Trialling a Seabird Sensitivity Mapping Tool for Marine Renewable Energy Developments in Ireland

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Executive Summary

- BirdWatch Ireland supports the production of energy from marine renewable energy (MRE) sources (i.e. wind, wave, tidal), where devices and infrastructure are sensitively located to minimise negative impacts on ecosystems and biodiversity. The positive environmental and economic benefits of MRE must not be compromised by poor planning and lack of due diligence when it comes to environmental impacts.
- Energy policy and legislation at European and national level is increasingly focusing on developing MRE and upcoming national legislation and marine spatial planning policies will bring clarity to the planning and licensing processes for this sector.
- Ireland's wind resource is relatively consistent around the coast, our wave energy resources are largely restricted to the west and northwest, and our tidal resource is predominantly concentrated off the east coast. Ireland currently has one small offshore wind farm in operation, with more in various stages of the planning and consenting process. There are two wave energy converter test sites in the west, but no tidal energy developments yet in operation.
- Ireland's marine waters support hundreds of thousands of seabirds, with some present here in numbers of regional, continental and even global importance. Seabirds and marine biodiversity are acknowledged as bringing monetary and non-monetary services and values to Irish society. International legislation requires that Ireland takes steps to ensure the protection and conservation of these species.
- The main potential impacts of MRE devices on seabirds are mortality by collision, disturbance and displacement, barrier effects and habitat loss. Because they are long-lived and with a low annual reproductive output, impacts on seabirds may not become apparent for several years.

- This project aimed to further develop a sensitivity mapping tool to highlight areas in Irish waters where seabird populations are likely to be impacted by MRE developments. This is the second phase of this project. The previous phase identified and outlined an appropriate methodology.
- The aim of a seabird sensitivity mapping tool for MRE is that it would be used to identify potential constraints early in the planning process. This would allow developers to commission more targeted seabird surveys to quantify the potential risk of impacts and include suitable mitigation measures where necessary. Consenting authorities and conservationists could also use the maps to see if a developer has paid due consideration to potential risks. Ultimately, regular use of a seabird sensitivity map in the early stages of planning would help reduce the consenting risk for MRE developments and minimise any potential conflict between MRE developments and legal obligations to protect birds and their habitats.
- This phase of the sensitivity mapping tool development trialled the previously outlined methodology with a limited number of species in a restricted geographic area. Six seabird species were chosen, broadly representative of the seabird community in Irish waters, and focusing only on the Irish Sea and Wexford coast. Future phases of this project will expand the process to all of Ireland's territorial waters and include all seabird species.

- The six species examined here were Northern Gannet, Razorbill, European Shag, Herring Gull, Black-legged Kittiwake and Common Scoter. Each of these species vary in terms of their presence in Irish waters, their feeding ecology, nesting habitat and the level of data available for them.
- Distribution data for these species was mapped on a presence/absence basis on a 4km*4km square grid. Data was compiled from a comprehensive list of sources including broad-scale at-sea seabird surveys, coastal bird surveys, species-specific at-sea surveys, at-sea surveys carried out for offshore MRE developments and data from seabird GPS tracking data and peer-reviewed studies.
- A sensitivity scoring system was used, based on work carried out in Scotland and outlined in Phase 1 of the development of this tool. Each species is assigned a different score depending on the renewable energy development in question, with separate scores for 1) collision with offshore wind turbines, 2) displacement by offshore wind turbines, 3) impact by wave energy developments, 4) impact by tidal energy developments.
- A different scoring metric is used for each of the four potential impacts depending on the relevant behavioural and ecological attributes of the species in question e.g. flight height, habitat specialisation, diving depths, conservation status etc. The sensitivity scoring indices are independent of each other, so a species may rank as highly vulnerable to one type of development but of low vulnerability to another. Four sensitivity maps were therefore produced.
- Each grid square is given a score based on the aggregate sensitivity scores for the species present within. Squares with more species that are highly sensitive to a development will score higher than one with a low number of species that are similarly sensitive. Squares with a low number of species may have a higher score than squares with more species, where the species in the former and are more sensitive than those in the latter.

- Users of a final sensitivity mapping tool will have access to the shapefile or an interactive map hosted online, which they can browse and click on individual grid squares to see what species were present and how they contributed to the squares overall sensitivity score.
- This trial sensitivity map, and any final sensitivity map, would not create 'no-go areas' where development cannot proceed. They represent a qualitative baseline assessment to help evaluate the potential impacts of specific offshore renewable energy projects on the seabird communities in a given location. It is intended that these sensitivity maps should be used early in the site-selection, planning and scoping processes for proposed offshore renewable energy developments.
- The list of caveats associated with these trial maps means that they can't be used in place of pre-construction baseline seabird surveys. These sensitivity maps provide a qualitative overview of the sensitivity of a location, but a quantitative assessment based on current data should follow. Properly designed and executed baseline data surveys are critical for establishing the condition of the receiving environment for Appropriate Assessment (AA) and Environmental Impact Assessment (EIA).

- A workshop was held in June 2018 and attended by a wide variety of stakeholders relevant to the future of MRE in Ireland, including energy developers, commercial consultants, government bodies, planning authorities and environmental interests.

- Feedback from stakeholders indicated an overall positive reaction to such a tool and an appreciation for its potential in the early scoping and planning stages of development. Stakeholders agreed that this tool should be developed nationally and that it would be useful in the EIA, NIS and planning processes. Strengths and technical limitations of the sensitivity map were outlined and a number of recommendations came out of this discussion.

- This project successfully trialled the development of a seabird sensitivity mapping tool for MRE developments in Ireland, on a limited geographic area with a shortlist of species. A list of 7 recommendations for the future development of the tool came from this trial process and the subsequent stakeholder workshop. Furthermore, important datasets that will be available in the future have been listed and a number of recommendations have been made to fill notable data gaps in the future so that a final seabird sensitivity mapping tool can reach its full potential.
- A full-scale seabird sensitivity mapping tool should be developed as a next step, to include all 38 seabirds that regularly occur in Irish waters, and cover all of the Irish EEZ. The next phase should heed the recommendations and feedback from the current project and the data gaps outlined here should be addressed, though this need not stall the development of a final mapping tool.
- The final mapping tool should include plans for regular updates to incorporate new information on seabird sensitivity and distribution.
- A future full-scale seabird sensitivity mapping tool, used by developers and consenting authorities alike, will help ensure the true sustainability of the Irish MRE into the future.

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1. Introduction

1.1 BirdWatch Ireland Policy on Marine Renewable Energy

BirdWatch Ireland supports the production of energy from marine renewable energy (MRE) sources (i.e. wind, wave, tidal), where devices and infrastructure are sensitively located to minimise harm to ecosystems and biodiversity. Climate change threatens the species and habitats we value in Ireland and the ecosystem services these provide. Developing a low carbon economy based on energy policies that secure sustainable energy sources and achieve better energy efficiency is a vital part of the response required to stabilise greenhouse gas emissions. A diverse range of renewable energy sources will help reduce our greenhouse gas emissions and so reduce our climate impact. MRE is still in the early stages of development and deployment and so there is a valuable opportunity for Ireland to establish and demonstrate 'best practice' in terms of true sustainability of the industry, while reaping the economic benefits of job creation and export potential.

> "…if Ireland is to develop our offshore renewable energy potential, we must improve our understanding of the impact such developments may have on our marine environment."
>
> -Dept. of Communications, Climate Action & Environment (DCCAE), 2018

Large developments in the offshore environment carry a risk of direct impact on seabird populations and other marine biodiversity. However, MRE devices, if located and constructed in a sensitive manner will help decarbonise our economy and critically minimise the risk of impacts on seabirds. Ireland has one of the largest marine areas in Europe, around ten times its land area, and a wealth of marine biodiversity as a result. The early identification of sensitive ecological sites is therefore a priority, to influence potential MRE developments at the planning stage, minimise risk and maximise confidence in the consenting process, and to provide assistance with meeting legal obligations to protect birds and their habitats. This will allow for a smoother application, consent and construction process and help ensure true sustainability in developing Ireland's offshore renewable energy resources. Recent policy and strategy documents from the Irish government have stressed the value of Ireland's rich and diverse range of species, habitats and ecosystems as part of 'Our Ocean Wealth' and the importance of an ecologically sustainable future that maximises the use of our marine resources and protects our marine environment. At present, the Irish government is developing a Marine Spatial Plan that will provide an overarching framework for the balanced and sustainable territorial development of Irish marine waters and coastal zones, with a goal of finalising and adopting the plan in 2020. The development of a bird sensitivity mapping tool for MRE development is therefore very timely. This tool will help strategic planning to address some of the potential conflicts in relation to exploration and development of renewable energy installations offshore and rich marine birdlife. By facilitating better decision-making and planning in this way we can help establish Ireland as a global leader in sustainable offshore renewable energy.

1.2 Policy and Legislative Framework for Marine Renewable Energy in Ireland

The history of the MRE industry is a recent one, with the first offshore wind farm being installed in Denmark (Vindeby) in 1991. It is only in the last 10 years or so, as the industry has become more viable, that governments and policy makers have put increased focus on large-scale deployment of MRE devices to exploit the significant economic and environmental potential therein. Developing a new industry in the marine environment has thrown up challenges in terms of feasibility, planning and sustainability that governments at national and international level are continuing to try and get ahead of. Outlined below are some of the key policy statements, reports and relevant legislation that have influenced the recent trajectory of the offshore renewable energy industry in Ireland and are sure to have a deciding influence on the future growth of the industry here.

1.2.1 European Legislation & Policy

EU Marine Strategy Framework Directive (Directive 2008/56/EC)

- Protect the resources on which marine-related economic and social activities depend.
- Requires 'good environmental status' for the EU's marine waters by 2020.
- Implementation of a common approach to protection and sustainability in the marine environment at regional and European level.
- To include spatial protection measures contributing to coherent and representative networks of MPAs, adequately covering constituent ecosystems.

EU Renewable Energy Directive (Directive 2009/28/EC)

- Requires the EU to meet at least 20% of its energy needs with renewables by 2020.
- Each country set individual targets based on their existing and potential renewable energy resources and required to publish a national renewable energy action plan.
- Ireland set target of producing 16% of its energy needs from renewable sources by 2020.
- Under the Renewable Energy Directive EU Member States have agreed a EU Clean Energy Package with targets defined for 2030 and 2050. As part of this Member States have agreed a target of 32% of all energy consumed in the EU to be from renewable sources by 2030. Member States must also produce a National Energy & Climate Plan 2021-2030 to be finalised by the end of 2019 and outline national contributions to meet the 2030 targets.

EU Maritime Spatial Planning Directive (2014/89/EU)

- Develop consistent, transparent, sustainable and evidence-based decision-making to support sustainable development.
- Requires each member state establish and implement a maritime spatial plan by 2021.
- Process of implementing a marine spatial plan in Ireland began in 2017 and is expected to be complete in 2019.

EU Habitats Directive (92/43/EEC) *and* ***EU Birds Directive (2009/147/EC)***

- Seek to maintain and restore the favourable conservation status of habitats and species.
- This is partly attained through the designation of Special Areas of Conservation (SAC) and Special Protection Areas (SPA) to form a network of 'Natura 2000' sites across states including in the marine environment.
- An Appropriate Assessment (AA) screening and potentially full AA is required for any plans or projects that are likely to have significant effects on any such site.

1.2.2 National Legislation & Policy

National Renewable Energy Action Plan (2010)

- Set out strategies to meet target of producing 16% of Ireland's energy needs from renewable energy sources by 2020, as required under the EU Renewable Energy Directive.
- Highlighted Ireland's rich potential for offshore renewable energy development and stated that the Irish government is looking beyond 2020 to realise that potential.
- Committed to streamlining the consent process for offshore developments to more closely resemble that for terrestrial projects as the current consent process (via The Foreshore Act 1933 as amended) was noted as a barrier to development.

Government Strategy for Renewable Energy: 2012-2020 (2012)

- Development of Ireland's offshore renewable energy resources is a priority in the short, medium and long-term on economic grounds, as well as to reduce our carbon footprint.
- Five strategic goals outlined, including those to increase offshore wind for domestic and export markets, and to foster research and development in wave and tidal renewables.

Harnessing Our Ocean Wealth (2012)

- An integrated marine plan setting out high-level goals and integrated actions across policy, governance and business to enable Ireland to develop a diverse marine economy.
- Targets to increase turnover from ocean economy to over €6.4bn by 2020, and to double the value of our ocean wealth to 2.4% GDP by 2030.
- Highlighted offshore wind and ocean renewable energy as some of the most promising activities for future economic growth.
- High-level goal of achieving healthy ecosystems that provide both monetary and non-monetary goods and services. Healthy marine ecosystems identified as an important enabler for harnessing our ocean wealth. Maximising the use of our marine resources to fuel economic growth must strike a balance with protection of our marine environment.

Proposed Maritime Area and Foreshore (Amendment) Bill (2013)

- Aims to align the foreshore consent system with the planning system, to provide for a single environmental impact assessment (EIA) for projects and to provide a coherent mechanism to facilitate and manage development in the maritime area, such as oil and gas projects and offshore renewable energy.
- Will define a **maritime area** to encompass the foreshore, EEZ and continental shelf.
- Will provide that decisions on development consent for projects in the maritime area should be made either by Local Authorities or An Bord Pleanála, depending on the location, size and scale of the development, and on whether EIA is required.

Offshore Renewable Energy Development Plan (OREDP) (2014)

- Set out key principles, policy actions and enablers for the sustainable development of the offshore renewable energy sector in Ireland.
- Stressed the economic opportunity and environmental importance of realising the huge potential of the offshore energy sector in Ireland, while also safeguarding the public interest in terms of protection of the marine environment.

OREDP Strategic Environmental Assessment and Appropriate Assessment (2014)

- Published alongside the OREDP, taking into account environmental constraints to be assessed when developing offshore wind, wave and tidal energy in Irish waters.
- Concluded that it would be possible for Ireland to achieve the 'high' scenario of 4,500MW from offshore wind and 1,500MW from wave and tidal devices without likely significant adverse effect on the environment. Potential for 1200-1500MW fixed wind in the north part of the east coast, and 3000-3300MW fixed wind and 750-1500MW of tidal energy in the south part of the east coast, without likely significant adverse effects on the environment (taking into account mitigation).
- Measures to avoid, reduce or offset adverse impacts on the environment at various stages of development and across a range of timescales are outlined.
- Data, knowledge and information gaps are a key limitation of the assessment. The continued collection of data to improve our knowledge of the marine environment is crucial to the progression of the OREDP, as is that data being made available to all stakeholders so that it can be taken into account for the siting, design, consenting and permitting of individual projects.

Marine Spatial Plan (2017 - 2019)

- To be a decision-making tool that defines the planning and licensing processes and considerations for future developments, mirroring the terrestrial planning process.
- Plan to provide clarity going forward as to how we manage the marine environment effectively and sustainably to integrate social, economic and environmental needs.
- Presently in the development stage where the goals are to consult extensively with a wide range of stakeholders, and to identify data and information required to provide a robust evidence base to underpin the plan.
- Will be finalised and implemented in the latter half of 2020.

National Planning Framework – Ireland 2040 (2018)

- Reiterates the goals of the OREDP and sets out a policy objective to support the progressive development of Ireland's offshore renewable energy potential, including domestic and international grid connectivity enhancements to bring the energy ashore and connect to major sources of energy demand.

Ireland's Grid Development Strategy – Your Grid, Your Tomorrow (2017) and ***draft Grid Implementation Plan 2017-2022 for the Electricity Transmission System in Ireland***

- Plans produced by Eirgrid outlining Ireland's grid transmission needs now and into the future to ensure safe and secure energy supply.
- The draft Implementation Plan identifies those parts of the transmission system that are likely to need development over the five-year period (2017 - 2022).
- The opportunity for an electrical link with France – the Celtic Interconnector – was identified in EirGrid's 'Interconnector Economic Feasibility Report' in 2009. The proposed interconnector would have a capacity of 700MW of electricity, providing an annual transmission capacity of 6.1 TWh between Ireland and France/Europe. It would be Ireland's only direct energy connection to the European mainland, and the only connection to an EU member state after the UK leaves the EU. Would provide another export route for Irish-produced energy and enhance security of supply for the Irish grid.

1.3 Potential for Marine Renewable Energy in Ireland

The development of renewable energy is central to overall energy policy in Ireland (DCENR, 2012). The legislation and plans outlined above (Section 1.2) illustrate the determination with which the Irish and European governments are moving towards offshore renewable energy, for economic, social and environmental reasons. Ireland's geographic position in the north Atlantic, with territorial waters 10 times the area of its land mass, means the country is uniquely placed in terms of the MRE resources at its disposal (DCENR, 2014). At present Ireland has yet to exploit this potential.

One of the constraints on the industry at present is the current application and planning process for the marine environment, which is viewed by the industry as unclear and difficult to navigate. The forthcoming Maritime Area and Foreshore Bill and upcoming marine spatial plan aim to provide clarity on this front going forward by describing the planning and licensing processes that MRE developments will need to undertake. Further challenges as the industry grows will include intermittent supply from the development (e.g. low wind or wave levels), though as the industry matures and diversifies it is likely that complimentary resources can be exploited at different times of high/low output. At present Ireland does not have the necessary grid infrastructure in terms of location and capacity to accommodate a large volume of energy from a broad range of sources, so this too will have to develop in advance of large-scale growth in the offshore renewable energy sector.

These challenges aside, the offshore renewable energy industry and its capacity to cater for the Irish and export energy markets is expected to grow considerably in the short, medium and long terms as infrastructure is improved and technological advancements enhance the efficiency of devices and open up potential new sites for development.

1.3.1 Offshore Wind Energy in Ireland

There is currently 15.8GW of installed offshore wind power capacity in the EU (WindEurope, 2018). The Strategic Environmental Assessment Statement presented in conjunction with the OREDP (DCENR, 2010) concluded that, with appropriate mitigation measures and with some qualifications, that it would be possible to achieve 4,500MW of offshore wind capacity without significant effect on the environment in the period to 2030. However, each proposed MRE development will need to undertake its own suite of surveys and assessments of impacts. Ireland's first offshore windfarm was deployed as a demonstrator project in 2004 at the Arklow Bank on the east coast. As of 2018 it remains Ireland's only operational offshore windfarm, though additional licenses have been granted for larger developments which are not yet built, and a number of other projects are in the early planning and consenting stages (Table 1). With the exception of a relatively small proposed development at Sceirde Rocks, all proposed commercial windfarms are in the Irish Sea. The strongest wind power in Ireland is in the northwest and west, though the wind energy resource is consistent around the coast (800-1200 W/m^2; Gallagher *et al*., 2016), see Figure 1. The east coast offers more accessible sites of depths under 50m however, hence the initial focus of the industry on the Irish Sea. For turbine deployment and maintenance, the east coast is much more accessible too, particularly in winter (Gallagher *et al*., 2016). The availability of grid infrastructure and large population centres on the east coast are also advantageous. Lastly, the winds on the east coast are more consistent than those in the west. All of these reasons have led the east coast and Irish Sea to be the initial focus of wind farm deployment in the state, but advancing technologies, improved grid infrastructure and increased demand will ensure that the wind energy potential on the south, west and northwest coasts will be similarly explored for development potential in the future. The world's first commercial floating offshore windfarm off the coast of Scotland (Hywind, Statoil) became operational in 2017. This technology is likely to facilitate the development of the wind energy resource around the rest of the Irish coast in the future (2025 and beyond), particularly along the western seaboard (DCENR 2010), and at depths of up to 200m.

Table 1. Proposed windfarms in Irish waters, via 4C Offshore (2018).

Name	County	Sea	Capacity	Turbines	Developer/Owner	Status
Oriel Windfarm	Louth	Irish Sea	330 MW	55	Oriel Windfarm Ltd., Parkwind NV.	Consent Application Submitted
Clogherhead	Louth	Irish Sea	500 MW		Hibernian Wind Power Ltd., ESB	Concept/Early Planning
North Irish Sea Array (NISA)	Louth, Meath, Dublin	Irish Sea	750 MW		Element Power	Concept/Early Planning
Dublin Array	Dublin, Wicklow	Irish Sea	364 MW+	145	Innogy Renewables Ireland, Saorgus Energy Ltd.	Consent Application Submitted
Codling Wind Park	Wicklow	Irish Sea	1,100 MW	220	Fred Olsen Renewables, Hazel Shore Ltd.	Consent Authorised
Codling Wind Park Extension	Wicklow	Irish Sea	1,000 MW	200	Fred Olsen Renewables, Hazel Shore Ltd.	Consent Application Submitted
Arklow Bank Phase 1	Wicklow	Irish Sea	25.2 MW	7	SSE Renewables, Acciona Energia, GE Energy	Fully commissioned
Arklow Bank Phase 2	Wicklow	Irish Sea	494.8 MW	193	SSE Renewables	Consent Authorised
Kilmichael Point	Wexford	Irish Sea	500 MW		ESB	Concept/Early Planning
Sceirde Rocks	Galway	Atlantic Ocean	100 MW	20	Fuinneamh Sceirde Teoranta	Consent Application Submitted

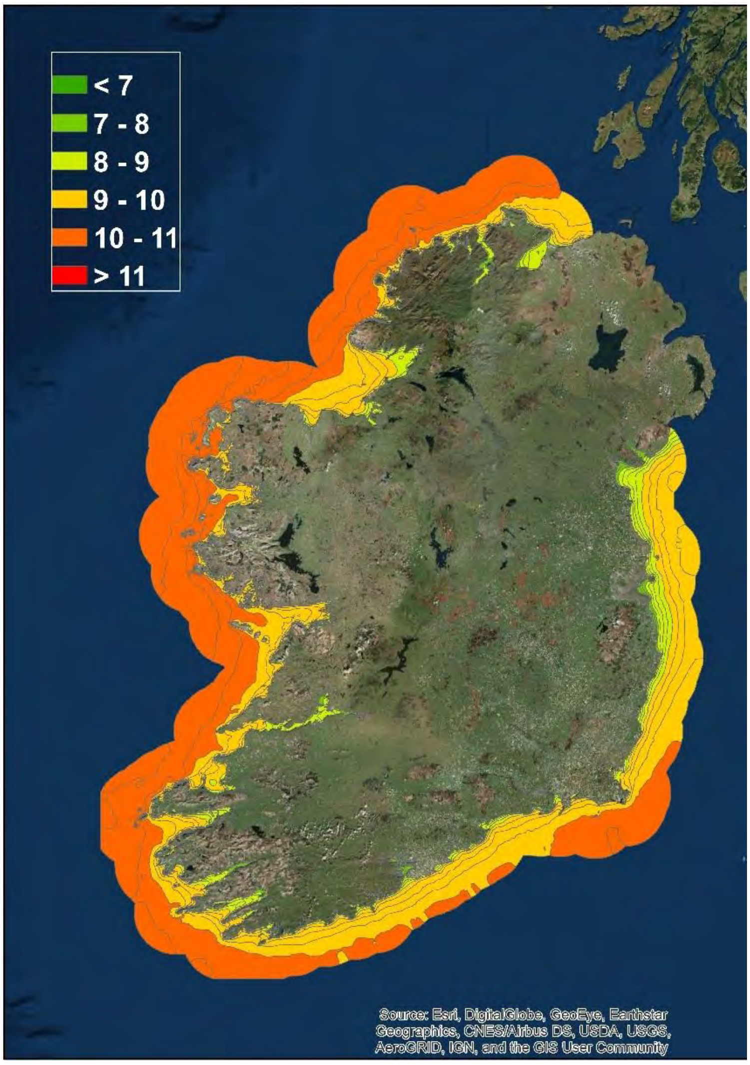

Figure 1. Offshore wind speed at 100m height (metres per second, upper estimate) from SEAI Wind Atlas 2013.

1.3.2 Wave Energy in Ireland

Wave energy is still in the research, development and demonstration stages in Ireland but is anticipated to be in commercial operation by 2030. Ireland's potential wave energy resources are largely restricted to the west and northwest Atlantic coasts (Gallagher *et al.* 2016). As of 2018 there are wave energy converter test sites in Galway Bay (quarter-scale, Galway Bay Marine and Renewable Energy Test Site) and Belmullet (full-scale, Atlantic Marine Energy Test Site – AMETS), with ESB also developing a 5MW demonstration site off the west coast of Clare (WestWave). Site accessibility for marine operations is a potential problem for some of those sites with the best wave resources (Gallagher *et al.,* 2016). It is likely that the first phase of wave energy development will occur in depths of 10-100m, with deeper waters (100-200m) being exploited in the longer term (2025 to 2030 and beyond; DCENR, 2010). Intermittence of the resource is also a potential problem with wave energy, though there is potential to develop combined wind-wave farms on the west coast that could exploit the lag between energetic wind and wave resource availability to provide a more consistent energy output (Gallagher *et al*., 2016).

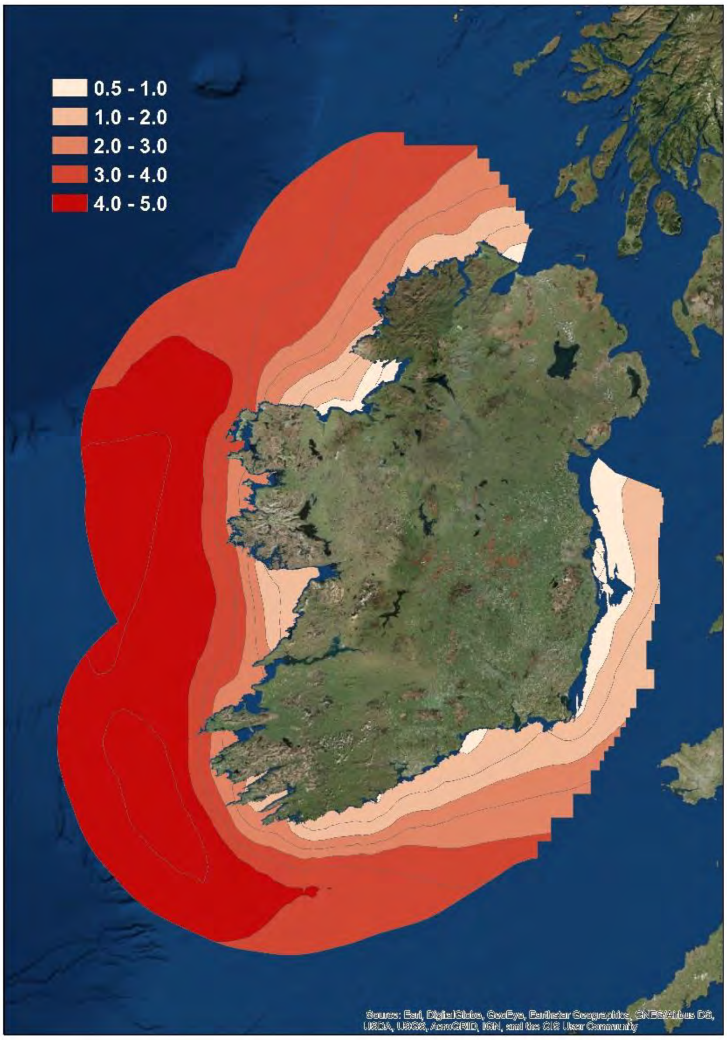

Figure 2. Mean annual practicable wave energy resource (Pelamis) around Ireland (MWhe/km; ESB International 2005).

1.3.3 Tidal Energy in Ireland

The Irish tidal resource is largely concentrated off the East Coast, with isolated locations in the north and west also showing a strong current, see Figure 3. A report by Sustainable Energy Authority of Ireland (SEI 2007) concluded that viable tidal energy sites existed at Codling and Arklow Banks (east), Tuskar Rock and Carnsore Point (east) and the Shannon Estuary (west) in the Republic of Ireland. Other sites with energy potential existed elsewhere but were constrained by technical, physical, institutional and commercial viability matters. The viable tidal energy resource at the time of publishing was estimated as 0.915 TWh/year and it was expected that it would be at least 2015 before tidal energy devices would be capable of operating in peak tidal velocities of 1.5m/s. As of 2018 there are no tidal energy developments in operation in Ireland and this sector within the MRE industry is in its infancy compared to offshore wind and wave, both of which are expected to have a greatly enhanced operational presence by 2030. Research into tidal devices and infrastructure is ongoing in Ireland however (e.g. FloTEC and Taoide at MaREI). In Northern Ireland, planned tidal energy projects at Fair Head and Torr Head off the coast of Antrim are proposed to deliver a combined 200MW in the future.

Figure 3. Potential tidal resource around Ireland (DCENR, 2012).

1.4 Potential effects of Marine Renewable Energy Installations on Seabirds

Behind each piece of legislation and strategic plan related to offshore renewable energy is an acknowledgement of the potential for conflict with obligations to protect biodiversity and other sectors operating in the marine, as well as a reminder that sustainability is key. From an environmental point of view, offshore renewable energy is likely to be a key player in the shift towards a decarbonised economy. At present offshore wind farms are essentially restricted to a relatively short distance from the coast, or shallow offshore banks, where there may be other competing interests. The efficiency of renewable energy devices continues to improve, and deployment costs continue to come down. The world's first floating offshore windfarm began operation in Scotland in 2017, and the use of similar technology here is likely to be a game-changer in unlocking vast areas in Irish territorial waters to potential energy development, including areas where the number of potential conflicting activities and uses may be lower.

Ireland has a wealth of important marine biodiversity, for many of the same reasons that it has such potential for offshore energy – our extensive and diverse coastline, vast offshore territorial waters and our position in the north Atlantic. Our marine waters support hundreds of thousands of seabirds, with some species present here in numbers of regional, continental and even global importance. Each of these species exists in their own niche and relies on the marine environment in a unique way to other species. Different species will choose different places to breed, to hunt for food, to spend the summer or the winter. Some fly high, others low, and some spend most of their time sitting on the water. Species such as Arctic Terns migrate from Ireland and Europe at the end of the summer, whereas Little Gulls only appear here from autumn to spring. Puffins breed on coastal cliffs and offshore islands before moving north and west to exploit feeding opportunities out in the north Atlantic when they're not required to make regular return journeys to a nest. Seabirds and marine biodiversity are credited with bringing monetary and non-monetary services and values to Irish society. As a result, international legislation (most notably the EU Birds Directive and Habitats Directive) requires that Ireland takes steps to ensure the protection and conservation of these species and their habitats. Seabirds are generally long-lived species, usually with delayed breeding and low annual reproductive output, so factors that influence adult survival will have a strong influence on population dynamics that may not be recognised for several years (Stienen *et al.,* 2007). Many of the seabirds frequenting our waters are classified as vulnerable or endangered at European or global level. Seabirds are more threatened globally than any other comparable group of birds with over one quarter of species threatened and five percent of species critically endangered. Loss of breeding habitat and reduced food supply are two of the main causes of seabird declines, both of which are amplified by widescale overfishing and ocean warming due to climate change. The increased use of the marine environment to host renewable energy devices presents a significant opportunity to make big steps towards decarbonisation of our society and cleaning up the environment, but it's important that we are wary of the potential environmental impacts of these developments too. We must be cautious too of the risk of cumulative impacts from a number of separate developments within the range of seabirds in a given area.

Table 2. Summary of potential pressures, impacts and indicators, in relation to negative effects of MRE projects and seabirds (taken from DCCAE, 2018).

3.1 Birds (construction and operation)	
Potential Pressures	• The construction and operation of MRE installations. • The presence, movement and activity of construction vessels.
Likely Negative Impacts	• Direct impacts are: Disturbance, displacement, attraction, collision (above and below water), entrapment and barrier effects. • Indirect impacts are changes in sedimentary process, pollution, predation (use of devices as land bridges by predators) and displaced fishing effort with implications for foraging resources (positive and negative)
Indicators for Identified Impact	• Regional effects may be determined by changes in the: composition of species present, their abundance, density and spatial distribution and by changes in patterns of temporal abundance (season, tide, time of day), habitat use (surface, mid water, seabed, air space) and changes in use of particular habitat features (e.g. shallows, tidal race). • Local effects include micro avoidance, injury or mortality. Where disturbance to breeding sites occurs, productivity* may be affected.

**Young fledged per nesting pair*

1.4.1 Wind Energy

Amongst the offshore renewable energy developments discussed here, wind is the only one considered 'mature' at this stage with a number of windfarms likely to be constructed in the Irish Sea in the coming years and the likelihood of floating turbines opening up areas of deeper water to development. Activities such as pile driving and increased vessel traffic during the construction phase of offshore windfarms have the potential to negatively impact seabirds, though it is the operation phase which is of greatest concern (Bailey *et al*. 2014).

The main risks of offshore wind farms to seabirds (Drewitt & Langston, 2006) have been identified as:

- Collision mortality
- Disturbance and displacement
- Barrier effects
- Habitat loss

The most obvious risk for seabirds from offshore windfarms is mortality through collision with the rotor blades, towers, nacelles and other associated infrastructure (Drewitt & Langston, 2006). The extent of this risk for an individual species will depend on the altitude at which the bird flies, their flight manoeuvrability, and how long on average they spend in flight, amongst other factors. Seabirds are long-lived and most don't begin to breed until they are several years old which would likely lead to a lag-effect between mortalities occurring and population-level impacts becoming noticeable (Stienen *et al*., 2007). At onshore windfarms, where appropriately designed post-construction monitoring programmes are in place, carcasses of birds killed by collisions with turbines can be collected and used to estimate number of deaths per unit time and confidence intervals, helping to quantify uncertainty and remove bias from collision risk models (Green *et al*. 2016). Some studies have indicated low collision mortality rates for offshore turbines, but recovering carcasses from offshore windfarms is highly impractical, leading to an underestimation of the actual numbers of collisions and a high level of uncertainty as a result (Langston & Pullan, 2003). It should also be noted that existing windfarms on which studies were based are likely to have been placed away from large concentrations of birds (Drewitt & Langston, 2006). Collision risk is also likely to vary depending on the stage of the annual cycle of the species (e.g. Henderson *et al*., 1996), weather conditions (e.g. Erickson *et al.,* 2001), tides and offshore currents (Drewitt & Langston, 2006). Careful site selection is therefore key to minimising collision risk.

Disturbance and displacement are possible risks both during construction and operation of offshore windfarms, where birds avoid an area due to noise or visual intrusion and resulting in increased energy expenditure. Though this is arguably preferable to mortality from collision, increased energy expenditure is often costly and may manifest itself in reduced breeding productivity and survival, which will ultimately have impacts at population level. The cumulative impacts of a number of offshore developments are likely to greatly increase energy expenditure and significantly enhance the risk of impact at population level as a result.

Offshore wind farms can also act as barriers to movement, a particular concern for migrating birds that are already expending a large amount of energy on route to breeding, wintering or moulting grounds (Drewitt & Langston, 2006; Fox *et al.*, 2006; Langston & Pullan, 2003). Avoiding large windfarms by flying around them will again incur an additional energetic cost for the bird in question as they have to fly further than anticipated, decreasing their chances of survival on migration or of being able to provide for chicks over the full course of the breeding season. As with the other risks, careful choice of location for developments in the offshore environment and consideration of cumulative impacts are vital to minimise the impacts of barrier effects. The size of the windfarm and spatial arrangement of the turbines are also important factors.

Habitat loss or damage to offshore habitats resulting from the wind farm infrastructure presence can be of concern if they cover feeding areas (Langston & Pullan, 2003). The operation phase could also affect the movements and navigation of other marine species that are sensitive to electro- or magnetic fields, which include fish species, particularly elasmobranchs, sea turtles, some teleost fish and decapod crustaceans. The location and scale of developments in relation to the existing habitat will dictate the scale of direct habitat loss. There may also be habitat loss on land where transformer stations are constructed (Drewitt & Langston, 2006). There are examples to indicate offshore windfarms may function as combined artificial reefs and fish aggregation devices for small demersal fish (Wilhelmsson *et al*., 2006, Vanerman *et al*., 2014), though this is likely difficult to predict in advance and will only be of net benefit to birds if risk of collision or displacement aren’t otherwise increased by the development (Drewitt & Langston, 2006).

As discussed previously by Ramiro & Cummins (2016), there are still very few comprehensive studies that have examined pre- and post- construction analysis on the impacts of offshore wind farms, despite a significant number of developments now operational across Europe. Two of the most studied cases are the Danish offshore wind farms Nysted and Horns Rev (Petersen *et al*., 2006) and the Egmond aan Zee windfarm in the Netherlands (Krijgsveld *et al*., 2011; Leopold *et al*., 2011; Lindeboom *et al*., 2011). Petersen *et al*. (2006), Krijgsveld *et al*. (2011) and Leopold *et al*. (2011) found similar results in their analysis: some seabirds avoided the area, whilst others were attracted or showed no difference. Before-After Control-Impact (BACI) studies at the Belgian Bligh Bank found similarly varied results, with some gull species increasing in abundance within the windfarm area but Gannets, Common Guillemots and Razorbills avoiding the area (Vanerman *et al*., 2014). A recent study monitoring bird behaviour at Thanet Offshore Wind Farm in the UK has generated the most extensive dataset of observations of seabird behaviour in and around an operational offshore wind farm that is currently available. Skov *et al*. (2018) found that the majority of seabirds examined avoided the windfarm and/or turbines, with only a very small number of collisions recorded. The Thanet study also indicated that seabird flight activity around offshore windfarms during the night were very limited. There is still, however, no consensus on the impacts for some species with calls for further research and more comprehensive survey designs whenever possible. For example, in contrast to findings in the Danish and Belgian case studies, Lindeboom *et al*. (2011) did not detect any significant avoidance behaviour of the wind farm by divers, Common Guillemots and Razorbills, with no effect on their distribution.

In Ireland, routine monitoring of our seabird populations is very much limited to individual species and sites (e.g. Roseate tern monitoring on Rockabill Island). We are still lacking much comprehensive data on the most important offshore areas for our seabirds in the breeding season and during migration. Furthermore, how wintering waterbirds such as the seaducks utilise the waters around our coastal estuaries and bays remains largely unknown in most areas. Thus, significant data gaps remain, and more information is needed on patterns of distribution and timing of movements of vulnerable bird species in the Irish marine environment at key times of year in order to evaluate and assess the ecological considerations and sensitivities of developing MRE offshore (Ramiro & Cummins, 2016). Addressing these ecological data gaps will allow us to make informed decisions about how best to utilise our marine environment in a truly sustainable way, ensuring we can harness the social, economic and environmental potential of our ocean wealth.

1.4.2 Wave Energy

The wave energy industry is in the trial stages in Ireland, with testing facilities in Galway Bay, the ESB Westwave project in Killard in Co. Clare and the Sustainable Energy Authority of Ireland's (SEAI) Atlantic Marine Energy Test Site (AMETS) planned for Belmullet, Co. Mayo. Ireland has great potential to harness wave energy, particularly along the Atlantic coast (Figure 2).

The potential impacts of wave-powered devices on seabirds include (Grecian *et al*., 2010):

- Risk of collision above water
- Risk of collision under water
- Disturbance
- Displacement & Redirection/Barrier Effects
- Pollution

Given the relative infancy of the wave-energy industry, little work has been done on their potential impact on seabirds to date in comparison to wind turbines. As with other MRE devices, there is a collision risk for seabirds from wave-powered devices. The collision risk above water is relatively low compared to that of wind turbines, given that wave-device structures are unlikely to rise above 4m over the water surface (Michel *et al*., 2007, Grecian *et al.,* 2010). With that in mind, the suite of species likely to collide with these structures might be quite different to those with taller structures (i.e. wind turbines). Further research is necessary to quantify the risk posed to seabirds by devices such as these. Underwater, the fixed structures that form part of wave-energy devices are likely to pose no real threat, but the mobile components (e.g. energy converters) will pose a risk of collision for diving species (Wilson *et al*., 2007, Grecian *et al.,* 2010). An understanding of prey distribution and behaviour around wave devices will aid in assessing the risk of collision for diving seabird species (Grecian *et al.,* 2010). The risk of disturbance from wave-energy devices is likely to be highest during device installation (and maintenance) (Madsen *et al*., 2006), though there is a lack of research quantifying operational noise from these devices and their potential impact on wildlife. (Grecian *et al.,* 2010). As for other MRE developments, there is a risk of displacement and barrier effects, and extreme care should be put into ensuring the placement of these devices away from key foraging grounds in particular (Snyder & Kaiser 2009, Grecian *et al*., 2010). The risk of barrier effects for migrating species is likely to be lower than that for structures with a higher above-water profile i.e. wind turbines. Wave-energy devices require substantial amounts of oil and lubricant for effective operation, and the potential and risk of an oil spill should not be underestimated (Votier *et al.,* 2008, Grecian *et al.,* 2010). Grecian *et al.* (2010) also highlight the significant and varied potential negative impacts that wave-energy developments might have on local habitats and prey species, though there is also potential for them to act as fish aggregation devices (FADs) that attract fish seeking shelter, or as *de facto* Marine Protected Areas (MPAs) where fishing cannot take place and therefore enhancing local fish stocks.

1.4.3 Tidal Energy

As of 2018, tidal energy has no real commercial presence in Ireland as much of the technology is still in development and working towards viability. Significant tidal potential has been identified on the east coast of Ireland, and in the Shannon Estuary on the west coast (SEI, 2007). Tidal energy, therefore, is likely to have an important part to play in Ireland's renewable energy sector in the medium-term.

Effects from tidal and wave energy developments are largely unknown because there have not yet been enough deployments (Witt *et al*., 2012). To date, tidal energy devices have been largely restricted to testing sites and therefore data on wider biodiversity impacts is limited for this technology (Frid *et al.* 2012). Many tidal stream turbines resemble wind turbines, but other designs have been identified which include horizontal or vertical axis turbines, oscillating devices, venture effect devices, screw and kite type devices (EMEC, 2018). Current tidal energy developments include barrages/fences which are built across an estuary or bay and tidal stream farms that are situated in the water column. They bring with them a risk of collision mortality, though given that most tidal turbines are designed to be placed at significant depths this risk will be limited to the deeper-diving species, such as Common Guillemots and Razorbills which regularly dive to depths of ca. 30-70 m (Thaxter *et al*., 2010). The slow turbine speeds should make the risk of mortality very low (Awatea, 2008), given the underwater agility of most deep-diving species.

Tidal barrages alter water flow, thereby changing the exposure time of tidal flats to feeding birds such as waders and wildfowl. Although there might be an increase in food availability when the tidal flats are exposed, feeding time could also be reduced with the delay in the falling tide (Frid *et al*., 2012). Hence, potential impacts on birds could include lower food quality, reduced feeding areas and increased foraging trips between sub-optimal grounds. The altered water flow is also likely to alter the benthic habitat (Frid *et al*., 2012) through changing sediment transportation and extracting energy from the system, which is likely to significantly affect estuarine waterbirds.

1.5 Aims and scope of this study

Before consent is given for a MRE project, an Environmental Impact Assessment Report (EIAR) and/or Natura Impact Statement (NIS) to support Appropriate Assessment may be required to evaluate potential impacts of the project on the marine environment. One of the most notable environmental impacts of offshore renewable energy developments is on birds, and developers must prove to the consenting authorities that there is no likely significant impact on the conservation interests of any Natura 2000 sites.

This study aims to progress the development of a seabird sensitivity mapping tool for offshore renewable energy developments. Critically, it is a tool which aims to support proper planning decisions and to minimise the impacts on seabirds from MRE developments in Irish waters. It will help to reduce the consenting risk for MRE developments by highlighting potential areas of seabird sensitivity so that any sensitive species or locations can be identified early in the planning stages and the necessary preparations and modifications can be made. It is hoped that the free availability and regular use of this seabird sensitivity mapping tool will lead to a smoother planning and consenting process for developers and consenting authorities and will help to minimise any potential conflicts between conservation bodies and other stakeholders as a result.

The scope of this phase of the project is 1) to trial the methodology outlined by Ramiro & Cummins (2016) to develop a seabird sensitivity map for MRE developments in the Republic of Ireland, 2) demonstrate the sensitivity mapping tool to a diverse group of stakeholders (including MRE developers) and invite their feedback, 3) make recommendations for the future development of this tool based on tasks 1) and 2).

2. Methodology

2.1 Phase 1 – Feasibility Study & Recommended Methodology

In phase one of this project, Ramiro & Cummins (2016) detailed how seabird sensitivity mapping for offshore renewables has been developed successfully in other countries and outlined the best approach for delivering a similar mapping tool for MRE developments in Ireland. Their findings, index calculations and recommendations formed the basis for the current stage (phase two) of development of this tool. A list of 38 marine birds regularly occurring in Ireland, migratory and breeding, was compiled from the Birds of Conservation Concern in Ireland (BoCCI) 2014-2019 list (Colhoun & Cummins, 2013) and the Action Plan for Sea Cliff and Coastal Bird Species 2011 – 2020 (BirdWatch Ireland, 2011).

Ramiro & Cummins (2016) determined a species sensitivity score (SSS) for each of the 38 seabird species based on established methodologies developed elsewhere and updating the conservation importance of each species for an Irish context. For offshore wind energy, the sensitivity index approaches established by Garthe & Hüppop (2004) and Furness *et al*. (2013) were recommended, and for wave and tidal energy developments the approach used by Furness *et al.* (2012). Factors used to calculate the conservation score for each species in an Irish context were: 1) status in relation to the EU Birds Directive, 2) Percentage of the biogeographic population in Irish waters, 3) status in BoCCI 2014-2019 list (Colhoun & Cummins, 2013) and 4) Adult survival rate. Each species was scored and ranked for each development and impact type, the results of which are provided here in Tables 3-6 and full details of which are outlined in Ramiro & Cummins (2016).

Table 3. Ranked species score for sensitivity to collision impact (Ramiro & Cummins, 2016).

Species	Scientific name	Risk Collision Score
Herring Gull	*Larus argentatus*	1225
Great Black-backed Gull	*Larus marinus*	1225
Lesser Black-backed Gull	*Larus fuscus*	780
Common Gull	*Larus canus*	550
Mediterranean Gull	*Larus melanocephalus*	542
Common Tern	*Sterna hirundo*	510
Gannet	*Morus bassanus*	480
Kittiwake	*Rissa tridactyla*	455
Sandwich Tern	*Sterna sandvicencis*	397
Little Gull	*Hydrocoloeus minutus*	390
Roseate Tern	*Sterna dougallii*	363
Little Tern	*Sterna albifrons*	350
Cormorant	*Phalacrocorax carbo*	261
Shag	*Phalacrocorax aristotelis*	243
Great Northern Diver	*Gavia immer*	227
Great Skua	*Stercorarius skua*	220
Red-throated Diver	*Gavia stellate*	200
Black-throated Diver	*Gavia arctica*	195
Arctic Skua	*Stercorarius parasiticus*	187
Black-headed Gull	*Chroicocephalus ridibundus*	187
Arctic Tern	*Sterna paradisaea*	175
Scaup	*Aythya marila*	99
Common Scoter	*Melanitta nigra*	96
Velvet Scoter	*Melanitta fusca*	96
Northern Fulmar	*Fulmarus glacialis*	88
Eider	*Somateria mollissima*	66
Great Crested Grebe	*Podiceps cristatus*	66
Atlantic Puffin	*Fratercula arctica*	52
European Storm Petrel	*Hydrobates pelagicus*	51
Leach's Storm Petrel	*Oceanodroma leucorhoa*	45
Common Guillemot	*Uria aalge*	35
Razorbill	*Alca torda*	16
Black Guillemot	*Cepphus grylle*	14
Manx Shearwater	*Puffinus puffinus*	0
Great Shearwater	*Puffinus gravis*	0
Balearic Shearwater	*Puffinus mauretanicus*	0
Cory’s Shearwater	*Calonectris diomedea*	0
Sooty Shearwater	*Puffins griseus*	0

Table 4. Ranked species score for sensitivity to disturbance and/or displacement from habitat (Disturbance score x Habitat flexibility x Conservation importance score)/10. (Ramiro & Cummins, 2016).

Species	Scientific name	Disturbance Risk Score
Black-throated Diver	*Gavia arctica*	26
Great Northern Diver	*Gavia immer*	25.5
Red-throated Diver	*Gavia stellate*	24
Common Scoter	*Melanitta nigra*	24
Cormorant	*Phalacrocorax carbo*	22.4
Velvet Scoter	*Melanitta fusca*	18
Razorbill	*Alca torda*	14.4
Black Guillemot	*Cepphus grylle*	14.4
Scaup	*Aythya marila*	14.4
Common Guillemot	*Uria aalge*	13.5
Eider	*Somateria mollissima*	13.2
Great Crested Grebe	*Podiceps cristatus*	13.2
Little Tern	*Sterna albifrons*	12
Shag	*Phalacrocorax aristotelis*	11.7
Sandwich Tern	*Sterna sandvicencis*	10.2
Roseate Tern	*Sterna dougallii*	10.2
Common Tern	*Sterna hirundo*	10.2
Arctic Tern	*Sterna paradisaea*	9
Atlantic Puffin	*Fratercula arctica*	7.8
Great Black-backed Gull	*Larus marinus*	6
Black-headed Gull	*Chroicocephalus ridibundus*	5.6
Mediterranean Gull	*Larus melanocephalus*	5.2
Kittiwake	*Rissa tridactyla*	5.2
Balearic Shearwater	*Puffinus mauretanicus*	4.5
Common Gull	*Larus canus*	4.4
Little Gull	*Hydrocoloeus minutus*	3.9
Manx Shearwater	*Puffinus puffinus*	3
Herring Gull	*Larus argentatus*	3
Gannet	*Morus bassanus*	3
Lesser Black-backed Gull	*Larus fuscus*	2.6
Great Skua	*Stercorarius skua*	2.2
European Storm Petrel	*Hydrobates pelagicus*	1.7
Arctic Skua	*Stercorarius parasiticus*	1.6
Sooty Shearwater	*Puffins griseus*	1.5
Leach's Storm Petrel	*Oceanodroma leucorhoa*	1.5
Cory's Shearwater	*Calonectris diomedea*	1.4
Northern Fulmar	*Fulmarus glacialis*	1.2
Great Shearwater	*Puffinus gravis*	0.8

Table 5. Species vulnerability index for tidal turbine impacts on Marine birds (ranked by species score). (Ramiro & Cummins, 2016).

Species	Scientific name	SSS	Descriptor on 5-score scale
Razorbill	*Alca torda*	9.6	4: high vulnerability
Black Guillemot	*Cepphus grylle*	9.12	4: high vulnerability
Cormorant	*Phalacrocorax carbo*	8.96	4: high vulnerability
Common Guillemot	*Uria aalge*	8.4	4: high vulnerability
Shag	*Phalacrocorax aristotelis*	8.32	4: high vulnerability
Great Northern Diver	*Gavia immer*	4.08	3: moderate vulnerability
Atlantic Puffin	*Fratercula arctica*	3.12	3: moderate vulnerability
Black-throated Diver	*Gavia arctica*	2.964	3: moderate vulnerability
Red-throated Diver	*Gavia stellate*	2.88	3: moderate vulnerability
Great Crested Grebe	*Podiceps cristatus*	1.672	2: low vulnerability
Arctic Tern	*Sterna paradisaea*	1.65	2: low vulnerability
Common Scoter	*Melanitta nigra*	1.512	2: low vulnerability
Velvet Scoter	*Melanitta fusca*	1.512	2: low vulnerability
Sandwich Tern	*Sterna sandvicencis*	1.36	2: low vulnerability
Manx Shearwater	*Puffinus puffinus*	1.35	2: low vulnerability
Balearic Shearwater	*Puffinus mauretanicus*	1.35	2: low vulnerability
Sooty Shearwater	*Puffins griseus*	1.35	2: low vulnerability
Cory's Shearwater	*Calonectris diomedea*	1.26	2: low vulnerability
Gannet	*Morus bassanus*	1.26	2: low vulnerability
Eider	*Somateria mollissima*	1.254	2: low vulnerability
Roseate Tern	*Sterna dougallii*	1.122	2: low vulnerability
Great Black-backed Gull	*Larus marinus*	0.96	1: very low vulnerability
Kittiwake	*Rissa tridactyla*	0.832	1: very low vulnerability
Scaup	*Aythya marila*	0.792	1: very low vulnerability
Little Tern	*Sterna albifrons*	0.78	1: very low vulnerability
Black-headed Gull	*Chroicocephalus ridibundus*	0.756	1: very low vulnerability
Common Tern	*Sterna hirundo*	0.748	1: very low vulnerability
Herring Gull	*Larus argentatus*	0.72	1: very low vulnerability
Great Shearwater	*Puffinus gravis*	0.72	1: very low vulnerability
Mediterranean Gull	*Larus melanocephalus*	0.702	1: very low vulnerability
Little Gull	*Hydrocoloeus minutus*	0.702	1: very low vulnerability
Common Gull	*Larus canus*	0.594	1: very low vulnerability
Lesser Black-backed Gull	*Larus fuscus*	0.546	1: very low vulnerability
European Storm Petrel	*Hydrobates pelagicus*	0.51	1: very low vulnerability
Great Skua	*Stercorarius skua*	0.462	1: very low vulnerability
Leach's Storm Petrel	*Oceanodroma leucorhoa*	0.45	1: very low vulnerability
Northern Fulmar	*Fulmarus glacialis*	0.36	1: very low vulnerability
Arctic Skua	*Stercorarius parasiticus*	0.336	1: very low vulnerability

Table 6. Species vulnerability index for wave turbine impacts on seabirds (ranked by species score) (Ramiro & Cummins, 2016).

Species	Scientific name	SSS	Descriptor on 5-score scale
Great Northern Diver	*Gavia immer*	323	4: high vulnerability
Black-throated Diver	*Gavia arctica*	260	3: moderate vulnerability
Red-throated Diver	*Gavia stellate*	240	3: moderate vulnerability
Razorbill	*Alca torda*	224	3: moderate vulnerability
Common Guillemot	*Uria aalge*	195	2: low vulnerability
Common Scoter	*Melanitta nigra*	180	2: low vulnerability
Black Guillemot	*Cepphus grylle*	168	2: low vulnerability
Velvet Scoter	*Melanitta fusca*	168	2: low vulnerability
Little Tern	*Sterna albifrons*	165	2: low vulnerability
Atlantic Puffin	*Fratercula arctica*	156	2: low vulnerability
Great Crested Grebe	*Podiceps cristatus*	154	2: low vulnerability
Sandwich Tern	*Sterna sandvicencis*	153	2: low vulnerability
Roseate Tern	*Sterna dougallii*	153	2: low vulnerability
Common Tern	*Sterna hirundo*	153	2: low vulnerability
Greater Scaup	*Aythya marila*	144	2: low vulnerability
Arctic Tern	*Sterna paradisaea*	135	2: low vulnerability
Gannet	*Morus bassanus*	135	2: low vulnerability
Eider	*Somateria mollissima*	132	2: low vulnerability
Shag	*Phalacrocorax aristotelis*	130	2: low vulnerability
Cormorant	*Phalacrocorax carbo*	126	2: low vulnerability
Manx Shearwater	*Puffinus puffinus*	90	1: very low vulnerability
Balearic Shearwater	*Puffinus mauretanicus*	90	1: very low vulnerability
Sooty Shearwater	*Puffins griseus*	90	1: very low vulnerability
Cory's Shearwater	*Calonectris borealis*	84	1: very low vulnerability
Black-headed Gull	*Chroicocephalus ridibundus*	84	1: very low vulnerability
Mediterranean Gull	*Larus melanocephalus*	78	1: very low vulnerability
Little Gull	*Hydrocoloeus minutus*	78	1: very low vulnerability
Kittiwake	*Rissa tridactyla*	78	1: very low vulnerability
Great Black-backed Gull	*Larus marinus*	75	1: very low vulnerability
European Storm Petrel	*Hydrobates pelagicus*	68	1: very low vulnerability
Common Gull	*Larus canus*	66	1: very low vulnerability
Great Skua	*Stercorarius skua*	66	1: very low vulnerability
Leach's Storm Petrel	*Oceanodroma leucorhoa*	60	1: very low vulnerability
Lesser Black-backed Gull	*Larus fuscus*	52	1: very low vulnerability
Northern Fulmar	*Fulmarus glacialis*	48	1: very low vulnerability
Great Shearwater	*Puffinus gravis*	48	1: very low vulnerability
Arctic Skua	*Stercorarius parasiticus*	48	1: very low vulnerability
Herring Gull	*Larus argentatus*	45	1: very low vulnerability

2.2 Phase 2 – Development of a Trial Map Layer

2.2.1 Selection of Species and Study Area

Phase one of this project identified a suitable methodology to map marine bird sensitivities, informed by best practice. The current phase of the project set out to test this methodology with a subset of the species present in Irish marine waters, across a limited geographic area. The species were picked to represent the different ecological traits and foraging guilds of birds in the marine environment, and thereby to include the likely range of interactions between birds and MRE structures in the offshore sphere. An additional consideration was the likelihood of available data for each species, including species-specific survey and tracking data. A mixture of species likely to have much and little available data were chosen for this phase of the project, to accurately represent the breadth of opportunities and difficulties in accurately mapping the presence of different species and groups in Irish marine waters. This will also help inform recommendations for future areas of study to address any significant knowledge gaps. The final species chosen for this phase of the project were: Northern Gannet *Morus bassana* (plunge-diving), Razorbill *Alca torda* (underwater pursuit-diving auk), European Shag *Phalacrocorax aristotelis* (pursuit-diving marine cormorant), Herring Gull *Larus argentatus* (scavenging gull), Black-legged Kittiwake *Rissa tridactyla* (surface-feeding gull) and Common Scoter *Melanitta nigra* (diving seaduck, non-breeding season only).

The trialling of the methodology set out in Phase I, with the six species listed above, was carried out on waters in the Irish Sea and Wexford coast within the Irish Exclusive Economic Zone (EEZ). This subsection of Irish marine waters was chosen as it holds Ireland's first and only wind farm to date (Arklow Bank), with three other offshore windfarms planned in the coming years (i.e. Oriel, Dublin Array, Codling Bank). There are also a number of important seabird breeding colonies and coastal Special Protection Areas (SPAs) in this part of Irish inshore and offshore waters.

2.2.2 Data Sources

Data has been obtained from a variety of sources to ensure the resulting maps showing species presence are as complete, relevant and up-to-date as possible. Data from the marine environment is more limited than its terrestrial counterpart due to the difficulties in surveying birds at sea and the ecology of marine birds. Recommendations to address notable data gaps and improve on existing data are listed in Section 5.3 below. Table 7 outlines the data used for this project.

The primary source of data was from boat-based seabird surveys. The European Seabirds at Sea (ESAS) database is a shared database containing results of ship-based and aerial seabird surveys from different sources in northwest European waters, since 1979. The database is managed by the Joint Nature Conservation Committee (JNCC) in the UK and has been used in a number of studies and publications (e.g. Stone *et al.,* 1995; Bradbury *et al.,* 2014). The ESAS methodology is the industry standard for offshore seabird surveys (Jackson & Whitfield, 2011; DCCAE, 2018). The strengths of the ESAS database are the large spatial and temporal scale on which data is available, though the depth of information in some areas can be somewhat shallow and arguably dated. These issues were addressed by the collation of datasets from seabird surveys carried out as part of proposed and planned offshore wind farms. Offshore wind energy is still in its infancy in Ireland, and the initial focus for development has been the east coast of Ireland and the Irish Sea. Data from four wind energy projects, in various stages of the planning, consenting and development processes, were made available by the respective developers (Table 7) and provided monthly data over a number of recent years. As an aside, each of the developers from whom data was requested were happy to make it available to the project, indicating a desire to work towards a tool that ultimately aims to benefit the industry and to minimise potential conflict with seabirds and conservation interests.

Two studies that modelled breeding seabird foraging distributions based on recent high-resolution GPS tracking projects also made their data and results available for this project (Table 7). Gannet tracking projects at Irish colonies contributed to the study by Wakefield *et al.* published in the journal *Science* in 2013, and similar efforts on Shags, Kittiwakes, Razorbills and Common Guillemots allowed Wakefield *et al.* (2017) to predict regional seabird distribution by also incorporating habitat information. The Gannet study did not incorporate habitat data, though a study is currently underway to model foraging areas in a similar way to the latter study. An outline of tracking data likely to be available in the future, and data gaps that could be efficiently addressed through the deployment of tracking technology, is outlined in Section 5. These studies illustrate the increased amount of information it has been possible to glean from tracking studies over the last six years. Our knowledge of the distribution of migrating and wintering species is far behind that of breeding species however, and there is no data comparable to the above for Common Scoter wintering in Irish waters.

Data from the Irish Wetland Bird Survey (I-WeBS) was included here, but the survey design means that numbers and distribution of species like seaducks (e.g. Common Scoter) and gulls (e.g. Herring Gull) are underestimated. The Marine Institute commissioned aerial surveys in the Irish Sea in 2014, which gave particular focus to Common Scoters, thus providing additional information on the target species for which we were are most data-deficient at present.

Datasets used to determine the presence of the six target seabird species within the Irish Sea and Wexford coast study area are listed in Table 7. Recommendations for future study to address data gaps, as well as data likely to become available in the near future, are given in Sections 5.2 and 5.3.

2.2.3 Creation of Map Layer

Survey data was collated, and each database of locational information was visualised in ArcMap 10.4.1 (ESRI Inc., Redlands, California), transforming co-ordinate systems where necessary into Irish National Grid. For tracking data, it was decided after consultation with in-house experts to restrict the modelled range to the top 95%, to avoid including areas that individuals were unlikely to be using with any regularity. To use 100% of the modelled distribution for each species would have included a very large proportion of the study area. Polygon rasters based on modelled data were converted to shapefiles and treated in the same way as the point data shapefiles from seabird surveys.

Species presence was then joined to the 4km*4km square with which it overlapped, based on an ID created for each square to enable relating the databases in MS Access, giving a composite layer displaying the species present in that square. Four copies were made of this grid-based species distribution map – one each for sensitivity to collision with offshore wind farms, disturbance/displacement from offshore wind farms, impact from wave energy developments and impact from tidal energy developments. An additional field of information was added containing the Species Sensitivity Index for each species present, depending on the sensitivity map in question. A field was created to show the summed values of the sensitivity index values in each square and this total field was used to visually represent the sensitivity of that area to the offshore renewable energy development in question. The colour within each 4km square is intended as a guide to the potential sensitivity of the seabirds using that area to the offshore renewable energy development in question.

Table 7. Seabird datasets used in this project to determine the presence of European Shag, Black-legged Kittiwake, Northern Gannet, Herring Gull, Common Scoter and Razorbill in the Irish Sea.

Type	Project	Data Holder	Area	Period	Data Format	Additional Information
Seabird survey data from state bodies and NGO's	European Seabirds at Sea (ESAS)	Joint Nature Conservation Committee (JNCC)	All Irish EEZ waters	1979 – 2010	Database with coordinates	Data from boat and aerial surveys. Data recorded by research institutions, universities and the JNCC.
	Irish Wetland Bird Survey (I-WeBS)	BirdWatch Ireland, National Parks & Wildlife Service	Coastal wetland sites	Winter 1994/95 – 2016/17	Database with subsite centrepoint coordinates	Offshore species groups (i.e. seabirds, divers, seaducks) under recorded.
	Marine Institute Scoter Survey Ireland	Marine Institute	Irish Sea (Dundalk to Carnsore)	March & December 2014	Database with coordinates	Aerial survey to assess spatial overlap of seabirds with fishing fleets. Particular focus given to Common Scoters.
Seabird survey data from windfarm projects	Oriel Windfarm	Parkwind & Oriel Windfarm Ltd.	Area south-east of Dundalk, north-east of Drogheda, 8km from Louth shore	April 2006 – September 2008	Transposed from PDF report.	Boat survey of $2km^2$ grid squares on 25 dates over 30 month period. Proposal of 55 turbines with capacity of 330MW.
	Dublin Array Windfarm	Saorgus Energy & Innogy SE	Kish & Bray Banks, 10km from Dublin/Wicklow shore	September 2001 – 2002, June 2010 – June 2011, September 2016 – July 2017	2001/02 and 2010/11 surveys transposed from PDF reports. 2016/17 survey results available as database with coordinates.	Boat transects, fixed point surveys and aerial surveys in 2001/02. Boat transect surveys in 2010/11 and 2016/17. Proposal of 600MW capacity development.
	Codling Bank Wind Park	Fred. Olsen Renewables & Hazel Shore Ltd.	Codling Bank, 13km from north Wicklow shore	April 2013 – March 2014	Database with coordinates	Boat transect surveys. Proposal of 220 turbines with potential capacity of 1.1GW consented. Proposal for a second phase of a further 200 turbines submitted for planning.
	Arklow Bank Wind Park	SSE Renewables	Arklow Bank, 10km from the Wicklow shore	July 2000 – June 2009	Transposed from PDF reports	Boat transect surveys. Currently 7 turbines operational (25MW capacity), with plans for a further 193 turbines (520MW capacity).

Type	Project	Data Holder	Area	Period	Data Format	Additional Information
Modelled Seabird Tracking Data	Gannet Tracking Study	Wakefield *et al.*	Foraging areas used by Gannets around Irish breeding colonies	-	GIS Raster Files	Wakefield *et al*., 2013. Study predicts foraging ranges of breeding Gannets using high-resolution satellite tracks, based on a 'density-dependent hinterland' model.
	Predicting Regional Seabird Distribution	Wakefield *et al.*	Foraging areas used by Shags, Kittiwakes and Razorbills around Irish breeding colonies	-	GIS Raster Files	Wakefield *et al*., 2017. Study predicts foraging ranges of Shags, Kittiwakes and Razorbills (and Common Guillemots) based on GPS-tracking data and habitat.

3. Results

3.1 Trial Map Layers & Interpretation

Trial sensitivity maps indicating the risk posed to a selection of six seabird species by offshore MRE developments are illustrated in Figures 4-7. These maps present a depiction of seabird sensitivity to collision with and disturbance by offshore wind farm developments (Figures 4 and 5 respectively), wave energy developments (Figure 6) and tidal energy developments (Figure 7). A five-step colour system is used in each map to depict the relative sensitivity of an area from lowest to highest, based on the aggregate sensitivity score for each square. The scoring system is dependent upon the species present and the relative sensitivity scores of those species, as outlined in Section 2.2. The scoring systems for each development-type differ in number and scale and scores are not comparable between maps. Where a 4km square is not delineated within the study area, no species had been recorded there based on the data outlined in Section 2.2.2.

The total score for each square, and the species recorded as present therein, is stored within the shapefile layer (Figures 8 & 9). It is envisaged that an expanded version of this information would be contained in a full map layer (i.e. Phase 3 or beyond of this project), similar to that for the bird sensitivity map for terrestrial wind energy projects (McGuinness *et al*., 2015), and containing additional information such as the species present, their conservation status, closest breeding colony and other relevant ecological data.

3.2 Trial Map Caveats

As with the final maps produced for the terrestrial wind sensitivity mapping project (McGuinness *et al.,* 2015), there are a number of caveats associated with the interpretation of a tool such as this. Given that the current phase has produced trial sensitivity maps for a limited number of species there are additional caveats associated with the interpretation and use of Figures 4-7.

- These trial maps are based on a small number of species and are therefore not representative of the true sensitivities of the areas depicted. The purpose of these trial maps is to inform the design of final map layers, which would include 38 species. The relative sensitivity of a given 4km square would therefore change significantly based on the addition of another 32 species to the maps.
- Species absence from any squares, especially those with no sensitivity score, should not be assumed. The absence of a species from a given location indicates that it was not recorded there in any of the verified datasets used for this phase of the project. Areas for which there is better data available are more likely to have recorded each species. These maps therefore illustrate known species presence, but not known species absence.
- It is intended that the final versions of these maps (i.e. future phases of this project) would be updated on a regular basis to include new distribution data. The relative scores for each species in each sensitivity index would also be updated based on new studies quantifying aspects of their behaviour, ecology or conservation status. Updates will be dependent on future funding however.
- These maps do not identify 'no-go' areas, but rather quantify the potential effect of the respective offshore energy development on the seabird species included in this phase of the project.

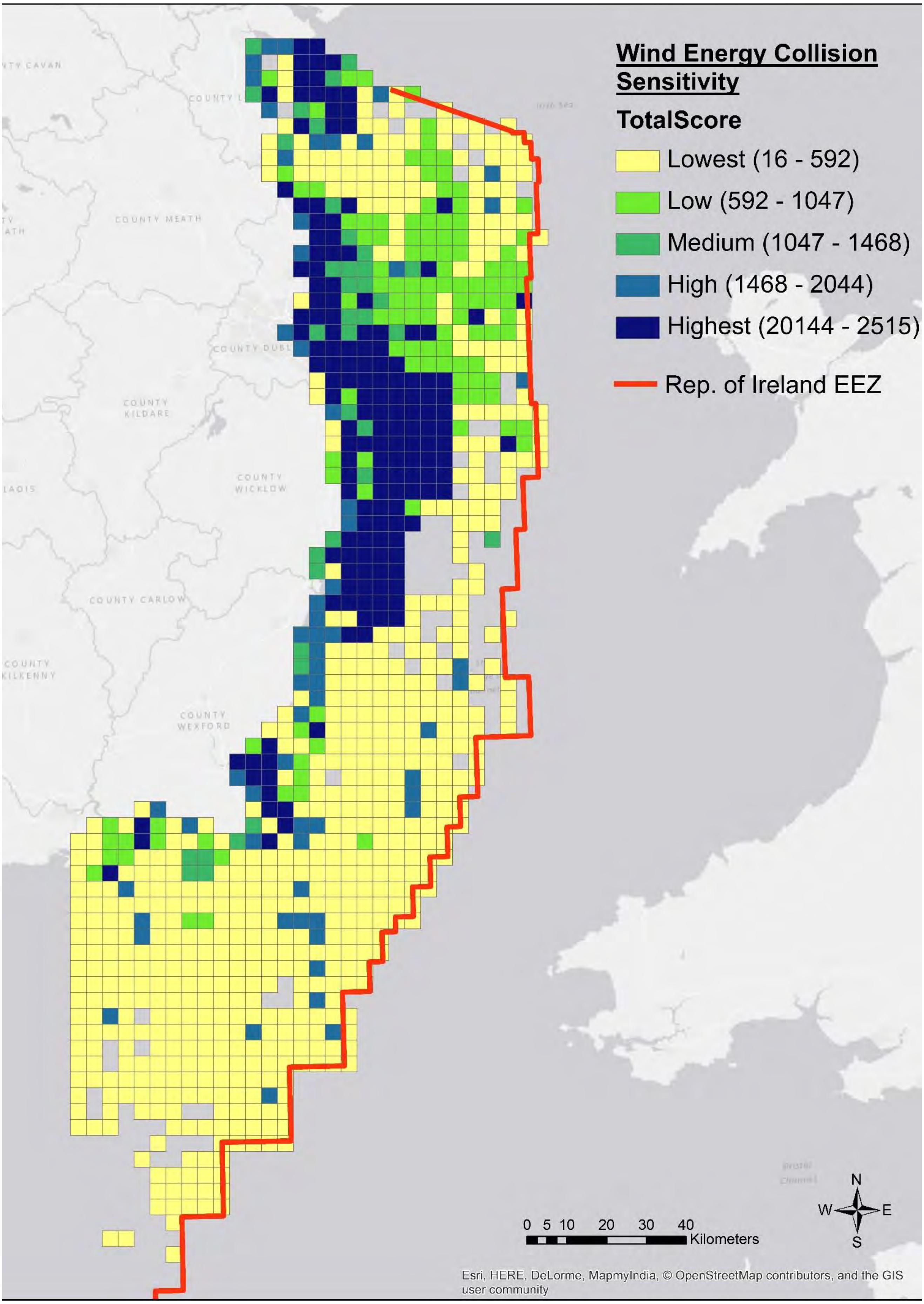

Figure 4. Trial composite sensitivity map of the Irish Sea (within the Republic of Ireland EEZ), following mapping and assessment of six seabird species in relation to the collision risk posed by wind energy developments.

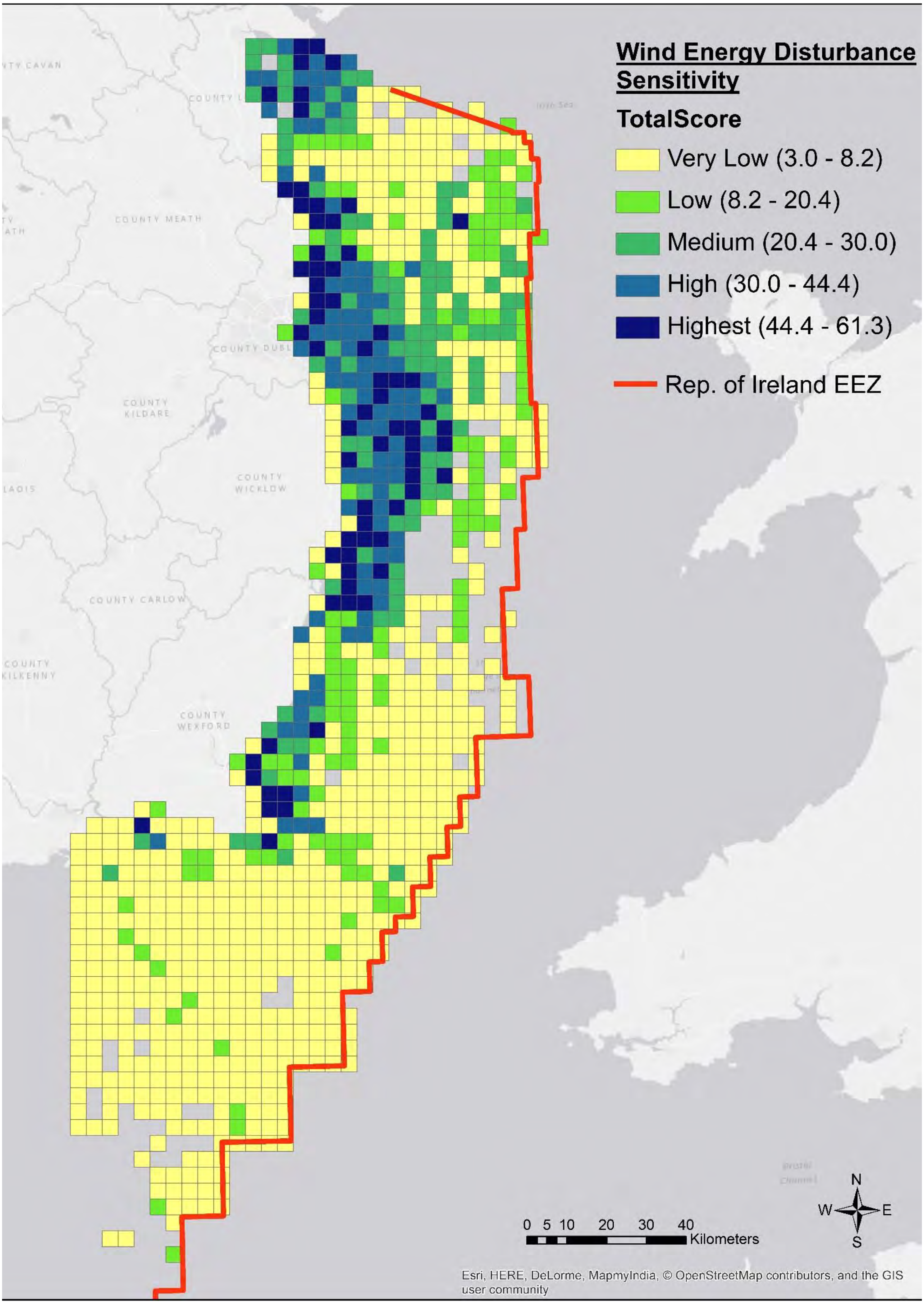

Figure 5. Trial composite sensitivity map of the Irish Sea (within the Republic of Ireland EEZ), following mapping and assessment of six seabird species in relation to the disturbance risk posed by wind energy developments.

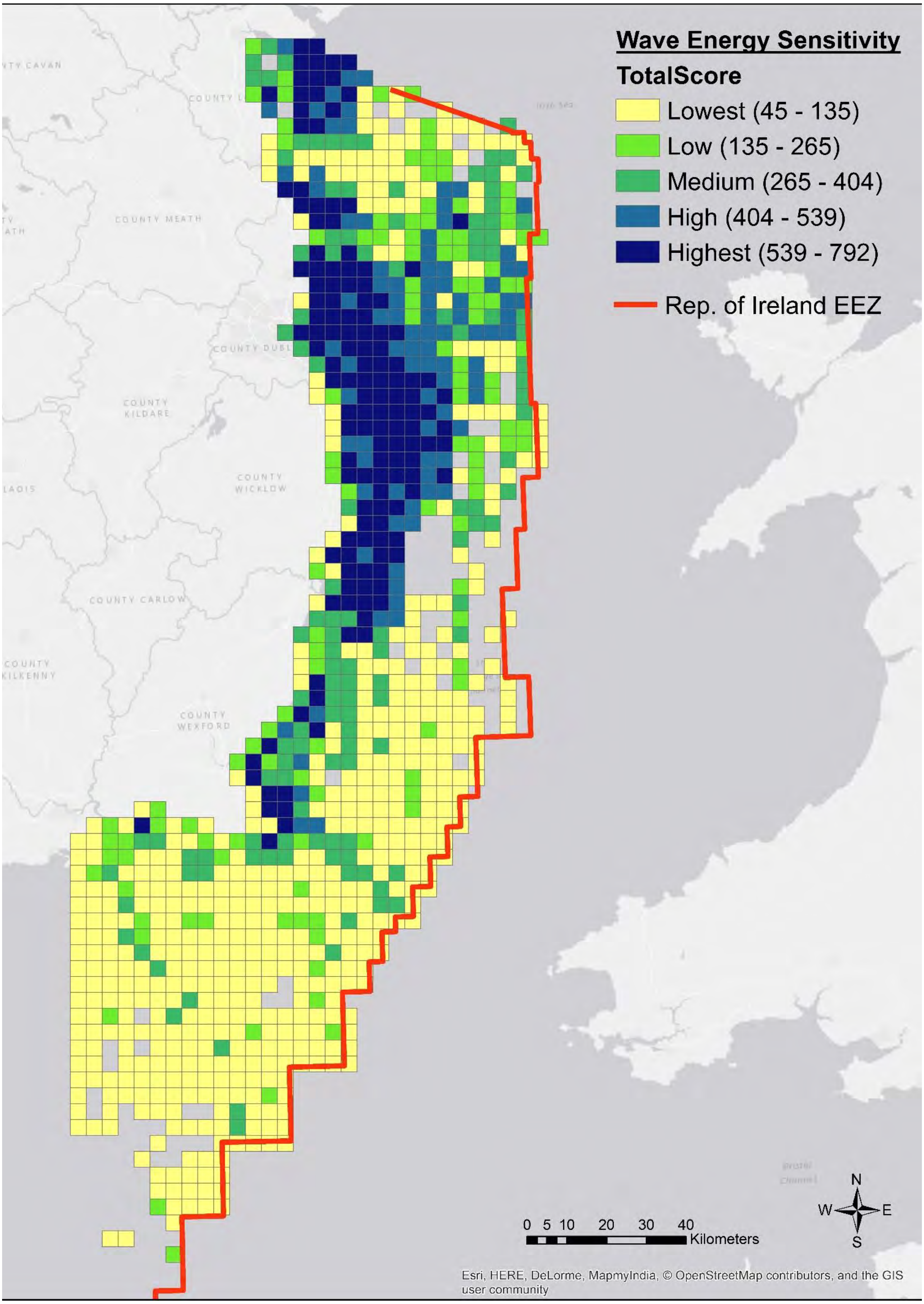

Figure 6. Trial composite sensitivity map of the Irish Sea (within the Republic of Ireland EEZ), following mapping and assessment of six seabird species in relation to the risk posed by wave energy developments.

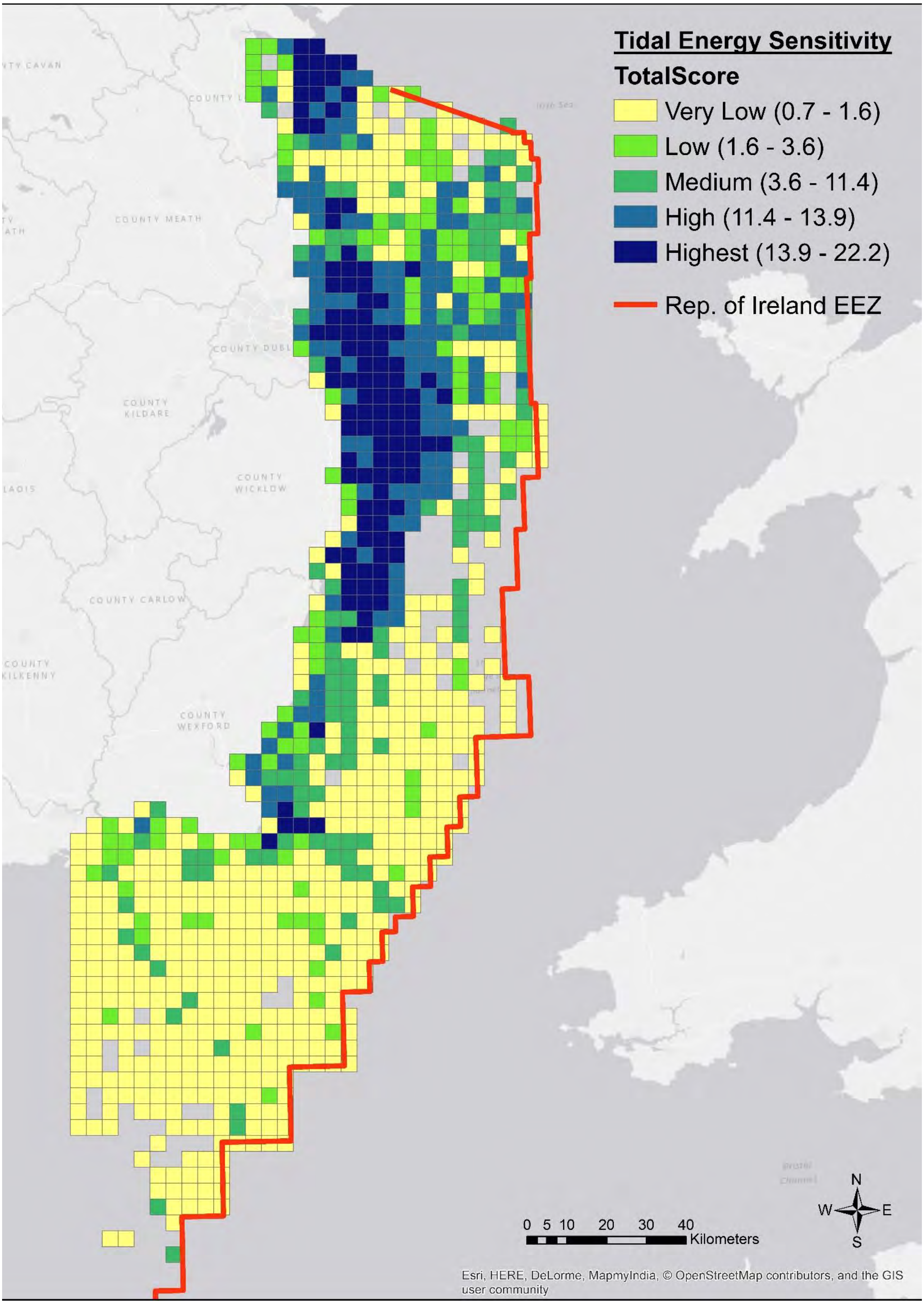

Figure 7. Trial composite sensitivity map of the Irish Sea (within the Republic of Ireland EEZ), following mapping and assessment of six seabird species in relation to the risk posed by tidal energy developments.

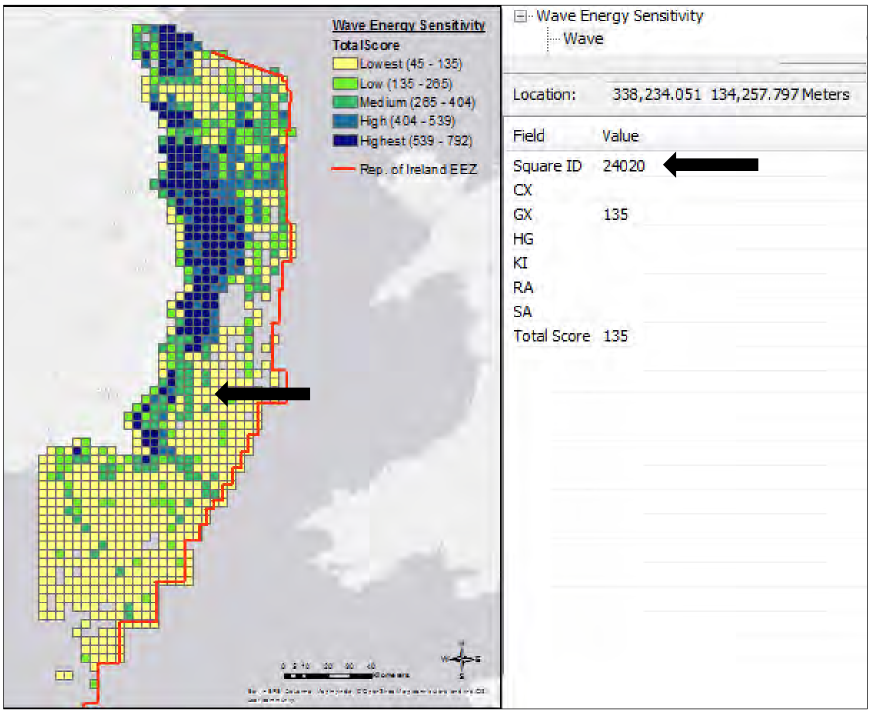

Figure 8. Example of an information pane for an individual 4km square in the trial wave energy sensitivity map, containing a square ID (24020), the species present via BTO species code (Gannet) and their species sensitivity score (Gannet = 135), giving a total score for the square (135).

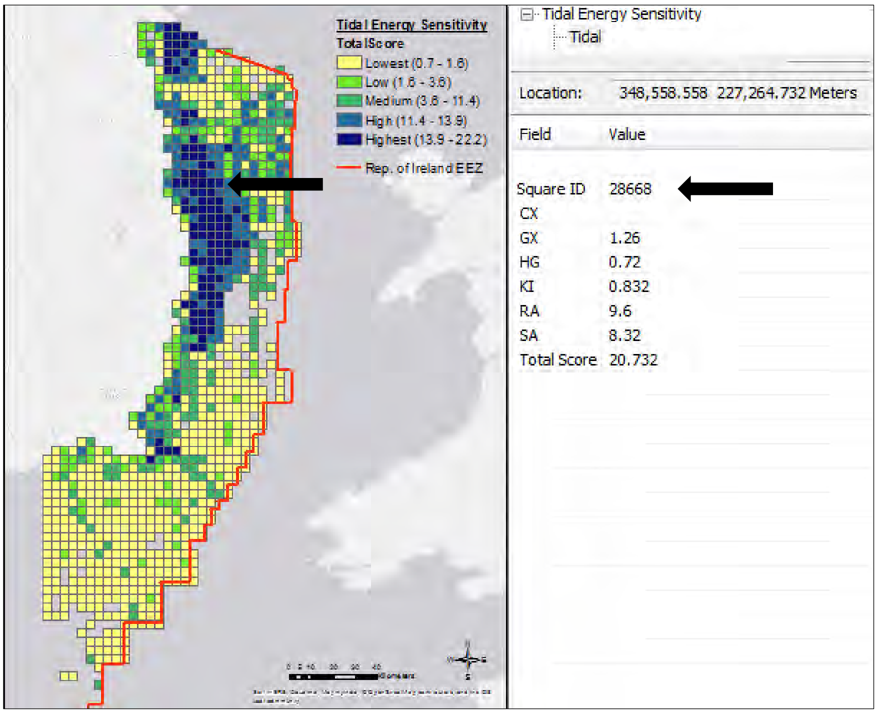

Figure 9. Example of an information pane for an individual 4km square in the trial tidal energy sensitivity map, containing a square ID (28668), the species present via BTO species code (Gannet, Herring Gull, Kittiwake, Razorbill, Shag) and their species sensitivity score (Gannet = 1.26, Herring Gull = 0.72 etc), giving a total score for the square (20.732).

3.3 Practical Application of a Seabird Sensitivity Map

The maps in Figures 4-7 represent a form of species-richness indicator, with higher weighting given to species most at risk. This approach to mapping provides an overview of the species that have been recorded in a given location, and the total sensitivity of a location based on species presence and absence. It therefore represents a qualitative baseline assessment to help evaluate the potential impacts of specific offshore renewable energy projects on the seabird communities in a given location. It is intended that these sensitivity maps should be used early in the site-selection, planning and consenting processes for proposed offshore renewable energy developments.

In May 2018 the Department of Communications, Climate Action & Environment published guidance documents summarising the baseline data requirements and monitoring that may be necessary to evaluate potential impacts of offshore renewable energy projects on the marine environment. The initial scoping stage of a project should identify potential environmental pressures and receptors that are likely to be significant during the preparation of the Environmental and/or Natura Impact Assessment reports. Receptors are described as species which could be adversely affected by a proposed development and will require future monitoring as a result. The sensitivity maps trialled here are based on a thorough collation of existing data and both outline what seabird species are present in a given area as well as indicating their relative sensitivity to the development in question based on detailed, peer-reviewed indices of sensitivity. These maps can therefore be used to establish what receptors are present and help influence survey design thereafter to ensure that an accurate baseline is established against which any potential impacts of development can be compared. For example, many diver and seaduck species (e.g. Black-throated Diver, Common Scoter) are highly vulnerable to impact from wave energy devices. If the seabird sensitivity mapping tool indicates these species are present in the location proposed for such a development, the developer may commission additional surveys to target these species (e.g. additional winter surveys) to establish an accurate baseline for these receptor species. Such a response is likely to instil greater confidence in the planning and conservation authorities that due regard has been paid to vulnerable species in the associated impact assessments. Monitoring effort should be proportional to the sensitivity of the site and the risk from the project (DCCAE, 2018), so additional survey effort targeted at areas or species flagged as particularly sensitive is advisable. Given that these seabird sensitivity mapping tools will be accessible to all stakeholders, planning authorities and conservation bodies will also be able to see what sensitive species are in an area proposed for development and ensure due regard has been paid by the developer to establish an accurate baseline and include appropriate mitigation measures where necessary. Alternatively, these sensitivity maps may lead a developer to change the proposed location of their project based on the presence of sensitive species at the original location (i.e. site-selection stage).

These seabird sensitivity maps will prove useful for stakeholders at the planning, scoping and consenting stages of a new proposed development. The list of caveats associated with these maps included in Section 3.2 mean that they can’t be used in place of pre-construction baseline seabird surveys however. These sensitivity maps provide a qualitative overview of the sensitivity of a location, but a quantitative assessment based on current data should follow. Properly designed and executed baseline data surveys are critical for establishing the condition of the receiving environment for Appropriate Assessment (AA) and Environmental Impact Assessment (EIA) (DCCAE, 2018).

4. Stakeholder Consultation

4.1 Stakeholder Workshop

Since the inception of this project it has been stressed that stakeholder feedback would be a vital part of the development of the mapping tool. Engagement with stakeholders is necessary to ensure that the resulting tool meets the needs of energy developers, ornithological consultancies, government bodies and planning departments, all of whom are part of the process of MRE development in the offshore. To this end, a workshop was held at meeting facilities in Dublin Zoo on Wednesday the 20th of June 2018 to showcase a draft version of the mapping tool to a broad range of stakeholders. The workshop provided a platform for stakeholders to give input into the design of the mapping tool and associated guidance, and to ensure wider understanding of the value of a seabird sensitivity mapping tool in reducing potential conflicts between stakeholders and making a positive contribution to the planning and consenting processes.

The workshop was attended by 18 people representing a range of energy developer, government body and environmental interests including representatives of An Bord Pleanála, Aquafact, Brookfield Renewables, British Trust for Ornithology Northern Ireland (BTO NI), DCCAE, Department of Housing, Planning and Local Government (DHPLG), Eirgrid, ESB International, Marine Institute, Natural Power, NPWS, ParkWind, SEAI, SSE and University College Cork (UCC) and Marine and Renewable Energy Ireland (MaREI) amongst others. As they entered, attendees were posed the question “What do you want to learn today about Seabirds and Marine Energy Development?”. This prompted a variety of replies, including:

<u>Responses - Specific questions about the development of the tool:</u>

- “I want to understand what the project is trying to achieve and how can it be integrated into marine projects moving forward.”
- “I want to learn how the experiences of the development of the onshore sensitivity mapping too is being transferred offshore.”
- “I want to learn about the tool. How were the indices calculated? What are the distributional hotspots like?”
- “How have the vulnerability indices been calculated and how are they applied to distributions?”
- “To see how the project is progressing, what the methodology is and how the various aspects of the project are being delivered upon.”
- “How will this tool interact with the grid?”

<u>Responses - Species-specific questions about ecology and wind energy interactions</u>

- “Interested in species-specific behaviour and how these differences affect the way seabirds potentially interact with wind energy developments.”
- “Interested in learning more about the vulnerability of different seabird species to offshore wind energy.”
- “What is the range of the different species? Do seabirds fly at night?”

The workshop was opened by Mark Robins, Head of Conservation & Policy at BirdWatch Ireland, who introduced what this tool and workshop hoped to achieve in terms of a cooperative approach to ensuring Ireland's MRE sector can move forward in a truly sustainably way. Oonagh Duggan, Assistant Head of Policy & Advocacy, then outlined BirdWatch Ireland's position on wind energy and gave an overview of the previous sensitivity mapping tool for terrestrial wind energy developments. The project officer, Brian Burke, then gave a detailed presentation on the current project to date, including background, methodology and sensitivity indices, data collation and visualisation of the mapping tool. Some questions followed, most of which fed into the interactive process that followed.

After the initial presentations and questions, attendees were given a questionnaire that was designed to capture their thoughts on the mapping tool and how it might be improved going forward. This part of the workshop followed the 'delphi process' to gather the information from participants in a structured way. Everyone was first invited to answer three of the six questions posed, after which they were merged into groups of three and then nine to summarise and prioritise their individual answers as a group, eventually reaching a level of group consensus. Those final answers were then read out to the room, at which point attendees were invited to challenge or agree with the points made or seek clarification or discussion where desirable. This interactive part of the workshop proved highly successful. Participants very actively engaged with the process and there was much discussion between stakeholders with varying areas of expertise and interest within the renewable energy sector. From the point of view of BirdWatch Ireland and the project officer, much of the discussion and points raised will be very useful in the future shaping of the sensitivity mapping tool to ensure it meets the needs and has the confidence of the relevant stakeholders.

4.2 Stakeholder Feedback and Recommendations

The questionnaire distributed as part of the workshop, and the final answers provided by the participants, are outlined below:

1. Is the potential of a sensitivity mapping tool like this realisable?

- Yes, it is realisable, though challenges exist. Limitations need to be made clear, adequate resourcing into the future (i.e. financial) is a necessity. Stakeholder buy-in too is crucial.
- The example of data limitations on the west coast of Ireland was raised – where will data come from? Who will fund its collection? Will the filling of data gaps be developer-led? Is there a precedent from other jurisdictions in this regard?
- Some work needs to be done with regards densities of seabirds. Challenges on scoring matrices.

2. **What are its technical limitations? What are its strengths?**

Limitations:

- Data: Data quality, where is it coming from? How is it compiled? Need for statistical analysis?
- Bias in data – East coast bias due to past scoping. Some areas heavily surveyed, others not.
- Is the tool dynamic, or a snapshot in time? The data used will need to be updated periodically to stay relevant.
- Temporal analysis of the data in terms of breeding and non-breeding seasons would improve the tool.
- Not looking at density data.
- Need for peer review?
- Assumptions – species-specific assumptions.
- Not looking at migration routes (limited to seabird presence).
- The tool doesn't rule out sensitivity.
- Geographical limitations of the data. Where? How far from shore?
- Technical limitations – broader scope – grid connections and onshore infrastructure need to be considered/included.

Strengths:

- Excellent for awareness.
- Presence or absence.
- Should be useful to inform survey requirements for potential developments. Good for potential constraints and feasibility studies.
- Visually easy to interpret and use.
- It should encourage data sharing.
- It has educational value for the general public.

3. **Does this sensitivity mapping tool work to de-risk the development of marine renewables?**

- It has the potential to reduce risk – useful as a first step only. Need for follow up scoping etc. Doesn't replace an EIA process.
- It asks the right questions.
- The tool does need to reflect uncertainty/limitations. Would increase the risk if there's no measure of uncertainty in relation to the distribution.
- Could increase the risk if the tool is misused. Minor projects with a light touch approach a risk. Important that strict guidelines are issued and that all stakeholders are aware of how this tool should and should not be used.
- The tool may influence public perception during the planning process.

4. **Do you see this as useful in your early scoping and planning stages? Why?**

- Yes, it will be useful for targeting resources towards baseline mapping.
- It will be important to keep the model updated after deployment.
- The lack of density data needs to be addressed, there should be some attempt to try and include it.
- Species-specific avoidance and disturbance data/peer reviewed data
- Must communicate early the limitations of the tool.
- It should/must reach its full potential in terms of highlighting sensitivity and no-go areas.

5. **What is the place of a sensitivity mapping tool like this in the consenting process?**

- It will be useful in the EIA, NIS and planning process to inform monitoring programmes. It is only a first step to inform the rest of the process. It's a reference for developers, data is there as a first look, but site-specific data will still always be needed.
- Transparency of data is important – mapping system should have an attribute table behind it to indicate what data underpins the score of a given square.
- It's important that there is version control after deployment. Any changes or updates to the tool need to be communicated to inform planning decisions in the right way.
- It must be robust and credible to gain the trust of all stakeholders in the planning process. It should be subjected to peer review – the information underpinning it should be subjected to peer review. The issue of data quality and standardised methodologies are also important.

6. **Should this tool be developed nationally and how should this be enabled?**

- Yes it should – to include all Irish marine waters. Need to identify other data sources – published work, ObSERVE programme, see UCC's recent work too. Again, noted that a lot of data is available for the Irish Sea (current study area) but that most other areas will be data-deficient.
- Transboundary issues should also be considered. Some fora exist for transboundary cooperation e.g. MSP Forum.
- Transparency again raised. Quality layer needed – data bias must be addressed.
- Tool must be flexible – adaptable to new data. Need to communicate the changes to the tool data. Gap analysis needs to be done to help target resources in future.
- Seabird populations are dynamic, and the tool must reflect this reality. Breeding and non-breeding season data. Temporal extent of data – years/seasons etc would be helpful.
- Technology – how do we reflect changes in the technology.

Overall there was a very high level of engagement during the workshop, and an overall interest and approval of the seabird sensitivity mapping tool being developed. The feedback above forms a significant part of the discussion section below and the recommendations that will shape the future of the mapping tool.

5. Discussion

This phase of the project aimed to trial the methodology set out by Ramiro & Cummins (2016) to develop a seabird sensitivity mapping tool for marine renewable energy developments. By trialling the methodology on a limited area and focusing on a shortlist of species representative of the wider seabird community, it allowed us to identify any potential difficulties and to remedy them in advance of full scale development of the mapping tool. In addition, it provided an opportunity to demonstrate a prototype of the mapping tool to a broad range of stakeholders in the MRE industry. The driving motivation for the development of this tool is to make it easy for developers, ornithological consultants, consenting authorities and conservation bodies to know where seabird communities and populations are potentially most sensitive to MRE development. This will help ensure that sensitive seabirds in a target location will be included in the planning and development process from an early stage, that appropriate survey methodologies will be commissioned and will ultimately lead to lower risk for developers seeking project consent. It should also ensure minimal conflict between developers and conservation bodies and help ensure a smoother consenting process. Ultimately, by taking sensitive seabird populations into account early in the planning process, and taking the necessary monitoring and mitigation measures, it will help facilitate a truly sustainable MRE industry in Ireland. The stakeholder workshop in June proved invaluable in sourcing guidance and recommendations for further development of the mapping tool to ensure it is used by stakeholders with confidence and ease in the future. In addition, BirdWatch Ireland includes here information on a review of data sources in relation to seabirds, gaps in this data and recommendations on filling these gaps in order to help progress MRE developments to ensure 'beyond reasonable doubt' that there is no likely significant impact on species. A summary of all gaps and recommendations is presented in Appendix 1. However, we underline that while filling the data gaps is essential, it shouldn't hold back the development of a full sensitivity mapping tool in the near future.

5.1 Mapping Recommendations

Data Coverage

One issue with the current approach to development of this tool revolves around the potential survey bias, where areas appear to be more or less sensitive than others as a direct result of having been subjected to high or low levels of survey coverage. In the cases where survey data was supplied by wind farm developers in the Irish Sea, these areas were subjected to near-monthly surveys over several years and so these localised areas are more likely to have a higher number of species recorded within them compared to nearby areas which have never been the focus of targeted surveying. Similarly, within the ESAS database there are a multitude of survey datasets from different sources including ferry-based surveys carried out over many years, meaning that there was an increased likelihood of our study species being recorded along those routes compared to other parts of the Irish Sea. While a more uniform approach to surveying would be preferable, it is hardly practical. It should be remembered that the focus of the mapping tool is whether a species uses a specific area, and therefore the high levels of surveying in some areas are more representative of the true sensitivity of an area compared to those areas with poor or infrequent survey coverage. It is the areas with low survey coverage that suffer from a degree of bias, rather than those with high levels of coverage. The presentation of the final sensitivity maps may give a false impression of survey coverage being somewhat uniform however. Another caveat is the fact that the trial maps here are based on six species only, so the relative sensitivity scores in well-surveyed areas here appear overly high, especially when five of our 6 study species are relatively widespread in the Irish Sea. Final maps looking at 38 seabird species will show greater gradients of contrast to what has been illustrated here however.

> **Recommendation 1:** An information field indicating the data sources covering an area should be included for each 4km square. For example, categories could be used to indicate whether an area has been covered by a) a targeted survey (e.g. focused on an area for a specific development), b) a general at-sea survey (e.g. survey of the Irish Sea), c) a general coastal survey (e.g. I-WeBS, seawatching records), d) a species-specific survey (e.g. for seaducks or divers), e) tracking data for an individual species. An index system that scores data availability for a given square may also be beneficial in highlighting areas of low confidence based on poor data availability.

Temporal Variation

The issue of temporal variation in seabird presence and behaviour was also raised in the workshop. Some species sensitive to certain types of development are only present in Irish offshore waters for part of the year e.g. Great Northern Divers are highly vulnerable to wave turbine developments and are present in the non-breeding season. Similarly, most tracking studies have been done on central-place foragers during the breeding season when they are restricted to movements to and from a breeding colony. The current approach, compiling data from throughout the year, functions to highlight the total sensitivity of offshore areas, which is likely to be the initial information sought when a location is being chosen for development. Some stakeholders requested a finer-scale temporal breakdown of available data. In tandem with the above recommendation to highlight the spatial scale at which data is available for a given location, providing information separately for the breeding and non-breeding seasons will provide greater clarity on data availability for a given area and the period which presents the highest risk to seabirds.

> **Recommendation 2:** As well as an overall sensitivity map, separate maps should be produced based on data for the breeding and non-breeding seasons. That is to say that for each type of development three maps should be produced – one for the breeding season, one for the non-breeding season, and a third map to incorporate both.

Densities

Early on in the development of this tool it was decided that it would be based on species presence or absence. This was largely to facilitate integration of a broad range of datasets with a complex scoring index system and to provide a 'level playing field' of sorts. Modelled tracking data produces different information to seabird survey data, but both comment on the presence or absence of species in an area, so the approach taken for this tool allowed for both to be combined with ease. Perrow *et al*. (2015) highlighted the fact that areas that are infrequently used or temporally limited (e.g. by tidal state) may still be important to foraging birds and that these areas should not be excluded from protection. The intention for this tool was that it would flag species presence in the area, and comment on the relative sensitivity of that species. It would not comment on the relative importance of the area for the species – something that can only properly be achieved by regular and recent surveys of an area. It ensures that the burden of proof in terms of establishing the relative importance or unimportance of that area for the species in question remains predominantly with the developer.

The thought behind this approach to sensitivity mapping is that all species are displayed on a single map for each type of development – someone can look at a map and tell which of Ireland's 38 regularly occurring seabird species have been recorded in an area and get an idea of how sensitive the area is likely to be to development depending on the species present. Incorporating density data into this system invites the question of the relative importance of an individual bird of one species versus another – and following on from that the relative importance of 100 of one species versus 50 of another etc. The age of data used will also then become a factor – 25 Roseate Terns in 1990 might have been 10% of the NW European population, but 25 Roseate Terns in 2018 is 1% of the population. There is also the difficulty of a lack of breeding seabird population estimates since Seabird 2000, and the complete absence of any sort of estimates of wintering numbers of seabirds in Irish waters.

Recommendation 3: Keeping in mind the difficulty in integrating data density into the sensitivity maps in a consistent way, it is recommended that additional density map layers for species of high and moderate sensitivity (circa 20 species) are provided alongside sensitivity maps. Given the above recommendations, these maps would have to be produced for both the breeding and non-breeding seasons and also incorporate information on data availability or lack thereof. It should be stressed that density data provided should not be interpreted as sufficient information for EIA's and NIS's however and that 'ground-truthing' is still required to be carried out by or on behalf of the developer.

Inshore Sensitivity Mapping

The current mapping tool is designed to indicate areas where seabird species and communities are likely to be vulnerable to different types of MRE development in the offshore environment. Inshore areas are important for a minority of seabirds (e.g. gull species, Little Tern, Sandwich Tern) but are hugely important for what are commonly referred to as 'wintering waterbirds' (i.e. wildfowl, waders and allies). Ireland's location on the migratory flyway means our coastal waters and habitats are used by internationally important numbers of a range of these species. At the stakeholder workshop, it was noted that the task of bringing energy ashore from MRE developments is likely to encounter a different set of issues with regards potential impacts on a different suite of bird species. In addition, tidal devices in particular are more likely to be deployed inshore or within estuaries and inlets than either wind or wave devices. MRE therefore presents potential impacts to coastal waterbirds as well as seabirds.

Recommendation 4: Ramiro & Cummins (2016) recommended an approach for inshore sensitivity mapping for MRE tidal and wave developments. The potential impacts of bringing energy ashore should be included in this. A project to map coastal and inshore areas where waterbirds may be vulnerable to different types and aspects of MRE development should be pursued separate to the marine bird sensitivity map that has been trialled here.

Peer-review

Attendees highlighted the importance of the peer-review process for a tool like this, to validate the methods used and help instil confidence in stakeholders and end-users of the tool. The Species Sensitivity Indices employed here were taken from peer-reviewed work by Furness *et al.* (2012 – tidal stream turbines and wave energy devices) and 2013 (offshore wind farms) in Scottish waters. The same data underpinning the indices was used here, with the exception of the relative conservation importance for each species which was updated for an Irish context. The relative scores for the other factors used by Furness *et al.* (2012, 2013) were based on a detailed literature review and consultation with species experts, and there is scope to update those scores in the light of new evidence in the future.

In terms of the use of those scoring systems with seabird survey and tracking data, this should be peer-reviewed before deployment of the final tool.

> **Recommendation 5:** The peer-review process is vital to the development of this tool. Datasets used, particularly those where data has been modelled, should be peer-reviewed and validated before inclusion, and the final mapping tool should also be subjected to peer-review, similar to Bradbury *et al*. (2014).

Future Funding

With regards gaps in data, e.g. locations, species, times of year, this phase of the project has identified a list of data gaps based on the trial versions of the maps to date (See Section 5.3 below). The question of who will or should fund the filling of these data gaps was raised early on in the workshop discussion. The SEAI, National Toll Roads Foundation, ESB Networks and Eirgrid have made a significant contribution in funding Phases 1 and 2 of the development of this mapping tool, but future funding will be necessary to further develop and roll out a full seabird sensitivity mapping tool. The identification of funders for future pieces of work is beyond the scope of this report. It is worth pointing out that addressing data gaps for sensitive species and/or potentially sensitive areas in Irish waters is likely to provide clarity for, and therefore benefit, a broad range of stakeholders and developers going forward. Stakeholders from other industries operating in the marine environment would also likely benefit from better knowledge of seabird distributions.

Stakeholders at the workshop expressed the need for the final mapping tool to be dynamic and updated when new data becomes available. Financial support should be put in place to ensure these updates can be rolled out on a regular basis (e.g. annually). Version control of an updated mapping tool will also be important to ensure that stakeholders are basing decisions on the most recent version of the tool available at the time. Any references to the tool in scoping or planning documents should cite the version number used, and this should be made clear in any guidance documents.

> **Recommendation 6:** The final sensitivity mapping tool should make recommendations for future data updates, and version control to ensure consistent and clear use of the tool.

Recent Data

Though it was not subject to the same focus as some of the other points raised at the workshop, the age of the data used was brought up by one stakeholder. Much of the data pre-2000 came from the ESAS database whereas survey data associated with windfarms and the Marine Institute Common Scoter survey were all carried out more recently. There is an argument that changing seabird numbers, fish stocks, marine habitats and the shifts in distribution seen with climate change will all have played a part in potentially changing what areas are important for seabirds in recent decades. The modern-day practical use of data gathered as far back as 1979 (ESAS) is therefore open to some challenge. The vast majority of records for our study area in the ESAS database were from pre-2000 (1981 onwards), so to exclude these would be akin to removing the ESAS database from inclusion in the project. That being said, the impending availability of more recent broad-scale survey data (ObSERVE, Celtic Explorer survey – see Section 5.2 below) will fill any gaps left by the removal of ESAS data from the tool.

> **Recommendation 7:** The inclusion of data from the year 2000 onwards only should be considered.

5.2 Future Data Sources

ObSERVE Seabird Surveys

ObSERVE Aerial was a three-year programme of extensive aerial seabird surveys, commissioned by DCCAE and NPWS, to collect data on the distribution and abundance of seabirds in Irish offshore waters. The project was led by University College Cork (UCC), with project partners Aerosotravia, IMARES and Alnilam. Broad-scale surveys were carried out of offshore waters within the Irish EEZ in summer and winter 2015 and 2016 using zig-zag lines. A GAM modelling approach was then used to model the distribution of each seabird species and fill in gaps between survey lines. Finer-scale surveys were also carried out in the Irish Sea in summer, autumn and winter 2016, which did not require a modelling approach. The ObSERVE surveys therefore represent a recent and very complete dataset of both seabird distributions and densities within the Irish EEZ in both the breeding and non-breeding seasons. It should be remembered though that the outputs from ObSERVE are based on a limited number of survey days, and more frequent surveying is always preferable. The report from this project is due for release in late 2018 and the data is under embargo until June 2019 (M. Jessopp, pers. comm.). The ObSERVE dataset should be considered the top priority for future seabird sensitivity mapping.

UCC Projected Seabird Distributions

A recent paper published by researchers in UCC (Critchley *et al*., 2018a) used a distance-weighted foraging radius approach to project foraging distributions of breeding seabirds to identify hotspots of high density and seabird richness and examine overlap with marine protected areas. The approach took breeding seabird numbers at colonies around Ireland and combined them with maximum foraging radii from published GPS tracking studies for each species, to predict foraging densities around the colony. The UCC team are currently in the process of validating those predicted distributions against GPS tracking data and distributions from the ObSERVE project (Critchley *et al*., 2018b). Overall there is good agreement between the predicted distributions and empirical observations. One of the main strengths of this approach is that the models can be updated with different maximum foraging radii based on more recent or more local GPS tracking studies. NPWS have recently commissioned a broad range of seabird surveys around Ireland, and these breeding numbers can be used to update Critchley *et al*.'s (2018a) predicted distributions. This dataset therefore represents a robust estimation of foraging distributions of seabirds during the breeding season around the Irish coast.

RV Celtic Explorer Seabird Surveys

The RV Celtic Explorer research vessel is run by the Marine Institute and facilitates national and international research in a number of fields relevant to the offshore environment. Seabird surveys following the ESAS methodology have been carried out alongside other projects including Cetaceans on the Frontier (2009 – 2016), Blue Whiting Acoustic Survey (2014 – 2018), Celtic Sea Herring Acoustic Survey (2012 – 2017), Western European Shelf Pelagic Acoustic Survey (2016 – 2017), Transatlantic 2015, 2016 and 2017, TRASNA 2016 and CV14020 (2014). Though each survey is limited in time, many will have covered extensive areas that have received little coverage to date. These data are in the process of being modelled. The Celtic Explorer surveys therefore represent a very valuable dataset for establishing important seabird areas in Irish waters, particularly off the south and west coasts.

Development-related seabird surveys

Seabird surveys were carried out in advance of the Galway Bay Marine & Renewable Energy Test Site, and the Atlantic Marine Energy Test Site (AMETS) in Belmullet. Surveys carried out as part of the planning and consent processes for offshore windfarms in the Irish Sea were of significant value to the current phase of developing a seabird sensitivity map, and similar work carried out for offshore developments on the north, west and south coasts should also be integrated into future phases of this project.

UCC Seabird Tracking Studies

The UCC Ornithology research group have carried out GPS tracking studies of Manx Shearwaters, European Storm-petrels (Kane *et al*., 2017), Puffins (Bennison *et al*., 2017), Fulmar, Gannet and Razorbill in recent years. The outputs from this research are likely to be of significant use to future iterations of seabird sensitivity mapping in Ireland.

MarPAMM

BirdWatch Ireland is one of eight partner organisations in the 'Marine Protected Area Management and Monitoring (MarPAMM)' project, which will develop models and management plans for protected habitats and species across the regional seas of Scotland, Northern Ireland and Ireland. As part of the project, ESAS boat surveys will be carried out in Donegal Bay, Carlingford Lough and Dundalk Bay, as well as islands on the NW coast, to identify key areas for breeding and wintering seabirds and waterbirds (divers, grebes and seaducks). In addition, there will be tagging and tracking of breeding Shags, Kittiwakes, Herring Gulls and Great Black-backed Gulls. BirdWatch Ireland will be working in partnership with UCC to analyse and model the survey and tracking data to produce detailed distribution. Both the outputs from the survey and tracking elements of the project will be very informative for future development of a seabird sensitivity mapping tool given that they focus on species of high sensitivity to some marine renewables and species and areas for which there is little data currently available.

5.3 Current Seabird Data Gaps

Location and significance of seabird colonies

Knowing what seabird colonies currently exist in Ireland, and their relative importance at a national and international scale, is of major importance in establishing the sensitivities of different areas to MRE development. The last comprehensive census of seabird colonies in Ireland was carried out as part of Seabird 2000 (1998-2002; Mitchell *et al*., 2004). Only a very small number of colonies have been comprehensively counted since then, as part of separate conservation work (e.g. Rockabill tern colony; McKeon *et al.*, 2017) or as part of individual research projects (e.g. Fulmars on Little Saltee; Cordes *et al*., 2015). In the intervening 16-20 years many colonies will have changed significantly in size, some will have been lost and new colonies will have established. It is therefore of critical importance to have up-to-date information on the status of Irish seabird colonies if potential impacts from developments such as MRE are to be avoided.

A national census of seabird colonies commissioned by NPWS is currently ongoing (scheduled for 2015-2018). This census includes most cliff-nesting species (Fulmar, Kittiwake, Guillemot, Razorbill, Cormorant, Shag), gulls and terns, as well as individual species such as Great Skua and Black Guillemot. The results of this work are currently being compiled. In addition, a national survey of Gannet colonies was commissioned in 2013-14, for which data is available (Newton *et al*., 2015). Some important gaps remain in the current seabird census however, most notably for burrow-nesting species including Puffin, Manx Shearwater and European Storm-petrel. These species require highly specialised methods for accurate censusing (Walsh *et al.*, 1995) and will require accessing remote sites that will prove logistically difficult. It is expected that NPWS will put out requests for tenders to survey these species at key sites in 2019, to complement the work already done on other seabird species. Ireland holds internationally important numbers of Manx Shearwater (7-18%) and European Storm Petrel (11-43%) (Mitchell *et al.*, 2004), which further enhances the urgency with which we need to update our estimates of their breeding numbers here. There are other gaps in the seabird census carried out from 2015-2018, including at some low-density cliff colonies and some coastal areas which have yet to be surveyed for Black Guillemots. It is expected that some of these survey gaps will be filled by NPWS conservation rangers in 2019. Additional surveys of Cormorant and Shag colonies would also be beneficial, given that these species nest in seasonal waves (i.e. prolonged breeding season, numbers breeding at any one time vary), though it is not clear if these are planned. Urban nesting sites are becoming increasingly important for both Herring Gulls and Lesser Black-backed Gulls and at present we have no idea how many urban-nesting gulls there are in Ireland. Significant numbers nest on rooftops in Dublin city centre and county, as well as Galway city, and large inland towns including Navan and Mullingar. GPS tracking work in the UK found that some urban-nesting Herring Gulls moved >50km offshore during the breeding season and roosted at sea (Rock *et al*., 2016), so the number and status or urban-nesting gulls is of relevance to offshore interests as much as those breeding on offshore islands.

> **Gap 1** – Census of colonies needed for burrowing seabird species around the Irish coast, including Puffin, Manx Shearwater, European Storm-petrel and Leach's Storm-petrel. Priority areas include coastal and offshore colonies in Kerry, Clare, Mayo, Donegal. Significant expertise required to carry out specialised survey methodologies and accessing some sites will prove logistically challenging. Note that NPWS may fund this work, or part thereof, in 2019.
>
> **Gap 2** – Gap-filling required for some species and areas based on national seabird census carried out from 2015 to 2018. Gaps include low-density nesting cliffs and some coastal Black Guillemot nesting areas. Note that NPWS may address these gaps with their conservation ranger staff network in 2019.
>
> **Gap 3** – Some gap-filling required for Little Tern colonies, notably in Wexford and some coastal beaches and offshore islands in Donegal. Possible these could be covered by NPWS conservation rangers and BirdWatch Ireland MarPAMM project staff, but consultation needed.
>
> **Gap 4** – There is no existing information on the number of urban roof-nesting gull populations in any of Ireland's cities or towns. A census is badly needed to accurately assess species population numbers, address conflict in some areas, and because urban-nesting gulls in coastal areas are vulnerable to marine renewable energy developments at sea. The majority of work is needed in Dublin city and county. There are no plans at present to carry out such a census and a source of funding is needed.

Key foraging areas

Trialling the marine bird sensitivity mapping tool has made it clear that there is huge variation in data availability between seabird species in Irish waters. With that in mind, the wealth of distributional data available for a minority of species illustrates what can be done with targeted efforts.

The availability of modelled distribution data for Kittiwake, Shag and Razorbill, based on state-of-the-art GPS tracking studies with large sample sizes, colony size data and habitat variables (Wakefield et al., 2017), provides particular confidence around the mapped distributions of adults of these species in Irish waters during the breeding season. The same level of data is also available for Common Guillemot from the same study. Modelled foraging ranges for Gannets, based on GPS tracking data and colony size, was also very valuable (Wakefield *et al.,* 2013). Furthermore, researchers at the Centre for Ecology and Hydrology (UK) are currently modelling Gannet feeding distribution data in a similar way to the other species in Wakefield *et al.* (2017), which will increase the accuracy of and confidence in our knowledge of this species' whereabouts during the breeding season. With the exception of the above-mentioned 5 species though, this high level of distribution data for breeding species is not available at present.

Work is ongoing by UCC to carry out GPS tracking on Storm Petrels, Manx Shearwaters, Puffins and Fulmars at Irish colonies, with the intention of producing predictive distribution models incorporating colony locations, colony sizes and species foraging behaviour. Recent UCC work on tracking Razorbills, Puffins, Gannets and Fulmar has been carried out in the south-east and Storm-petrel and Manx Shearwater tracking has been carried out on the west coast, so additional sampling from other parts of the country for each species would be particularly useful. In 2016, with funding from the SEAI, BirdWatch Ireland carried out a tracking project for Herring Gull, Lesser Black-backed Gull and Great Black-backed Gull on a number of coastal islands in county Dublin (Moss *et al*., 2016). Building on this study would allow for similar modelled distributions for these species, which top the sensitivity index for wind farm collision impact (Table 3). Additional tracking on the east coast would increase the sample size for this study and increase the reliability of any outputs. Similar work on the west coast would also reduce potential geographic biases in mapping the foraging distributions of large gulls. Some tracking of large gulls in the north-west is planned by BirdWatch Ireland in the coming years through the MarPAMM (Marine Protected Area Management and Monitoring) project. Other notable gaps in Irish seabird foraging data include Cormorants and Black Guillemots, both of whom are vulnerable to disturbance from offshore windfarms and who are sensitive to tidal turbines. BirdWatch Ireland have carried out some tracking (GLS geolocators) of Black Guillemots outside the breeding seasons to determine their wintering areas but identifying foraging areas requires different technology.

To date only the Roseate Tern has been the subject of tracking studies in Ireland, to determine their migratory behaviours and routes between breeding seasons. All five of our tern species would be ideal candidates for future tracking studies in a similar vein to those above to determine fine-scale foraging ranges, flight heights and other behavioural information during the breeding season. Perrow *et al.* (2015) used multiple data sources (i.e. tracking, boat-based surveys, foraging radius) from multiple seasons to derive a marine protected area for a breeding seabird of high conservation concern (Little Tern) and recommended that, where resources restrict the use of multiple methods, that GPS tracking be carried out of as many individuals as possible over multiple years to deliver the most robust estimate of foraging distribution. In an Irish context this type of work would be particularly useful at important seabird colonies in offshore areas with significant renewable energy potential. The data derived would have applications for that specific colony, but also other Irish colonies. The Irish Sea hosts the most important tern colonies in Ireland, including Rockabill, Dublin Port, Kilcoole Beach and Lady's Island Lake, and these should be the first priority for tern-tracking work in the future.

GPS tracking studies should be a priority for seabird research in Ireland going forward, to identify foraging ranges, key foraging areas and quantify relevant behaviours (e.g. flight heights etc) relevant to the risks posed by different types of MRE developments. Such studies should include a large-enough sample size and geographic spread to ensure that results are broadly applicable. Follow-up plans to develop distribution models in a similar vein to Wakefield *et al*. (2017) should be encouraged. Filling the gaps below would significantly improve our knowledge of how our breeding seabird populations use Irish waters:

Gap 5 - No GPS tracking studies have been done on Cormorants in Ireland. A suitable GPS tracking study should be carried out to determine their foraging ranges, identify key feeding areas and quantify foraging behaviours during the breeding season, similar to work carried out on Shags in recent years.

Gap 6 - No GPS tracking studies have been done on Black Guillemots in Ireland. A suitable GPS tracking study should be carried out to determine their foraging ranges, identify key feeding areas and quantify foraging behaviours during the breeding season.

Gap 7 - Existing tracking data for breeding Great Black-backed Gulls, Lesser Black-backed Gulls and Herring Gulls in Ireland should be reviewed for gaps to be filled. Gaps are likely to concern geographic area (only east coast so far), colony type (urban, coastal, offshore island), species and sample sizes (more data for Herring Gull) and tag type deployed (GPS UHF, GPS GSM, IGOTU tags). Some of these gaps will be addressed through MarPAMM project.

Gap 8 - All of Ireland's five tern species are of significant conservation concern and are listed on Annex I of the E.U. Birds Directive, with Special Protection Areas (SPA's) designated for their protection. GPS tracking work to determine their foraging ranges, areas and behaviours would be hugely beneficial in ensuring they are not impacted by future MRE developments, particularly in the Irish Sea where all five species breed and move through on passage during migration.

Gap 9 – Many current GPS tracking work in Ireland is biased to a few easily accessible colonies. Additional GPS tracking of Razorbills, Puffins, Gannets and Fulmar from locations away from the south-east (i.e. Saltee Islands) would be beneficial in ensuring results are applicable to a wide-range of colonies. Similarly, tracking data from a greater variety of colonies for Storm-petrel and Manx Shearwater than those few that have been sampled on the west coast would be very useful to help make the best possible use of existing data.

In the absence of fine-scale foraging distribution data based on GPS tracking, colony information and habitat variables, there exists more generalised projected distributions for breeding seabirds based on foraging ranges. This amounts to drawing a circle around seabird colonies, based on a distribution radius from collated results of a variety of tracking studies (e.g. Thaxter *et al.,* 2012). The resulting distribution is likely to be less precise than those generated by Wakefield *et al*. (2017), though still captures the majority of space use by nesting seabirds and therefore provides a good substitute until more detailed data is available. Critchley *et al.* (2018a) used a distance-weighted foraging radius approach to project breeding season foraging distributions for 25 seabird species in Irish and UK waters. The study includes density data based on colony size, foraging radius and proportion of the colony likely to be foraging at any given time, and Critchley *et al*. (2018b) are currently in the process of validating their outputs using empirical data from various sources. Many colony counts for this study were taken from Seabird 2000 (Mitchell *et* al., 2004) but more recent data (circa 2015 – 2019) should be available soon, with which the density estimates could be updated. Distance to colony is usually the most important factor in predicting seabird distribution at sea, so this approach is likely to prove very useful in providing a baseline species distribution in areas of low seabird survey coverage.

Gap 10 - In the absence of fine-scale modelled GPS-tracking data in the vein of Wakefield *et al.* (2017), predicted breeding season distributions) using a foraging radius approach should be incorporated into the mapping tool. Any such predictions should incorporate recent seabird colony data from the 2015-2018 census.

At-sea seabird distribution (non-breeding season)

Inclusion of the above-mentioned modelled foraging distributions will greatly enhance the completeness and confidence of the sensitivity mapping tool. The breeding season is limited to a circa 3-month window in the year for each species however. As yet there is no 'shortcut' to at-sea surveys to determine the distributions of those same species during the non-breeding season. Many of the same species that breed around the coast will winter in Irish waters to some extent, though they have more flexibility in terms of feeding areas as they aren't restricted to a nest/colony. At-sea surveys that cover a wide area (e.g. Aerial ObSERVE, R.V. Celtic Explorer surveys) will prove a valuable source of distribution records for wintering seabirds.

The ObSERVE dataset, as discussed above, will be the definitive dataset for seabird distribution in Irish waters going forward and it represents an unprecedented body of work in an Irish context. Focus should now shift to filling the few gaps associated with the dataset, most notably the lack of sufficient coverage off waters off the south, west and north coasts. The fine-scale aerial survey coverage carried out in the Irish Sea should be replicated along the south, west and north coasts of Ireland in both summer and winter over at least two years to determine with similar precision the important areas used by seabirds in these areas. This part of Irish waters has been surveyed by observers on the R.V. Celtic Explorer in recent years so there may be some complementarity amongst these datasets. Given the variability of seabird distribution depending on time of year, weather, fish movements etc., repeated surveying following the methodology of the ObSERVE surveys would be very welcome, to ensure greater confidence in the results and ensure movements and distributions of breeding, passage and wintering species are adequately captured.

> **Gap 11 -** The success of the Aerial ObSERVE survey programme should be built upon in the coming years by addressing gaps and areas of lower confidence (e.g. west coast) and ideally by replicating the work done at regular intervals (10-year) to ensure it remains up to date. Survey data from the R.V. Celtic Explorer may provide greater resolution for seabird distribution along the south-west coast, but the north-west coast (Sligo, Donegal) will need to be surveyed in greater detail.

> **Gap 12 –** Some species such as European Storm-petrel move through the Irish EEZ in large numbers on migration in late summer and autumn. Current knowledge of these movements from at-sea surveys (primarily R.V. Celtic Explorer, also Aerial ObSERVE) should be reviewed with a view to carrying out more targeted surveying to map these post-migration movements.

Some species such as the divers, grebes and seaducks only occur in Irish marine waters in any significant numbers during the non-breeding season and often rely on inshore areas as well as offshore. Though some information on their distributions are known from shore-based surveys such as I-WeBS, these counts are inadequate for accurately determining the true numbers using Irish waters, nor do they provide us with a full picture of the areas they used throughout the winter. Targeted surveys such as the Marine Institute Common Scoter survey (Table 7) are therefore very important in trying to build an accurate picture of their distribution. In addition, these species are sometimes the focus of targeted surveys in harbours and bays where development is planned. BirdWatch Ireland will be carrying out seabirds-at-sea surveys, with a focus on wintering Common Scoter and Diver species, as part of the MarPAMM project as outlined above. These localised surveys are important in building an accurate account of the important areas for these species, many of which are significantly vulnerable to wave and tidal devices. Similarly, targeted surveys are needed elsewhere, particularly areas on the west and south coasts near Clew Bay, outer Galway Bay, Aran Islands, the outer Shannon Estuary, Tralee Bay and the Dingle peninsula, Kenmare Bay, Bantry Bay, Roaringwater Bay and similar areas.

Gap 13 - Localised at-sea surveys targeting wintering seaducks, divers and grebes should be carried out. If sufficient surveying was carried within a short period of time it may allow for an estimation of the wintering population size of these species and thus facilitate estimations of the relative importance of each flock and area to the national population. Such information would be invaluable in assessing the potential relative impact of offshore development in a given area.

6. Conclusion

This project has progressed the development of a seabird sensitivity map for offshore renewable energy developments in Ireland. This is the second phase of the seabird sensitivity map development, following on from work by Ramiro & Cummins (2016) which identified a suitable methodological framework around which to base the tool. In this phase the methodology was trialled on a limited geographical area, with a shortlist of seabird species, using a diverse range of available datasets. Through trialling the tool development and holding discussions with a broad range of MRE stakeholders we have made a number of recommendations for the full-scale development of a seabird sensitivity mapping tool. We have also identified seabird datasets that will become available in the near future and others that cover offshore areas outside of our trial zone, which will be hugely valuable to the full development of a seabird sensitivity mapping tool for Irish waters. Lastly, we have identified a number of data gaps which should be prioritised to improve our knowledge of seabird distribution in Irish waters and ensure that a final sensitivity mapping tool is complete in this regard.

It is recommended that a full seabird sensitivity map for offshore renewable energy developments in Ireland be developed in the next phase. This full-scale tool should include all 38 seabird species identified in Ramiro & Cummins (2016) (i.e. Phase 1) and cover all of Ireland's offshore waters inside the EEZ. It should heed the recommendations from this project (Phase 2) and source each of the datasets outlined above. The next phase should also include plans for deployment of the tool to ensure it used by stakeholders in the development, consenting and conservation spheres of the MRE industry in Ireland, and outline how and when the tool should be updated on a regular basis. Attempts should be made to fill the data gaps outlined in this project, though this need not postpone the development of the final sensitivity mapping tool. A number of funders from the MRE sector have supported the development of a seabird sensitivity mapping tool to date, including SEAI, NTR Foundation, ESB Networks and Eirgrid. There may also be some scope to broaden the remit of this tool to include other developments which may negatively impact seabird species in Irish waters e.g. vulnerability to surface pollutants (oil spills etc.). Given the broad interest in the future applications of this tool, a broad range of government and private company funders should be approached to help fund the project into the future, helping to ensure a smoother planning and consenting process for developers, ensuring the protection of our vulnerable seabird populations, and allowing for a truly sustainable MRE sector in Ireland into the future.

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Appendix I

Mapping Recommendations

1) An information field indicating the data sources covering an area should be included for each 4km square.

2) As well as an overall sensitivity map, separate maps should be produced based on data for the breeding and non-breeding seasons.

3) Additional density map layers for species of high and moderate sensitivity (circa 20 species) should be provided alongside sensitivity maps.

4) A project to map coastal and inshore areas where waterbirds may be vulnerable to different types and aspects of MRE development should be pursued separately to the marine tool.

5) The final mapping tool should be subject to peer-review process before deployment.

6) The final sensitivity mapping tool should make recommendations for future data updates, and version control to ensure consistent and clear use of the tool.

7) The inclusion of data from the year 2000 onwards only should be considered.

Data Gaps & Recommendations

1 – Census of colonies needed for burrowing seabird species around the Irish coast, including Puffin, Manx Shearwater, European Storm-petrel and Leach's Storm-petrel.

2 – Gap-filling required for some species and areas based on national seabird census carried out from 2015 to 2018. Gaps include low-density nesting cliffs and some coastal Black Guillemot nesting areas.

3 – Some gap-filling required for Little Tern colonies in Wexford and Donegal.

4 – Census of urban roof-nesting gull colonies needed, with Dublin city and county a top priority.

5 - A suitable GPS tracking study of Irish-breeding Cormorants should be carried out to determine their foraging ranges, identify key feeding areas and quantify foraging behaviours during the breeding season.

6 - A suitable GPS tracking study of Irish-breeding Black Guillemots should be carried out to determine their foraging ranges, identify key feeding areas and quantify foraging behaviours during the breeding season.

7 - Existing tracking data for breeding Great Black-backed Gulls, Lesser Black-backed Gulls and Herring Gulls in Ireland should be reviewed for gaps to be filled. Gaps are likely to concern geographic area sampled, colony type, species and sample sizes and tag type deployed (GPS UHF, GPS GSM, IGOTU tags).

8 - GPS tracking work should be carried out to determine the foraging ranges, areas and behaviours of all five Irish tern species.

9 – Additional GPS tracking projects for Razorbill, Puffin, Gannet and Fulmar on the west coast, and Storm-Petrel and Manx Shearwater in the north or south, would be hugely beneficial in capitalising on existing studies to ensure results are as broadly applicable to Irish seabirds as possible.

10 - In the absence of fine-scale modelled GPS-tracking data in the vein of Wakefield *et al.* (2017), predicted breeding season distributions) using a foraging radius approach should be incorporated into the mapping tool. Any such predictions should incorporate recent seabird colony data from the 2015-2018 census.

11 – Gaps and areas of lower confidence (e.g. west coast) from the Aerial ObSERVE survey programme should be filled. Aerial ObSERVE work should be replicated at regular intervals (ideally 10-yearly) to ensure data remains current and increase confidence in modelled distributions.

12 –Current knowledge of the movements of migratory Storm-petrels through Irish waters be reviewed with a view to carrying out more targeted surveying to map these movements.

13 - Localised at-sea surveys targeting wintering seaducks, divers and grebes should be carried out.

Future Data Sources

- ObSERVE Seabird Surveys
- Critchley *et al.* 2018a & 2018b – predicted breeding seabird foraging distributions
- Cetaceans on the Frontier seabird surveys (2009 – 2016)
- Blue Whiting Acoustic Survey seabird surveys (2014 – 2018)
- Celtic Sea Herring Acoustic Survey seabird surveys (2012 – 2017)
- Western European Shelf Pelagic Acoustic Survey seabird surveys (2016 – 2017)
- Celtic Explorer Transatlantic seabird surveys (2015 – 2017)
- TRASNA seabird surveys (2016)
- CV14020 seabird surveys (2014)
- Galway Bay Marine & Renewable Energy Test Site seabird surveys
- Atlantic Marine Energy Test Site (AMETS, Belmullet) seabird surveys
- Manx Shearwater GPS tracking outputs (Kane *et al*., 2017)
- European Storm Petrel GPS tracking outputs (Kane *et al*., 2017)
- Puffin GPS tracking outputs (Bennison *et al*., 2017)