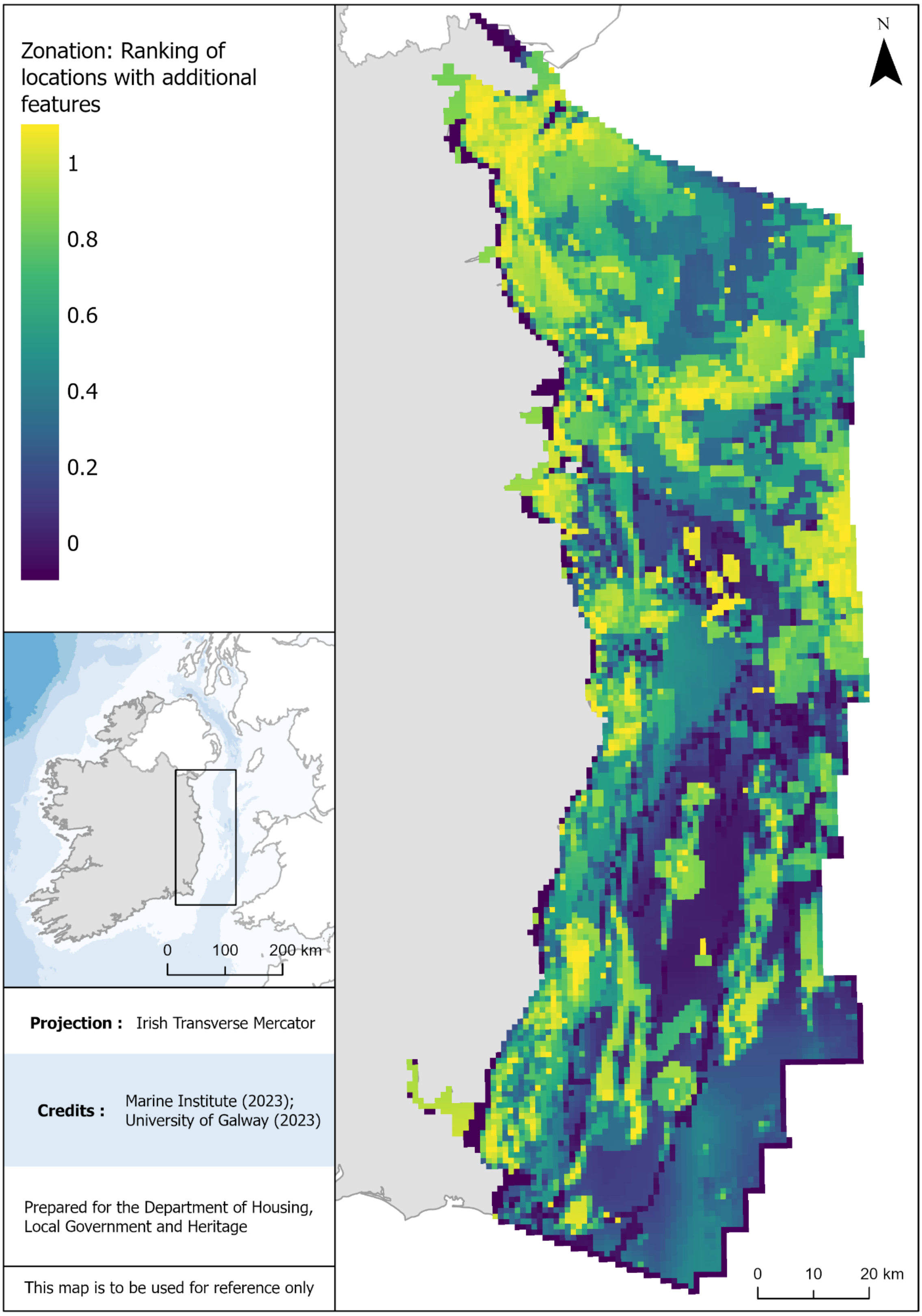


Figure 3.5.4. Zonation ranking of locations based on the main 33 feature layers with additional features included. Data for the additional features were considered incomplete or uncertain, so output shown in this figure has a lower level of confidence than in Figure 3.5.3. Additional features were: angel shark, bull huss, edible sea urchin, starry smooth-hound, tope and barrel jelly.

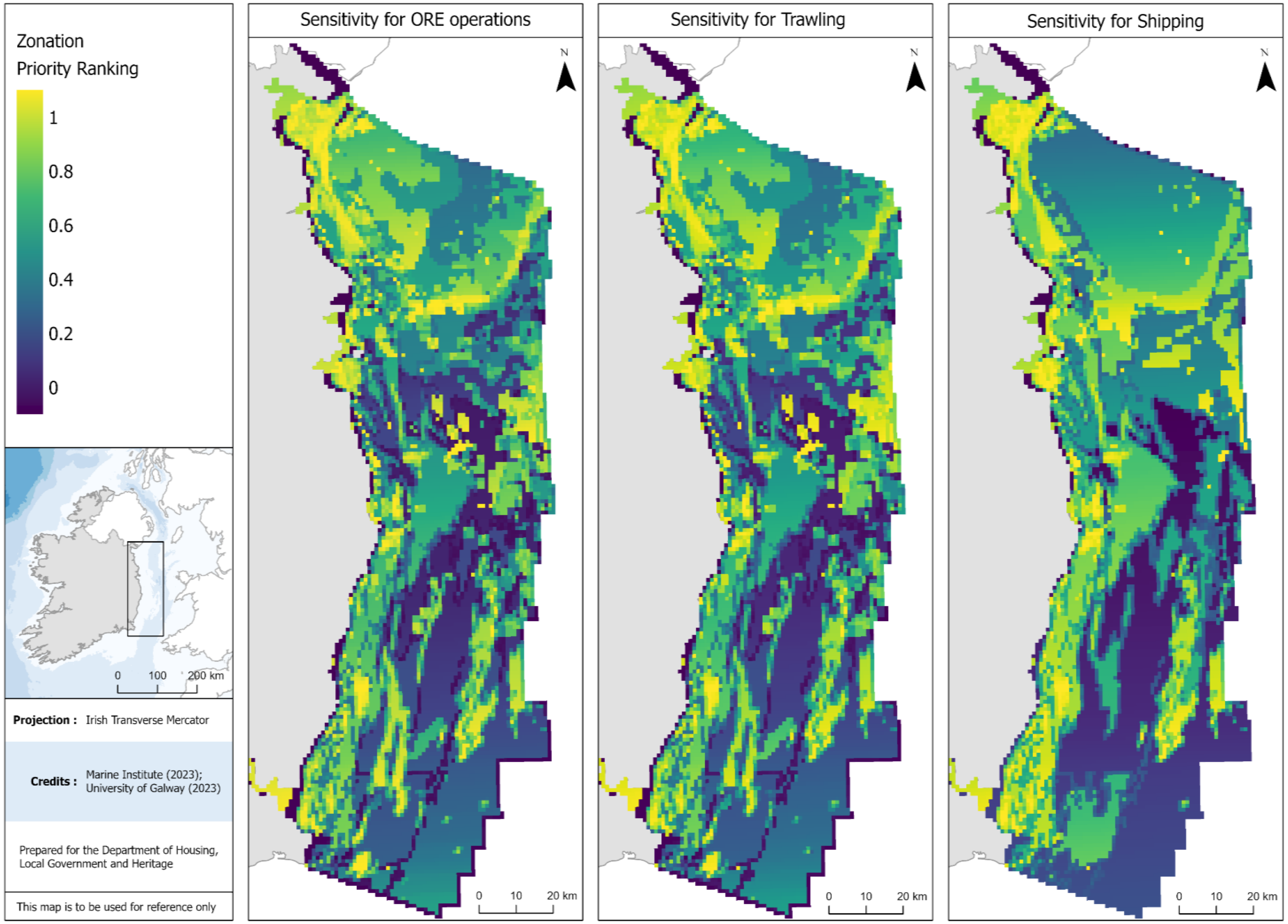


Figure 3.5.5. Comparison of Zonation ranking where sensitivity to selected sectors has been used to weight the importance of features. Brighter colours indicate higher prevalences of features that are sensitive to the named sector. The maps do not incorporate the spatial distribution of sector activity (see the next section on *prioritizr* for uses of this information). ‘Trawling’ refers to bottom trawling here.

The high similarity between fishing and ORE Zonation maps implies that it is difficult to find a trade-off where different sectors could be focused in separate areas to minimise the regional impacts on species and habitats. However, the relatively high sensitivities across all features for fishing and ORE partially reflect the methodology of taking the worst-case sensitivity from the pressures associated with the different sectors.

There are two ways by which sectors could be managed in a targeted way to minimise impacts. Firstly, the sensitivities in different sectors may reflect different pressures and/or may be more amenable to management actions in different sectors. Secondly, the activities of sectors will vary in intensity and spatial scale. There may be trade-offs and mitigations that could be implemented in specific cases and at certain scales that could minimise the combined spatial impact of all sectors. These sorts of detailed mitigations for sectoral impacts are likely to be quite case-specific and would require further research.

The top-ranked (brightest) cells in Zonation analyses indicate the most efficient capture of the selected features if no other constraints apply. These are locations that should be prioritised for spatial conservation. As the selection is optimised, the capture of features exceeds the actual proportion of the area selected: cells ranked in the top 10% contain an average of 46% of the distribution of individual features. For five features with low spatial coverage (basking shark, blonde ray juveniles, cuckoo ray juveniles, spotted ray juveniles and infralittoral mixed sediment), the top 10% of cell ranks in the unweighted Zonation analysis contain all the features' locations. Moving to the top 30% of ranks in Zonation captures an average of 75% of the distribution of selected features, with nine features where the entire range is within the top 30% of cells. The lower-ranked (darker) cells in Zonation do not contain important areas for the selected features and there would be less of a conservation impact if these areas were allocated to other uses. On average, the lowest 10% of cells in the Zonation ranking contain 1% of the selected features, with some features not found at all in the lowest ranked cells and those that remain broadly distributed habitats.

A comparison with existing designations emphasises the difference between the features in this report and previously considered conservation priorities: the existing SACs account for approximately 9% of the region and contain an average of 10% of the distribution of the 33 prioritised conservation features that data existed for in the current analysis. The important areas for the features in this report are therefore mostly outside the existing SACs.

Constraints on the selection of priority areas for protection can include additional considerations. The clumping of sites into coherent management areas and overlaps with the spatial distributions of activities in different sectors are explored in the following section using *prioritizr*.

3.5.2.2 *prioritizr*

The potential MPA network solutions that we present here always meet the targets that we set for the proportion of features included and represent a compromise between boundary lengths and sectoral activity values. Lower overlap with sectoral activities can be obtained by selecting very specific and sometimes discrete planning units (grid cells); for example only those illustrated by *Zonation* to have high value for biodiversity. However, a realistic and implementable solution requires planning units to be clumped. Where features are widespread, *prioritizr* has a wide range of potential solutions. Rare features however can cause certain cells to frequently appear in solutions, often not as part of a larger clump. For example, the presence of the Icelandic cyprine, a long-lived bivalve listed as Threatened and Declining by OSPAR, and to a lesser extent the presence of European Eels, drives the selection of a small 'potential MPA' near Howth in many of our solutions, and the presence of infralittoral mixed sediment, relatively sparse sediment in the Irish Sea, drives the selection of a small 'potential MPA' north of Wicklow, at Leemore Beach (Figure 3.5.6).

In most cases, we targeted an overall MPA network solution of approximately 30% coverage of the Irish EEZ within the Irish Sea. This was to provide a reasonable level of protection for the non-Natura 2000 (i.e., not Birds and Habitats Directive) features in the area while being mindful of general policy goals around area coverage. In the initially presented solution (Figure 3.5.6), the total potential MPA network area is 30.8%. It is based on targets of 28% distribution coverage for each feature, except the Western Irish Sea Front, the target for which was raised to 60% in recognition of the very important ecological role that fronts play (Section 3.1; Case Report 39, Appendix 10).

The initial MPA network solution (Figure 3.5.6) is generated against a sectoral activity layer combining the activities of six considered sectors. This combined solution (Figure 3.5.7) overlaps to varying degrees with sectoral activities, ranging from 7.9% for ORE (i.e., 7.9% of this sector's assumed activity [see methods, Appendix 5] falls within the MPA network solution) to 23.8% for fishing by bottom trawling. The higher overlap with the fishing industry likely reflects the wide footprint of this sector and the interplay between the fishing industry and the features considered important for conservation.

Independent widespread surveys are very important to inform where features for conservation exist outside fishing areas, as this could help to site MPAs with minimal overlap with the fishing sector. In this MPA network solution, the very large potential MPA in the centre of the area of interest has a higher overlap with sectoral activity than other potential MPAs in the network due to its size; it intersects most with fishing by bottom trawling. Surprisingly, the large potential MPA in the southwest of the area has a quite low overlap with the activities of most sectors, although the overlap is slightly higher with the static gear fishing sector.

It is, of course, possible to optimise a potential MPA network to decrease the overlap with a particular sector, but the disregard of other sectors understandably leads to greater overlap with these sectors. To illustrate this point, we set similar targets (slightly varied to always produce a solution with 30% overall coverage) but optimised the potential MPA network to minimise the overlap with the activities of each of the six considered sectors in turn. The different potential MPA network solutions have very low overlaps with the activities of the sector for which they are optimised (from 1% for ORE to 8.5% for fishing by dredge and beam trawling), but considerably higher overlaps (from 49% to 72%) with some other sectors (Figure 3.5.7).

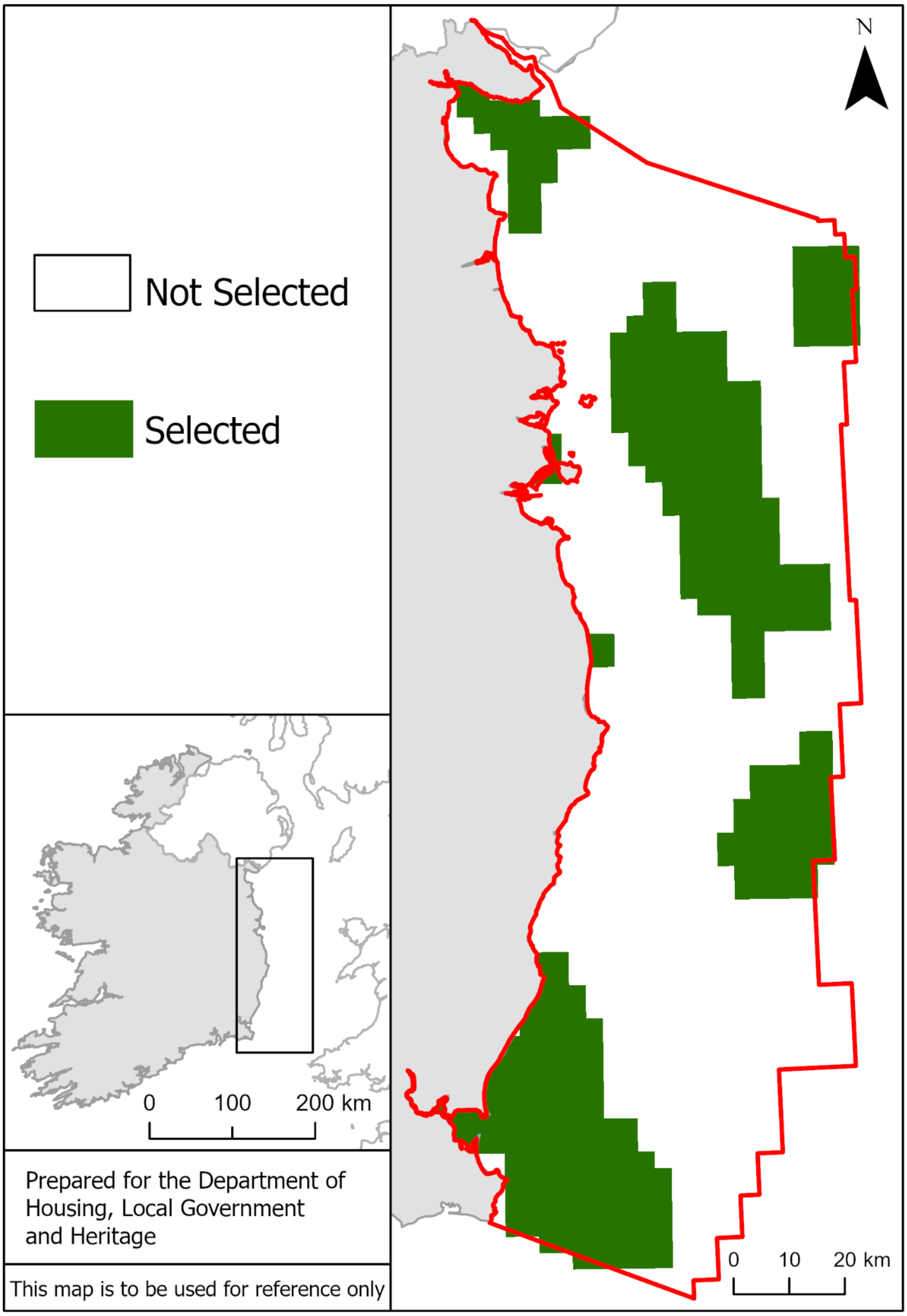


Figure 3.5.6. Initial MPA network solution generated using *prioritizr*. Network objectives: 28% coverage target set for all features except for the northwest Irish Sea front (60%), against a combined sectoral activity layer.

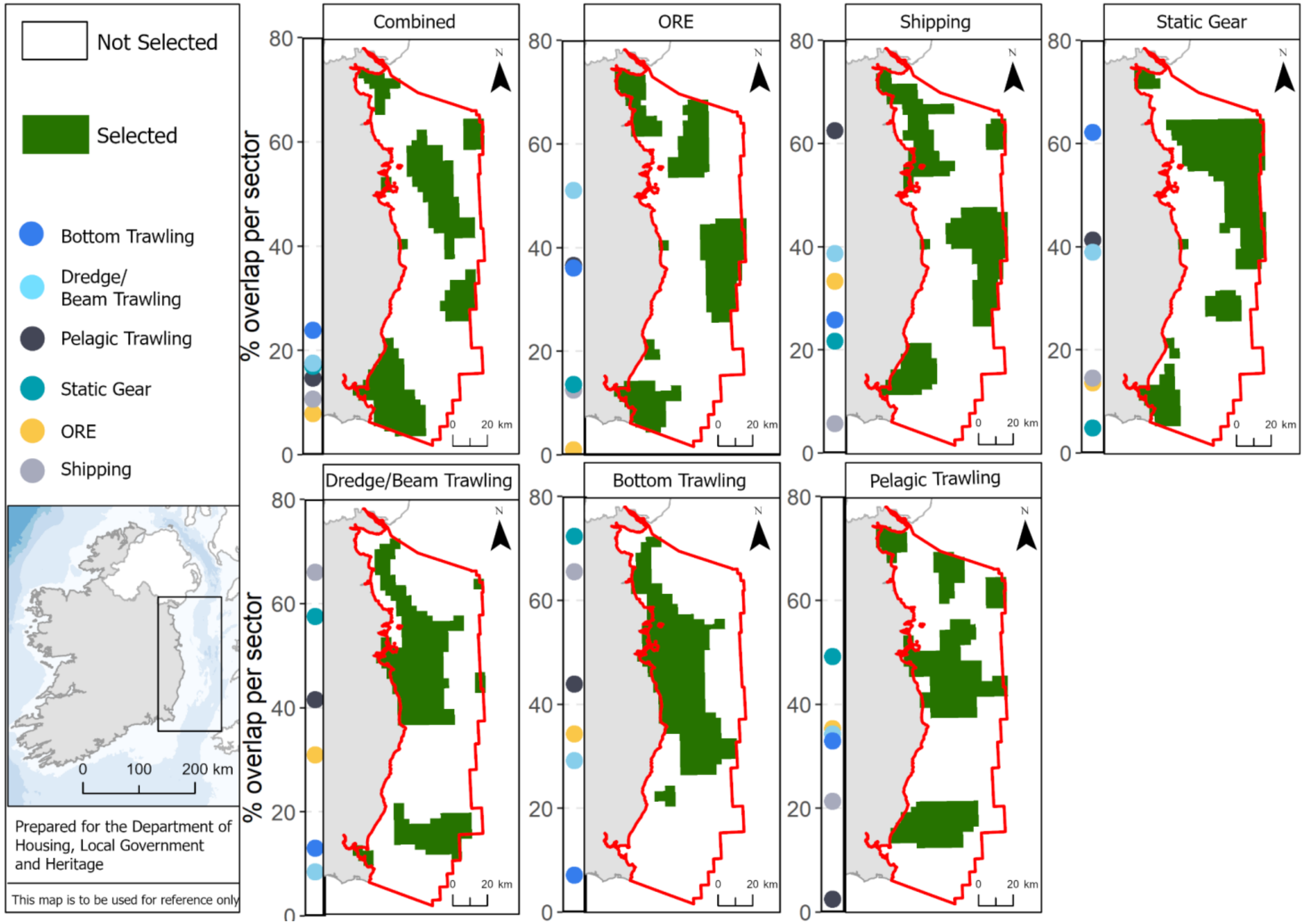


Figure 3.5.7. Optimising solutions to minimise the overlap of the MPA network solution with the activity of a single sector alters the network shape, substantially reduces the overlap with that sector, but considerably increases the overlap with other sectors. Each is optimised for a separate sector (indicated above) except the first map ('Combined') which was optimised for the activities of all sectors combined. Percentage overlap of the MPA network solution with sectoral activities is shown to the left of each map (as % overlap per sector).

There may be scenarios where policymakers wish to explore features of high ecological significance without consideration of sectoral activities. Setting targets of 30% feature coverage for selected features recognised for their high biodiversity value (i.e., fronts), ecosystem service (i.e., carbon sequestration), and ecological importance (i.e., herring spawning areas, forage fish) illustrates the ecological importance of the northwest Irish Sea (Figure 3.5.8). The potential 'costs' of such a potential MPA are high however, particularly to ORE and fishing where the overlap of the selected potential protected area with potential sectoral activities is 32.6%, with fishing by dredge and beam trawls (56%), pelagic trawling (58.2%), and fishing by bottom trawl (65.6%).

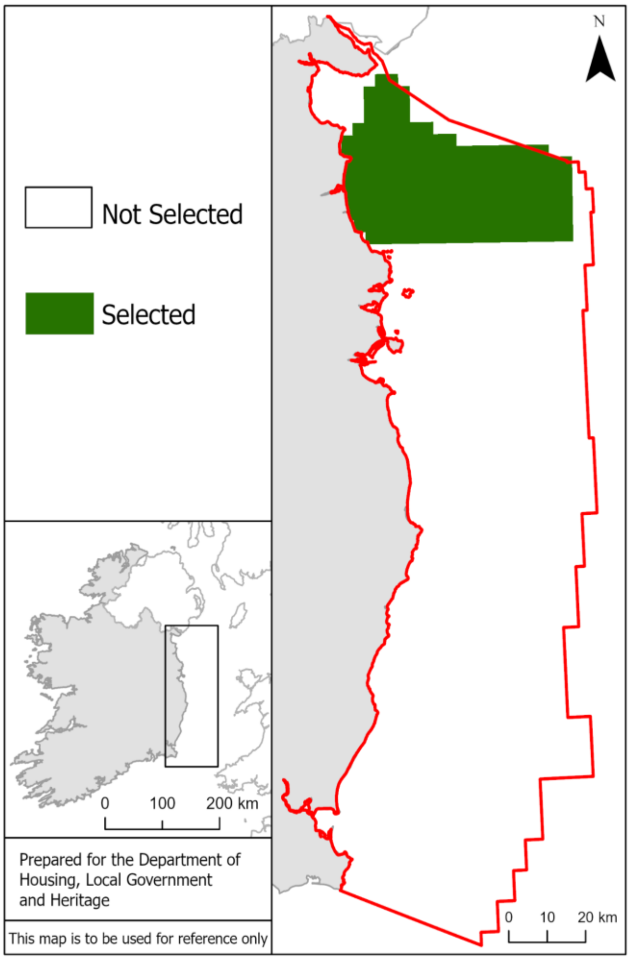


Figure 3.5.8. Ecological significance MPA network solution. Network objectives: 30% coverage target set for features recognised for their high biodiversity value (fronts), ecosystem service (carbon sequestration), and ecological importance (herring spawning areas, forage fish). Sectoral activity layers are not considered.

Alternatively, the focus may be on habitat representativity. An MPA network solution based only on the included MSFD habitats (target feature coverage 30%), and without considering sectoral activities, yielded a network with a large potential MPA in the southern Irish Sea (Figure 3.5.9). Potential 'costs' for all sectors were unsurprisingly high, with overlap between the MPA network solution and sectoral activities ranging from 17.8% to 45.3 %, with the potential MPA in the northeast of the area overlapping particularly with activities of bottom trawlers. The small potential MPA north of

Wicklow at Leemore Beach again results from the requirement to include infralittoral mixed sediment, which has a very limited distribution in the Irish Sea.

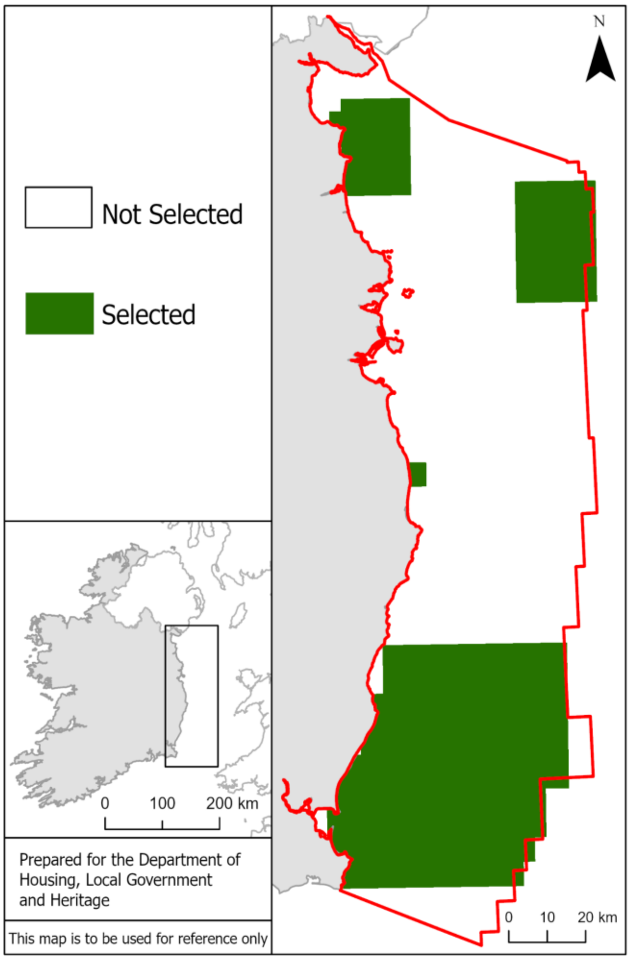


Figure 3.5.9. Habitat representativity MPA network solution. Network objectives: target coverage of 30% for MSFD habitats. Sectoral activity layers not considered.

The very straight boundaries in both the ecological significance and representativity solutions above reflect that sectoral activities were not considered, meaning that boundary length played a greater role in determining the potential MPA network solution.

We considered generating MPA network solutions for threatened species only and for biogenic habitats only, but we were constrained by the patchiness of some of these feature layers, which makes generating MPA network solutions difficult. In the case of threatened species, the patchiness is often a result of poor data. Increasing data quality through broad-scale survey work, supported by ground-truthed species distribution modelling, is essential for informing future MPA planning.

One way to consider the needs of threatened or declining species and habitats is to increase the targets for those threatened features (i.e., those listed by OSPAR or IUCN) for which good (and preferably non-patchy) data are available, and to leave all other targets as before. Herein, as an exemplar, targets were raised to 60% for juvenile and adult cuckoo rays, herring spawning grounds, witch flounder, and turbot, as the data for these features were of reasonable quality and there were good grounds for them to be considered threatened (Table 3.1.1). All other features (threatened and non-threatened) were included in the analysis at 28%, as in the initial potential MPA network solution (Figure 3.5.6). Some benthic habitats for which the data are good but inherently patchy (see below) were not given raised targets, because high targets for inherently patchy features are not compatible with generating a solution which would have fewer but larger and more manageable MPAs in the MPA network.

Although the MPA network solution (Figure 3.5.10) generated with raised targets for some threatened species had a slightly larger overall area (35%), it was not dissimilar to the first presented solution (Figure 3.5.6). The overlaps with sectoral activities were not dissimilar, although there were slightly higher overlaps with fishing sectors using gears causing bottom abrasion (bottom trawling, dredging, and beam trawling).

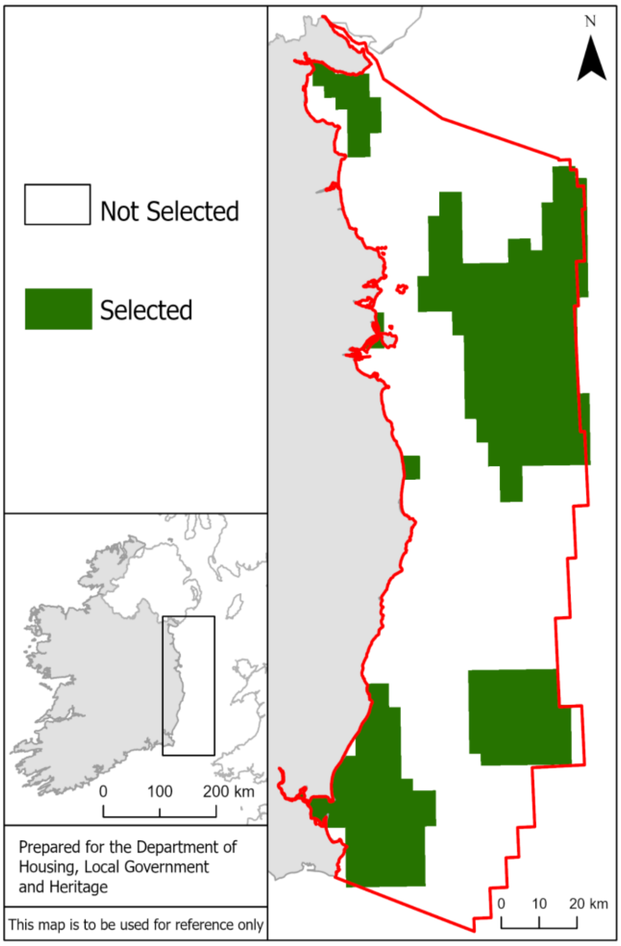


Figure 3.5.10. Higher targets for threatened features MPA network solution. Network objectives: target coverage of 28% for non-threatened features and 60% for selected threatened features, against a combined sectoral activity layer.

In the case of benthic biogenic habitats, the data are often better quality, but the inherent small-scale patchiness of the distribution of these features (i.e., < 1 km scale) means that when these features are considered alone, their distribution among widely separated planning units does not lend itself to clumped potential MPAs; at least not at the 3 km x 3 km grid scale across the entire Irish EEZ of the Irish Sea implemented here. Such features may merit consideration at a finer resolution.

The impact of these patchy features was explored by comparing the original potential MPA network solution (Figure 3.5.6) to one including the combined sectoral activity layer, but only the features included in the representativity and ecological significance solutions presented above. Targets for the MSFD habitats were set at 25%, and those for features of ecological significance at 40%, resulting in a solution with 30% coverage of the total area.

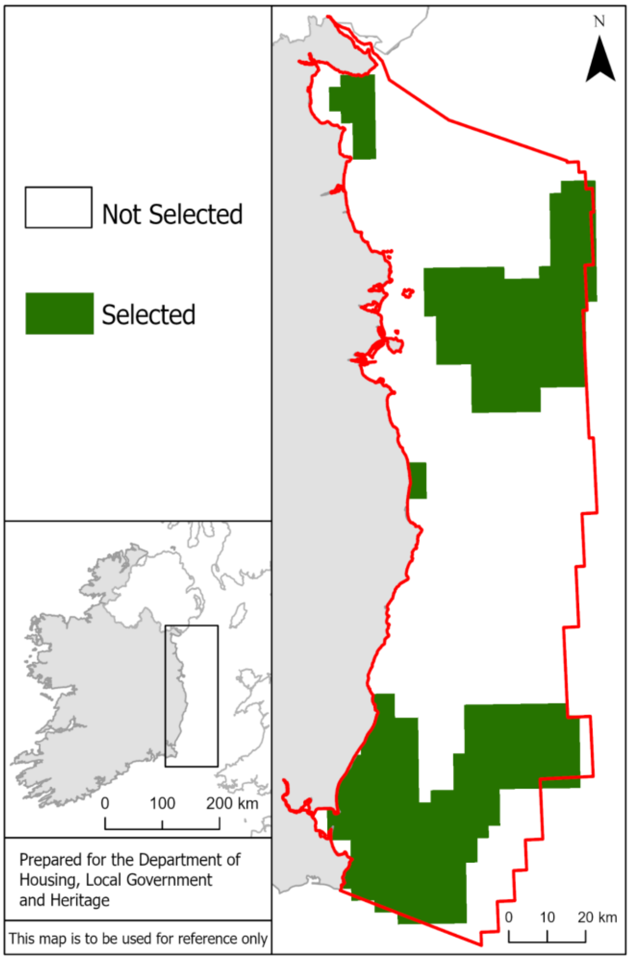


Figure 3.5.11. Pragmatic MPA network solution. Network objectives: target coverage of 25% for MSFD habitats, and 40% for features of ecological significance, against a combined sectoral activity layer.

The resulting solution (Figure 3.5.11) captured more than 25% of adult and juvenile cuckoo rays, adult blonde, spotted and thornback rays, basking sharks, turbot, witch flounder, ross worm reefs, and seed mussel beds. It also captured 9% of Icelandic cyprine, 11% of American plaice and 17% of sea pens and burrowing megafauna communities. It did not capture any estuarine eel habitat nor juvenile blonde or spotted rays. Nonetheless, it perhaps illustrates how including representative benthic substrates and ecologically important features can tend to capture other important features, and this could be a pragmatic way to tackle data-poor areas. The process requires high-quality habitat data for benthic communities, and ideally a suitable European Nature Information System (EUNIS) habitat level should be mapped and ground-truthed across the area.

The overlap of this MPA network solution with sectoral activities is low, ranging from just 2.2% for ORE to 16.8% for bottom trawl fishing, compared to 7.9% for ORE to 23.8% for bottom trawl fishing in the initial MPA network solution (Figure 3.5.6).

While our remit was to not consider features that are protected by the EU Habitats or Birds Directives, the potential impact of existing SACs on policy decisions needs consideration. Policymakers may find the extension of existing SACs as an attractive way to increase the MPA network. It could, for example, promote ecological coherence, by ensuring connectivity between features.

It is evident from our analysis that existing SACs do not capture the features considered herein well (see *Zonation* results), which is not surprising since the SAC sites were designated for the protection of different features. Existing SACs do capture some features well, particularly European eels, Icelandic cyprine, seed mussel beds, ross worm reefs, and infralittoral sand and mud. However, forcing a potential MPA network solution that incorporates them, and that has a total spatial proportion close to 30% captures much less of our targeted features than solutions which do not consider the position of existing SACs. To generate this solution (Figure 3.5.12) required coverage targets to be dropped to 15% (although we were able to maintain a higher proportion of the front feature). The proportion of many features within the proposed potential MPA network solution does in fact exceed the 28% target of our original solution (Figure 3.5.6). Four features have 21-27% representation, four have 16-20% representation, and three features have just 15% representation.

Another issue with this MPA network solution is the relatively high overlap with sectoral activities. The inclusion of Dublin Bay raises overlaps with the activities of the shipping industry to 67% due to that sector's heavy use of this area. The overlap of this MPA network solution with the static fishing sector and dredge/beam trawling is also high (46% and 42% respectively) because these sectors operate in areas relatively close to shore that are incorporated into this MPA network solution to ensure contiguity with coastal SACs.

It is also possible to lock SPAs into the MPA network solution at the outset, but the more areas that are locked in, the more difficult it is to obtain a useful solution. The best network that we could generate when also including SPAs had nine potential MPAs, several of which were quite small and isolated. Even the large potential MPAs had highly irregular boundaries.

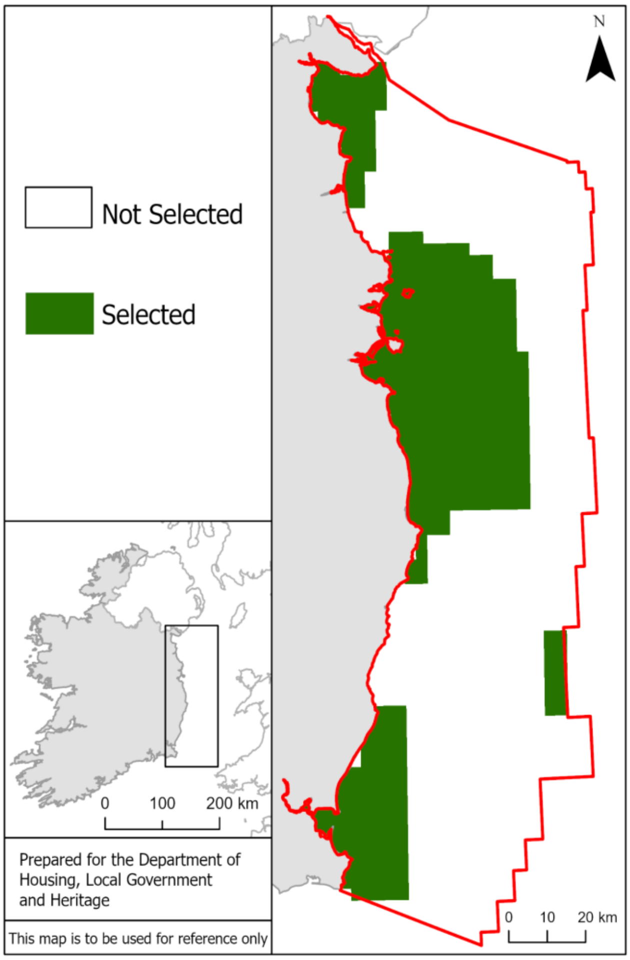


Figure 3.5.12. MPA network solution with SACs locked in. Network objectives: target coverage of 15% for all features except front (40%), against a combined sectoral activity layer.

Policymakers may also wish to generate a solution with less than 30% spatial coverage, to account for the area of protection already in place (currently approximately 9% in SACs and 5% in SPAs). A meta-analysis (O'Leary et al., 2016) reviewing 144 previous studies indicated on average 37% coverage by MPAs was required to meet six UN objectives on MPA networks, namely: (1) protect biodiversity; (2) ensure population connectivity among MPAs; (3) minimise the risk of fisheries/population collapse and ensure population persistence; (4) mitigate the adverse evolutionary effects of fishing; (5) maximise or optimise fisheries value or yield; and (6) satisfy multiple stakeholders.

With this knowledge we therefore do not advocate reducing overall targets, but we have included a solution that does this, as it would allow policymakers flexibility to immediately enact some protection, with the possibility of designating further areas in the future when the distributions of, for example, some threatened species, are better understood.

The initial potential MPA network problem (the solution for which is shown in Figure 3.5.6) was replicated but with targets reduced by 9% (equivalent to the SAC coverage of the Irish Sea) to just 19%, and the existing SAC areas locked out of the conservation prioritization process. This yielded a network solution with 22% total coverage (Figure 3.5.13).

Despite setting high boundary penalties, it was difficult to generate a cohesive solution. Most of the proposed potential MPAs are quite small and many have irregular boundaries. In relative terms (i.e., relative to the amount of area protected, costs are like the original solution). This could be repeated to also account for areas currently protected as SPAs, dropping feature targets even lower, but dropping targets to such low levels is not compatible with meeting ecological conservation objectives for the selected features. The overlap of some features considered herein with existing SACs (see above), coupled with the difficulty in generating a cohesive solution in this analysis, might suggest that locking SACs and/or SPAs out of the MPA network objectives is not useful. There is no scientific reason a new future network of MPAs cannot overlap with existing SACs and/or SPAs (see Section 4.6).

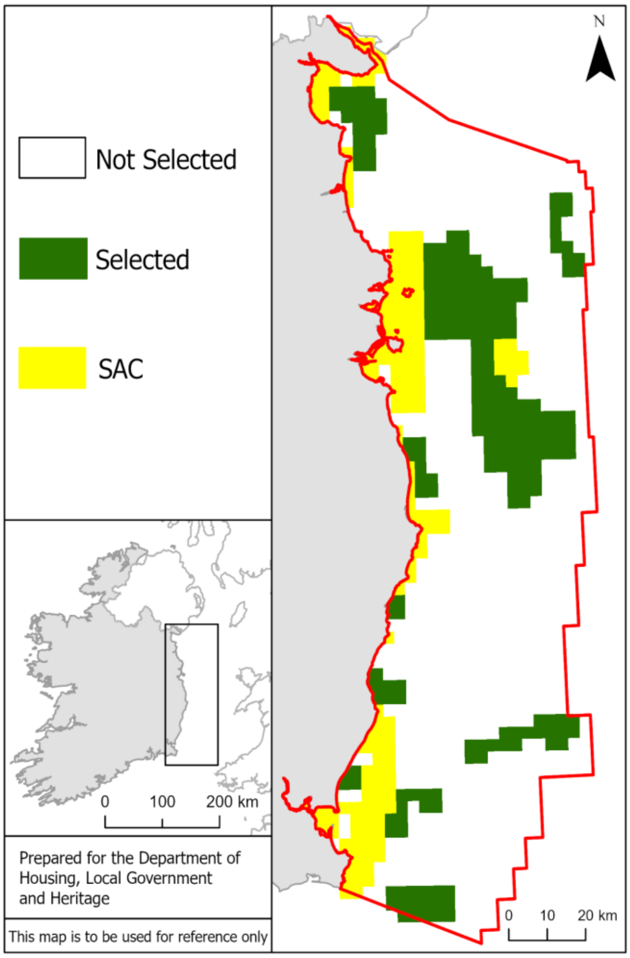


Figure 3.5.13. MPA Network solution with SACs locked out. Network objectives: target coverage of 19% for all features except front (51%), against a combined sectoral activity layer. Note that SACs are shown at 3 km x 3 km grid cell size and the actual footprint is slightly smaller than shown.

In addition to considering the balance of features and trade-offs with sectors, decisions about how to consider existing designations within a network should also consider the complementarity of management in several types of MPAs. Management regulations typically vary, with the majority of MPAs not currently preventing all human activities. This additional layer of complexity should be considered when moving on to the broader process of MPA identification and designation under the new legislation once it is enacted.

4 Conclusions and key recommendations

4.1 Comments on the process and its outputs

Overall, the process presented here was quite conservative in its selection of features. Only those features for which a clear objective basis for protection could be presented were selected. Many other features could be considered for protection in the western Irish Sea (including many of those in Appendix 6), but further deliberations and stakeholder engagement would be required to determine their suitability for inclusion. In addition, many other features in the Irish Sea that are already protected as part of Ireland’s Natura 2000 network under the EU Birds and Habitats Directives were not considered here, but these do need to be considered in combination with new MPA proposals as part of the future MPA process.

Due to its terms of reference, this work also had a particular emphasis on ORE and the other key sectors that operate in areas of the Irish Sea that have been identified as potentially suitable for ORE development. Less attention was paid to coastal areas or to sectors with less potential to occur in the same areas as ORE, such as the tourism and recreation sectors for example. There is also an inherent concern that with very limited information available for some species or other features, we were not able to identify areas potentially important to them, such that these areas may be at risk of being disturbed or damaged without even being known about. In this regard it is imperative that the evidence base is improved as quickly as possible to provide an even better basis for informed decisions, particularly for those species or features about which so little is known (see Sections 4.3, 4.4 and 4.5 below).

The project’s sensitivity analyses (a) enable an initial assessment of potential spatial incompatibilities between sectoral activities and conservation objectives relating to the selected features (and were used in that way in the conservation prioritization work), and (b) can form the basis for more detailed discussions in the future about management measures and approaches to mitigation, etc. In evaluating sensitivity, the process was designed to ensure that if there was potential for impact by a sector on a feature, it would be highlighted. In that way, potential impacts are not ignored at the outset of further discussions about management measures, including further discussions with stakeholders.

The sector-pressure matrix, for example, associates pressures with sectors if they have the potential to arise through that sector’s activity. This should not be taken as a definitive assessment of the pressures that are exerted by all parts of each sector. It may be that some aspects of that sectoral activity may not actually exert a particular pressure or could be modified to avoid exerting it or to exert it in a reduced form that could be considered sustainable. The approach taken here also makes no comment on the spatial extent of any impact that may arise. For example, the footprint of bottom trawling may be larger than the footprint of a wind turbine, but each may result in the same sensitivity score in relation to its potential impact on the sea-floor.

In assessing the sensitivity of a feature to a sector, we based that assessment on the highest sensitivity of any of the pressures it exerts. This makes sense because that would be the pressure that would define the level of sensitivity to the sector. The most important influence of bottom trawling on a seabed habitat, for example, should not be considered in terms of smothering and siltation changes (to which sensitivity may be low), but in terms of seabed abrasion (to which sensitivity may be high). Again, however, there may be scope to discuss and develop mitigation measures for some of the most potentially damaging pressures, and the sensitivity analysis provides a good starting point for those discussions.

In determining the sensitivity of MSFD priority habitats and ecologically important species assemblages (e.g., forage fish), we also took the conservative approach of setting the sensitivity for the habitat to the highest sensitivity of any one of its characterising species. The habitat would still be acceptably intact if one of the characterising species were greatly reduced in abundance, particularly if it was a comparatively unimportant species ecologically (e.g., not an ecosystem engineer or important food source). For future analyses, it may be appropriate to set the sensitivity of the habitat to the lowest sensitivity of, say, the most sensitive 20% or 25% of characterising species. It may even be appropriate to identify the characterising species that are most important ecologically and to focus on their sensitivity. This deliberative work was beyond the scope and capacity of the current project, but it could be considered in the future.

In developing the sectoral trade-off layers for the conservation prioritization work, we could only use readily available data, for example on fishing effort, as a metric of the value of a particular planning unit. These do give a good indication and can serve the intended purpose of enabling the model to identify areas of relatively low socio-economic value in which to recommend potential MPAs while still achieving the conservation targets. A full exploration of the actual (rather than the relative) cost and what to include as a "cost" (e.g., jobs, landed value, number of vessels) of restricting fishing in a particular planning unit would involve more detailed socio-economic analysis and discussion, including through consultation with fishers, local communities, processors, suppliers, etc. This kind of analysis would be needed to underpin a full evaluation of the trade-offs between sectors of activity and the economic, social, and cultural costs and benefits of proposed designations in the future (see MPA Advisory Group, 2020 and Section 4.2.3 below).

> *"A key concern is how we are taking sectors' interests. There is a clear lack of data regarding sectors' interests."* Paraphrased from a representative from the fishing industry.

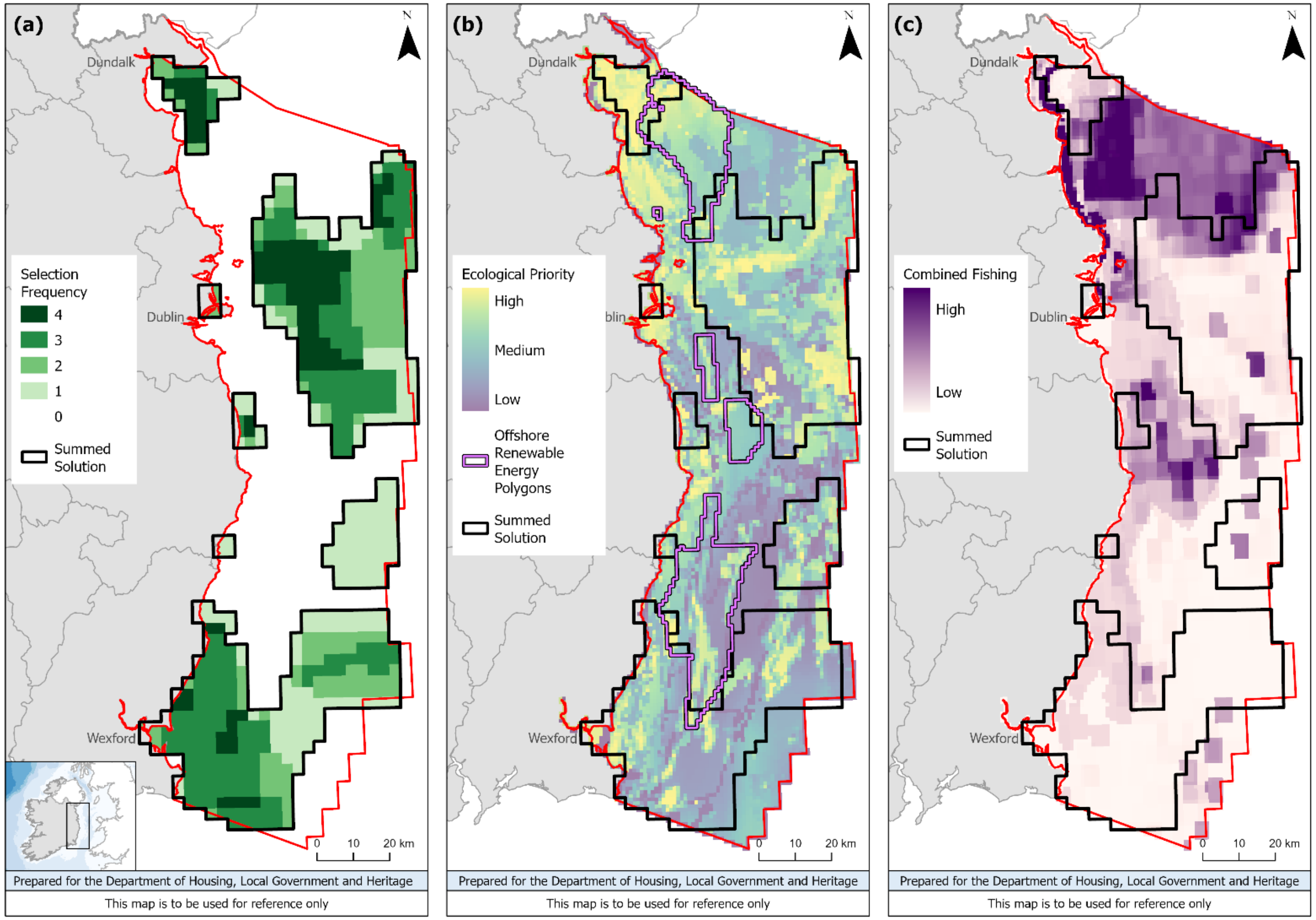
The setting of different overall targets (% of the distribution of the feature to be protected) or different targets across features obviously provides different potential MPA network solutions. In this respect, we have been more conservative in the case of ecologically significant features or for species whose conservation status is poor. Although there is a compelling case for setting very high targets for species that are already endangered, even then the potential MPA network solution for such features reflects their rarity (and resulting rarity of observations) rather than an aspiration for recovery to some, unknown, former 'less rare' state.

Overall, it is important to remember that this project had specific terms of reference. It was time constrained, based only on available evidence and had limited opportunities for stakeholder engagement within its narrow timeframe. The scientific and analytical work was nevertheless rigorous, and the recommendations are transparent and based on the best available evidence and the precautionary principle. It should therefore provide a legitimate basis to inform decisions in the coming months about ORE development in the western Irish Sea. It should also inform the full process of MPA selection that will be initiated in Ireland once the new legislation is in place. It provides some initial recommendations to consider and some potentially valuable protocols and procedures that could be applied in that context. It should, however, be seen only as contributing to that process, not as an alternative to it or to be pre-empting it.

4.2 Areas of low and high priority for protection

4.2.1 Consideration of areas of low priority for protection

Four potential MPA network solutions are presented here (initial, threatened, pragmatic, SACs out; Figures 3.5.6, 3.5.10, 3.5.11 and 3.5.13) that consider the same sectoral activity layers but consider features at different proportions. Layering these four solutions highlights areas that are selected in multiple potential MPA solutions (the 'summed solution') and areas that are never included in an MPA solution (Figure 4.2.1a). Although other solutions that select other areas are clearly possible, siting ORE development operations in areas outside the presented solutions guarantees the flexibility to implement an MPA network that can hit conservation targets. Placing ORE developments in areas outside potential MPA network solutions that also have a low cell ranking in the Zonation analyses, would further minimise the impact of ORE on the ecological features considered here (Figure 4.2.1b). The selection of many cells ranked highly by Zonation in MPA network solutions is apparent (Figure 4.2.1b), illustrating the importance of highly ranked cells to meet conservation targets. The areas with the greatest intensity of fishing activity also mainly fall outside the summed solution (Figure 4.2.1c).



Credits: Combined Fishing: ICES(2023), Marine Institute (2023); Offshore Renewable Energy Polygons: Department of Housing, Local Government and Heritage (2021).

Figure 4.2.1. (a) Combination of four potential MPA network solutions from conservation prioritization analysis for the selected species, habitats, and other ecological features. The white 3x3 km grid cells are not included in any of the four potential MPA solutions (score 0 indicated in the legend). Cells included in one, two, three or four MPA solutions (darker shades of green) encompass areas that could be considered for the protection of features. (b) Polygons that are subject to applications for ORE licensing overlaid with the summed solution from Panel (a) and the results of an additional prioritisation analysis showing the relative ecological importance of 1x1 km grid cells to the selected ecological features. Yellow cells contain important areas for the selected features (high ecological priority) and blue/purple cells have lower importance (low ecological priority). (c) Combined fishing activity overlaid with the summed solution from conservation prioritization shown in Panel (a).

Three of the conservation planning solutions presented in Section 3.5.2 have extremely high overlaps with sectoral activity (Figure 4.2.2). The ‘ecological significance’ solution and the ‘representativity’ solution have high overlaps because sectoral activities were not considered in the generation of these solutions. The solution forcing existing ‘SACs into’ the potential MPA network did consider sectoral activities, which suggests that integrating existing SACs into any future potential MPA network solution could be unnecessarily detrimental to the sectors using the Irish Sea since this solution also had an exceedingly high overlap with sectoral activities. The solution forcing ‘SACs out’ has a low overlap with sectoral activities, but the overall area of this MPA network solution was approximately two-thirds that of other solutions that considered sectoral activity, so this is not a better solution, but simply a smaller one.

Three solutions that captured 30% of the area had the lowest overlaps with sectoral activities. How sectoral activity layers are derived has major implications for the interpretation of these data, and this is discussed in more detail in Section 4.2.2 below. However, given the sectoral activity layers used, the ‘threatened features’ solution had low overlap with all sectors except bottom trawling, the ‘initial’ solution has slightly lower overlap with all sectors apart from ORE and static gears, and the solution based on representativity of MSFD habitats and features of ecological significance (the ‘pragmatic’ solution) has the lowest overlap with the fishing sectors and the ORE sector, but slightly higher overlap with the shipping industry. These could all be considered acceptable solutions from a conservation standpoint: the decision on which objectives to give precedence to lies with policymakers.

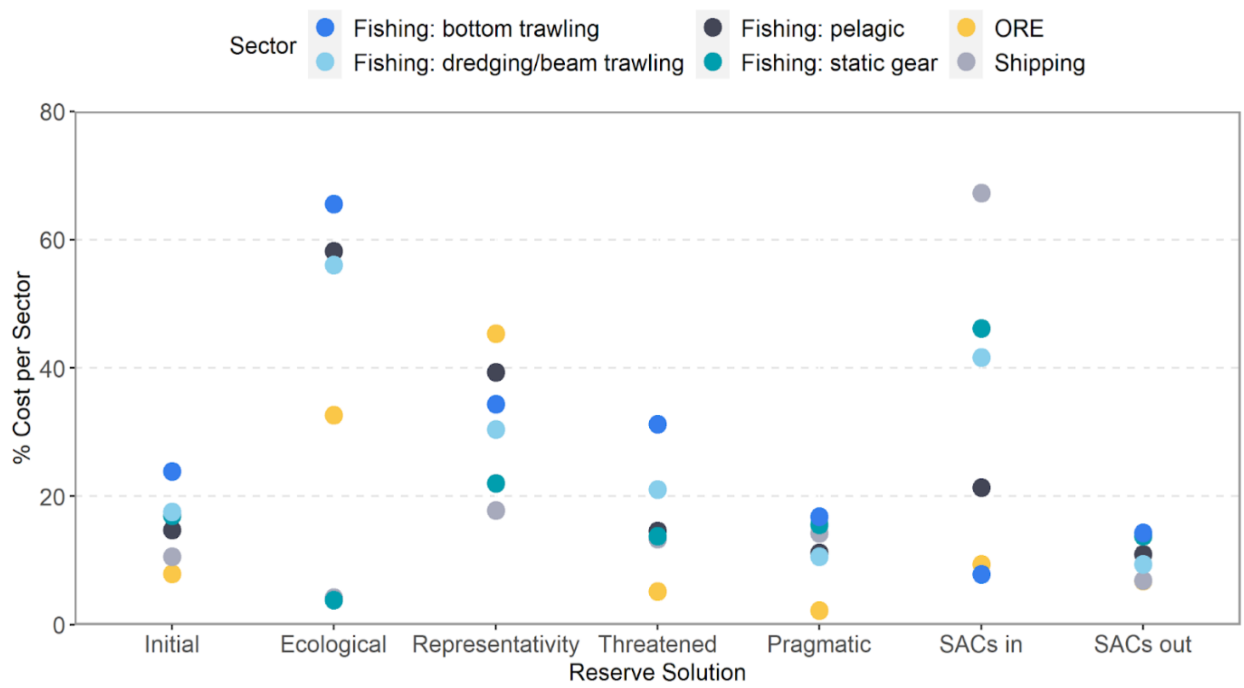


Figure 4.2.2. Comparison of sectoral trade-offs for each of the MPA network solutions presented.

4.2.2 Consideration of areas of higher priority as potential MPAs

The project's analysis identified areas off the east coast of Ireland from Dundalk Bay to Dublin, North of Wicklow and closer to Wexford, that contained a higher proportion of conservation features that were selected for prioritisation. Offshore areas of higher conservation priority existed in the south, central and northern parts of the region, with further areas of potential conservation value along the northeastern perimeter of the EEZ. These areas of interest are reflected in several of the *prioritzr* solutions, including the layering of different options in Figure 4.2.1.

The *prioritizr* suggestions include some consideration of trade-offs with the spatial distribution of sectoral activity. Further development around these solutions requires the broader engagement of the full MPA designation process, including stakeholder engagement and discussions on data gaps, impacts, unconsidered trade-offs, socio-economic and cultural considerations, detailed conservation objectives and management measures.

Areas in the northeast along the edge of the EEZ would be consistent with preserving an area for the critically endangered angel shark, while the area adjacent to County Wexford could include an area previously identified as important for the barrel jellyfish.

Outside the main areas of interest for conservation, there are locations of lower priority (darker in Figure 3.5.3) that are also areas where fishing activity may be lower (Figure 2.2.1). These are areas that may be suitable for avoiding sectoral conflicts when developing options for ORE.

If all the areas identified above are recognised as meriting interim protection at this point, it should be possible to find a final network solution by designating a subset of suitable areas within it during the MPA process.

Key messages

- A range of conservation prioritization MPA network solutions was presented (Figure 1.1.1, Figure 4.2.1). Although other solutions that select other areas are clearly possible, siting future ORE developments only in areas outside the summed MPA network solutions identified here gives the flexibility to implement an MPA network that can achieve conservation targets. However other key sectoral interests in the region, and fishing activity, need to be factored into the development of optimal MPA network solutions when the MPA process moves forward under the forthcoming legislation.
- As such, the conservation prioritization process suggests that four or five potential MPAs could be implemented within the areas of summed solutions to protect features of conservation importance in the western Irish Sea based on the targets set for their protection.

Recommendations

- Potential network solutions developed in this project should be incorporated into the development of MPAs as part of an expanded process involving stakeholder participation and other provisions of forthcoming MPA legislation and interacting with marine spatial planning for the region.

- Though subject to further considerations as outlined in Section 4.2.3, as an interim measure, fixed ORE developments should be situated outside the areas of the summed MPA network solutions developed in this project (Figure 1). This will enable future MPAs to achieve conservation targets for the features analysed in this report. Where possible, avoiding additional areas with high ecological priority (Figure 1) is also recommended to further reduce the impact of ORE on ecological features.

4.2.3 Further considerations in identifying areas for protection

For this project, measures of sectoral activity have been used to indicate any potential burden or cost for a given sector when including a planning unit in an MPA network solution. For the fishing sector, for example, maps of fishing effort were used to assign values to planning units in the sectoral activity layers. Had sectoral activity values been assigned based on monetary value, MPA network solutions would have differed. In many respects the decision on whether to use effort, employment, economic value of landings or other metrics per planning unit for the fishing sector is a policy decision. Most of the fishing fleet in the Irish Sea consists of vessels under 12m in length and the socioeconomics of this fleet is different from the larger vessel fleets working in deeper water for instance (Vega & Hynes, 2017). Social and cultural considerations could also be used to further alter the values assigned to sectoral activity. These are policy decisions that can be developed with further research and stakeholder engagement.

When developing activity layers, data were not available for all sectors at the same resolution. All vessels over 12m in length, for instance, have positional data at a 2-hour resolution from Vessel Monitoring Systems (VMS), while dredging vessels under 12m have data at a 10-min resolution. In the case of static gear vessels under 12m, the data used are based on polygons or general areas of activity with no indication of how fishing effort varies spatially within a polygon. Similarly, only broad-scale planning application data (i.e., general areas of interest) were available for the ORE (wind) sector. While higher-quality data may not yet be available, low-quality data can result in the true trade-off activity costs to a sector being inaccurately considered when running conservation prioritization exercises. In addition, the overestimation of the true footprint of a sector, which is typically the case when data resolution is low, makes finding an MPA network which satisfies all stakeholders more difficult, and in some cases, coarse data may overinflate the overlap of some MPA network solutions with ORE and some fishing activity.

All sectors were weighted equally in these analyses. It would be possible to run scenarios where sectors were weighted differently in the combined sectoral activities layer. Different weights could be investigated to generate solutions where the overlaps with each sector were equal in the solution for example. A similar exercise might weight industries by monetary value to the Irish economy. Such exercises, however, were beyond the scope of the current project and would be more appropriate within a full socio-economic analysis which could then feed into the prioritization process.

An understanding of data quality is hugely important for the prioritization process, and for selecting how to weight targets within that process. There is often a desire to set higher targets for the most threatened species, but distribution data for threatened species is often extremely sparse. Species distribution modelling might help fill some of those data gaps but it could be supplemented by animal tracking and other data to support ground-truth models (See Sections 4.4 and 4.5). Setting high targets with inadequate quality data could lead to the inappropriate selection of areas such that little conservation benefit is gained but with potential costs to sectoral activities.

The conservation prioritization approach presented here allows for many workable solutions and scenarios that policymakers and stakeholders might wish to see. The value of the outputs is dependent on the quality of the data used to generate them. In the present case, none of the data layers for the selected ecosystem features were of the highest quality category. Where spatial coverage of data is incomplete, the solution is constrained to where data exists, even though the feature might also exist elsewhere. The value in the systematic approach undertaken in this project, however, is clear; it is transparent, reproducible, can benefit from improved data and is understandable to stakeholders in its objective of finding solutions that minimise overlaps with sectoral activities. In this respect the process addresses some key comments from stakeholders during the project's engagement stages (Section 3.2.3.3); e.g., desire for co-existence with protected features, inclusion of sectoral activities in searching for solutions, while being "honest about the conflicts that are ahead".

It is recognised that there is a 30% target for spatial protection of Ireland's Maritime Area and that Natura 2000 sites (i.e., SACs and SPAs) are also contributing to that target. In this project focusing on the western Irish Sea, the 30% target was considered but it did not strictly constrain the analyses, which were based on seeking valid solutions for the focal features of the project. An ecologically coherent MPA network combining both Natura 2000 sites and new MPAs under national legislation will need to be developed (Figure 1.1.2) for the whole of the Irish Maritime Area, also taking account of sectoral and transboundary considerations. These considerations are further discussed in Sections 4.5, 4.6 and 4.7 below.

It is of note that this project has not considered the possibility of OECMs being designated for some features that are not sensitive to certain sectoral activities, thereby contributing to the 30% spatial coverage target such that the overall footprint of the MPA network overlaps with some areas of ORE and/or certain fishing activity, diminishing the overall sectoral trade-off necessary (see also Box 4.2.1 below – Critical considerations in relation to the fishing sector).

It should also be noted that specific management measures will need to be developed for each MPA that is proposed under the forthcoming legislation, depending on its specific conservation objectives. Although 'strict protection' will undoubtedly be merited for some features in some areas, for others the management measures may need to restrict only a subset of sectoral activities. Such measures can be informed by the types of sensitivity analyses presented here and by further discussion, including with stakeholders.

As indicated throughout this report, new evidence and wider stakeholder engagement would be required to give the best basis possible for the identification and proposal of MPAs in the western Irish Sea, and the development of management plans as part of their designation. Ultimately, the final decisions about which areas should be afforded protection lie within the future MPA process and, as highlighted in the MPA Advisory Group report (2020) and indicated in the General Scheme of the MPA Bill (2022), these should involve a process that includes ecological, economic, social, and cultural considerations.

Key messages

- Sectoral activity layers used in these analyses were essentially based on where the industries operate or would operate. This does not fully capture information to be considered in marine spatial planning or MPA designation and management, including the cumulative or synergistic effects of multiple pressures for example, and more detailed considerations of economic, social, or cultural aspects.
- Transparency and engagement are highly valued by stakeholders, as they can help to establish a strong connection and build trust between the scientific community, stakeholders, and end-users. Such a connection is essential for the successful implementation of MPAs.

Recommendations

- In the MPA process under the new legislation, expand the scope and representation of activities to allow a more nuanced consideration of economic, social, strategic, and cultural aspects of different sectors in decision-making processes.
- Continued and more widespread stakeholder participation at multiple levels, in advance and during the decision-making process, is recommended to enhance the overall process of MPA design and implementation and improve the success of the MPA network.

Box 4.2.1 Critical considerations in relation to the fishing sector

The fishing industry is an important stakeholder in the Irish Sea and parts of the region are home to high-value commercial fisheries, particularly for bottom-dwelling species. Generally, but with exceptions, commercial species were not included in the features list for conservation in the current project as they are managed through the procedures and provisions of the CFP. Nevertheless, the single and layered MPA network solutions proposed here had various activity trade-off costs for the fishing industry and its sub-sectors.

The sensitivity profile for fishing and ORE to the ecological features considered for protection here was similar, meaning that both industries could be similarly affected and therefore left to areas outside of the layered solutions. However, the activities that may or may not be compatible with potential MPA solutions are more nuanced than that and require further consideration, including engagement with fishers to clarify how individual fishing approaches within sub-sectors operate, and to establish the actual level of risk they pose to MPA features.

The features list considered here includes forage fish (including juveniles of commercial gadoids; cod, whiting, haddock), herring spawning grounds and several skates and rays which are currently not managed through individual TACs. Protecting these features can only have positive outcomes for fishing in the future. Reducing the mortality of juvenile fish is a conservation measure that is well-accepted in the fishing industry.

Various seabed sedimentary habitats were included in the MPA solutions and similarly, various proportions of such habitats also occur in the potential ORE areas considered in this project. These spatial protection solutions may have knock-on benefits to fishing outside of these areas and have additional ecological and climate benefits; spillover of mobile species or larvae of benthic sedentary species from MPAs or from ORE areas acting, effectively as OECMs, may occur.

If significant ORE projects are developed in the Irish Sea and if both fishing and ORE are restricted to areas outside of MPAs, the level of ‘spatial squeeze’ may be significant. We haven't considered ORE and fishing activity trade-offs outside of the layered MPA solutions presented in this report. Government policy is that ORE and fishing co-exist in such areas, although operationally it is yet unclear how this might work.

Fishing activity for all fleets was included in the analysis but with different levels of data quality, depending on the vessel size and type of gear used, for example. There is a clear need for high-resolution spatial data from the fishing sector if the effects of potential MPA solutions on fishing are to be accurately captured.

There are already good examples of the co-existence of fishing and protected areas (i.e., SACs, SPAs) in the Irish Sea. In Dundalk Bay, the cockle fishery adopts 5-year fishery management plans that explicitly consider the conservation objectives for these sites and adapt to what fishery and environmental monitoring data shows. Fishing activity and income have become more stable since the first plan was adopted in 2009.

4.3 Sources and levels of uncertainty

> *“I think communication on the data gaps and uncertainties presented by the current analysis will be important.”* Paraphrased from a representative of a government department.

The project was based on the principles of using the best available evidence and applying the precautionary principle where appropriate, as specified in the General Scheme of the MPA Bill (2022). As such, the project team sought to draw conclusions and make recommendations based on the data and knowledge that were available. Nevertheless, there were some features for which it was considered that the evidence base was insufficient to undertake an analysis or to make any recommendation. In most other cases, there were two primary sources of inherent uncertainty in the basis for conclusions and recommendations, due to the evidence available to underpin them. The first was the amount and quality of data on the distribution and nature of features in the western Irish Sea and the second was the level of knowledge of the biology, ecology and sensitivity of the features, as based on published scientific literature, unpublished reports and/or expert opinion.

To ensure transparency, assessments were made of the nature and quality of the data underpinning the conservation prioritization exercise (Section 3.1.1, Appendices 7 and 8) and of the confidence that should be placed in sensitivity assessments based on the quality, applicability, and concordance of the evidence available (Appendix 5d). These assessments were based on classifications and criteria, adapted from existing frameworks. Terminology linked directly to these classifications was developed to indicate data quality and confidence underpinning statements throughout the text and in figures and tables. This approach aligns with that used by organisations such as the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES). This is an important principle for researchers providing evidence bases for decision-making, and is part of the foundation for transparency, objectivity, and trust in the process.

Key data gaps and approaches to filling them are outlined in Section 4.4 below. Other research needs are highlighted in Section 4.5. Many of those research needs are related to sensitivity analysis and the level of knowledge about the impacts of pressures on conservation features. These gaps were identified after following the established MarESA protocol for sensitivity assessment, which entails a systematic approach to enable reproducibility and provide a clear trail of evidence.

In keeping with the MarESA protocol, the review of the evidence for features without existing sensitivity assessments was limited to a two-day period. Searches were conducted using a single search engine (Web of Science), which only retrieved peer-reviewed articles written in English. Not all peer-reviewed papers are accessible on the Web of Science, meaning that a literature search using another search engine might provide similar but not identical results. However, the MarESA guidelines allow the addition of key papers or grey literature that were not identified in the initial search, which is based on expert knowledge of the subject area. The rare cases in which this was applied introduced some subjectivity, e.g., which expert was consulted, what papers were considered key, etc. With more time these issues could be addressed but, under the circumstances, the impact on the overall outcome of the sensitivity analysis was minor.

The evidence base describing the potential interactions between sector-driven pressures and specific species was limited in several cases. The most accurate assessment possible was made with the evidence available but in some cases, in keeping with the precautionary approach, an additional degree of caution about potential yet unclear impacts was recommended. Equally, in cases where expert knowledge could not be used, pressures may have been classed as ‘No evidence’ and, therefore, not included in the conservation prioritization analyses.

Owing to time constraints and the scope of this project, identified pressures were treated as separate, rather than additive, synergistic or antagonistic in their impacts (Lyons et al., 2015; Piggott et al., 2015). Additionally, the intensity of the pressure and the frequency of its occurrence was not considered (e.g., in these sensitivity analyses, a feature would be considered similarly sensitive to a single dredging event in one year, or to multiple dredging events). These factors can considerably modify the impact of pressures on species, habitats and ecosystems (Lyons et al., 2015) and they should be given greater consideration in future analyses using emerging approaches to modelling their consequences (e.g., PlanWise4Blue, Kotta et al., 2020).

Key messages

- Transparency about the quality of the evidence base underpinning recommendations is an important consideration and can help to enable informed discussion and trust in the process.

Recommendations

- The frameworks provided in this report to indicate the quality of data and confidence in sensitivity assessments should be further developed and applied in future work on MPAs in Ireland, to help ensure clarity about the nature of the evidence base underpinning each decision and to identify areas requiring further research or examination.

4.4 Key data gaps

> *"One of the biggest concerns that this report can address is prioritising or identifying the need for certain data collection"* Paraphrased from a representative of a local authority.

This project identified that there is an urgent need to use a synoptic sampling approach to obtain an accurate picture of the population status and distribution of species and habitats in the Irish Sea. As a result of data insufficiencies, several features, including dog whelk, edible sea urchin and short-snouted seahorse, were deemed not suitable for inclusion in the conservation prioritization component of the work (Table 3.1.1) and a systematic data collection programme to bridge such data gaps is essential to increase data provision for all features.

Most species data used in this project were sourced primarily from fisheries, directly, or from fisheries-independent surveys designed to target demersal fish species, primarily gadoids. The resultant sampling data is not a true representation of the species range and does not capture the diversity of life present in the Irish Sea. The adoption of a combined monitoring approach that better captures the movements of a diverse range of species (including non-demersal, non-commercial and migratory species) could include the use of underwater cameras (e.g., baited remote underwater video to assess habitat and species presence and community composition), biotelemetry (animal-borne transmitters used to track fine-scale and broadscale animal movements), and eDNA (environmental DNA that can identify species presence/absence) and genetics (e.g., fin clipping to identify population connectivity and relatedness).

The adoption of a holistic monitoring approach is essential to understand the movements of critically endangered species in the Irish Sea, such as angel sharks and flapper skates. Recent empirical and anecdotal evidence indicates that the angel shark is not absent, as was thought, or is experiencing an increase in numbers in the Irish Sea. In either case, it is important that the increase in sightings is understood so the remaining population can be protected.

Priority should be given to the production of species distribution models (SDMs) for ecologically sensitive species that have sufficient data support to enable unbiased estimates of distribution, with an emphasis on ground-truthing the results with observed data. For example, modelled data was used to represent the distribution of elasmobranchs (i.e., sharks, skates, and rays) in the Irish Sea due to spatial and temporal gaps in direct observation data.

The distribution of habitats can only be described currently at a broad scale resolution and based on their physical (sedimentary) description. Although the habitat maps presented are of high quality with very high-resolution data support, they lack biological information on the structure and function of marine biological communities that occur in association with them. This information would result in more nuanced and more highly resolved information on the distribution of marine communities, that could then be the focus for conservation. Benthic biological surveys of the study area are needed to bridge this gap.

Some species of commercially caught fish were included in the feature list on the basis that they were not individually or effectively managed under current fisheries regulations. For instance, many elasmobranch species are included in or assigned generic TACs (i.e., total allowable catches). It was also discussed by the project team that in many cases where effective management of commercial species is in place, this affords such species sufficient protection. The future management of commercial species therefore could be directly through the CFP measures and these could include spatial protection measures on a case-by-case basis. For instance, accurate quantification and species identification of both landings and discards, or landings of unwanted catch, are key to assessing the true population status of sensitive and threatened species. For example, while bull huss (*Scyliorhinus stellaris*, a benthic shark species) is regarded as a species of Least Concern by the Irish Red List (Clarke et al., 2016), the latest ICES advice for the relevant stocks (ICES, 2021) could not quantify landings, catches or discards, with misidentification and categorisation of this species under other names including “dogfish” and “catshark”.

Some commercially exploited species such as sprat, for example, are not subject to rigorous scientific stock assessment at all, leaving us blind to their true status, as reflected in Ireland’s MSFD Descriptor 3 assessments for commercial fish (DHLGH, 2020). This assessment shows that the status of a sizeable proportion of stocks (i.e., 99 out of 177 assessed) is unknown and although a higher proportion of the assessed stocks are in good status, many assessed stocks are not. The dramatic changes in commercial fish biomass in the Irish Sea in the past 60 years (see Section 2) demonstrate that fishing or fishing in combination with environmental change can have ecosystem-wide effects and lead to the extirpation of individual species. Recent ecosystem assessments of the Irish Sea (Bentley et al., 2019) indicate a way forward for understanding change and the causes of change, one that has included stakeholder engagement and the application of fishers’ knowledge.

Key messages

- A main challenge presented for the systematic conservation prioritization analysis in this study was the limited availability of data, high-quality extensive spatial data, for the selected features.

Recommendations

- A systematic data collection programme should be established to increase data provision for all features that potentially merit spatial protection in the Irish Sea. Future work should also concentrate on the production of ground-truthed species distribution models for ecologically sensitive species.

- Clear data acquisition and management guidelines should be presented to ORE developers so that data collected during the development process is fit for purpose and can contribute to better decisions and more effective management of the ecological landscape. This information should be collated together in a single data hub that can be used by the state, public and commercial interests alike.

4.5 Other research needs

The work undertaken in this project highlights a need for targeted scientific studies to significantly improve our understanding of the fundamental biology and ecology of sensitive and vulnerable marine species and to identify areas of importance at their various life stages, in particular their breeding grounds and significant areas for juveniles (see detailed consideration of research needs for each feature in the case reports in Appendix 10).

This is the case, for example, for elasmobranchs (i.e., sharks, skates, and rays). The movements of highly migratory threatened megafauna including porbeagles and tope sharks in the Irish Sea require further investigation. Whether the western Irish Sea is an important area for feeding, breeding or simply an area transited through, remains uncertain. For example, local knowledge suggests that shallow sandy areas along the coast of Co. Wicklow may provide essential nursery habitats for pregnant tope sharks (*Galeorhinus galeus*). Tope tracking data from North America (Nosal et al., 2020) suggests triennial migration and philopatry (i.e., faithfulness to their birth area) of female sharks, which indicates that spatial protection of nursery sites may be an effective conservation measure.

Additionally, for less mobile elasmobranchs including commercially targeted species, the distribution of egg-lay and recruitment sites in the western Irish Sea requires additional study. Existing egg case data for this region is limited and poorly described, therefore a precautionary approach was adopted by the project to assess the sensitivity of juvenile skate and ray species. Further research and delineation of these areas could include data collection to support the development of habitat suitability models and ground-truthing the resultant potential egg-laying areas.

Of importance for many sensitive species are seasonal frontal systems which occur in the Irish Sea every year. The Western Irish Sea Front, which is part of the Irish Sea gyre, influences the abundance and distribution of plankton (including fish larvae) and important forage fish, which in turn influence the occurrence and ecology of larger predators. There is empirical evidence that Manx shearwaters use the front to forage and that blue sharks, basking sharks and ocean sunfish use other similar seasonal fronts as foraging areas (Scales et al., 2014).

Fisheries sampling and visual observations are important tools, but often cannot detect the association between a species and a frontal system. For example, tracking of basking sharks revealed a frontal association that overlapping visual observations failed to detect (Southall et al., 2005). Benthic rays and skates are also reported to aggregate at some fronts (Lucifora et al., 2012) and underwater video sampling could be used to investigate this further in the Irish Sea. The same systems are also capable of more generally mapping the substrate and prey field in a non-destructive way. Lastly, modelling predicts that climate change will create a warmer Irish Sea (+1.9° C), a stronger gyre, and more intense and prolonged surface warming annually (Olbert et al., 2012). These changes will alter the Irish Sea Fronts, impacting the habitat and distribution of benthic and pelagic species. Future studies must factor these changes into sampling and monitoring programmes to capture species' responses.

The prevailing science suggests that areas of the sea-floor that are dominated by mud-grade sediments can potentially store significant amounts of organic carbon, acting as a carbon sink and forming a key part of the carbon cycle (e.g., Atwood et al., 2020; Lee et al., 2019). This carbon stock can be disturbed by anthropogenic activity (e.g., ORE development, benthic trawling) potentially causing resuspension and remineralisation of carbon that can be released back into the atmosphere, through the water column (Avelar et al., 2017; Sala et al., 2021). Initially, quantifying carbon stock levels and qualifying carbon flow processes in less mobile marine sediments (i.e., mud) is a first-order need in terms of managing their disturbance (Luisetti et al., 2019; Smeaton et al., 2021).

The effective management of seabed areas in relation to sedimentary carbon disturbance will depend on the environmental settings as well as the chemical characteristics of the carbon (e.g., reactivity) (Epstein & Roberts, 2022; Smeaton & Austin, 2022). Depending on these factors, the resuspended carbon in the sediment could make its way into the atmosphere from the water column. Research is needed to determine whether this is the case in each water body such as the Irish Sea. Under the precautionary principle, a lack of direct evidence should not prevent us from making recommendations to offset the risk in the meantime, for example in relation to ORE and fishing causing abrasion of the seabed.

At present, our understanding of several pressures associated with multiple sectors (e.g., fishing, shipping and ORE development and operation) is limited. For example, current evidence suggests that the response of species to underwater noise may either result in attraction or repulsion depending on factors such as the species-specific life history characteristics, the animal's life stage, and the frequency (of occurrence, and signal frequency) and strength of the sound signal (Mickle et al., 2020; Cresci et al., 2023). How aquatic species respond to and are impacted by sector-specific noise requires further investigation across a range of marine animal groups. The resulting data could be used to inform the development of mitigation or adaptive approaches to effectively reduce the impact of underwater noise, e.g., using bubble curtains to attenuate noise associated with ORE pile driving during the construction phase (Dähne et al., 2017). Collection of such data is particularly important given that the western Irish Sea is a shallow water environment (<120m deep), which may potentially compound noise effects for aquatic species.

The known negative environmental impacts of ORE development, primarily offshore wind turbines, are generally placed into six broad categories: 1. changes to atmosphere and ocean (water flow changes), 2. noise pollution, 3. electromagnetic fields (EMF), 4. habitat modification (change of habitat type), 5. barrier effects, and 6. water quality (chemical pollution) (Farr et al., 2021; Gill et al., 2020; Hammar et al., 2015). Evidence from existing wind farms would suggest that the environmental impact from these pressures has not been as severe as initially predicted (Inger et al., 2009; Wilson et al., 2010; Wilson & Elliott, 2009). However, there are concerns that current monitoring and research programmes have a narrow ecological focus that is poorly aligned with real ecosystem processes at relevant spatial and temporal scales, and may therefore lack the ability to detect ecosystem change (Dannheim et al., 2020; Maclean et al., 2014; Wilding et al., 2017).

Our level of understanding of these six categories is varied. Offshore wind farms have been operational for almost 10 years in the North Sea and long-term monitoring indicates that reef-associated fish (e.g., wrasse, pouting) can benefit from the presence of the turbines (as structures promoting the formation of artificial reefs). However, larger mobile species (e.g., plaice) have not increased in abundance inside wind farms that have been closed to commercial fishing (Mavraki et al., 2020, 2021). In contrast, our understanding of how wind farms will change the atmosphere and ocean is poor and is based primarily on modelling studies at present. The wake and turbulence created by wind turbines (whether fixed or floating) may have implications for the pelagic ecosystem within hundreds of metres from the structures and as far as 60km from the windfarm itself (Carpenter et al., 2016; Christiansen et al., 2022; Ludewig et al., 2015). The current evidence would suggest that localised turbine wakes dissipate rapidly, and the large-scale oceanographic changes do not exceed natural variation, and therefore might not impact dynamic and ecologically prominent features like the Western Irish Sea Front (see case report 39, Appendix 10). Nonetheless, resuspension of sediment and vertical mixing, particularly in seasonally stratified areas of the Irish Sea may increase coastal darkening and impact primary productivity, with negative implications for carbon sequestration (Blain et al., 2021).

Key messages

- Significant knowledge gaps exist in relation to the biology and ecology of many important and threatened species, habitats and other features and their sensitivity to many sectoral pressures. These gaps may result in inefficiencies in policy and decision-making, such as conservation actions being targeted in suboptimal locations and management measures being unnecessarily or insufficiently restrictive.

Recommendations

- The prioritisation of research is recommended to fill recognised knowledge gaps on priority species, habitats, and other features, and to better characterise feature sensitivity to key sectoral pressures.
- End-to-end ecosystem models should be developed which can incorporate biological, physical, and socio-economic features of the marine environment to provide insight into how these components may interact under selected scenarios of change.

4.6 Interaction with Natura 2000 network sites

While the qualifying features covered by the Natura 2000 sites (i.e., SPAs and SACs under the EU Birds and Habitats Directives, respectively) (Appendix 3) were not considered under the current study, there are at least two ways in which the processes are inextricably linked and complementary: spatial overlap and wider ecosystem functioning.

Spatial overlap. Natura 2000 sites have and will be chosen based on a set list of species and habitats which must be protected, as set out in the Annexes of the Habitats and Birds Directives. As shown above, however, there are numerous other ecologically sensitive features that may warrant protection in Irish waters and some of these also occur within existing Natura 2000 sites but yet do not come within the scope of the Directives. By layering the features considered in this analysis with existing Natura 2000 sites (Figure 4.6.1) it has been possible to identify cases where additional sensitive features could be afforded protection in Natura 2000 sites through 'double badging' (using a combination of National MPA legislation and the EU Habitats or Birds Directives).

Wider ecosystem functioning. The Irish Sea can be thought of as a large ecosystem, with all species and habitats linked in some way and depending on and contributing to ecosystem processes that can influence the system. SPAs for certain nesting and foraging seabirds are already in place in the western Irish Sea and some SACs are also designated for certain marine habitats and mammals. However, the measures put in place under these designations pertain to the listed features themselves (or the habitat required by the species at a certain life stage) and not necessarily the wider food web or habitats on which the species rely. Although 'site integrity' is a key aspect in assessing the effects of activities on these features and implies the need to protect ecosystem functioning, explicit identification of key aspects of ecosystem functioning for species would improve their protection. By including ecologically important species assemblages (i.e., forage fish) or physical features (i.e., Irish Sea Front), the current study has identified areas that, should they be protected, could supplement feature protection in the Natura 2000 network, and thereby benefit the species and habitats protected by it. Forage fish are a key prey item for birds and mammals in the Irish Sea and the integrity of the Celtic Sea Front is also important for large pelagic animals. Similar arguments could be made for the marine stage of certain anadromous fish that fall under the Habitats Directive and have protected freshwater sites, but for which data on their location while at sea and their amenability to spatial protection during that life stage is sparse.

In these ways, the processes of designating and managing sites under these two frameworks - Natura 2000 and MPAs under the new MPA Bill - can be considered complementary. Strong communication and coordination between the government authorities responsible for these different designations are necessary to maximise the degree of ecological coherence and mutual benefit that can be achieved, and to ensure that the wider consequences for society and the economy can be considered in an holistic way in order to maximise overall benefits and minimise negative impacts.

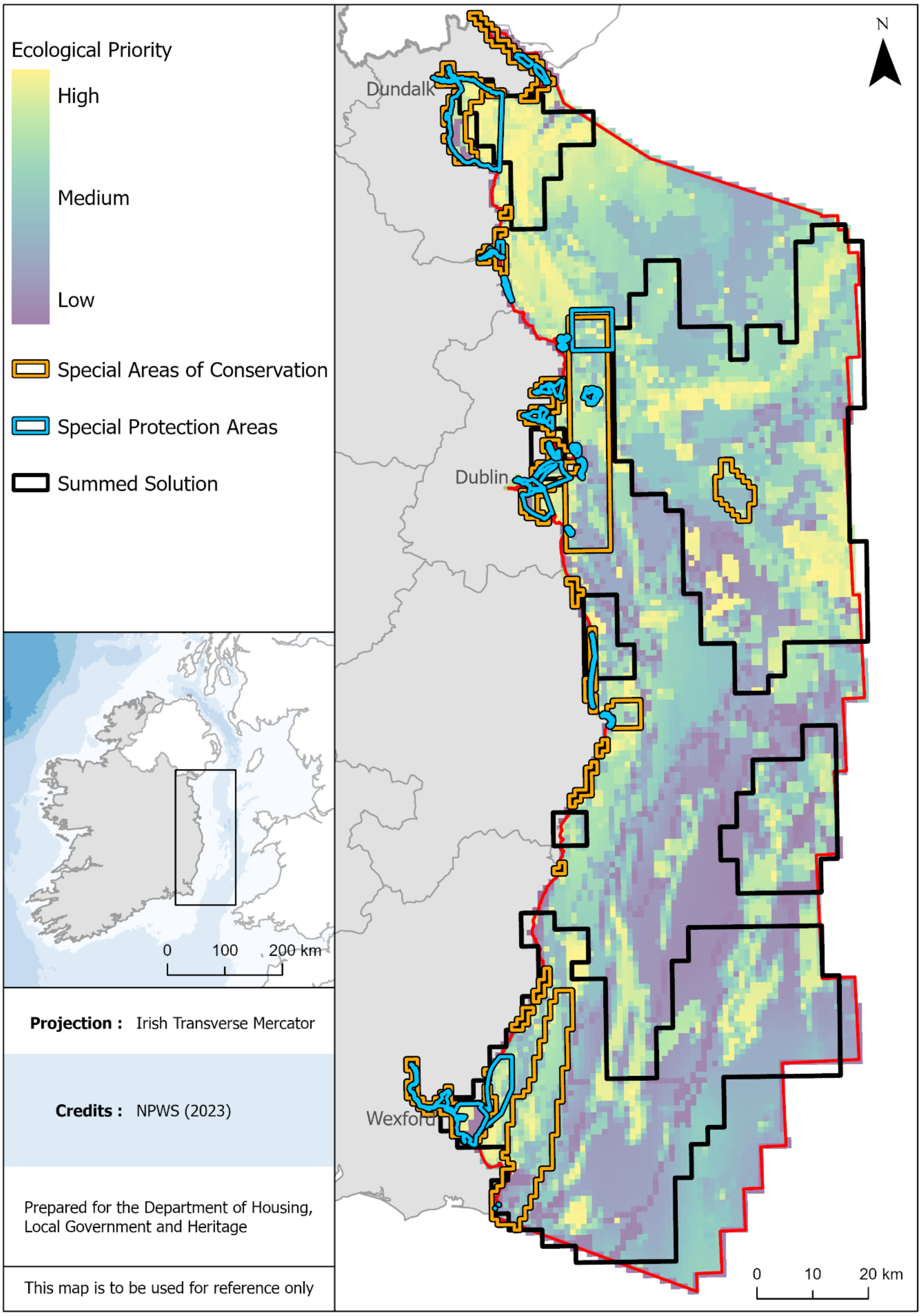


Figure 4.6.1. Current Natura 2000 designated sites (SACs and SPAs) combined with outputs of the current *prioritizr* and Zonation analyses (as shown in Figure 4.2.1).

4.7 Interaction with the wider Irish Maritime Area

The overall targets for MPA coverage in the Irish Maritime Area are to achieve 10% MPA coverage as soon as is practicable, aiming for 30% coverage by 2030, as stated in the Programme for Government (2020). The 30% figure is notably aligned with the UN CBD Kunming-Montréal Global Biodiversity Framework adopted in December 2022 and with similar ambition for area-based conservation set out in the EU Biodiversity Strategy for 2030.

As such, in this project spatial targets for each individual feature have been set at approximately 30% of their distribution in the western Irish Sea. This approach ultimately presented conservation solutions that cover approximately 30% of the study area and which are intended to underpin an effective and ecologically coherent network for these specific features selected by the project team.

In addition to considering interaction with the existing Natura 2000 sites in the western Irish Sea, and the features for which they are designated (Section 4.6), it is also important to note that the analysis in this project was undertaken without consideration of the wider Irish Maritime Area and features and/or locations that might warrant spatial protection under the forthcoming MPA legislation. In designing a network of MPAs for the whole Maritime Area, the eventual recommended coverage for spatial protection in the western Irish Sea may indeed be higher or lower than the approximately 30% of the current study.

Future decision-making in this regard is likely to depend on a multitude of factors that are linked to the forthcoming MPA legislation and to its implementation, including for example the contents of the Ocean Environment Policy Statement provided for in the General Scheme of the MPA Bill (2022), priorities and delivery timelines set out for the MPA process post-enactment and to 2030, existing spatial protection that occurs outside of the western Irish Sea area, the representativity of sensitive features, core areas of species ranges, the existing state of habitats in different areas (e.g., ‘pristine’ or ‘degraded’) and, importantly, socio-economic and cultural considerations.

To highlight the critical issue of context further, in this project carbon sequestration was included in the feature list for the western Irish Sea, with a target of 30% for conservation prioritization. Mobile bottom-contacting fishing gears are known to resuspend various sedimentary substrates, potentially releasing the carbon that is stored within them. However, to protect vulnerable elements of the marine ecosystem, since 2016 the EU deep sea access regulation under the CFP has banned bottom-contact trawling in EU waters at a sea-floor depth greater than 800 m. In terms of surface area in an Irish context, this accounts for over 40% of Ireland's Maritime Area.

A secondary consequence of this ban is that a high proportion of sedimentary carbon in Ireland’s Maritime Area is already effectively protected from the main source of man-made disturbance or damage to the seafloor. This observation was also made during the ‘Engage’ sessions with non-government and sectoral stakeholders. Against this background, proposals under the forthcoming MPA legislation for the spatial protection of high-value areas for carbon sequestration would benefit from clear and coordinated policy lines around this potential feature, whether in the Irish Sea or a broader Maritime Area context. A wider MPA network analysis and conservation prioritization process for the entire Irish Maritime Area will need to be undertaken in the future as part of the MPA process to better inform spatial targets and resolve considerations around network areas and their coherence.

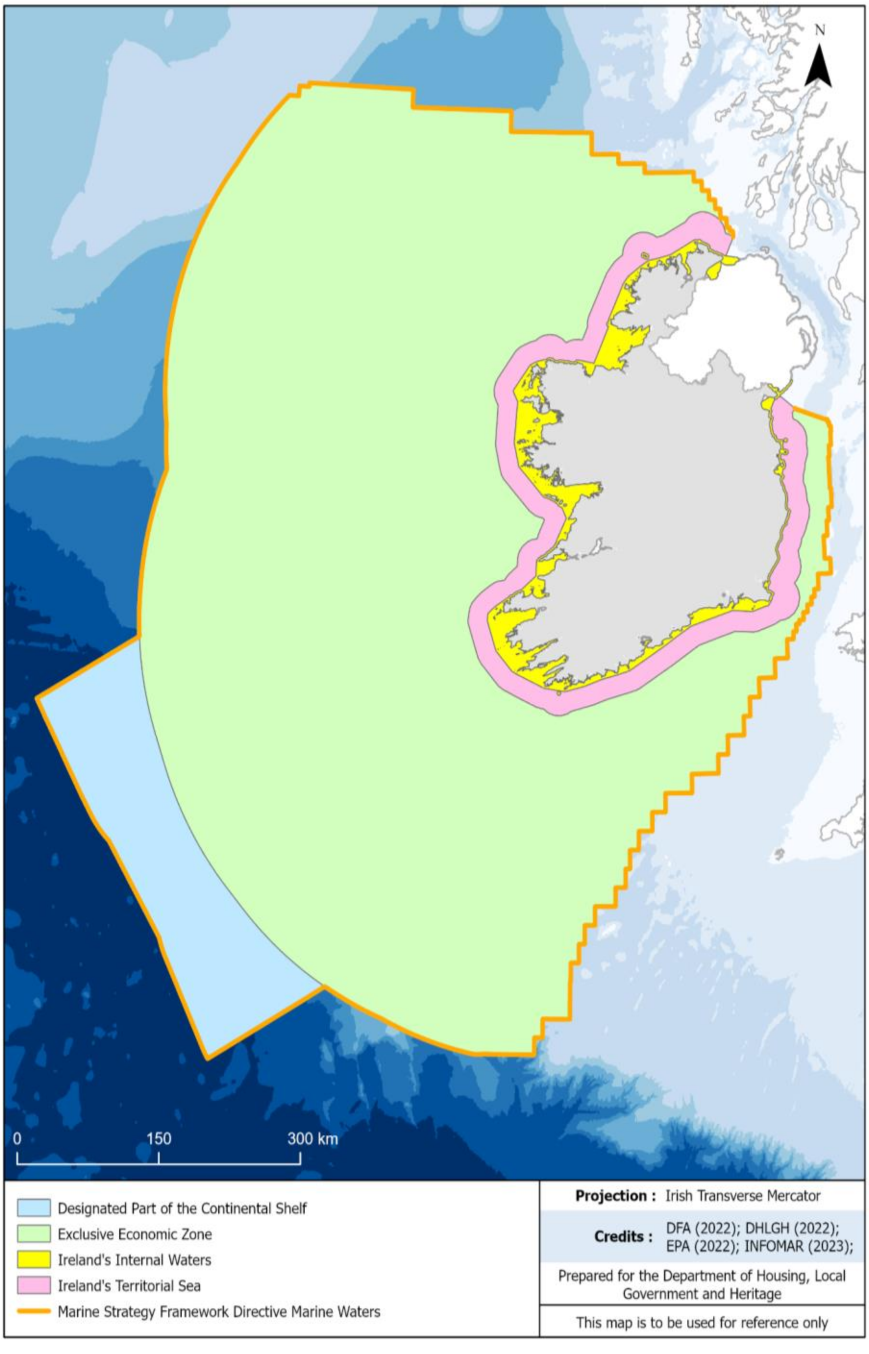


Figure 4.7.1. Ireland's Maritime Area; official classifications as described in Section 2: internal waters, Territorial Sea, the Exclusive Economic Zone (EEZ) and designated parts of the Continental Shelf.

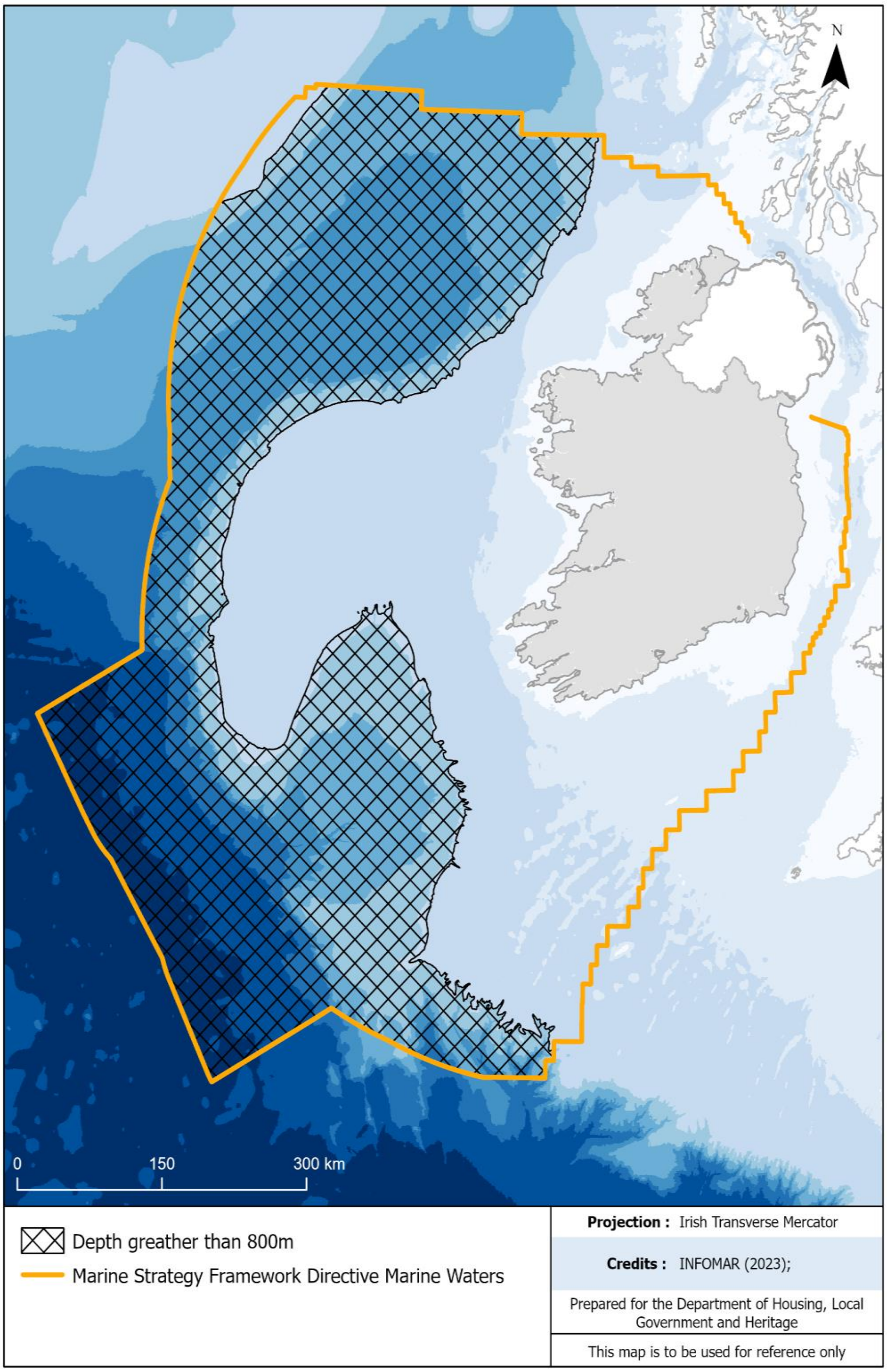


Figure 4.7.2. The area within Ireland's MSFD marine waters that is >800m deep and within which bottom-contact trawling is banned by the EU deep sea access regulation under the CFP.

4.8 Transboundary considerations

> *"This is more of a question to you, how migratory species and transboundary considerations would be dealt with in the Irish Sea project?"* Paraphrased from a representative of a government department:

As outlined above, it was outside the scope and timeframe of this project to substantively consider area-based protection measures for ecologically sensitive features outside of the western Irish Sea. Nevertheless it is considered by the MPA Advisory Group that the most efficient and effective means of conserving identified features would be to have a coherent network of MPAs at the level of the Irish Sea and its marine ecosystems, considering the protections in place in other jurisdictions.

While transboundary issues were considered to some extent during the current project, there is some uncertainty about how to treat MPA networks in other jurisdictions. In addition to knowledge gaps in relation to how networks of MPAs function in ecological terms, different legislative, political, management and enforcement frameworks add further complexity to how a transboundary network might function. This is clearly a major area for research and policy development and coordination if conservation benefits are to be maximised on a scale that is relevant for many features, particularly those features that are mobile in an ecological sense via juvenile dispersal, migration, or seasonal movements for example.

There are 71 MPAs in parts of the Irish Sea and its approaches that are administered by other jurisdictions (Figure 4.8.1, below). These include 22 SPAs designated for birds, 21 SACs originally designated for features defined by the Habitats Directive and 28 areas designated as Marine Conservation Zones (England, Northern Ireland, and Wales), Marine Nature Reserves (Isle of Man), and Scottish Marine Protected Areas. Some designations are overlapping, such that an area may be covered by more than one type of MPA. Some sites are nominated for the OSPAR MPA network, with all OSPAR-nominated sites also designated as European or national sites. This is also the case for three of 21 OSPAR MPAs that have so far been nominated by Ireland and which are situated in the western Irish Sea: (i) Dundalk Bay MPA, (ii) Malahide Estuary MPA, and (iii) North Dublin Bay MPA.

There is some overlap between the features prioritised in this report and those chosen for protection outside of the Natura 2000 network in the Irish Sea. For example, for the Manx Marine Nature Reserves, legislation names the 'Iceland clam' *Arctica islandica*, in addition to eels. Many of the eastern and northern Irish Sea MPAs are coastal in nature. Many of the features examined in the current report, however, occur in deeper waters and the most relevant MPAs may be those that are offshore, including those that lie close to the eastern edge of the Irish EEZ. These mid-Irish Sea sites extend beyond the 12nm limits, and they are listed in Table 4.8.1.

Table 4.8.1. Offshore Welsh, English and Northern Irish marine protected areas in the Irish Sea. Only MPAs that are situated at least partially beyond the 12 nm Territorial Sea limit are listed.

Site name	Site status	Area (ha)	Marine features for which the designation is established
Croker Carbonate Slabs	SAC	11599	Submarine structures made by leaking gases
Irish Sea Front	SPA	18000	Manx shearwater
Liverpool Bay/Bae Lerpwl	SPA	252758	Waterbird assemblage Red-throated diver Little gull Little tern Common tern Black (common) scoter
North Anglesey Marine/Gogledd Môn Forol	SAC	324949	Harbour porpoise
North Channel	SAC	160367	Harbour porpoise
Pisces Reef Complex	SAC	873	Reefs
Queenie Corner	MCZ	14592	Sea-pen and burrowing megafauna communities Subtidal mud
South Rigg	MCZ	14108	Moderate energy circalittoral rock Sea-pen and burrowing megafauna communities Subtidal coarse sediment Subtidal mixed sediments Subtidal mud Subtidal sand
West of Copeland	MCZ	15774	Subtidal coarse sediment Subtidal mixed sediments Subtidal sand
West of Walney	MCZ	38777	Subtidal sand Subtidal mud
West Wales Marine/Gorllewin Cymru Forol	SAC	737614	Harbour porpoise

Queenie corner, the Croker Carbonate Slabs, and North Anglesey Marine/Gogledd Môn Forol are adjacent to the Irish EEZ and could potentially link into protected areas in the northwest of the region studied in this report. Carlingford Lough also contains an SPA designated for terns and brent geese, and an MCZ designated for sublittoral mud, and including the gastropod *Philine aperta* and sea pen *Virgularia mirabilis*.

There are policy objectives for the MPAs in networks represented in the Irish Sea to function in mutually supporting ways. For example, the Natura 2000 network of SACs and SPAs is meant to be 'ecologically coherent'. Ecological coherence is multifaceted and can be assessed with different criteria. One dimension of coherence is that MPAs support each other as they are connected by the movement of adults and/or juvenile stages. Issues of this sort of connectivity are complex and depend on the management regime applied in each MPA.

A full analysis of MPA network function, whether national or transnational, requires a scientific programme that may be composed inter alia of genetics, monitoring, modelling, and potentially tagging of focal species. In the context of this study and its focus on the western Irish Sea, Ireland's Codling Fault Zone SAC complements existing protection established in the UK for the Croker Carbonate Slabs SAC. Furthermore, there is scope for offshore spatial protection in the eastern margins of the Irish EEZ to directly complement the protection of mud communities in the Queenie Corner MCZ, and to interact with protections in place for South Rigg, and the Pisces Reef Complex SAC. Habitats in the West of Copeland and West of Walney MCZs are further away, although the importance of any connectivity remains to be determined.

In addition to the above transboundary considerations concerning the Irish Sea, once the MPA legislation is enacted in Ireland (expected later in 2023) and processes for MPA site identification, designation and management are being taken forward in earnest, consideration will need to be given as to how Ireland's MPA network will contribute to wider international networks of MPAs. In this regard, Ireland has already committed to expand its nomination of sites to the OSPAR network of MPAs throughout the North-East Atlantic from the current base of 21 nominated sites, most of which are coastal SACs in nature. In striving to augment its network of spatially protected sites within the Maritime Area and reach the Government target of 30% MPA coverage by 2030, Ireland can make an important and ecologically prudent contribution to the conservation of diverse marine flora and fauna that have been identified internationally as threatened, vulnerable and/or otherwise meriting area-based protection.

Key messages

- The current project was necessarily focused only on a specified area of the western Irish Sea, did not consider species and habitats explicitly protected in the Natura 2000 network or individually managed through the CFP and did not give extensive consideration to designations in other jurisdictions.

Recommendations

- An ecologically coherent MPA network combining Natura 2000 sites and new MPAs under national legislation will need to be developed for the whole of the Irish Maritime Area and take account of sectoral and transboundary considerations.

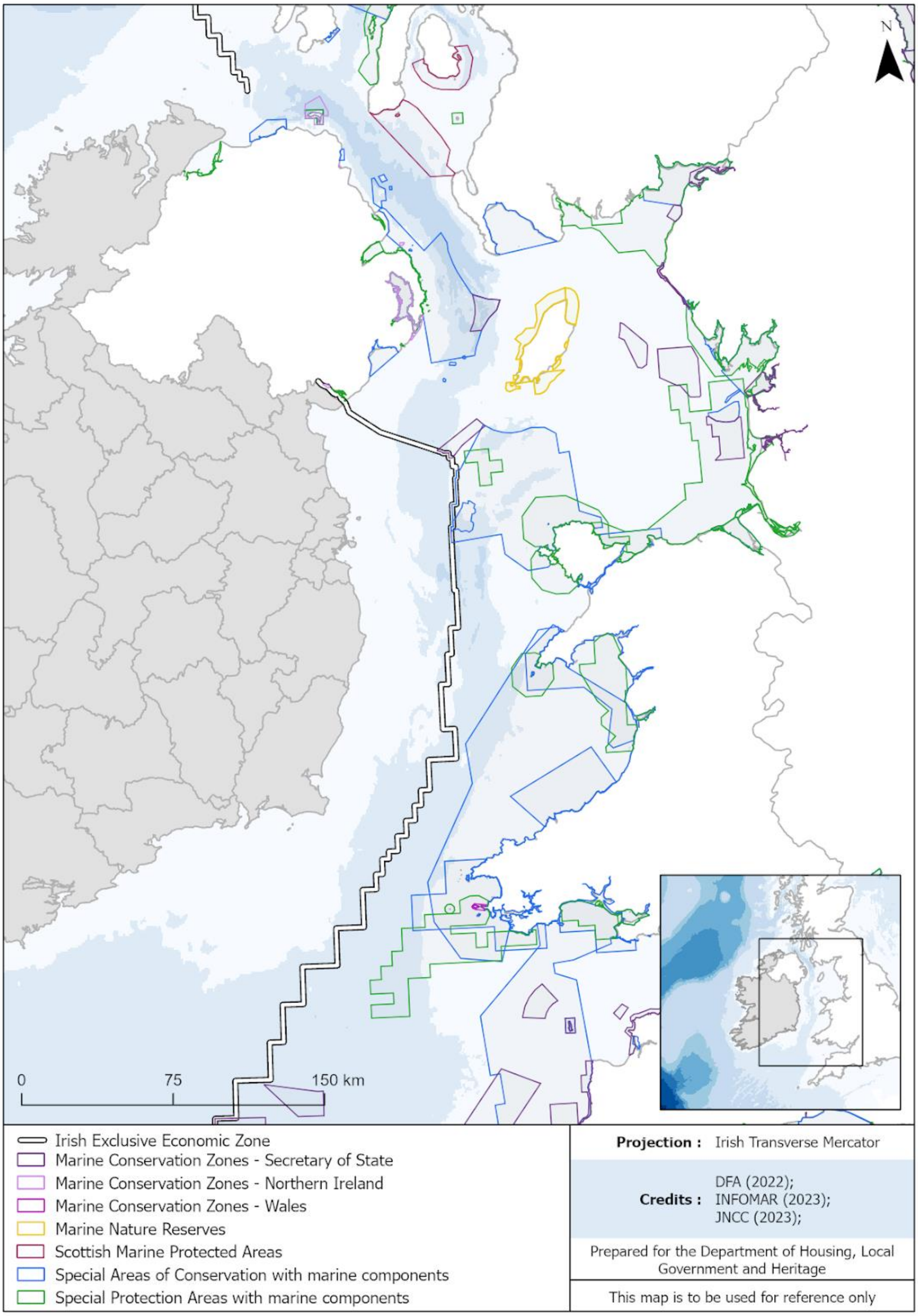


Figure 4.8.1. Marine protected areas in the northern and eastern Irish Sea and adjacent areas outside of the Irish EEZ; based on data hosted by the UK's Joint Nature Conservation Committee.

4.9 Concluding remarks

"What we need is a healthy environment, having space for everyone."
Paraphrased from a representative of the fishing industry.

This project has worked hard to deliver a robust scientific analysis using established international practice, at a scale that had not been undertaken in Ireland before now. It is also one of important strategic, operational, and social value in the context of (1) increasing ambitions for Ireland's Maritime Area from economic, developmental, and environmental standpoints, and (2) increasing pressures on marine ecosystems because of climate change, pollution, and biodiversity loss.

In this, the project reflects the recognised importance of evidence-based decision-making and meaningful stakeholder participation in the development of a durable, effective network of MPAs to restore and maintain diverse, healthy, and productive ecosystems as part of an holistic ecosystem-based approach to the management of our seas and ocean.

The study has identified ecologically important and/or threatened ecological features in the western Irish Sea that are sensitive to ongoing and future sectoral developments. The conservation status of a number of those features is poor (in the Irish Sea, and/or more broadly at a European and/or global scale) and the continuation or expansion of pressures to which they are sensitive could lead to further deterioration of their status.

In keeping with the stated objectives of the project, a systematic and transparent approach has been developed and used by the MPA Advisory Group and the wider project team to identify spatial protection options in the western Irish Sea for the features identified. While such an approach is important, it is also demanding spatial data and timely evidence both on the ecological features themselves and on the so-called "activity cost layers", i.e., the spatial data representing various sectoral activities in the Irish Sea.

Given limitations encountered in the underlying data, some knowledge gaps identified by the study and the need for wider stakeholder participation, some of the conclusions and recommendations are the best that could be made under these circumstances. Such instances provide a signpost to processes by which more definitive outputs may be generated in the future, once better data and knowledge are available. In addition, a more substantive and longer-term process of stakeholder engagement and participation is anticipated to be undertaken under the new MPA legislation when it comes into force.

In addressing such challenges, the project's collation of data on the spatial distribution of ecological features and sectoral activities, combined with sensitivity assessments undertaken for all selected features, constitutes the best evidence base that is currently available. The conservation prioritization modelling based upon this extensive dataset, which includes trade-off analyses of spatial protection goals against existing and planned sectoral activities, provides new and valuable insights into areas and features that should be considered in the planning of new maritime activities and the management of existing ones.

It is intended that this considered scientific work and its outputs will help to pave the way forward for wider and increasingly effective area-based protection of marine biodiversity and associated management decisions in the western Irish Sea in the months and years ahead. It is also anticipated that the project will provide methodological and informational/data platforms of immediate value to future designation and management processes to come under forthcoming Irish MPA legislation.

5 Key messages and recommendations in relation to each project Objective

Objective 1. To undertake a comprehensive scientific screening exercise for potential future MPAs in a defined marine region off the east and southeast of Ireland. This will be done through a process and using selection criteria and features that are as consistent as possible with the provisions set out in the forthcoming MPA legislation.

Key messages		Recommendations	
1.1	A detailed set of criteria were developed for inclusion of features in the further work of the project. The criteria were based on the General Scheme of the MPA Bill (2022)[14] and on the project Terms of Reference. In total 40 distinct features met the criteria and were included in the ecological sensitivity analysis (Section 3.1.2).	1.1	Clear criteria based on those established here should be used in further developing the feature list for the MPA process that will take place under the new MPA legislation.
1.2	The following features were included for consideration based on the criteria used and have medium or high sensitivity to all aspects of ORE and all sub-sectors of fishing: American plaice, Angel shark, Basking shark (but no evidence in relation to ORE cables), Blonde ray, Bull huss, Icelandic cyprine, Pink sea fan, Short-snouted seahorse, Starry smooth hound, Thornback ray, Turbot, Witch flounder, Ross worm reefs, Sea-pen and burrowing megafauna communities, Herring spawning beds, Forage and juvenile fish, Sub-tidal mussel beds, all MSFD priority habitats, European flat oyster. Other features have varying sensitivities to various aspects of ORE and different sub-sectors of fishing and shipping (Section 3.4.2).	1.2	In principle, ORE development and fishing should be considered incompatible with MPAs designated for features with a medium or high level of sensitivity to the pressures they exert. In practice, management measures will need to be developed based on more detailed consideration of risk, impact, and potential mitigation in relation to individual aspects of sectoral activity. In the interim, these sensitivities can inform conservation prioritization to identify potential MPA solutions to protect these features while taking account of sectoral trade-offs (Sections 3.5 and 4.2).

[14]General Scheme of Marine Protected Areas Bill (2022). https://www.gov.ie/en/publication/2fd71-general-scheme-of-marine-protected-areas-bill-2022/

1.3	The current assessment of ecological sensitivity to the ORE and fishing sectors suggests that they affect the selected features in similar ways, and this work indicates that there is no option to direct such sectoral activity to regions where the environment is more resilient to a particular sector while being sensitive to a sector that should be excluded. However, assessments of sensitivity can be made more specific to the activities in particular sectors, including considerations of scale and intensity of activities through risk assessment. This may facilitate more targeted zoning or mitigation of activities to reduce the net impact on ecosystems and the activity costs or trade-offs for different sectors.	1.3	Promote research on the levels of pressure exerted by activities and the response of species and habitats to support development of effective management plans for future MPAs.
1.4	Sectoral activity layers used in these analyses were based on where the industries operate or would operate. This does not fully capture information to be considered in marine spatial planning or MPA designation and management, including the cumulative or synergistic effects of multiple pressures for example, and more detailed considerations of economic, social, or cultural aspects.	1.4	In the MPA process under new legislation, expand the scope and representation of activities to allow a more nuanced consideration of economic, social, strategic, and cultural aspects of different sectors in decision making processes.
1.5	Transparency about the quality of the evidence base underpinning recommendations is an important consideration and can help to enable informed discussion and trust in the process.	1.5	The frameworks provided in this report to indicate the quality of data and confidence in sensitivity assessments should be further developed and applied in future work on MPAs in Ireland, to help ensure clarity about the nature of the evidence base underpinning each decision and to identify areas requiring further research or examination.

Objective 2. To facilitate open and constructive engagement with key Government and non-Government stakeholders that have extensive maritime interests in the Irish Sea (e.g., culture/heritage, defence, fisheries, ORE, transport, recreation), to integrate their participation and consider their interests as part of the analysis and mapping processes within the project.

Key messages		Recommendations	
2.1	Transparency and engagement are highly valued by stakeholders, as they can help to establish a strong connection and build trust between the scientific community, stakeholders, and end-users. Such a connection is essential for the successful implementation of MPAs.	2.1	Continued and more widespread stakeholder participation at multiple levels, in advance and during the decision-making process, is recommended to enhance the overall process of MPA design and implementation and improve the success of the MPA network.
2.2	The stakeholders thoroughly understood the constraints of the project's tight schedule and data gaps, which have been acknowledged and addressed during the multiple participation levels.	2.2	Sufficient time should be allocated for MPA processes and data gaps should be addressed as a matter of urgency.
2.3	To build constructive collaborations with stakeholders in planning MPAs it is essential to recognise the valuable contributions they can make at the planning, implementation, and management stages.	2.3	Potential contributions of stakeholders to future collaboration should be identified and recognised for the successful implementation and management of MPAs, including contributions to increasing awareness and stewardship.

Objective 3. To ensure that any rationales and recommendations for the potential designation of MPAs in the study area, as determined by the work of the reconstituted MPA Advisory Group, will be up to date and in time for active consideration by the Department of Housing Local Government and Heritage (DHLGH) when the MPA legislation comes into force.

	Key messages		**Recommendations**
3.1	A main challenge presented for the systematic conservation prioritization analysis in this study was the limited availability of data high-quality extensive spatial data, for the selected features.	3.1	A systematic data collection programme should be established to increase data provision for all features that potentially merit spatial protection in the Irish Sea. Future work should also concentrate on the production of ground-truthed species distribution models for ecologically sensitive species. Clear data acquisition and management guidelines should also be presented to ORE developers so that data collected during the development process is fit for purpose and can contribute to better decisions and more effective management of the ecological landscape. This information should be collated together in a single data hub that can be used by the state, public and commercial interests alike.
3.2	Significant knowledge gaps exist in relation to the biology and ecology of many important and threatened species, habitats and other features and their sensitivity to many sectoral pressures. These gaps may result in inefficiencies in policy and decision-making, such as conservation actions being targeted in suboptimal locations and management measures being unnecessarily or insufficiently restrictive.	3.2	The prioritisation of research is recommended to fill recognised knowledge gaps on priority species, habitats and other features, and to better characterise feature sensitivity to key sectoral pressures. End-to-end ecosystem models should be developed which can incorporate biological, physical, and socio-economic features of the marine environment to provide insight into how these components may interact under selected scenarios of change.
3.3	The current project was necessarily focussed only on a specified area of the western Irish Sea, did not consider species and habitats explicitly protected in the Natura 2000 network or individually managed through the CFP and did not consider designations in other jurisdictions.	3.3	An ecologically coherent MPA network combining Natura 2000 sites and new MPAs under national legislation will need to be developed for the whole of the Irish Maritime Area and which takes account of sectoral and transboundary considerations.

Objective 4. To facilitate potential future identification by the Government of viable "go-to-areas" for offshore energy projects in the Irish Sea, in view of any biodiversity/environmental/cultural/other sectoral constraints that are concluded via the project.

Key messages		Recommendations	
4.1a	A range of conservation prioritization MPA network solutions were presented (Figure 1 above). Although other solutions that select other areas are clearly possible, siting future ORE developments only in areas outside the summed MPA network solutions identified here gives the flexibility to implement an MPA network that can achieve conservation targets. However other key sectoral interests in the region, and fishing activity, need to be factored into the development of optimal MPA network solutions when the MPA process moves forward under the forthcoming legislation.	4.1a	Potential network solutions developed in this project should be incorporated into the development of MPAs as part of an expanded process involving stakeholder participation and other provisions of forthcoming MPA legislation and interacting with marine spatial planning for the region.
4.1b	As such, the conservation prioritization process suggests that four or five potential MPAs could be implemented within the areas of summed solutions to protect features of conservation importance in the western Irish Sea based on the targets set for their protection.	4.1b	Though subject to further considerations as outlined in Section 4.2.3, as an interim measure, fixed ORE developments should be situated outside the areas of the summed MPA network solutions developed in this project (Figure 1). This will enable future MPAs to achieve conservation targets for the features analysed in this report. Where possible, avoiding additional areas with high ecological priority (Figure 1) is also recommended to further reduce the impact of ORE on ecological features.
4.2	The conservation prioritization process has been informative and should be seen as an organic ongoing process within the MPA design process. There were limits to the resolution and detail of some sectoral information in the analysis undertaken This information, such as the actual siting of ORE infrastructure, can be improved. When this information is available, it will enable more	4.2	In undertaking further conservation prioritization analyses the highest possible spatial resolution data should be made available for all current and proposed sectoral activities.

	finely resolved and flexible spatial planning solutions for MPAs, ORE and other sectors.		
4.3	The fishing industry is an important stakeholder in the Irish Sea. Future MPAs in Irish waters will inevitably bring new challenges for the fishing sector and some MPA proposals could have the potential for significant impacts depending on the features and locations identified as meriting spatial protection, for example. However, MPAs can also bring benefits, including through the protection of spawning grounds, forage fish and other features essential for a healthy and productive ecosystem.	4.3	Based on the MPA process undertaken to date and the work in this project, the fishing sector must be a key consideration in the expansion of Ireland's network of MPAs under forthcoming legislation. Extensive research and engagement with fishers and their representatives are essential to underpin decision-making, to minimise negative impacts and to maximise positive benefits of MPAs to the sector. The intersection with ORE planning and development also requires careful consideration.

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7 Glossary

Activity – A human action which may influence the marine environment e.g., fishing, energy production. These different types of activity are also referred to as **Sectors**.

Benthic – A description of animals, plants and habitats associated with the seabed. All plants and animals that live in, on or near the seabed are referred to as benthos.

Biologging - Electronic tags can be internally implanted or externally attached to species of interest to track their movements using acoustic, radio or satellite tracking technology. These devices can provide movement data on fine-scale space use including space use, habitat selection and home range across hundreds of metres, to large-scale migratory movements spanning hundreds of kilometres.

Birds Directive - Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. http://data.europa.eu/eli/dir/2009/147/oj

Connectivity – In the design of a network, connectivity allows for linkages whereby protected sites benefit from larval and/or species exchanges, and functional linkages from other network sites. In a connected network, individual sites benefit one another.

Conservation objective – General usage: A statement of the nature conservation aspirations for the feature(s) of interest within a site and an assessment of those human pressures likely to affect the feature(s).

Conservation objective – Specific to the EU Habitats Directive: Aims to define favourable conservation status/condition using suitable attributes with targets in line with Favourable Conservation Status parameters. For habitats, FCS parameters are natural range and areas it covers within that range are stable or increasing; specific structures and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future; the conservation status of its typical species is favourable. For species, FCS parameters are the population dynamics data that indicate it is maintaining itself on a long-term basis as a viable component of its natural habitats; the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

Conservation prioritization – an analytical process to find efficient solutions to the problem of selecting a system of spatially cohesive sites that meet a suite of biodiversity targets, taking account of the distribution of features and sectoral activities. Software for this task includes Marxan, Prioritizr and Zonation. It can be part of a structured process of Systematic Conservation Planning.

Consultation – One-way communication flow, whereby information primarily flows from stakeholders to authorities or scientists. The main aim is to extract information from stakeholders.

Cultural and spiritual values - Including recreational, religious, aesthetic, historic and social values related to tangible and intangible benefits that nature and natural features have for people of different cultures and societies, with a particular focus on those that contribute to conservation outcomes (e.g. traditional management practices on which key species, biodiversity or whole ecosystems have become reliant or the societal support for conservation of landscapes for the maintenance of their quality in artistic expression or beauty) and intangible heritage, including cultural and spiritual practices.

Cumulative impacts – changes to the environment that are caused by an action in combination with other past-, present and future human actions.[77]

Demersal – Demersal fish live on or near the seabed and feed on bottom-living organisms and other fish. Although fisheries may be directed towards species or species groups, demersal fish are often caught together and comprise a mixed demersal fishery.

Dispersal – The movement of individual organisms away from a starting location, such as the site where they were spawned. Dispersal may be active (movement created by the organism) or passive (e.g., carried by the wind, current or gravity).

Ecosystem – A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (CBD Article 2).

Ecosystem approach – The comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, to identify and act on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity (OSPAR definition).

Ecosystem functioning – How plants, animals, micro-organisms, and the non-living environment that make up the ecosystem cycle, transfer and transform both energy and elements.

Ecosystem services - Processes by which the environment produces resources used by humans, such as clean air, water, food, and materials. Ecosystem services flow from **natural capital** (see below).

> **Cultural ecosystem services** – These ecosystem services are the intangible, psychological and spiritual benefits that humans obtain from contact with nature.
>
> **Provisioning services** – These ecosystem services are tangible goods and there is a direct connection between the ecosystem and the provision of these ecosystem services.
>
> **Supporting ecosystem services** – These services uphold and enable the maintenance and delivery of the other ecosystem service categories.
>
> **Regulation and maintenance services** – These ecosystem services regulate the world around us and often are consumed indirectly.

e-DNA - Environmental DNA describes cellular material shed by organisms (e.g., excrement, mucus etc.) into aquatic or terrestrial environments that can be sampled and investigated using molecular methods. This technique can be particularly useful in identifying the presence of invasive or rare species.

Exclusive Economic Zone (EEZ) - Under the UN Convention on the Law of the Sea (UNCLOS), the Exclusive Economic Zone comprises an area which extends from the 12 nm territorial sea limit to 200 nm.

Feature - A species, habitat, geological, geomorphological, or cultural entity for which an MPA is identified and managed.

Good Environmental Status (GES) – Defined through 11 Descriptors in the MSFD, the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy, and productive.

Habitat - The place or type of site where an organism or population naturally occurs (CBD Article 2).

Habitats Directive - Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. http://data.europa.eu/eli/dir/1992/43/oj

Information provision - One-way communication where information flows from authorities and scientists to stakeholders in MPAs. The main aim is to enhance knowledge or awareness among stakeholders.

Invasive non-indigenous species - Invasive non-indigenous animals or plants are those that can spread causing damage to the environment, the economy, our health, and the way we live.

Marine Conservation Zones (MCZs) - MPAs designated in the UK under the Marine and Coastal Access Act (2009) to protect nationally important, rare, or threatened species and habitats.

Marine Spatial Planning - The identification of marine natural resources and the current and potential use of those resources. The National Marine Planning Framework defines the process of MSP as "A process that brings together multiple users of the ocean to make informed and coordinated decisions about how to use marine resources sustainably. It is a process by which the relevant public authorities analyse and organise human activities in marine areas to achieve ecological, economic, and social objectives."

Mobile MPAs – MPAs with mobile boundaries that can shift based on real-time data with defined constraints over time and space according to the needs of key species, typically migratory species whose conservation needs may shift spatially.

Monitoring – The regular and systematic collection of environmental and biological data by agreed methods and to agreed standards. Monitoring provides information on status, trends, and compliance with respect to declared standards and objectives.[240]

Natura 2000 sites/network – EU-wide network of nature conservation sites, comprising Special Areas of Conservation (SACs) designated under the EU Habitats Directive, and Special Protection Areas (SPAs) designated under the EU Birds Directive.

Natural capital – The stocks of air, water, soil, and mineral resources as well as the living components of ecosystems. Natural capital underpins the provision of **ecosystem services** (see above).

ObSERVE - Government of Ireland funded scientific research programme involving aerial and acoustic surveys of seabirds and mammals but also recording other large species (e.g., sharks).

OSPAR - Refers to the Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic. http://www.ospar.org/

Other Effective Area-based Conservation Measures (OECM) - A geographically defined area other than a Protected Area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in-situ conservation of biodiversity with associated ecosystem functions and services and where applicable, cultural, spiritual, socio–economic, and other locally relevant values. (CBD Decision 14/8)

Precautionary Principle – Precaution can be considered "caution practised in the context of uncertainty". The Precautionary Principle is widely used in environmental policy and has various formulations. The CBD Rio Declaration (1992) proposes that "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." The most widely cited formulation is the Wingspread Statement on the Precautionary Principle (1998): "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically. In this context, the proponent of an activity, rather than the public, should bear the burden of proof."

Protected Area – "A geographically defined area which is designated or regulated and managed to achieve specific conservation objectives." (CBD Article 2).

Pressures – The mechanism through which activity influences any part of the ecosystem, e.g., through changes in water flow, sedimentation, chemical contamination, or modifications to a habitat. The nature of the pressure is determined by activity type, intensity, and distribution.

Recruitment –The addition of a new cohort to a population, or the new cohort that was added. The magnitude of recruitment depends on the time and life history stage at which it is recorded.

Replicability – Replication of ecological features means that more than one site shall contain examples of a given feature in the given biogeographic area. The term "features" means "species, habitats and ecological processes" that naturally occur in the given biogeographic area.

Representative – Representative networks of MPAs contain examples of all habitats and ecological communities of a given area, thus providing a cost-effective means of safeguarding large-scale processes while delivering local benefits.

Resistance (in the context of sensitivity analysis) - the degree to which a feature can remain unchanged when exposed to a pressure.

Resilience (in the context of sensitivity analysis) - if changed by a pressure, resilience is the time taken for a feature to recover once the pressure is removed or stopped.

Resilience – (common usage) The ability of an ecosystem to maintain key functions and processes in the face of stresses or pressures by either resisting or adapting to change. Resilience can be applied to both ecological systems as well as social systems.

Restoration – Ecosystem restoration is the "process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed".

Sector – A type of human activity that can influence the environment, e.g., fishing, ORE, shipping.

Sensitivity - The likelihood of change when a pressure is applied to a feature (receptor) and is a function of the ability of the feature to tolerate or resist change (resistance) and its ability to recover from impact (resilience).

Special Areas of Conservation (SACs) – Sites protected under the EC Habitats Directive (92/43/EEC) for species and habitats of European importance, as listed on Annex I and II of the Directive

Special Protection Areas (SPAs) – Sites protected under the EU Birds Directive, for rare and vulnerable birds (listed on Annex I of the Directive) and for regularly occurring migratory species.

Spillover - The emigration of adult and juvenile organisms across the MPA borders and into surrounding habitats.

Stakeholders - individuals, groups or organisations who are (or will be), in one way or another, interested, involved, or affected (positively or negatively) by a particular project or action toward resources' - Pomeroy and Douvere, 'The Engagement of Stakeholders in the Marine Spatial Planning Process'.

Substrate/substratum – The surface or medium on which an organism grows or is attached (e.g., seabed sediment).

Sustainable development –"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Sustainable use - "The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations." (CBD Article 2)

Territorial Sea - Under the UN Convention on the Law of the Sea (UNCLOS), a state's territorial waters extend from the baseline to a maximum of 12 nm.

8 List of Acronyms and Abbreviations

AIS	Automatic Identification System
BD	Birds Directive [EU]
BIM	Bord Iascaigh Mhara
CIL	Commissioners of Irish Lights
CFP	Common Fisheries Policy [EU]
DAFM	Department of Agriculture, Food and the Marine
DATRAS	Database of Trawl Surveys
DCF	Data Collection Framework [EU]
DECC	Department of the Environment, Climate and Communications
DHLGH	Department of Housing, Local Government and Heritage
DHPLG	Department of Housing, Planning and Local Government
DoT	Department of Transport
EC	European Commission
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data Network
eNGO	Environmental Non-Governmental Organisation
EPA	Environmental Protection Agency
EU	European Union
EUNIS	European Nature Information System
F	Fishing mortality
FeAST	Feature Activity Sensitivity Tool
GBIF	Global Biodiversity Information Facility
GIS	Geographic Information System
GES	Good Environmental Status (MSFD) [EU]
HD	Habitats Directive [EU]
HMPA	Highly Protected Marine Areas
ICES	International Council for the Exploration of the Sea
IFI	Inland Fisheries Ireland
IFPO	Irish Fish Producer Organisation
IGFS	Irish Groundfish Survey

INFOMAR	Integrated Mapping for the Sustainable Development of Ireland's Marine Resource
ISEPO	Irish South and East Fish Producers Organisation
ITM	Irish Transverse Mercator
IUCN	International Union for Conservation of Nature
iVMS	Inshore Vessel Monitoring System
JNCC	Joint Nature Conservation Committee [UK]
KFO	Killybegs Fishermens Organisation
MAC	Maritime Area Consent [MPDM]
MAP	Maritime Area Planning Act 2021
MarESA	Marine Evidence-based Sensitivity Assessment
MarLIN	Marine Life Information Network
MCZ	Marine Conservation Zone [UK]
MHW	Mean High Water
MI	Marine Institute
MLW	Mean Low Water
MPA	Marine Protected Area
MPDM	Marine Planning and Development Management Bill
MSFD	Marine Strategy Framework Directive; Directive 2008/56/EC http://data.europa.eu/eli/dir/2008/56/oj
MSP	Marine/Maritime Spatial Planning
NBDC	National Biodiversity Data Centre
NEv	No Evidence in sensitivity scoring
NIGFS	Northern Ireland Groundfish Survey
NGO	Non-Governmental Organisation
NHA	National Heritage Areas
NMPF	National Marine Planning Framework
NMS	National Monuments Service
NPWS	National Parks and Wildlife Service
NR	Not Relevant – in sensitivity analysis
OECM	Other Effective Area Based Conservation Measures [CBD]
OMPP	Overarching Marine Planning Policies
ORE	Offshore Renewable Energy

OSPAR	Oslo Paris Convention for the Protection of the Marine Environment of the North East Atlantic
PAH	Polycyclic Aromatic Hydrocarbon
QI	Qualifying Interest
REA	Rapid Evidence Assessment
RIFF	Regional Inshore Fisheries Forum
SAC	Special Area of Conservation [EU Habitats Directive]
SSB	Spawning Stock Biomass
SCP	Systematic Conservation Planning
SDG	Sustainable Development Goal
SDM	Species Distribution Model
SPA	Special Protection Area [EU Birds Directive]
TAC	Total Allowable Catch
UK	United Kingdom
UN	United Nations
UNCLOS	UN Convention on the Law of the Sea
UNEP	United Nations Environment Programme
VMEs	Vulnerable Marine Ecosystems
VMS	Vessel Monitoring System
WFD	Water Framework Directive [EU]
WFS	Web Feature Service
WMS	Web Map Service