Master's thesis

Towards a more robust Irish Marine Atlas: An analysis of data gaps in relation to a proposed offshore wind farm

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Towards a more robust Irish Marine Atlas: An analysis of data gaps in relation to a proposed offshore wind farm
45 ECTS thesis submitted in partial fulfilment of a Master of Resource Management degree in Coastal and Marine Management at the University Centre of the Westfjords, Suðurgata 12, 400 Ísafjörður, Iceland
Degree accredited by the University of Akureyri, Faculty of Business and Science, Borgir, 600 Akureyri, Iceland

Printing:

Declaration

I hereby confirm that I am the sole author of this thesis and it is a product of my own academic research.

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Abstract

Although Ireland is an island nation, marine management has not received as much attention as one would expect in recent years. The advent of climate change and resultant renewable energy targets is slowly beginning to turn attention towards the potential of the marine area. Possessing a large potential for generating renewable energy from various marine renewable energy sources, Ireland stands to gain significantly from its marine resources. Marine management practices in Ireland to date have mainly involved the establishment of marine atlases. The basis of this study was an analysis of the Irish Marine Atlas (IMA) data in relation to an offshore wind farm using the Kish Bank as a case study site. Marine atlases of other countries were assessed for comparative purposes. Previous studies involving data analysis, environmental assessments of offshore wind farms and general offshore wind farm literature were also investigated. IMA data was assessed using a tailored data quality assessment rating system and planning constraints were visualised under separate themes consistent with EU standards for environmental assessments. The results suggest that a comprehensive environmental assessment of an offshore wind farm cannot currently be undertaken using the data available on the IMA. There are a number of reasons for this including non-downloadable datasets, insufficient knowledge of the effects of human activities on the marine environment, a lack of local scale data and the existence of two national marine atlases in Ireland. The data itself displayed deficiencies relating to availability, detail, timeliness, accuracy, completeness, clarification and resolution.

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Acknowledgements

First and foremost, I would like to express my sincere thanks and gratitude to my family and friends who helped me through the thesis process. I would particularly like to thank my mother Alison, father Ken and sister Eimear for their unwavering support. To my friends Karina Dracott , Joonas Kinni and Conor Devoy; I would like to thank you for taking the time out of your own studies to assist me in mine.

An important person in the making of this thesis was Mr. Trevor Alcorn of the Marine Institute who replied to all of my queries but most importantly supplied access to IMA data which was crucial for the outcome of this thesis. I would also like to express my gratitude to Mr. Mark Coughlan of Gaelectric who took the time out of his day to advise me about a case study site. Furthermore, I'd like to thank Mr. Rory Scarrott of MIDA for his replies to my queries.

I would like to recognise the efforts of my thesis advisor, Dr. Lorraine Gray, who put a lot of time into advising this thesis. I would also like to thank my external reader, Mr. Gunnar Páll Eydal, for his feedback. Finally, I would like to thank all of the staff at the University Centre of the Westfjords for their help and support throughout my time at the University.

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Acronyms

ACMA	African Coastal and Marine Atlas
CMA	Caribbean Marine Atlas
EBM	Ecosystem-based Management
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EEZs	Exclusive Economic Zones
GIS	Geographic Information Systems
ICAN	International Coastal Atlas Network
IMA	Irish Marine Atlas
IODE	International Oceanographic Data and Information Exchange Programme
HOOW	Harnessing Our Ocean Wealth Integrated Marine Plan
MEDIN	Marine Environmental Data and Information Network
MIDA	Marine Irish Digital Atlas
MMO	Marine Management Organisation
MSFD	Marine Strategy Framework Directive
MSP	Maritime/Marine Spatial Planning
NMP	National Marine Plan
ODINAFRICA	Ocean Data and Information Network for Africa
OREDP	Offshore Renewable Energy Development Plan
RLG	Regional Locational Guidance
SEA	Strategic Environmental Assessment
SMSP	Shetland Islands' Marine Spatial Plan
SMA	Scottish Marine Atlas

1 Introduction

A central component to the success of marine management is an evidence-based marine atlas (West Coast Aquatic, 2012). A marine atlas consists of data relating to the marine environment gathered from both primary and secondary sources. They can be used for different purposes such as informing evidence based policy in MSP (Marine Spatial Planning), conducting environmental risk assessments, or preparing any assessment or plan that requires knowledge about what is occurring where and when. However, the principle purpose of a marine atlas is to display and divulge spatial data. This thesis uses the Irish Marine Atlas (IMA) to identify gaps in knowledge and limitations of the data, in the case of assessing a proposed offshore wind farm development in the Irish Sea, namely Kish Bank.

1.1 Environmental Assessments of Offshore Wind Farms - The Wider Context

Currently, there are five different proposed and existing offshore wind farms in Ireland. The Arklow Bank Wind farm is the sole wind farm that has been developed, to date. However, it is still in the first phase of development despite being proposed in the early 2000s. The four other proposed wind farms (Fuinneamh Sceirde Teoranta, Oriel Wind farm, Codling Wind Park and The Dublin Array Wind farm) are all at different stages in the planning process. The site chosen for this study is Kish Bank which is located within The Dublin Array Wind farm in the Irish Sea off the coast of county Dublin.

The pursuit of offshore wind energy has historically acted as the catalyst for instigating marine management practices in Europe, for instance in Scotland and Germany. Coincidently, the EU has also set a target of 20% of all energy to come from renewable energy sources by the year 2020 (Department of Communications, Energy and Natural Resources, 2014). This was primarily introduced to help curb the effects of climate change by reducing fossil fuel emissions from non-renewable energy sources. Opposition to offshore wind farms is mostly based on user-user conflicts such as potential overlap of

wind turbines with shipping lanes or user-environment conflicts such as the smothering impacts on the seabed affecting the habitat. Indeed, it is recognised that the impact on human commercial activities is one of the main barriers for developing offshore wind farms (SEAI, 2012). Such issues and conflicts often stifle the marine management process.

Marine management can attract developers and help streamline processes like site selection and Environmental Impact Assessments (EIA) (Sullivan, 2011). An EIA plays a statutory role in the assessment of planning proposals in the marine area that may affect the environment. The EIA process involves several stages over a number of years, including the definition of the scope and zone of influence [1]of the proposal; which should be regularly revised based on consultation with the relevant authorities. There is also emphasis on ecological impacts such as the potential biophysical changes and the capability of a proposal to influence these changes, particularly in or on an ecologically significant habitat, feature, resource and/or species. Mitigation and compensation measures based on the significance of impact are also integral to the outcome of the process. This normally involves refinement of the proposal and further assessment post-refinement. Any identified impacts post-refinement are addressed through provision of advice on the consequences of decision-making based on the effect of the impact on the value of the affected resource, feature or function. Finally, monitoring and implementation issues are dealt with by provision of feedback regarding the predicted outcomes of the proposal post-EIA. This information is detailed in an Environmental Impact Statement (EIS) that accompanies the EIA (see Appendix B which gives an example of similar guidelines being applied to an offshore wind farm) (Institute of Ecology and Environmental Management, 2010). One of the key aspects of marine management is the creation of a central store of data such as a marine atlas. This can help the streamlining of the EIA process by avoiding the need for further environmental studies or surveys, depending on the quality of the data. Not only could marine management streamline the process, it could also help in achieving renewable energy targets and indirectly assist in mitigating climate change by doing so (Jay, 2010).

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[1] A zone of influence is defined as the areas/resources that may be affected by the biophysical changes caused by activities associated with a project (Institute of Ecology and Environmental Management, 2010)

1.2 Marine Data and Mapping Frameworks

The two main sources of marine metadata[2] in Ireland and the UK are the Irish Spatial Data Exchange (ISDE) and the Marine Environmental Data and Information Network (MEDIN). Both the ISDE and MEDIN essentially constitute repositories for descriptive spatial and environmental metadata, allowing for the collection and exchange of such marine datasets[3]. The ISDE provides a spatial data catalogue which facilitates interfaces that allow for the sharing and exchanging of ISO 19139 standard metadata that is subject to the metadata regulations of the INSPIRE Directive (Marine Institute, 2016). The MEDIN is similar to the ISDE in terms of its objectives of sharing and exchanging metadata in the UK, however its metadata is not subject to the regulations of the INSPIRE Directive but to its own set of agreed common standards. In Summary, both the ISDE and MEDIN represent geoportals that provide access to spatial and environmental metadata regulated by their own separate standards regarding the metadata, data format and content. They were both created, and are operated by a combination of partners, in order to catalogue and provide the vast amount of existing cross-sectoral metadata relating to the marine area.

In relation to the use and supply of marine data in Ireland, there are currently two active marine atlases in Ireland. They are, the Irish Marine Atlas (IMA), created and managed by the Marine Institute (Ireland), and the Marine Irish Digital Atlas (MIDA) created by a number of partners and managed by Marine Renewable Energy Ireland (MaREI) at the University College of Cork (UCC). Separate to this, a sub-set of the IMA has recently been launched in the form of Ireland's Marine Renewable Energy Atlas which is targeted at the marine renewable research and development industry. The MIDA is principally a data discovery and education facility, whereas the IMA is a decision support service focused on adhering to both the Marine Strategy Framework Directive (MSFD) and INSPIRE Directives (Scarrott, 2015). Although both atlases possess some similar data, they are characterised by their differing data tailored towards their aforementioned principles. As a result of this, the MIDA has slightly more of an emphasis on coastal data than the IMA. As can be seen in Figure 1 below, the displaying of data does not feature as prominently as the

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[2]   metadata – structured information that describes, explains, locates, and otherwise makes it easier to retrieve and use an information resource (National Information Standards Organisation, 2004). Often referred to as data about data.

[3]dataset – a collection of computer readable data records (National Information Standards Organisation, 2004)

IMA due to the equal emphasis on providing detailed information about the data i.e. the IMA atlas is dominated by the map whereas it is less dominant in the MIDA.
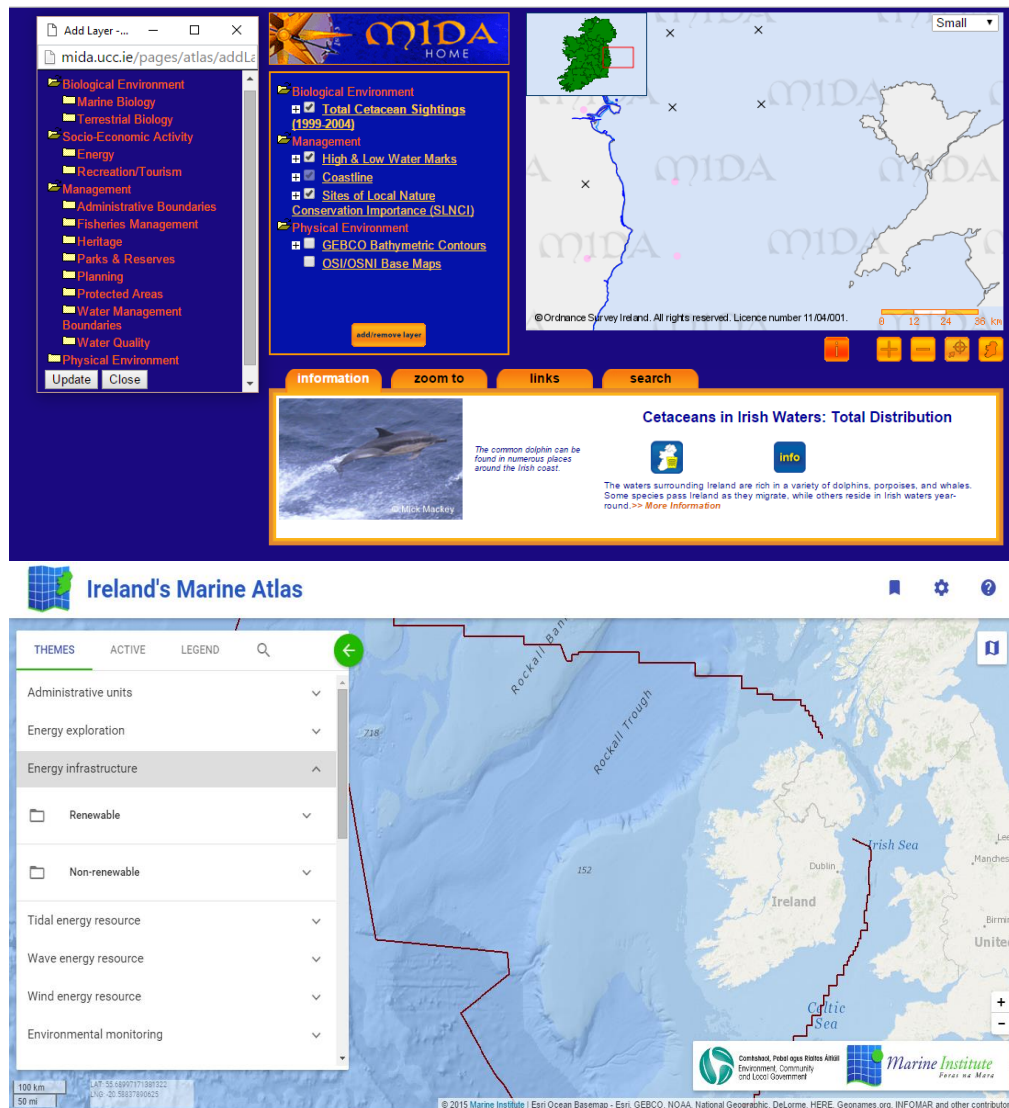
Figure 1 A comparison of the MIDA and the IMA (Marine Institute and Department of Environment, Community and Local Government, 2015; University College Cork, 2016)

There are no current plans to merge both atlases as it would be considered detrimental to both, considering their differing purposes (Scarrott, 2015). Notwithstanding this, there are efforts underway to increase cooperation between both atlases in terms of data sharing. Currently, there is limited data sharing between both atlases with a copy of the data on MIDA required by the IMA before it can be displayed on the IMA. It is intended to eliminate this obstacle by upgrading the MIDA so as to allow the IMA to directly draw datasets from the MIDA database. For example, anytime an update is made to a metadata record, the update automatically populates to all web atlases using the dataset and

associated metadata. This will be achieved by allowing metadata records to be generated through the ISDE (Scarrott, 2015).

The IMA facilitates the assessment of marine developments such as offshore wind farms, for example, by providing the data relevant to the development. This makes the IMA an important tool in achieving the goals of the Harnessing Our Ocean Wealth Integrated Marine Plan (HOOW) to develop a national maritime[4] spatial planning capacity and responsibility for data coordination and exchange (Department of Agriculture, Food and Marine, 2012). The IMA was developed in response to two EU Directives: the MSFD which promotes sustainable use of the marine area and the INSPIRE Directive which aims to create a spatial data infrastructure for the purposes of sharing environmental spatial information. Ecosystem based management (EBM) accentuates the balancing of ecological, economic, and social goals and objectives to achieve sustainable development (Ehler and Douvere, 2009) and is inherently linked to the aim of the MSFD to promote the sustainable use of the marine area.

1.3 Thesis Objectives and Expected Outcomes

Ireland is still very much at the research, development and demonstration stage regarding offshore wind farms (Department of Communications, Energy and Natural Resources, 2014). Recent experiences in Scotland, which has a similar planning system to Ireland (Flannery, 2013), have shown that it can take from 2-5 years or more for an environmental assessment to be undertaken for an offshore wind farm (Enablers Task Force on Maritime Spatial Planning, 2013). Therefore, it is imperative to identify data gaps in the IMA that could otherwise hinder and/or delay an environmental assessment of an offshore wind farm in Ireland. This is encouraged by an independent task force set-up by the Irish government to examine "a national maritime spatial planning capacity and responsibility for data coordination and exchange, to facilitate decision support through the visualisation of ecosystem features and of existing and proposed activities in our ocean space" (Department of Agriculture, Food and Marine, pg 33, 2012). The results of which recommended the utilisation of marine-related data as a sound evidence base such as that

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[4] The term maritime refers to the economic aspects of the sea whereas the term marine refers to the environmental aspects of the sea.

provided by the IMA, with an expert advisory group charged with identifying gaps in the data (Enablers Task Force on Maritime Spatial Planning, 2013).

The aim of the thesis is to analyse existing IMA-related data to assess potential knowledge gaps and associated challenges. Although a proposed offshore wind farm case study is being used for this thesis, the analysis is focused on the quality of data available on the IMA and not an environmental assessment of the impacts. Given that an environmental assessment and marine atlas are part of a wider marine management process, and that EBM is considered as the foundation of this process (Burns, 2012); it is the aim of the thesis to ensure that any identified data gaps help to achieve the principles of EBM which are to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need (McLeod *et al.,* 2005). There are a number of EU Directives indirectly related to marine management that underpin the ideal of EBM (see Appendix C which lists various EU and Irish nature conservation legislation relating to the marine area). This thesis is underpinned by two research questions:

- What are the knowledge/data gaps and associated challenges, if any, of the Irish Marine Atlas in relation to an environmental assessment for a proposed offshore wind farm at the Kish Bank?
- How can the Irish Marine Atlas data be improved to facilitate a comprehensive environmental assessment of an offshore wind farm? What are the associated challenges that need to be addressed?

1.4 Data and Methods

This thesis represents a desk study of data on the IMA in the case of a proposed offshore wind farm development in the Kish Bank. The primary methodology for this thesis was the use of an adapted data quality assessment rating system to locate data gaps on the IMA (Marine Management Organisation, 2013; Shucksmith *et al.,* 2014) similar to that of the pedigree matrix process used in other studies (Issaris, *et al.,* 2012). Subsequently, a case study site on the Kish Bank was chosen in consultation with a company involved with offshore renewable energy in Ireland and Great Britain and upon detailed examination of literature.

Data was then gleaned both directly from the IMA itself and from a prototype atlas via ArcGIS. This data was also used to create maps in ArcGIS, visually demonstrating various planning constraints under separate themes consistent with EU environmental assessment standards. The data was also displayed in a table representing its confidence rating, potential considerations and significance of impact based on the adapted data quality assessment rating system and the Kish Bank site. Quality of data was assessed and measured based on this rating system. Therefore, high quality data was considered to have used best practice research methodology, accredited quality control procedures, be precisely measured, explicitly stated, fully updated and in compliance with INSPIRE standards.

1.5 Thesis Structure

The next section, Chapter 2 will detail different marine management concepts and processes that focus on offshore wind farms, international marine atlases and their data collection processes, general offshore wind farm literature along with assessing previous environmental assessments of offshore wind farms and how spatial data was utilised.

Chapter 3 presents a detailed description of the methodology used for this study, including why it was used, how it was used and the limitations to the methodology.

Chapter 4 displays the results in the form of maps under separate themes consistent with EU environmental assessment standards and tables based on the adapted data quality rating assessment system.

Following on from this, Chapters 5 and 6 divulge the discussion, conclusions and recommendations relating to the results and research questions.

2 Literature Review

This chapter will focus on setting the general context of the study, investigating marine atlases and data collection of other countries, assessing previous studies involving marine spatial data analysis, analysing previous environmental assessments of offshore wind farms and addressing general offshore wind farm literature.

2.1 Marine Management in context of the IMA and Marine Spatial Data

The ultimate goal in most countries conducting marine management is to streamline decision making through policy which has been underpinned by evidence; typically, data presented in a Marine Atlas. An example of this can be seen in the Shetland Islands (see Section 2.2). Where spatial uses have been prioritised, trade-off analysis consists of prohibiting incompatible uses and permitting decisions. Adaptive management is therefore active whereby decisions on investing in information do not guide the planning process but rather plans change as information is gathered via monitoring activities (Doremus, 2007). Trade-offs can be decided by expert groups with or without a public process.

A fundamental aspect of marine management involves limiting the effects of human activities on ecosystem goods and services[5] such as natural storm protection, waste processing and climate regulation. Oftentimes, there is a lack of comprehensive knowledge regarding the impacts of human activities on ecosystem goods and services which can lead to ineffective marine management and consequently an ineffective marine atlas. For example, as there is no market for natural storm protection barriers such as wetlands or mangroves, it is difficult to determine their monetary value. This can materially affect the decision-making process, particularly in the case of a cost-benefit analysis when making trade-offs.

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[5] Ecosystem services can be defined as the outcomes from ecosystems that directly lead to good (s) that are valued by people (Austen, *et al.,* 2010) for example, the carbon sink that naturally sequesters carbon from the atmosphere.

Marine management in Ireland was brought to the forefront of government thinking with the launch of the HOOW in 2012 (Department of Agriculture, Food and Marine, 2012). However, the HOOW has very much directed the focus of government and private sector resources towards the economic potential of Ireland's marine area. Considering Ireland lays claim to a marine area approximately ten times the size of its landmass and a coastline longer than most European countries (see Figure 2) (Department of Agriculture, Food and Marine, 2012), there is plenty of potential for economic gain from the marine area. Indeed, a recent article suggested that the marine energy sector alone had the potential to be worth €15 billion to Ireland's economy by 2050 (O'Brien, February 24, 2016). The HOOW aims to capitalise on this, with one of the key actions aiming to develop a national maritime spatial planning capacity and responsibility for data coordination and exchange. (Department of Agriculture, Food and Marine, 2012).
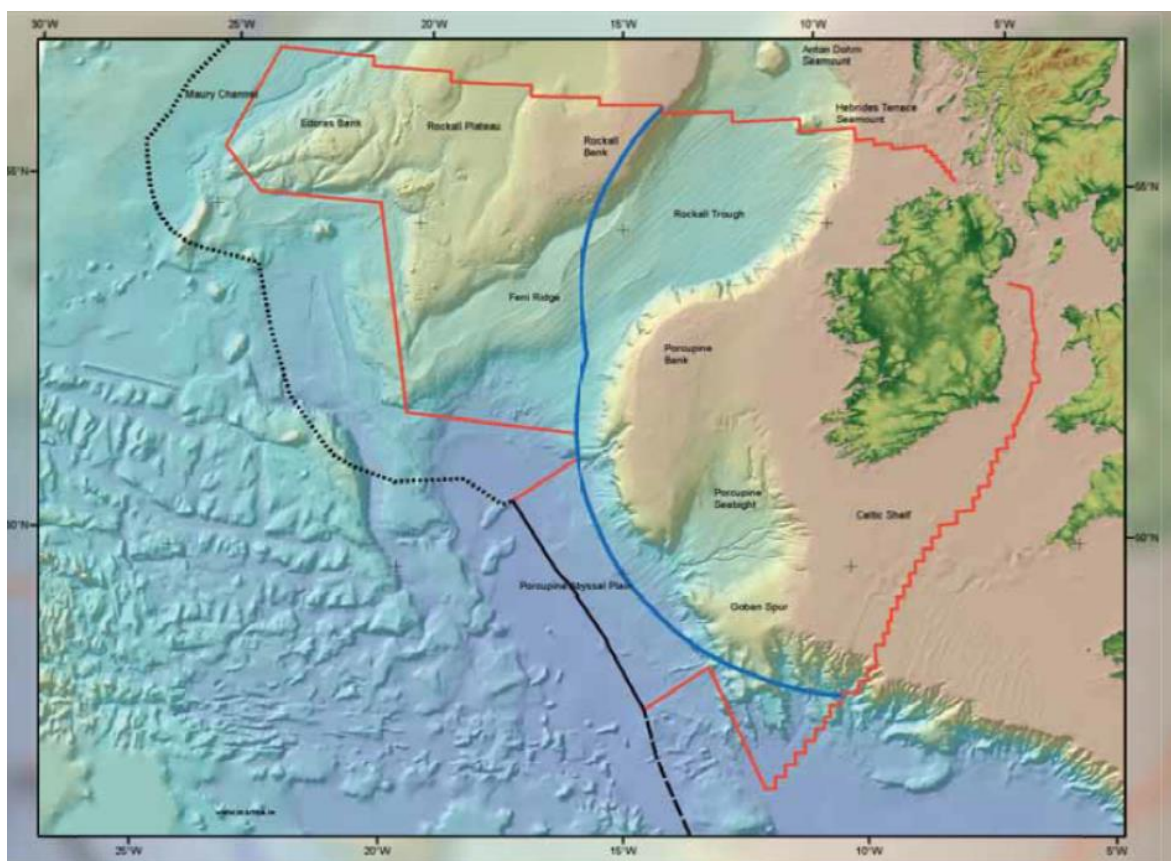
Figure 2 A map of Ireland's marine area with the red line representing Ireland's designated Continental Shelf and the blue line representing Ireland's 200 nautical mile Exclusive Economic Zone (Department of Agriculture, Food and Marine, 2012)

The Enablers Task Force on MSP have, since their establishment by the HOOW, compiled a report detailing recommendations regarding the development of an MSP framework for

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Ireland (Enablers Task Force on Maritime Spatial Planning, 2013). There are a number of key recommendations in this report mainly relating to MSP; however there is one recommendation of particular relevance to this study:

- The utilisation of marine-related data as a sound evidence base such as that provided by the IMA, with an expert advisory group charged with identifying gaps in the data.

2.2 Marine Atlases – A Question of Scale and Data Collection

How the marine atlas evidence or data is collected and collated varies depending on the source and the resources at hand. The quality of evidence gathering is often defined by this.

In Scotland, the National Marine Plan (NMP) is underpinned by Scotland's Marine Atlas (SMA) which provides a comprehensive analysis of marine data in relation to the existing and potential uses along with the NMP policies. The SMA was the basis for spatially explicit policies for renewables: data from the SMA was modelled in Geographic Information Systems (GIS) to show suitable areas for this emerging industry in the form of Regional Locational Guidance (RLG). Despite this RLG for renewables, the Shetland Islands Marine Spatial Planning (SMSP) Partnership felt the outputs were misleading because of the low quality baseline data used in the modelling. They were awarded funding from the Scottish Government to do their own modelling (Gray, 2015a) and publish their own Regional Locational Guidance (Tweddle *et al.,* 2014). The Shetland Marine Atlas data was gathered from an extensive public consultation process utilising local knowledge over a period of six years prior to modelling the RLG (Kelly *et al.,* 2014). The baseline data, the Partnership felt, was robust enough to proceed to the next level of modelling and this has led to the implementation of numerous spatially explicit policies aimed at increasing economic growth whilst safeguarding natural and cultural assets.

At the European level, the European Atlas of the Seas (EAS) is primarily focused on raising awareness of Europe's oceans and seas. Because of this, the data on the EAS is extremely broad in nature and not suitable for use in a comprehensive environmental assessment. However, there is the potential for the expansion and improvement of this atlas

to incorporate more detailed data. The EAS was first launched in 2011 and is being continually updated and improved overtime.

Similar regional-scale efforts in the Caribbean have focused on developing a data, information and services sharing platform in the form of the Caribbean Marine Atlas (CMA). This Atlas aims to contribute to the development of national and regional atlases in the Caribbean (GeoNode, 2015). In doing this, the nations of the Caribbean have identified common marine issues such as marine habitats, overexploitation of coastal resources, natural hazards, beaches and land-based sources of pollution which will help in developing coherent national and regional marine atlases. Furthermore, the differences in data management competency between various countries have emerged from this process. This allows for a more concerted effort by concentrating resources on areas or nations where inefficiencies lie in terms of data management and collection due to lack of resources (Review and Planning Workshop/ Saint Lucia Coastal Atlas Stakeholder Event, 2010), thus facilitating the development of a comprehensive regional marine atlas for the Caribbean which will facilitate and inform NMPs and national marine atlases. This is supported by a timeline for each participating nation in the CMA project that sets out the various components leading to the eventual development of a national marine atlas in each nation.

Conversely, a continent-wide marine atlas has been developed in Africa providing data in relation to eleven nations (as of March 2016) with marine EEZs (Exclusive Economic Zones); along with regional data for four different regions of the continent. This suggests that data of all scales and qualities can be displayed on the same platform. Unlike the CMA, the African Coastal and Marine Atlas (ACMA) has been developed to a high standard with a wealth of easily navigable data. However, the ACMA has been in development for a longer period of the time than the CMA which may explain the difference in quality. It is also the aim of this ACMA project to embark on development of national coastal and marine atlases for participating countries and sub-regional atlases based on large marine ecosystem regions which is presently underway through the ODINAFRICA (Ocean Data and Information Network for Africa) (ODINAFRICA, 2015). This further demonstrates the combined approach where all scales of data are provided.

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The Atlas of the Patagonian Sea provides an example of the progression of marine atlases in South America. This atlas aims to outline the need for "integrated ecosystem management" by providing basic scientific information regarding the movement of marine mammals and seabirds. Oceanographic data such as salinity, ocean currents, sea temperature is also provided in the atlas. Although the maps are not displayed on a web-based platform, they visualise data relating to the movements of various marine mammal and seabird species in the Patagonian Sea. Not only this, but they also visualise and demonstrate the environment of the marine areas in which these species reside (Falabella *et al.,* 2009).

The spatial scale of human activities and regulations is often smaller than the ecosystem. Therefore, implementation is often carried out on more local scales than covered by the full plan. Jurisdictions in the United States with longer coastlines divided their planning and implementation areas in to sub-regions to achieve implementation on a local scale (see Figure 3).
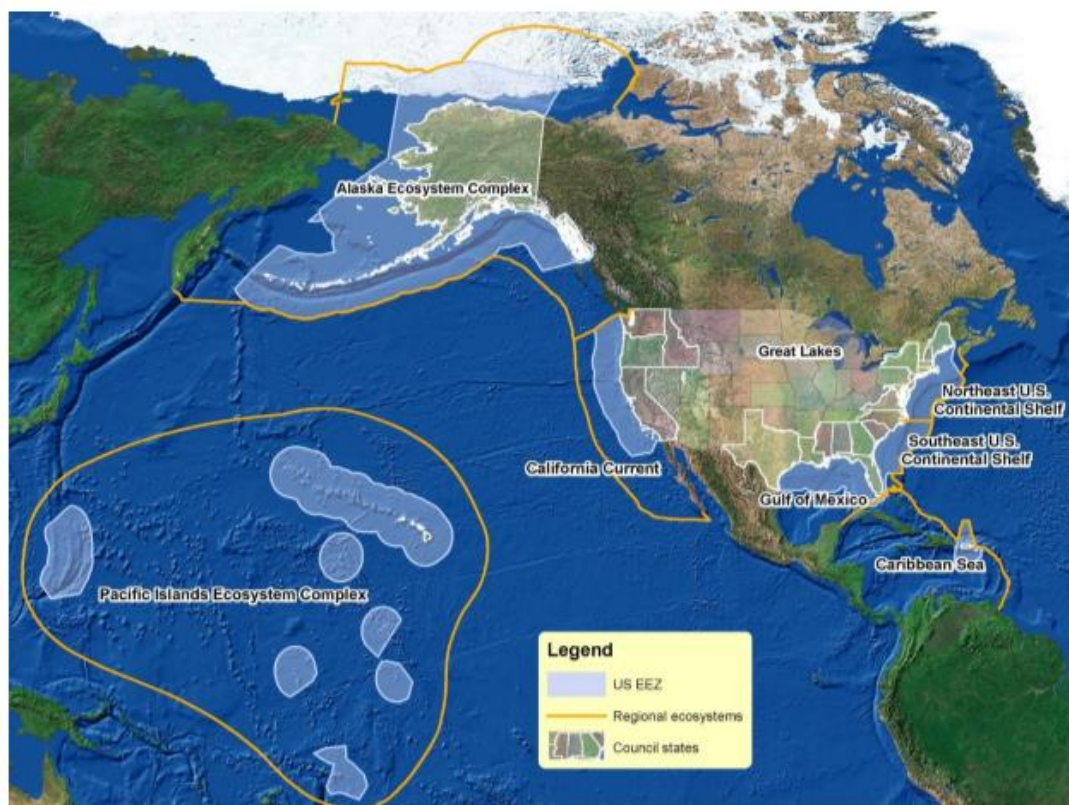
Figure 3 US Regional Ecosystems for Coastal and Marine Spatial Planning (NOAA Science Advisory Board, 2011)

It must be noted that The International Coastal Atlas Network (ICAN) has overseen the development of a large amount of coastal and marine atlases around the world including both the CMA and ACMA. Originally a project undertaken by the International Oceanographic Date and Information Exchange Programme (IODE), ICAN is essentially a gathering of different organisations involved with coastal web atlases. The primary aim of ICAN is to share experiences and to find common solutions to coastal web atlas development (Oregon State University, 2013). There is a strong Irish involvement in this network as the Coastal and Marine Research Centre in Cork is one of the founding members of ICAN.

Stakeholders and others often have excellent information on spatial patterns of use (e.g., fisheries) although proprietary rights considerations often impede the use of such data to inform decisions and trade-offs. Oftentimes, large amounts of data are gathered during the MSP process. However, few if any of the MSP efforts have a clear plan or framework for data management and decision support after the effort is completed. There is often a strong reliance on qualitative data and expert opinion, with few criteria or standards for data inclusion (NOAA Science Advisory Board, 2011).

Identifying issues can help to inform trade-offs that may occur due to a conflict of use. Indeed, a recent Marine Management Organisation (MMO) report recommends early structured stakeholder engagement and an improvement of baseline evidence relating to future trends in what is a constantly changing marine environment (MMO, 2014).

A recent MMO report questions whether EBM can support social and economic objectives in the marine environment, in particular regarding decision-making relating to trade-offs. It is contended in this report that the standard of data relating to the effects of human activities on the marine environment is not sufficient to achieve this. In effect, the report conveys that there is lack of data relating to the impact of human activities on ecosystem services (MMO, 2014).

Although the data presently supplied and presented on the CMA is fragmented and varying in standard, it does provide a platform for future enhancement of the atlas and development of national atlases. Indeed, the concept of developing a regional marine atlas with the

intention of data sharing is commendable as it avoids conflicts of uses from stymieing development and progression. The drive to achieve this in the Caribbean has been demonstrated by the hosting of numerous workshops to date. This has broadened the range of relevant stakeholders included in the process which has resulted in an improvement in data quality management and sharing abilities. However, it is recognised that there has been difficulty in maintaining interest and therefore upkeep of the CMA because of a lack of awareness of the importance of the CMA. The ACMA, like the CMA, is providing a platform for national and local scale marine management by disseminating data on a regional scale which allows for trans-boundary data sharing opportunities. Both the CMA and the ACMA are heavily supported and facilitated by international funding through various organisations.

2.3 Marine Spatial Data Quality Analysis

Previous studies relating to marine spatial data quality analysis have utilised a particular methodology for analysing data quality. An MMO published report relating to evidence quality assurance details an assessment rating system of data quality. The rating system involves a nought to three rating with nought representing irrelevant data and three representing highly accessible or high quality data. It also allows for the identification of data gaps via a methodological systematic process of review (see Table 2). As can be seen in Table 2, there are various potential considerations to take into account when using this methodology. For example, if a seabed habitat dataset has been surveyed to known standards, then it is regarded as good quality evidence and of a moderate rating 2. If this dataset had full metadata records, the rating would increase to 3. Similar potential considerations have been used in previous studies (Issaris, *et al.,* 2012).

A study by Shucksmith *et al.* (2014) on the data collection and mapping process in Scottish regional MSP used an adapted version of this methodology that increased confidence in data utilised to develop spatially-specific policies (Shucksmith *et al.,* 2014). The methodology was adapted to reflect that some data collection methodologies may not be published. Data ratings were translated to percentages with 0-60% representing low confidence data, 60-70% representing medium confidence data and over 70% representing

high confidence data. Each dataset was rated based on methodology, timeliness, spatial, completeness and quality standards confidence (see Figure 4)

Methodology confidence

0	Unable to assess	Unknown provenance (origin, source).	Unknown provenance (origin, source).	
1	low	Little or no identified methodology. Little or no indication if this was "best practice" by experts/professionals in that field. Little or no indication of any external verification/peer review.	Little or no **published** methodology can be identified.	Not all datasets published so methodology identified with discussion data holder/owner
2	Moderate	Methodology available but no indication if this was "best practice" by experts/ professionals in that field. Some external checking indicated.	**Published methodology** but no indication….	Not all datasets published so methodology identified with discussion data holder/owner
3	High	Methodology is considered "best practice" by experts/professionals in that field. Methodology is valid and reliable.	**Published** methodology is considered "best practice"…..	Not all datasets published so methodology identified with discussion data holder/owner

Timeliness confidence

0	Unable to assess	No details of data vintage known.
1	low	The data is out of date and an update is 2 or more refreshes overdue. No indication when the data is likely to be updated.
2	Moderate	The data is out of date and an update is overdue by one refresh. There may be an indication of a possible update, but no commitment that this will actually happen.
3	High	Data is current and is the most up-to-date it can be this stage (i.e. no refresh is overdue). Date of collection and collection period are known and the data will be updated with a known periodicity.

Spatial confidence

0	Unable to assess	Unknown or uncertain extent and location details.
1	low	Neither location nor extent are identifiable to a reasonable degree of accuracy.
2	Moderate	Location or extent accurately identified, but not both.
3	High	Both location and extent accurately identified.

Completeness confidence

0	Unable to assess	–
1	low	many gaps
2	Moderate	some known gaps
3	High	no gaps

Confidence in quality standards

0	Unable to assess	No evidence of quality assessment provided.
1	low	No quality control procedures completed at point of data collection or during data processing.
2	Moderate	Some quality control information however not accredited to a recognised standard or not from an authoritative source.
3	High	Detailed quality control information published and available for the data collection and/or during data processing and to a known standard.

Figure 4 Data Confidence Assessment Methodology (Shucksmith et al., pg 6, 2014).

A system similar to the MMO assessment rating system has been used in a previous study by Issaris *et al.* (2012) on ecological mapping and data quality assessment for the needs of ecosystem-based marine spatial management. This system is known as the pedigree matrix. The study utilised this system to assess the quality of data used to map ecosystem components and therefore take into consideration the inherent uncertainty (Issaris, *et al.,* 2012). The pedigree matrix uses data quality indicators to describe the aspects of data quality that influence the reliability of the data (Weidema and Wesnaes, 1996). Data was assessed based on five separate data quality indicators; reliability, completeness, temporal correlation, geographical correlation and data collection process quality (see Figure 5). These data quality indicators were modified to the study and do not represent typical data quality indicators of a pedigree matrix.

Indicator Score	1	2	3	4	5
Reliability	Measured Data	Verified data partly based on assumptions	Non-verified data partly based on qualified estimates	Qualified estimate (e.g. by scientific expert)	Non-qualified estimate
Completeness	Representative data from all sites relevant for the study area considered over an adequate period to even out normal fluctuations	Representative data from >50% of the sites relevant for the study area considered over an adequate period to even out normal fluctuations	Representative data from only some sites (<50%) relevant for the study area considered OR >50% of sites but from shorter periods	Representative data from only one site relevant for the study area considered OR some sites but from shorter periods	Representativeness unknown or data from a small number of sites AND/ OR from shorter periods
Temporal correlation	Less than 3 years of difference to year of study	Less than 6 years difference	Less than 10 years difference	Less than 15 years difference	Age of data unknown or more than 15 years of difference
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar environmental conditions	Data from area with slightly similar environmental conditions	Data from unknown area or area with very different environmental conditions
Data collection process quality	Data from targeted research conducted by the team involved in the case study	Data from targeted research conducted by other teams not involved in the case study	Data from targeted research conducted with different methodologies	Data from common research conducted with a standard methodology	Data from common research conducted with different methodologies

Figure 5 Modified Pedigree Matrix (Issaris, *et al.,* 2012)

2.4 Offshore wind farming – what to expect

Offshore wind farms, like many marine developments, involve various different problems due to the fluid and unsteady nature of the marine environment. This section will divulge some of the problems that arise during offshore wind farm developments, as well as discussing attempted solutions to those problems.

Ireland's sole constructed offshore wind farm to date, the Arklow Bank Wind farm, provides an example of the potential planning constraints and problems arising from the development of an offshore wind farm in Ireland and in a location approximately 45km to the south of the case study site. The Coastal Concern Alliance, an independent voluntary environmental group, outlined some of the inadequacies and problems that transpired during the permitting process. A number of issues were of concern in this case, including (Coastal Concern Alliance, 2009):

- The visual impact on the seascape.
- Potential impact on wildlife habitats such as sandbanks used by marine fauna for breeding purposes etc.

It is stated in this report that an EIA was conducted and a resultant EIS was produced which also involved a public consultation process one month in length, as part of statutory obligations.

The recently published Offshore Renewable Energy Development Plan (OREDP) for Ireland strongly advocates the use of offshore renewable energy to meet both national and EU energy needs and requirements. Indeed, it states that Ireland possesses one of the best offshore renewable energy resources in the world (Department of Communications, Energy and Natural Resources, 2014). Although government policy advocates the development of offshore renewable energy, it appears as though the funds are not available to facilitate the development of offshore wind farms in Ireland (Sustainable Energy Authority of Ireland, 2015). Recent developments have slightly contradicted this, in that the Sustainable Energy Authority of Ireland has recently allocated €4.3 million of funding to projects in Ireland related to marine renewable energy, including offshore wind (O'Brien, February 24, 2016). Research conducted by the European Environmental Agency on wind energy potential in the EU also suggests that there is a lot of potential to meet renewable energy targets.

Trade-offs often result in the re-distribution of uses and users in the marine area where uses and/or users deemed to be conflicting or incompatible are separated. However, some uses and users in the marine area can co-exist and therefore share the same space, otherwise known as multiple-use planning. A typical example of this would be maritime tourism and maritime traffic/shipping lanes. Research suggests that it may also be possible for aquaculture and wind farms to co-exist in a multiple-use format. The idea itself is currently being considered in Germany where a number of different designs are being evaluated (Michler-Cieluch *et al.,* 2009). It appears, however, that this idea has yet to be endorsed by both aquaculture and wind farm stakeholders alike due to the uncertainty surrounding navigation, legal issues, economic viability, and licensing amongst others (Michler-Cieluch and Krause, 2008). Cross-sectoral planning can often be quite taxing; perhaps integrative solutions such as multiple-use planning should be researched further to lessen the need for trade-offs in marine management.

2.4.1 Planning Constraints and Environmental Assessment

In relation to offshore wind energy potential, constraints are more prominent within the 0-10km zone closest to the coastline, declining in constraint in the 10-30km and 30-50km zones, and beyond 50km where marine activities are less concentrated and space is at a premium (European Environmental Agency, 2009).

The planning constraints for an offshore wind farm are addressed through the Environmental Impact Assessment (EIA) process in accordance with relevant EU and Irish regulations. The environmental impacts of a proposed project are assessed and written up as a legal document, the Environmental Impact Statement (EIS), and this is typically laid out in chapters with the following title themes (not in any particular order and dependent on sensitivities):

- Physical Environment
- Benthic and Intertidal Ecology
- Ornithology
- Marine Mammal Ecology
- Fish and Shellfish Ecology
- Commercial Fisheries
- Marine Historic Environment
- Shipping and Navigation
- Socioeconomics
- Aviation and Radar
- Seascape, Landscape and Visual Impact
- Potential Hydrocarbon and Chemical Spill
- Other Sea Users

Planning constraints are also identified at a slightly broader scale through the Strategic Environmental Assessment (SEA) process subject to EU and Irish legislation. The SEA process deals with public plans and programmes that are deemed likely to effect the environment. Similar to the EIA process, the SEA process involves the creation of an environmental report outlining a number of likely effects to consider.

When analysing and examining the data on the IMA in relation to an offshore wind farm, it was the aim of the author to loosely utilise the likely significant effects to be included in an

environmental report for an EIA or an SEA. These are known impacts established through many years of research which form the basis of an EIA and SEA. This resulted in a tailoring of the likely significant effects based on the principles of an environmental report for an EIA and/or SEA to section the data categories in the following themes for this study:

- Human Environment.
- Ornithology.
- Cetaceans and Seals.
- Fish Ecology.
- Marine Habitats.
- Commercial Fisheries.
- Seascape, Landscape and Visual Impact.

2.4.2 The Use of Marine Spatial Data in Environmental Assessments of Offshore Wind Farms

The SEA of the (OREDP) for Ireland in 2010 highlighted a number of data gaps to be noted in any future environmental assessments (Sustainable Energy Authority of Ireland, 2010). Identified data gaps included the following:

- Lack of environmental baseline data.
- Lack of military areas data.
- Marine mammal, fish and birds species distribution, abundance and migratory routes.
- Potential effects of offshore renewable energy devices on the marine environment.

Although an SEA involves a wider scope in terms of evaluating public plans and programmes, this particular SEA is relevant to this study as it assesses data gaps relating to offshore renewable energy in Ireland.

Analysis of previous EIAs of offshore wind farms in Ireland shows that a wide range of marine spatial data is used. However, EIAs require detailed data due to the site-specific focus. This can lead to the utilisation of data pertaining solely to the chosen site. For example, a recent environmental assessment of the Kish Bank site suggested that fish stock data was localised to the site (Saorgus Energy Ltd., 2012). Furthermore, another EIA stated that project specific investigation data was used as a data source (Aqua-Fact International

Services Ltd., 2007). A previous EIA of a proposed offshore wind farm, similar to Appendix B, has used data to assess the potential ecological effects arising from offshore wind farms (Aqua-Fact International Services Ltd., 2007). Analysis of both the SEA of the OREDP and EIAs of proposed offshore wind farms suggests that collection of ornithology data presented significant problems. It is hypothesised in the SEA of the OREDP that this is a significant problem due to the sheer geographical scale, harsh conditions and relative inaccessibility of the marine environment making data collection very challenging, costly and time consuming (Sustainable Energy Authority of Ireland, pg 426, 2010).

Data consistently used in previous environmental assessments (Aqua-Fact International Services Ltd., 2007; Saorgus Energy Ltd., 2012) of offshore wind farms relates to:

- Migration routes, distribution and abundance of marine mammals, birds and fish.
- Bathymetry and geology.
- Visual Impact of the wind farm.
- Marine archaeology.
- Marine habitats.
- Navigation.
- Marine tourism and recreational activities.
- Oceanography – tidal, waves and currents.
- Commercial fisheries.

This suggests that the aforementioned consistently used data represents the data required in an environmental assessment of an offshore wind farm.

2.5 Characteristics of the Irish Marine Atlas

The IMA, as previously stated, is used as a decision support tool in the plan development process of coastal and marine developments. Therefore, the IMA is ideally placed as a tool for identifying and assessing planning constraints for marine developments. As shown in Figure 1, the IMA displays a number of layers under various themes including:

- Administrative Units
- Energy Exploration
- Energy Infrastructure
- Land Cover
- Meteorological Features
- Ocean Features

- Tidal Energy Resource
- Wave Energy Resource
- Wind Energy Resource
- Environmental Monitoring
- Fisheries
- Geology
- Habitats
- Hydrography

- Protected Sites
- Reporting Units
- Sea Regions
- Species Distribution Marine Birds
- Species Distribution Marine Mammals
- Species Distribution Sea Fisheries
- Transport Networks
- Utility and Government Services

Within each theme are a number of layers and sub-layers which can be activated to clearly display the potential planning and environmental constraints on a site.

This chapter has placed the study in the context of the wider marine management sphere which allows for a greater understanding of the importance of marine atlases and high quality marine data for marine management. Analysis of international marine atlases and their data collection processes provided an example of best practice data collection and the differing scales of marine atlases. This facilitates the identification of data gaps in terms of the data collection methods and the relevance of scale to an environmental assessment. Examples of previous studies involving marine spatial data quality analysis help to inform the methodology for this study and provide a process for the identification of gaps in the data on the IMA in relation to an environmental assessment of an offshore wind farm at the Kish Bank site. Assessment of previous environmental assessments relating to offshore wind farms and general offshore wind farm literature outlines expected constraints, data gaps and deficiencies in relation to the IMA data.

3 Methodology

The chief means of undertaking an analysis of the IMA was using a data quality assessment rating system (Marine Management Organisation, 2013) similar to a pedigree matrix used in other studies (Issaris, *et al.,* 2012) and the descriptive case study method (Yin, 1993). Both methods were utilised in the analysis of spatial data and identification of data gaps on the IMA in the case of an environmental assessment of a proposed offshore wind farm. Maps were also created using ArcGIS according to separate themes consistent with EU environmental assessment standards. This was undertaken in order to visualise the spatial data in the context of the case study site and for ease of comparison to other spatial data used in previous environmental assessments. By displaying the data in this manner, gaps in the data could then easily be identified and visualised under each theme when comparing the data with previous environmental assessments of offshore wind farms. ArcGIS was also utilised to manually geo-reference the wind turbines of the proposed offshore wind farm on the Kish Bank onto the maps. This was done using the geo-coordinates supplied by the Site Layout Plan (OSI Background) document as part of the environmental assessment of Kish Bank (O'Brien P. , 2011). This chapter describes the above mentioned methods in more detail. It also explains access to the data and the descriptive case study method.

3.1 Access to Data

Access to spatial data in GIS format was provided through the IMA as this was the focus of the thesis. Any data on the IMA sourced from elsewhere was appropriately referenced on the maps created for this study based on the metadata provenance and the associated license. Table 1 below recognises these data sources. Access was secured to the prototype v2 IMA with the cooperation of the Marine Institute staff working on the IMA. It is recognised, as stated by the Marine Institute staff, that this is an unfinished web-atlas that is not available to the general public and will be incrementally added to over time. Therefore the author was required to designate a particular date as a cut-off point (12/03/2016). This allowed the author to use the most up-to-date data. The author utilised ArcGIS version 10.3.1. All data was examined systematically on this version of ArcGIS by

examining attribute tables and layer properties of all datasets. Along with reviewing the metadata, this assisted in the identification of data gaps in the IMA.

Table 1 Data Sources

Data Sources
Marine Institute
Saorgus Energy Ltd.
Irish Naval Service
Petroleum Affairs Division
Department of Transport, Tourism and Sport
INFOMAR
National Biodiversity Data Centre
Irish Whale and Dolphin Group
Geological Survey Ireland
Department of Agriculture, Food and the Marine
Sustainable Energy Authority of Ireland

3.2 Data Quality Assessment Rating System and Pedigree Matrix

The primary aim of this study is to identify gaps in the data on the IMA by assessing the quality of the data on the IMA. In order to do this, a data quality assessment rating system was adapted from the MMO and tailored to include the significance of impact of each dataset on an offshore windfarm (see Table 4). Such a methodology is comparable to the pedigree matrix devised by Weidema and Wesnæs (1996) in order to estimate uncertainty due to insufficient data quality (Weidema and Wesnæs, 1996).

Not only did this methodology allow for identification of data gaps, it also encouraged the assessment of data gathering standards, visual competencies of the data and comparison with INSPIRE standards. This subsequently provided a means for the identification of associated challenges.

Table 2 Adapted data quality assessment rating system (Marine Management Organisation, 2013)

Rating	Confidence	Definition	Potential Considerations
0	Not applicable	The question is not relevant to the assessment	This should only be used when certain that the question is not relevant
1	Low or unable to assess	• Insufficient detail available to assess confidence in the evidence. • Low confidence in the evidence. The decision maker must be aware that there are limitations to the use. • Further investigation required.	• Techniques and methods used may not be accepted, best practice method. • Incomplete or no metadata. • No clarity if the data is measured, modelled, predicted or estimated. • No clarity when recorded, over what period. • More up to date versions may be available that result in a low confidence in this data. • No quality control procedures identified at the point of evidence collection or during processing.
2	Moderate	Good quality evidence but may lack internal quality assurance, full documentation of records, and have inaccuracies	• Research methodology published but unable to determine if best practice was followed or considered standard by professionals in the field. • Data is modelled, predicted or estimated with details of such procedures provided. • Data is measured but precision is low or unclear. • Some data information is provided but incomplete. • Detailed metadata and sufficiently well populated to allow for assessment but not in INSPIRE standards. • Some quality control information published at the point of evidence collection and/or during processing.
3	High	High quality evidence, internally quality assessed, high confidence in methodology.	• Detailed research methodology published and using known best practice or is considered standard by professionals in that field.

Rating	Confidence	Definition	Potential Considerations
			• Data is measured and precision is high and explicitly stated. • Full date and update information is provided. • Detailed and fully populated metadata to INSPIRE standard. • Detailed quality control procedures published at the point of evidence and/or during processing.

3.3 Descriptive Case Study Method

The descriptive case study methodology is applied when knowledge of prior research and hypothesis development precedes actual experimentation (Yin, 2003). In this instance, marine management practices focusing on wind farms, marine atlases and environmental assessments of offshore wind farms were examined before the study site was selected. Also, a company involved with offshore renewable energy in Ireland and Great Britain was consulted beforehand in order to attain a professional opinion regarding site selection for a case study. It was also selected as stated in the previous section, due to the availability of a wealth of information relating to the site. This allowed for the maximization of what can be learnt in the period of time available for the study (Tellis, 1997).

3.4 Kish Bank Case Study Site

The Kish Bank site is part of a wider offshore wind farm development also including the Bray Bank, namely The Dublin Array offshore wind farm project. The bank itself is located approximately 10km off the coast of Dublin; covering an area of approximately 24.2km^2 (measured using Scotland's National Marine Plan Interactive). Seventy four wind turbines are proposed for the Kish Bank site which has a water depth ranging from 2 to 30 metres, a range considered to be suitable for a commercially viable offshore wind farm (Saorgus Energy Ltd., 2013) (see Figure 6). The area of Kish Bank is also considered to possess an excellent wind regime, suitable ground conditions for installation in the form of sand and gravel and moderate wave, current and tidal climates (Saorgus Energy Ltd., 2013) The Kish Bank site was chosen as the case study site for this thesis as it has yet to attain

permission for development from the Minister for Environment, Community and Local Government due to delays regarding the amendment of legislation relating to offshore developments in Ireland. This allowed for a fresh approach to the analysis of data for this particular site. There is also a considerable amount of information publicly available relating to the Kish Bank site as both an EIA and Natura Impact Assessment (NIA) has previously been conducted on the site from 2012-2013 as part of the process to achieve a grant of permission (ongoing since 2000). Along with the data accessible via the prototype v2 IMA, this would eliminate the problem of collecting data and would also provide more data to work with and analyse. Furthermore, the Kish Bank site was not included in the prototype v2 IMA as it has yet to achieve permission. Therefore, the selection of this site could enhance the data range of the IMA in the future.
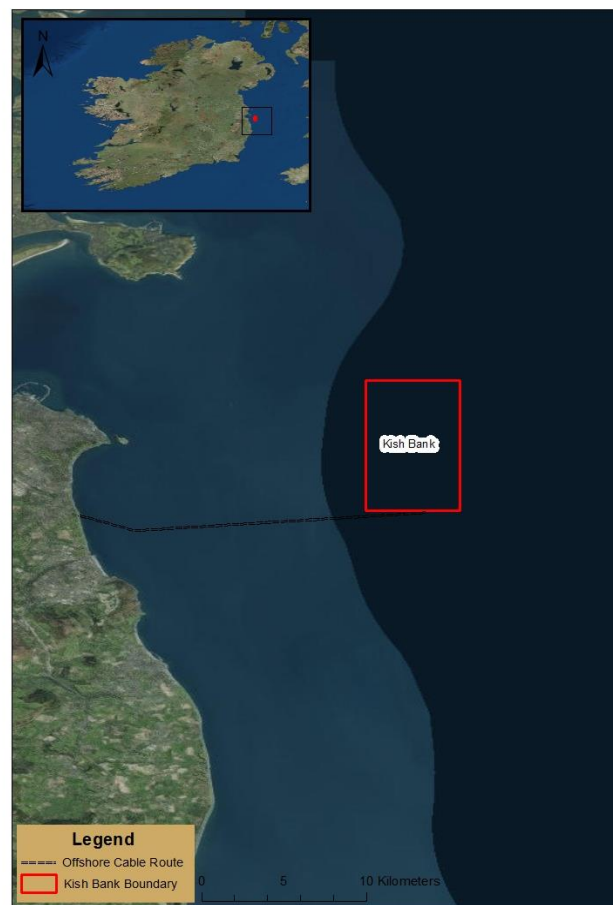

Figure 6 Kish Bank Site Location Map

3.5 Data Analysis

Each dataset was individually reviewed based on potential considerations outlined in the adapted data quality assessment rating system and the significance of impact on an offshore wind farm development. This allowed for gaps in the data on the IMA to be identified. The significance of impact section was added in order to highlight the impact of the data on the environmental assessment of an offshore wind farm using the Kish Bank case study site as an example of such. Site specific effects did arise due to the case study focus; however this did not prevent the identification of gaps in the data and associated challenges in relation to an environmental assessment of an offshore wind farm.

3.6 Methodological Limitations

One particular limitation arose during the study regarding data accessibility. Manipulation of the datasets and the display of the layers on the prototype was required for map-making purposes. Therefore, the datasets were downloaded directly from the IMA as the prototype did not facilitate this function. However, it was not possible to download all of the required datasets from the IMA due to licensing restrictions (see Appendix A which lists the non-downloadable datasets from the IMA for the Kish Bank site) i.e. data is compiled from various different sources on the IMA which leads to varying licensing restrictions. Therefore, the author used a combination of individually downloaded datasets and datasets harvested from the IMA prototype in the map-making process. In some cases, it was more suitable to use datasets harvested from the IMA prototype as individually downloaded datasets did not display a colour-coded symbology for the sub-layers nor was it possible to change the symbology. Any datasets harvested from the IMA prototype possessed pre-composed symbology that correctly reflected the sub-layers which improved the display of certain datasets. Notwithstanding this, it was simply beyond the scope of this study and the resources of the author to pursue licensing rights for the non-downloadable data.

4 Results

This chapter will focus on outlining and displaying the results of the data analysis and examination of the IMA data in relation to an environmental assessment of a proposed offshore wind farm at the Kish Bank site. Section 4.1 details the results of the data analysis and examination, outlining identified gaps in the data and associated challenges. This is expressed in the form of a tailored data quality assessment rating system (see Table 4). A summary table was also produced to allow for the clear delineation of these results (see Table 3). Section 4.2 visually displays the planning constraints of the Kish Bank site under separate themes consistent with EU environmental assessment standards. The planning constraints are displayed relative to the data available on the IMA. Clear and concise maps are used to display the planning constraints and to allow for the identification of gaps in the data under separate themes, in comparison with environmental assessments undertaken for other offshore wind farms. Subsequently, this highlights how the IMA data can be improved to facilitate a comprehensive environmental assessment of an offshore wind farm.

4.1 Results of Data Analysis and Examination

The results of the data quality analysis are briefly summarised in a table outlining the rating given to each dataset based on the adapted data quality assessment rating system (see Table 3). This acts as a pre-cursor to the detailed results outlined in Table 4. This table outlines the quality of the data in terms of completeness, validity, availability, timeliness and accuracy; all of which represent emerging themes from the potential considerations section in Table 2. Table 4 also addresses the significance of impact of each dataset on the Kish Bank site. In effect, Table 4 tailors the methodology from Table 2 to include an assessment of the impact of the dataset on the Kish Bank site.

Table 3 Data quality analysis summary

Data Quality Rating	Dataset
3 – High quality data	None
2 – Good quality data	• Celtic Voyager Underway Weather Station. • Petroleum Exploration License. • Separation Scheme Ship Navigation Channel. • Ferry Route. • Navy 12 Nautical Mile. • Range of Common Dolphin/Fin Whale/Grey Seal/Harbour Porpoise/Humpback Whale/Risso's Dolphin/Minke Whale. • Haddock/Cod/Mackerel/Horse Mackerel – Nursery Ground. • Haddock/Cod/Whiting – Spawning Ground. • EMODnet (European Marine Observation and Data Network) Collated Substrate. • Collated EUNIS (European Nature Information System) Habitats. • MSFD Predominant Habitat Type. • Pot Fishing. • Fishing Method Passive. • Fishing Method All Gears. • Effects Wind Turbine Seascape 5-15/24/35km.
1 – Low quality data	• INFOMAR Survey Shipwreck. • Observations European Herring Gull/Manx Shearwater/Auk/Common Guillemot/Northern Gannet/Kittiwake/Razorbill. • Range of Wild Atlantic Salmon.
0 – Not applicable	None

Table 3 shows that there was no data analysed that was not applicable to the case study site nor to an environmental assessment of a proposed offshore wind farm at that site. Also, the table shows that no analysed data was of high quality. Table 4 elaborates in greater detail about the potential considerations and significance of impact of each dataset that contributed to its data quality rating.

Table 4 Tailored MMO data quality assessment rating system

Dataset	Rating	Confidence	Potential Considerations	Significance of Impact
Meteorological Features – Weather Station- Celtic Voyager Underway Weather Station	2	Moderate	• Non-compliant with INSPIRE Regulations. • No other limitations.	• High cost of removal.
Energy Resources Exploration – Current Authorisations – Petroleum Exploration License	2	Moderate	• Non-downloadable dataset (see Appendix A). • Non-compliant with INSPIRE Regulations.	• Could lead to a user-user conflict with competing uses for the site.
Protected Sites – Underwater Archaeology - INFOMAR Survey Shipwreck	1	Low/Unable to access metadata	• Incomplete basic metadata. • Attribute table of dataset lacking detail.	• Potential obstruction for construction and access on the site.
Transport Networks – Navigation – Traffic Separation Scheme Ship Navigation Channel	2	Moderate	• Attribute table of dataset lacking detail. • Non-compliant with INSPIRE Regulations.	• Can complicate the anchoring of turbines. • Could lead to a user-user conflict with competing uses for the site.
Transport Networks – Traffic – Ferry Route	2	Moderate	• Non-compliant with INSPIRE Regulations. • No other limitations.	• Could lead to a user-user conflict with competing uses for the site.

Dataset	Rating	Confidence	Potential Considerations	Significance of Impact
Reporting Units – Maritime Surveillance – Navy 12 Nautical Mile	2	Moderate	• Attribute table of dataset lacking detail. • Non-compliant with INSPIRE Regulations.	• No significant impact.
Species Distribution Marine Mammals – Range of Common Dolphin/Fin Whale/Grey Seal/Harbour Porpoise/Humpback Whale/Risso's Dolphin/Minke Whale	2	Moderate	• Non-downloadable datasets (see Appendix A). • The data may be outdated or inaccurate. • No update interval clarified. • Non-compliant with INSPIRE Regulations.	• Noise impacts would result from all stages of development, but would be most prominent during the construction phase. • Could lead to user-environment conflict of use.
Species Distribution Marine Birds - Observations European Herring Gull/Manx Shearwater/Auk/Common Guillemot/Northern Gannet/Kittiwake/Razorbill	1	Low	• Non-downloadable dataset (see Appendix A). • Poorly displayed data. • Data is outdated by 13 years. • No update interval clarified. • No detail of flying patterns or migration routes. • Non-compliant with INSPIRE Regulations.	• Bird strikes (collision risk). • Disturbance / displacement from the increased vessel traffic and installation. • Increased collision risk for diving birds. • Could lead to user-environment conflict of use.
Species Distribution Sea Fisheries – Haddock/Cod/Mackerel/Horse Mackerel – Nursery Ground	2	Moderate	• The scale of the dataset is very broadly defined. • No update interval clarified. • Non-compliant with	• Behavioural attitudes could be affected during the construction phase through noise emissions and from electro-magnetic

Dataset	Rating	Confidence	Potential Considerations	Significance of Impact
			INSPIRE Regulations.	fields. • Potential for loss of habitat from wind turbines. • Could lead to user-environment conflict of use.
Species Distribution Sea Fisheries – Haddock/Cod/Whiting – Spawning Ground	2	Moderate	• The scale of the dataset is very broadly defined. • No update interval clarified. • Non-compliant with INSPIRE Regulations.	• Disturbance of the sediment during the construction and decommissioning phase. • Could lead to user-environment conflict of use.
Species Distribution Sea Fisheries – Wild Atlantic Salmon – Range of Wild Atlantic Salmon	1	Low/Unable to access metadata	• The range of the dataset is very broadly defined. • Incomplete basic metadata.	• Unknown due to severe lack of detail.
Habitats – Broadscale – EMODnet (European Marine Observation and Data Network) Collated Substrate	2	Moderate	• Poor dataset resolution. • Non-compliant with INSPIRE Regulations.	• Affects the type of anchor chosen for the wind turbines.
Habitats – Broadscale – Collated EUNIS (European Nature Information System) Habitats	2	Moderate	• Poor dataset resolution. • Non-compliant with INSPIRE Regulations.	• Affects the type of anchor chosen for the wind turbines.
Habitats – Broadscale – MSFD Predominant Habitat	2	Moderate	• Poor dataset resolution. • Non-compliant with INSPIRE	• Affects the type of anchor chosen for the wind turbines.

Dataset	Rating	Confidence	Potential Considerations	Significance of Impact
Type			Regulations.	
Fisheries – Inshore – Pot Fishing	2	Moderate	- Poor dataset resolution. - Some missing detail in the attribute table of the dataset. - Non-compliant with INSPIRE Regulations.	Could lead to a user-user conflict between the pot fishery and the offshore wind farm.
Fisheries – Offshore – Fishing Method Passive	2	Moderate	- Poor dataset resolution. - Incomplete metadata. - No clarity when recorded. - More up to date versions may be available. - Non-compliant with INSPIRE Regulations.	Could lead to a user-user conflict with competing uses for the site.
Fisheries – Offshore – Fishing Method All Gears	2	Moderate	- Poor dataset resolution. - Incomplete metadata. - No clarity when recorded. - More up to date versions may be available. - Non-compliant with INSPIRE Regulations.	Could lead to a user-user conflict with competing uses for the site.

Dataset	Rating	Confidence	Potential Considerations	Significance of Impact
Wind Energy Resource – Wind Turbine Impact Seascape – Effects Wind Turbine Seascape 5-15/24/35km	2	Moderate	- Lack of clarity in the metadata. - Non-compliant with INSPIRE Regulations.	Design and height of turbines may be compromised.

4.1.1 Significance of Impact

A recurring theme regarding the significance of impact of the data was the potential for conflicts of uses, all of which were characterised by a mixture of potential user-user and user-environment conflicts. Approximately six datasets presented a possible user-user conflict of use, whereas approximately four datasets presented a possible user-environment conflict of use for a proposed offshore wind farm at the Kish Bank site. The 'petroleum exploration license', 'traffic separation scheme ship navigation channel', 'ferry route', 'pot fishing', 'fishing method passive' and 'fishing method all gears' data signified potential user-user conflicts. The 'marine birds', 'marine mammals', 'nursery ground' and 'spawning ground' data signified potential user-environment conflicts.

Both the 'celtic voyager underway weather station' and 'INFOMAR survey shipwreck' data highlighted significant obstructions regarding access to and construction on the Kish Bank site (see Section 4.2.1). Firstly the aforementioned weather stations are described as permanent scientific equipment and form a significant obstacle due to their high cost of removal. Secondly, the 'INFOMAR shipwreck' data does not detail the size and type of each shipwreck which creates uncertainty regarding navigation and obstructs access to the site.

Another prominent impact of significance was the effect of a number of dataset features on the anchoring of the turbines. Approximately four dataset features included anchoring of the turbines as a potential effect on the proposed offshore wind farm on the Kish Bank site. Namely, the 'traffic separation scheme ship navigation channel', 'EMODnet collated substrate', 'collated EUNIS habitats' and 'MSFD predominant habitat type' data. Anchoring of the turbines can be influenced by both the surrounding habitat (see Appendix B) and the water depth (Aqua-Fact International Services Ltd., 2007; Saorgus Energy Ltd., 2012).

Some of the data displayed impacts specific to the data itself. The 'marine mammal' data highlighted a potential significant impact from noise emissions during every stage of development but particularly during the construction phase (see Appendix B). A number of potential significant impacts on the environmental assessment of a proposed offshore wind farm on the Kish Bank site were highlighted by the 'marine bird' data. Firstly, bird

strikes/collisions with the wind turbines represent a significant impact. Secondly, increased risk of collision for diving birds with mooring lines represents a further significant impact. Thirdly, disturbance and displacement from increased vessel traffic represents another significant impact.

The 'nursery ground' data also highlighted a number of potential significant impacts specific to the data. Nursery grounds are essential for the reproduction and survival of a species. Analysis of previous offshore wind farm environmental assessments suggests that, the behavioural attitudes of young Mackerel, Haddock, Horse Mackerel and Cod could be impacted during the construction phase through noise emissions and from electro-magnetic fields (see Appendix B). Also, there is potential for loss of habitat in the immediate vicinity of the turbine masts which would impact on the range of the nursery grounds. Similar to nursery grounds, spawning grounds are also essential for the reproduction and survival of a species. The spawning grounds facilitate the laying and fertilizing of eggs. Disturbance of the sediment during the construction and decommissioning phase could severely impact the spawning ground. These are issues commonly encountered during environmental assessments of offshore wind farms (see Appendix B).

The 'seascape' data represents a potential impact regarding the visual impact of the wind farm. This data can have a significant effect on the design and height of the wind turbines which would be partially defined based on a visual impact assessment. As the literature suggests, visual impacts of offshore wind farms often sway the public perception (Coastal Concern Alliance, 2009). The visual impact of offshore wind farms is normally addressed in the environmental assessment. This is evident as EU standards dictate that the visual impact of a project must be addressed in the environmental assessment (see Section 2.4.1).

The ensuing sections visually outline the data analysed and planning constraints under separate themes consistent with EU environmental assessment standards. This will allow for the clear identification of gaps in the data when comparing previous environmental assessments of offshore wind farms to the data for the Kish Bank case study site.

4.2 Offshore Wind Farm Planning Constraints

4.2.1 Human Environment

The data in this section pertains to traffic, shipping, navigation and oil exploration –
socioeconomic features that have a bearing on society. Shipwreck data is included in this
section as it bears an effect on navigation. The majority of exploration licences exist either
in the Celtic Sea or the Atlantic Ocean. These are not considered to be within areas of
significant deliverable offshore wind energy. However, as can be seen in Figure 7, a
petroleum exploration license has been granted covering the majority of the Kish Bank
site. Shipwrecks can provide a significant obstruction to navigation and are historically
prominent on sand banks such as Kish Bank. Figure 7 shows that there are a number of
shipwrecks, some of which are situated precariously close to wind turbines, on the Kish
Bank site. Ship navigation channels are generally constructed for the safe passage of large
ships through ports. One such channel traverses the Kish Bank site for the purposes of
accessing Dublin Port. Also, a ferry route from Dublin to Cherbourg which currently
dissects the Kish Bank site presents further navigation issues. Responsibility for patrolling
the 12 nautical mile limit lies with the Irish Navy. This is undertaken for fisheries
purposes. The site lies within this limit but is not materially affected by its imposition as no
fishing would generally occur on a wind turbine site.
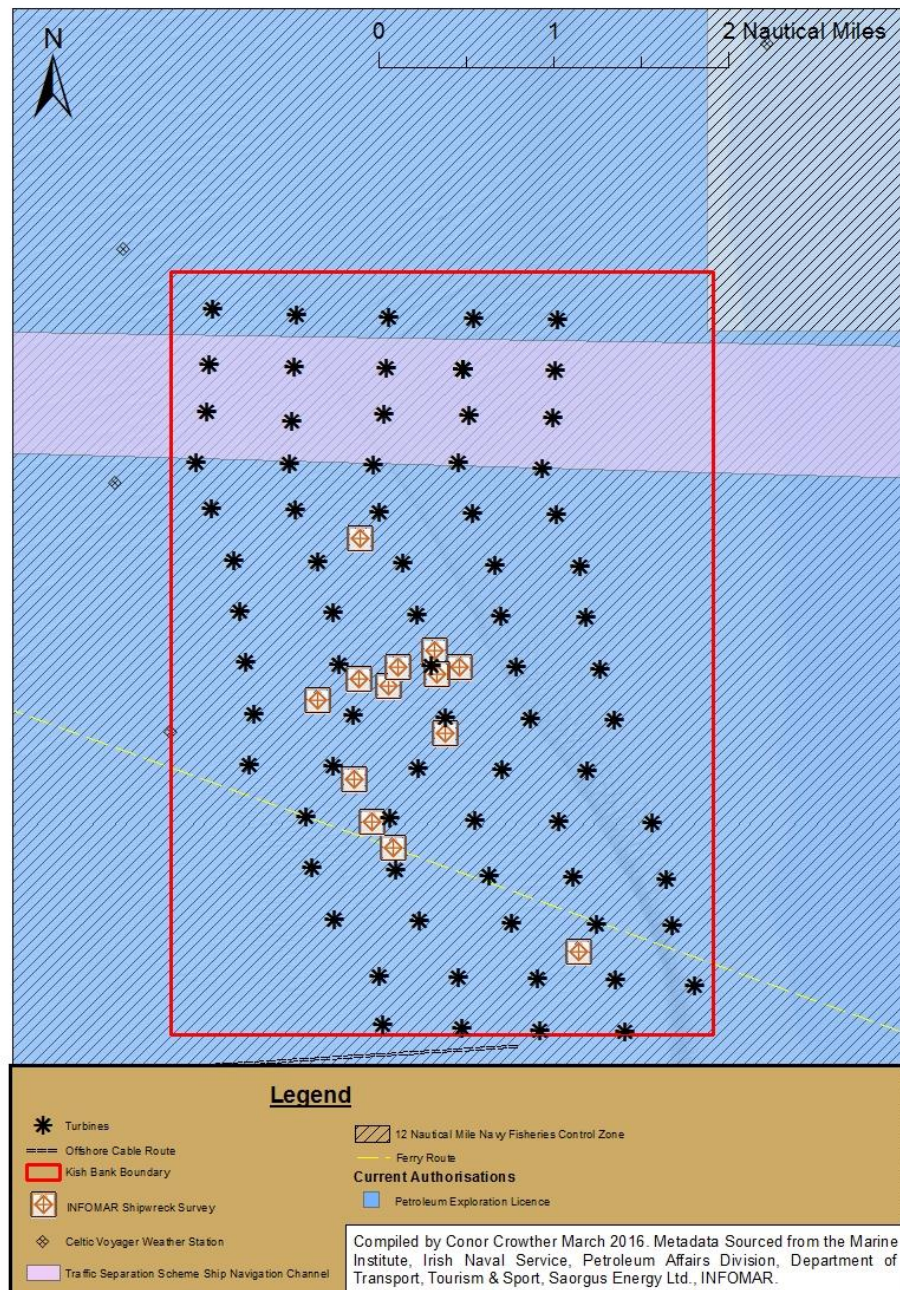
Figure 7 Human Environment Map

4.2.2 Ornithology

The data in this section relates solely to the ornithological species of a marine variety. As previously stated, this data is outdated by 13 years as it was collected from 1980-2003. Observations are represented by points of differing colours, dependant on the ornithological species. Two observations were made of the European Herring Gull at a point at the Northern Edge of the site. Seven observations were made of the Manx Shearwater at a point on the North-Eastern Edge of the site. Five observations were made

of the Auk at two points at the North-Eastern corner of the site. Seventy Four observations were made of the Common Guillemot at five points on the Northern part of the site. Six observations were made of the Northern Gannet at three points on the Northern part of the site. Twenty Eight observations were made of the Kittiwake at five points on the Northern part of the site. Eleven observations were made of the Razorbill at one point at the North-Eastern part of the site. It is not clearly evident in Figure 8 how many observations are made at each point which is one of the reasons why the marine bird data was rated as low quality data. The European Herring Gull, Manx Shearwater, Common Guillemot, Northern Gannet, Kittiwake and Razorbill are protected under a number of EU and Irish conservation regulations (see Appendix C). Further to this, the Auk, Common Guillemot and Northern Gannet are diving birds which increases their risk of collision.
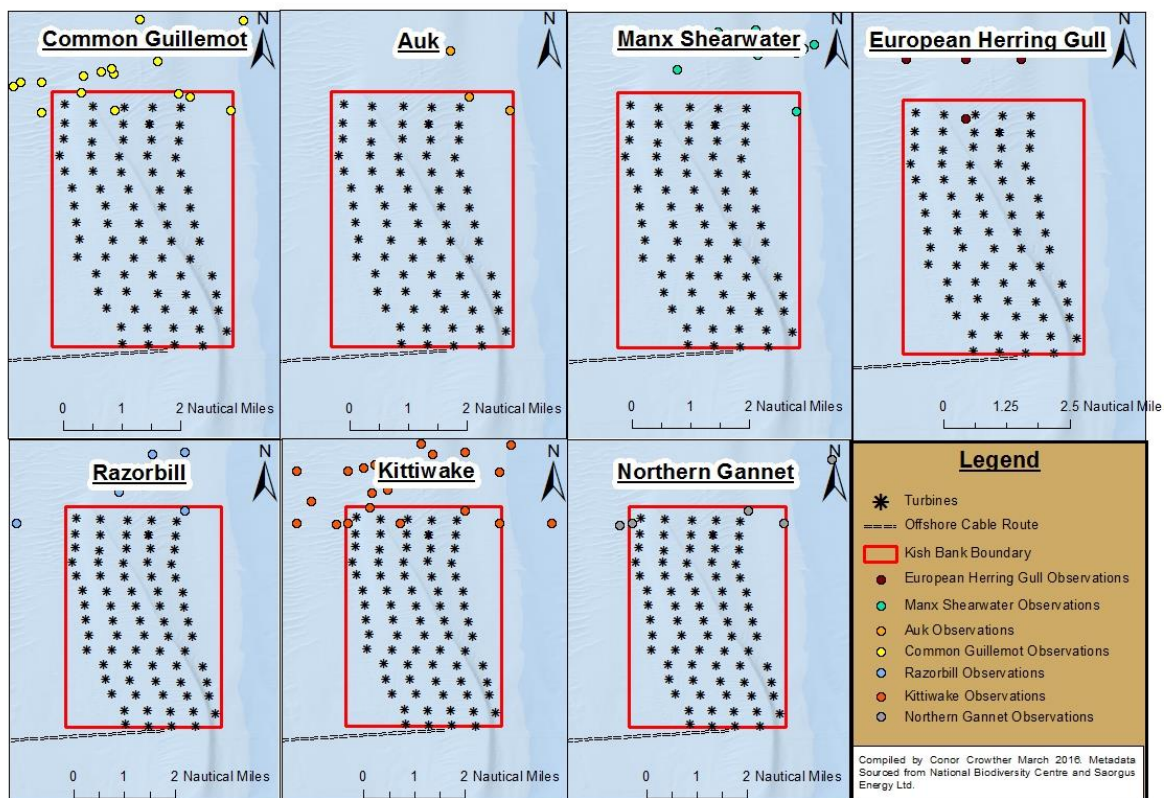

Figure 8 Ornithology Map

4.2.3 Cetaceans and Seals

This section deals with data pertaining to the range of cetaceans and seals. The range of each cetacean and seal refers to their distribution in the general area, the prominence of which is signified by grey shading (see Figure 9 and 10). No observations of any cetaceans or seals were made on the Kish Bank case study site. The range of the Common Dolphin was at the lower end of the scale (15 permanent). The range of the Fin Whale was at the lower end of the scale (3 permanent). The range of the Grey Seal was at the higher end of the scale (13 permanent). The range of the Harbour Porpoise was at the higher end of the scale (600 permanent). The range of the Humpback Whale was toward the lower end of the scale (2 permanent). The range of the Risso's Dolphin was at the lower end of the scale (1 permanent). The range of the Minke Whale was at the higher end of the scale (42 permanent). Furthermore, the Fin Whale is considered an endangered species and is protected along with the Humpback Whale, Minke Whale, Harbour Porpoise, and Risso's Dolphin under a number of different EU and Irish conservation regulations (see Appendix C).
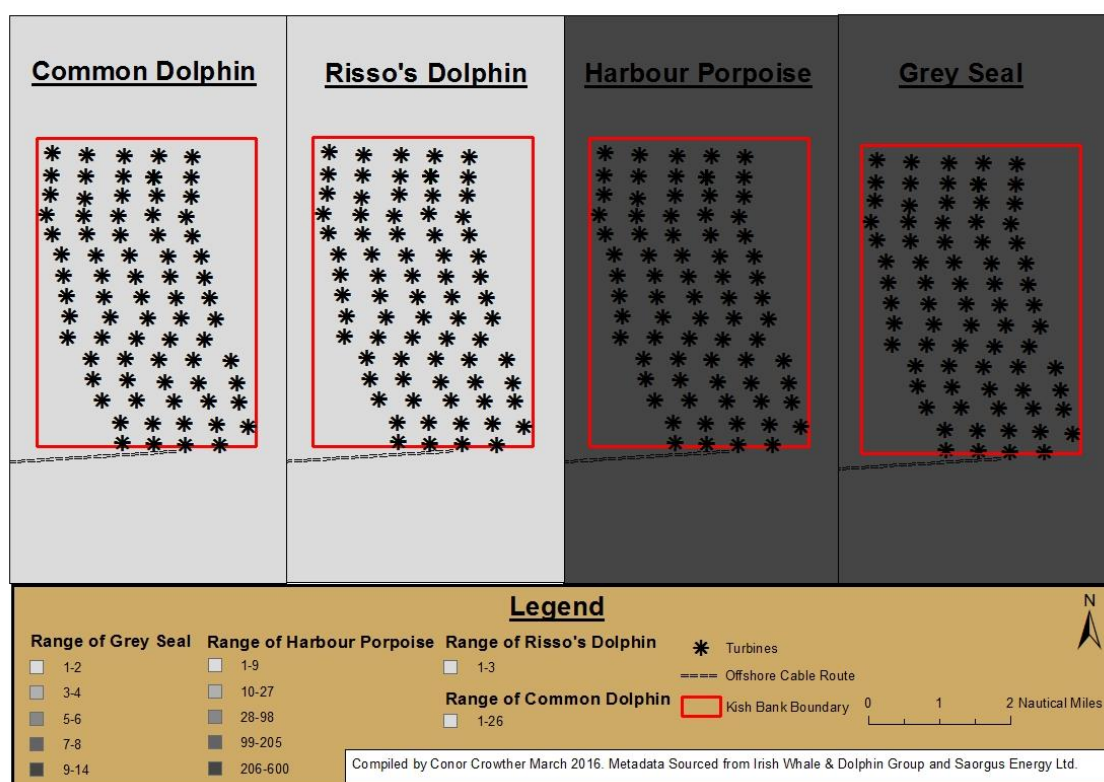
Figure 9 Dolphin, Porpoise and Seal Range Map
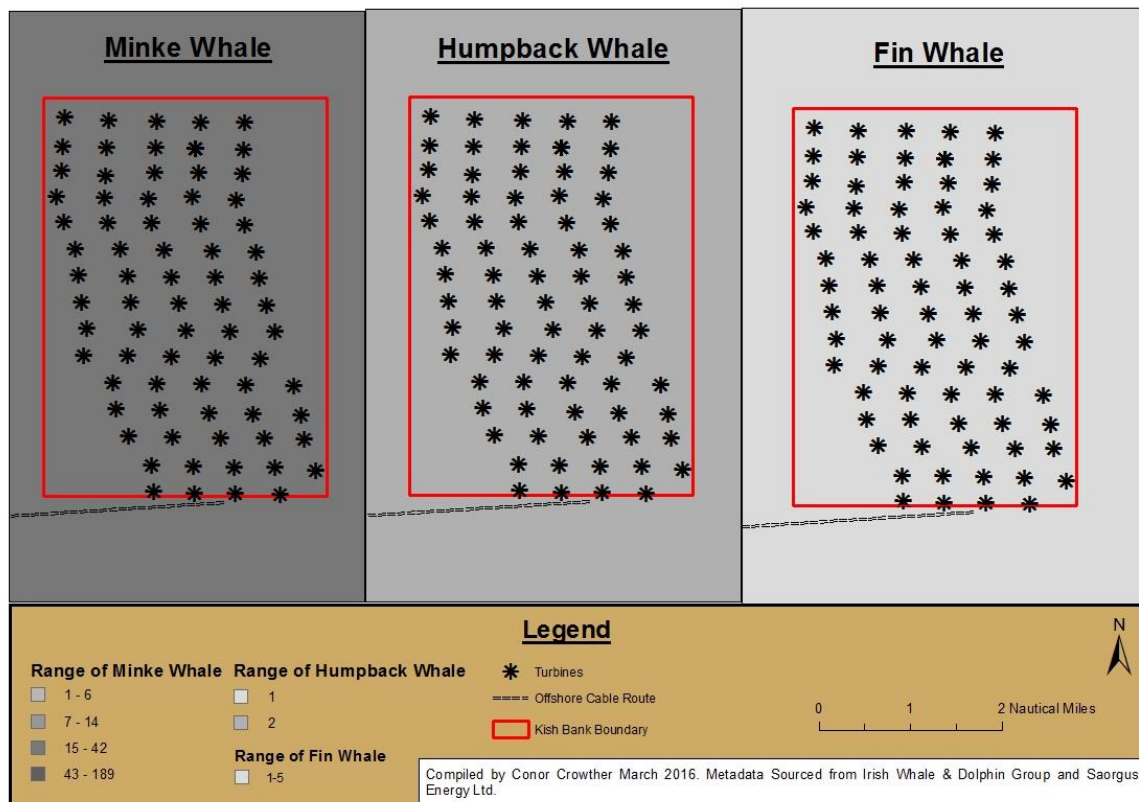
Figure 10 Whale Range Map

4.2.4 Fish Ecology

This section outlines the data relating to various fish nursery and spawning grounds along with the range of wild atlantic salmon (see Figure 11). It is not clearly evident exactly what the range of wild atlantic salmon refers to which was a contributing factor to its low data quality rating. The Kish Bank site comprises a part of the Haddock nursery ground in the Irish Sea and also one of the main Cod nursery grounds in Ireland. The Whiting spawning ground only includes an extremely small portion of the site and therefore has little impact of significance.

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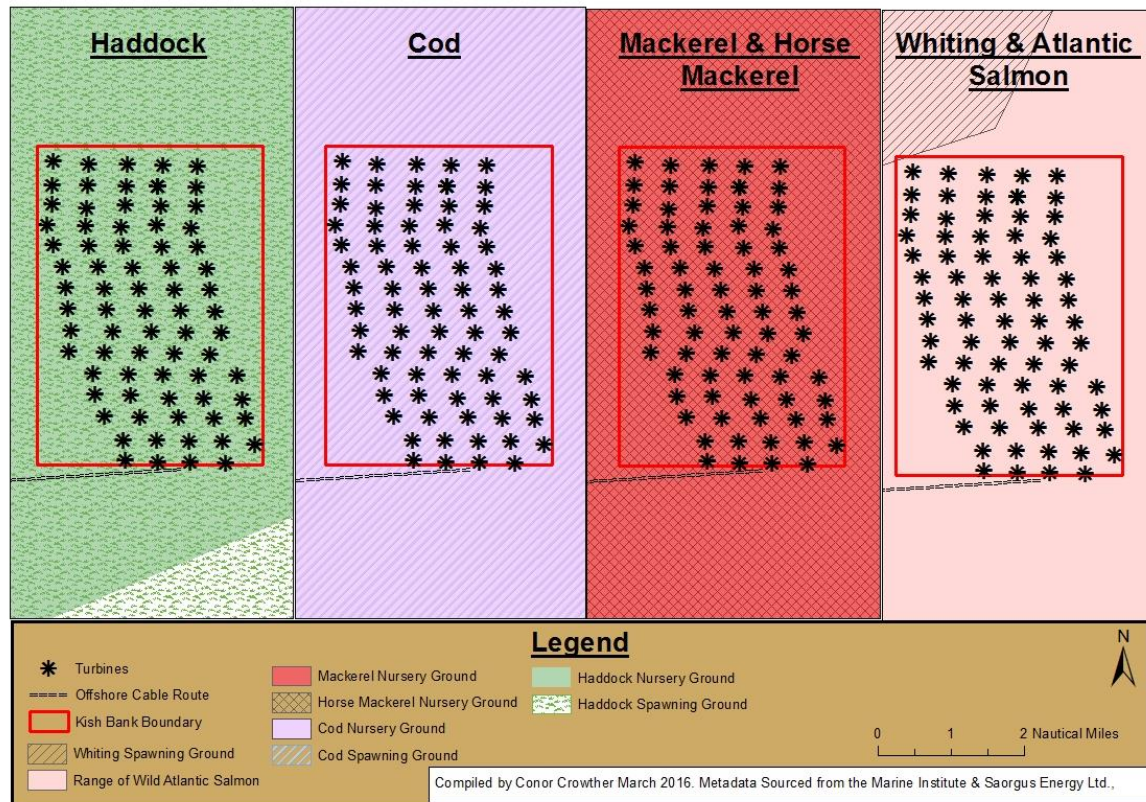
Figure 11 Fish Ecology Map

4.2.5 Marine Habitats

This section includes data pertaining to marine habitats. The 'EMODnet collated substrate' data shows that there is a mixture of sand, coarse sand and fine sand on the Kish bank site. Substrate such as this is often conducive to benthic habitats such as horse mussel beds, however none were found to be located within the site. Figure 12 also shows that there is a mixture of shallow sublittoral coarse sediment, mixed sediment, sand, deep circalittoral and circalittoral coarse sediment on the Kish Bank site. Circalittoral and sublittoral sediment is located closer to the sea surface. The metadata suggested that data from both the EUNIS habitats and EMODnet collated substrate datasets was used to create the 'MSFD habitats' data. This suggests that the 'MSFD habitats' data is representative of the marine habitat for this site. The 'EUNIS habitats' and 'EMODnet collated substrate' data was included for purpose of clarity. As can be seen in Figure 12 the resolution of this data is relatively poor which hinders ones interpretation of the data.
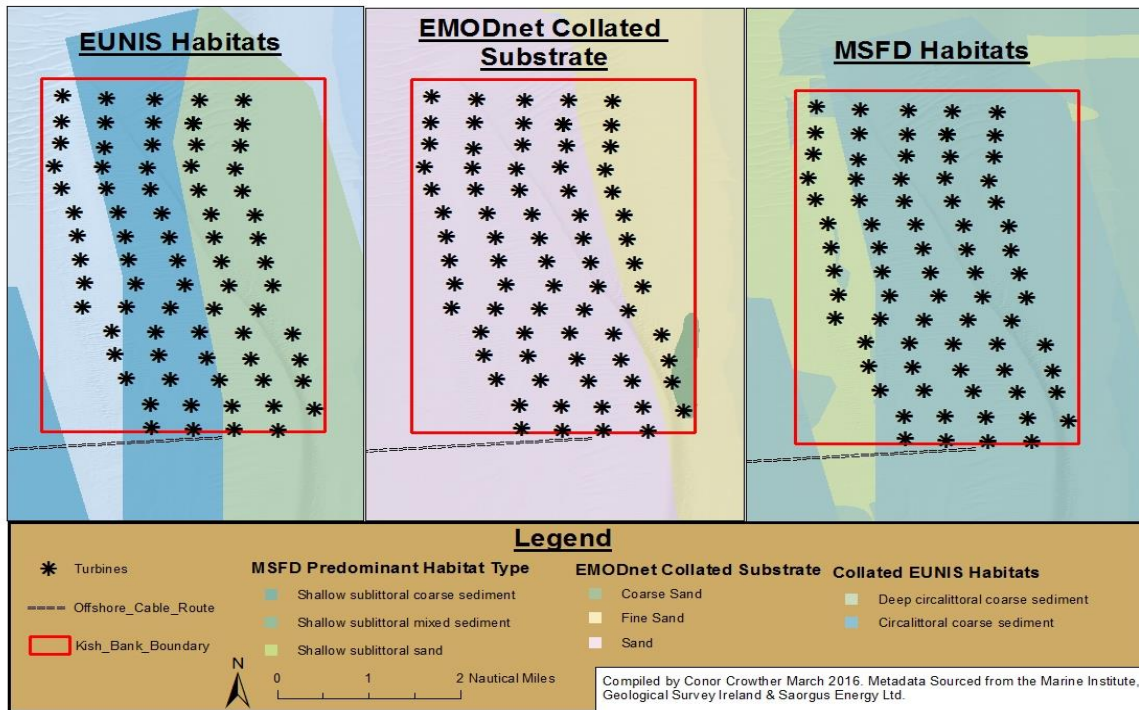
Figure 12 Marine Habitats Map

4.2.6 Commercial Fisheries

This section deals with commercial fisheries data which mainly demonstrates the presence of passive fishing in the form of pot fishing in the Kish Bank case study area. Pot Fishing is conducted mainly within the inshore area around the island of Ireland. Whelk is the main species fished in the Kish Bank area and it is fished all year round. Pot fishing directly correlates with passive fishing due to the static nature of the fishing gear. The 'passive fishing' data provides more location specific information, compared to the 'pot fishing' data, as to where the pot fishing is occurring and at what intensity. The pot fishing is occurring in the southern half of the site at an extremely low intensity. The 'all fishing method' data indicates that fishing is being conducted at a relatively low intensity in the southern half of the site (see Figure 13).
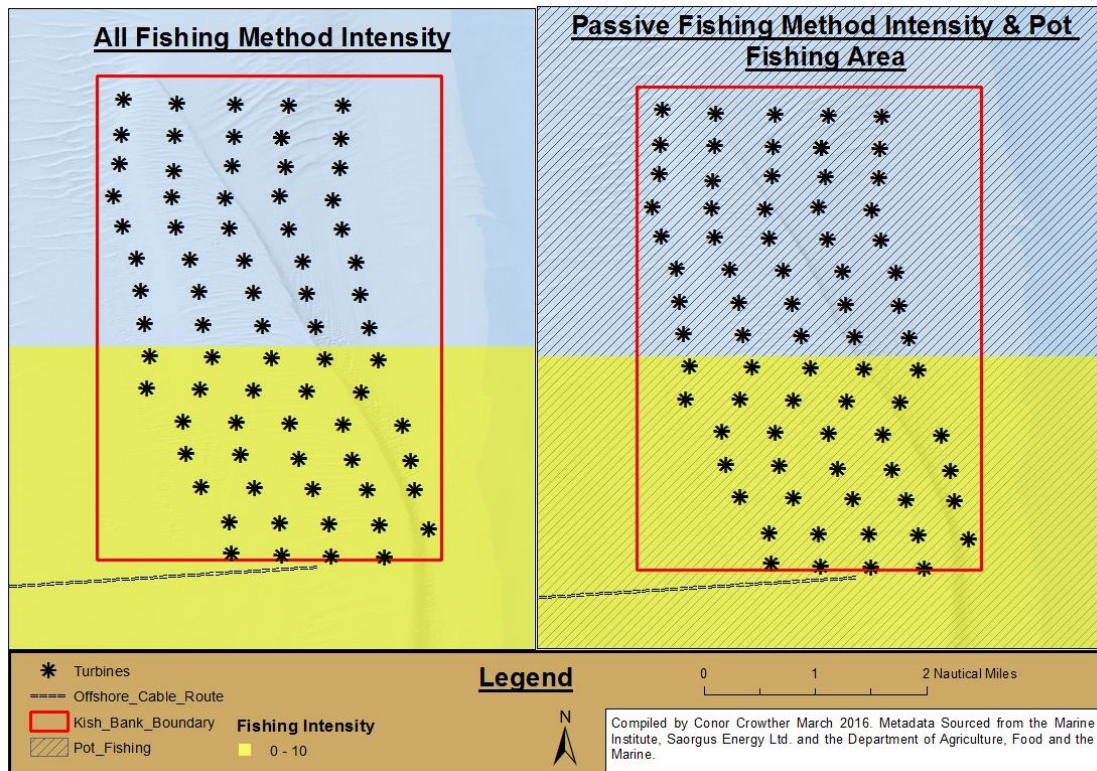
Figure 13 Commercial Fisheries Map

4.2.7 Seascape, Landscape and Visual Impact

This section includes data pertaining to the visual impact of the offshore wind farm on both the seascape and the landscape. Visual impact mitigation is one of the main aspects of an offshore wind farm as it often shapes the public perception of the wind farm (Warren *et al.,* 2005). Seascape, in this case, includes views from land to sea, views from sea to land, views along the coastline and the effect on landscape of the conjunction of sea and land. The visual effect of wind turbines on the Kish Bank site is moderate in the southern half of the site up to 35km, moderate on the northern half of the site up to 24km and substantial throughout the site up to 15km (see Figure 14).
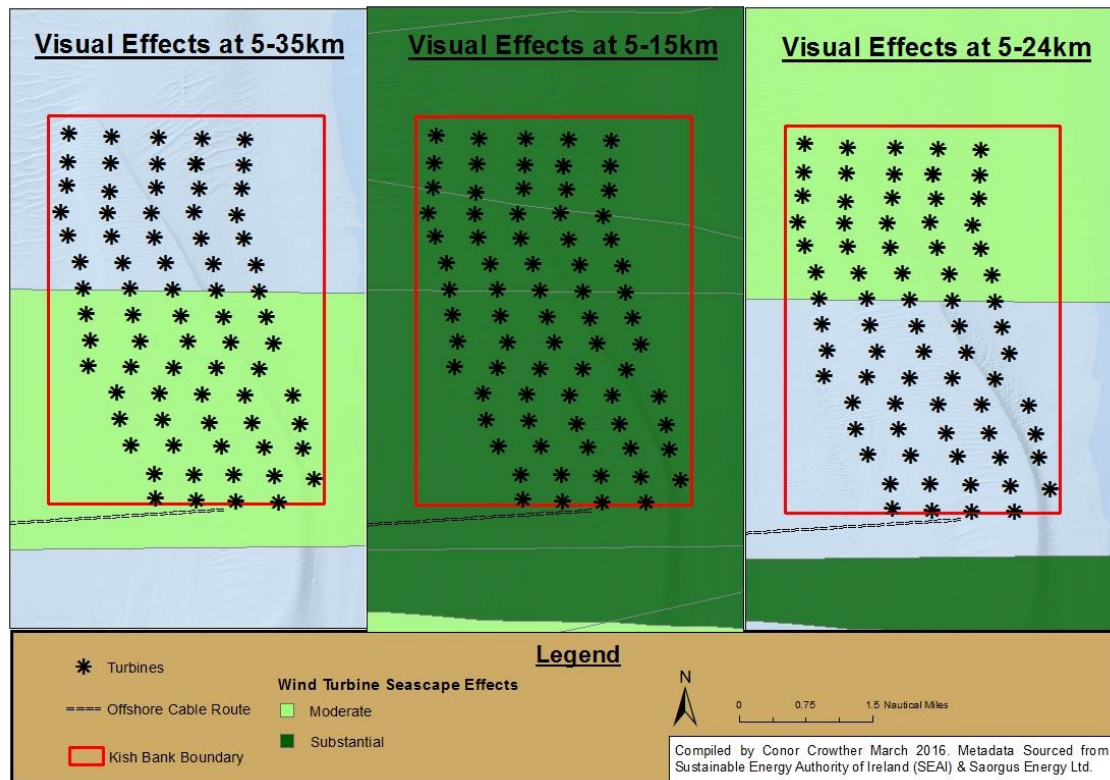
Figure 14 Visual Impact Map

In summary, there are varying impacts of the data and planning constraints on the Kish Bank case study site. This allows for the identification of data gaps and deficiencies whilst also highlighting the associated challenges of the IMA data in relation to an environmental assessment of an offshore wind farm.

5 Discussion and Conclusions

This section discusses and evaluates the identified data gaps, deficiencies, associated challenges and limitations in relation to an environmental assessment of a proposed offshore wind farm at the Kish Bank case study site using data from the IMA. Each research question is addressed individually and appropriate recommendations are developed based on the results and conclusions.

5.1 Key Findings

The results show that the data analysed possesses a number of different impacts on an environmental assessment of a proposed offshore wind farm at the Kish Bank case study site. Furthermore, it is evident from the results that a number of data gaps and deficiencies exist in the IMA data. Data improvements must focus on increased availability, detail, timeliness, accuracy, completeness, clarification and resolution to address these impacts and the identified data quality gaps and deficiencies.

5.1.1 Research Question 1: What are the knowledge/data gaps, if any of the IMA in relation to an environmental assessment for an offshore wind farm?

This sub-section discusses the identified data gaps and deficiencies in relation to an environmental assessment for an offshore wind farm. This research question was answered by utilising the adapted data quality assessment rating system after the relevant data was obtained from the IMA.

Some of the data that was assessed as low quality possessed incomplete basic metadata which limited the analysis of the data quality, namely the 'INFOMAR Survey Shipwreck' and the 'Range of Wild Atlantic Salmon' data. As a result of this, it was not possible to clarify how the data was measured, estimated and recorded. Upon analysis of the attribute tables of both datasets, some basic information was supplied but not enough to allow for data quality analysis or to constitute complete metadata. The 'range of the wild atlantic salmon' was also very broadly defined which did not add to the clarity of the data. It is

noted that the 'INFOMAR shipwreck' data may be legitimately restrained from public view to prevent looting of potentially lucrative cargo on-board the shipwrecks.

The other data considered to be of low quality was the data involving 'marine bird observations'. Issues encountered with this data related to the display, timeliness and general quality of the data. Firstly, the display of the data was poor as it did not clearly delineate between a point where multiple observations were made and a point where one observation was made (see Section 4.2.2). Secondly, it is stated in the metadata that the data was collected from 1980-2003, which means it is outdated by 13 years. Furthermore, there is no clarification of an update interval regarding the future updating of the data. This presents a huge concern regarding the possible existence of more up-to-date data. Thirdly, the lack of detail on migration patterns and flying patterns is insufficient as such details are crucial when conducting an environmental assessment of an offshore wind farm (see Appendix B). This is consistent with a previous study that used a similar data quality assessment system and found environmental data to be the data of lowest quality due to incomplete survey effort, issues with 'spatial confidence'(location and extent), and timeliness (Shucksmith *et al.,* 2014). Low quality data results in low confidence in the data. This increases the need for further surveys and studies in the case of an environmental assessment of an offshore wind farm, which adds to the length and cost of the assessment process.

Although a large majority of the data analysed is considered to be of good quality, there are some deficiencies and gaps in a portion of this data. The 'traffic separation scheme ship navigation channel' data does not detail the depth and width of the channel. This gap in the data could lead to uncertainty surrounding the anchoring of turbines in the case that a navigation channel traverses a proposed offshore wind farm (see Section 4.2.1). The 'navy 12 nautical mile' data does not convey the frequency of patrols or surveillance which creates uncertainty around the activity of the navy (see Section 4.2.1). The 'marine mammal' data analysed was collected from 2005-2011 which raises concerns regarding its accuracy and whether more up-to-date data exists. This is compounded by the fact that there is no clarification of an update interval for the future updating of the data.

Non-clarification of an update interval and when the data was recorded are prominent data gaps associated with four other datasets that achieved the rating of good quality data. Namely, the 'nursery ground', 'spawning ground', 'fishing method passive' and 'fishing method all gears' data. Further to this, the scale of both the 'nursery ground' and 'spawning ground' data was broadly defined which creates concern regarding the accuracy of the data.

The 'EMODnet collated substrate' data resolution was relatively poor which was also recognised in the metadata. Indeed the resolution of the accompanying 'collated EUNIS habitats' and 'MSFD predominant habitat type' data also demonstrated poor resolution (see Section 4.2.5).

The 'pot fishing' data does not detail the number of gear units used, however it is stated in the metadata that all known attributes were included. Poor data resolution was another commonly occurring data gap that was identified in two further datasets that achieved the rating of good quality data. Namely, the 'fishing method passive' and 'fishing method all gears' data (see Section 4.2.6).

The 'wind turbine seascape' data does not delineate between the land to sea, sea to land and coastline visual impact. It is presumed that the data represents a combination of these factors, however it is not explicitly stated as such which creates uncertainty in this regard. Notwithstanding this, all data considered to be of good quality did comply with the potential considerations for data of this quality to varying degrees (see Table 2).

The majority of metadata was not fully in compliance with the INSPIRE standards but was sufficiently populated to allow for assessment. It was not possible to determine adherence to INSPIRE standards where no metadata existed. Also, a number of datasets were non-downloadable directly from the IMA (see Appendix A) and were therefore accessed via the prototype. Ability to manipulate the datasets in the prototype was limited due to licensing restrictions (see Section 3.6).

There was some data of a high quality that espoused accuracy, good resolution, detailed methodology and up to date information, such as the 'weather station' and 'ferry route'

data. However, this data did not meet the full requirements of a grade 3 rating due to non-compliance with INSPIRE regulations. Therefore, no data on the IMA can achieve a grade 3 rating based on the adapted assessment method.

It is noted, from personal correspondence with the Marine Institute, that they are aware of a number of existing data gaps in the IMA including Integrated Mapping For the Sustainable Development of Ireland's Marine Resource (INFOMAR), sea regions, mineral resources, natural risk zones, bio-geographical regions, marine tourism and leisure data (Alcorn, 2016). Although INFOMAR data has not been included in the IMA, the metadata suggests that it has been utilised to help determine seabed habitats (see Section 4.2.5).The inclusion of INFOMAR data could help to improve resolution and quality of data as it has been collected using cutting edge technology over a long period of time (InfomarMapping, 2013).

There are a number of other data gaps identified by this study including:

- Marine cruise ship routes.
- Fish biomass productivity.
- Estimated flying patterns, migratory patterns and seasonal distribution of ornithological species.
- Low-flying aircraft flight paths.
- Military activity zones.

The marine cruise industry is a rapidly expanding industry in Ireland and is identified in the HOOW (Harnessing Our Ocean Wealth) document as a future growth opportunity with a value of up to €14.1 billion to the economy. It is also outlined in this document that 200 cruise ships visited Ireland in 2010 which represented a 200% increase compared to the preceding decade (Department of Agriculture, Food and Marine, 2012). This will result in increased marine traffic, further enhancing the need to appropriately display marine cruise ship routes on the IMA. Marine cruise ship routes, similar to shipping lanes, can create a conflict of use in the case of an environmental assessment of an offshore wind farm. Conflicts of uses are not issues specifically dealt with by environmental assessments, however they can contribute along with improved data quality to the deciding of trade-offs in these circumstances. An example of how environmental assessments can indirectly contribute to this process can be

seen in the mitigation and monitoring activities implemented as a result of environmental assessments (Doremus, 2007) (see Appendix B). There is also evidence to suggest that marine cruises can benefit from wind farms. A recent study in the South Baltic region shows that companies involved in the marine cruise industry have provided cruise tours to various wind farms in the region (Lise Damsbo-Andersen (LF), 2013). This presents an emerging opportunity for multiple-use planning between both uses.

From analysis of a previous environmental assessment of an offshore wind farm under the commercial fisheries theme (see Section 4.2.6) it is evident that fish biomass productivity data helps to evaluate and estimate the location of fish (Aqua-Fact International Services Ltd., 2007). It also provides a better representation of fish activity in comparison to nursery or spawning ground data which simply highlights the general location of fish (see Figure 11). Better knowledge of fish activity can help to reduce the impact of electromagnetic fields emanating from electricity cables on the seabed transporting the generated electricity from the turbines (see Appendix B).

The estimated flying patterns, migratory patterns and seasonal distribution of ornithological species can increase knowledge of ornithological behaviour, but more importantly it can help to decrease and/or avoid bird strikes and collisions with the wind turbines. A previous environmental assessment of an offshore wind farm shows that wind turbines can disorientate birds, in particular migratory birds (Aqua-Fact International Services Ltd., 2007). Previous environmental assessments of offshore wind farms have included seasonal distribution, flying pattern and migration patterns data under the ornithology theme (see Section 4.2.2) (Aqua-Fact International Services Ltd., 2007; Saorgus Energy Ltd., 2012). These are clear data gaps that are not included in the IMA data analysed.

Analysis of previous environmental assessments of offshore wind farms under the human environment theme (see Section 4.2.1) showed that aviation is a predominant issue (Aqua-Fact International Services Ltd., 2007; Saorgus Energy Ltd., 2012). Low-flying aircraft flight path data is therefore considered a data gap as no aviation data exists on the IMA. Similar to marine birds, low-flying aircrafts can also become disorientated by wind farms. Low-flying aircraft flight path data is important to include for health and safety reasons, to avoid collisions and disorientation of the pilot. A previous environmental assessment of an offshore

wind farm development suggests that interference with take-off and landing procedures, low flying manoeuvres and the operation of navigation/radar facilities are of concern in this case (Saorgus Energy Ltd., 2012).

Further analysis of previous environmental assessments of offshore wind farms under the human environment theme (see Section 4.2.1) also shows that military activity constitutes a data gap (Aqua-Fact International Services Ltd., 2007; Saorgus Energy Ltd., 2012). The majority of developed international marine atlases include military activity zone data (National Oceans Office, 2004; The Federal Belgian Government, 2014; The Scottish Government, 2015). It is imperative to include this data in order to avoid compromising military activities. Military activity can also lead to a conflict of use with wind farms as some military aircrafts such as helicopters operate at lower altitude to muffle noise and conceal their approach (Aqua-Fact International Services Ltd., 2007).

In conclusion, the deficiencies in the majority of data along with the identified data gaps limit the ability to conduct a comprehensive and carefully considered environmental assessment for an offshore wind farm. It also must be noted that some of the data gaps may be localised to the site and may not be a true reflection of the data gaps on the IMA. From analysis of previous environmental assessments of offshore wind farms, localised data can range from 'ornithological' and 'marine mammal distribution' to 'fisheries' data (Aqua-Fact International Services Ltd., 2007; Saorgus Energy Ltd., 2012). There were no data gaps identified under the cetaceans and seals, fish ecology, marine habitats and seascape,landscape and visual impact themes (see Section 4.2) when compared with data from the same themes in previous environmental assessments of offshore wind farms (Aqua-Fact International Services Ltd., 2007; Saorgus Energy Ltd., 2012). However, data under these themes did display deficiencies when analysed using the adapted data quality rating assessment system.

5.1.2 Research Question 2: How can the IMA data be improved to facilitate a more comprehensive environmental assessment of an offshore wind farm?

This sub-section discusses how the IMA data can be improved to facilitate a comprehensive environmental assessment of an offshore wind farm. The gaps in the data identified by research question 1 clearly showed the improvements that are required in order for a comprehensive environmental assessment of an offshore wind farm to be

undertaken (see Appendix B), thus also answering research question 2. There are a number of means of improving the IMA data to facilitate a more comprehensive environmental assessment of an offshore wind farm.

Regional Scale Data

Firstly, there needs to be a focus on providing location specific data i.e. regional scale data which will allow for more local input that may not otherwise happen on a national scale. Previous studies have shown that local scrutiny of data can add to the validity and quality of the data (Shucksmith *et al.,* 2014). In effect, regional scale data can lead to increased accuracy of data in comparison to national scale data due to the facilitation of stakeholder input. An environmental assessment informed by local scale data can allow for a more comprehensive assessment of the likely significant effects of an offshore wind farm. **[R1** - Create regional atlases that can be displayed within the IMA based on the RLG (Regional Locational Guidance) precedent utilised in the Shetlands.] **[R2** - Under pin the regional atlases by undertaking a nationwide public engagement process, akin to a roadshow, to facilitate the gathering of local data that can improve the quality of baseline data and the effectiveness of the IMA.]

Regular update intervals

Secondly, regular update intervals must be enforced for data that is prone to frequent changes. Otherwise, outdated data can lead to inappropriate developments that result in long-term environmental effects or loss of habitat, for example. As spatial data becomes out-of-date there is the potential for it to misinform decision making; therefore consideration should be given to the frequency in which the data are reviewed (Shucksmith *et al.,* pg 7, 2014). It is paramount to ensure that regular update intervals are established, particularly for environmental data, as research and the results suggests that timeliness in environmental data is a common deficiency. Environmental data represents a crucial aspect of environmental assessments. **[R3** – Undertake a review of the IMA data to address the data gaps and deficiencies relating to availability, detail, timeliness, accuracy, completeness, clarification and resolution.]

Greater detail

Thirdly, the conservation status of all species (see Appendix C) must be included in either the dataset or metadata in order to ensure the prioritisation and proper consideration of protected species. Greater detail must also be added to data where this has been identified as a deficiency. Increased detail allows for a more comprehensive and accurate environmental assessment of an offshore wind farm. This demonstrates the reflection of this study on real-life applications of environmental assessments of offshore wind farms where such detail is and has been required (Aqua-Fact International Services Ltd., 2007; Saorgus Energy Ltd., 2012). **[R3** – Undertake a review of the IMA data to address the data gaps and deficiencies relating to availability, detail, timeliness, accuracy, completeness, clarification and resolution.**] [R4** - Increase investment for research regarding the effects of human activities on the marine environment as it is highlighted as an area where data is lacking.**]**

Increased data availability

Fourthly, the issue of non-downloadable data must be remedied in order to increase data availability which would allow for a more comprehensive environmental assessment of an offshore wind farm. In this study, data licensing restrictions led to data accessibility problems (see Appendix A). Some datasets could not be analysed or examined without access to the IMA prototype. This issue of accessibility is recognised in a previous study relating to the development of a marine atlas in Ireland (O'Dea *et al.,* 2004). Limitations to data availability can lead to both elongation of the environmental assessment process and increased uncertainty regarding the accuracy of the assessment as it may not be clear if the data used is the most up-to-date data. **[R3** – Undertake a review of the IMA data to address the data gaps and deficiencies relating to availability, detail, timeliness, accuracy, completeness, clarification and resolution.**] [R6** - Create a greater synergy between the MIDA and the IMA or create a combined national marine atlas that fulfils the objectives of both atlases and includes all available marine data in order to avoid the overlooking of data and general confusion for the user.**]**

Nationwide study on data gaps

Finally, further study should be prioritised in order to attain the true extent of data gaps, deficiencies and limitations in the IMA. As outlined in the previous section, it is highly

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likely that some of the data gaps, deficiencies and limitations identified in this study are localised to the Kish Bank case study site. In that case, a wider study focusing on various environments and ecosystems around Ireland would help to alleviate that factor by analysing the data in varying ecosystems and environments. Thus, contributing to a more comprehensive environmental assessment of an offshore wind farm.**[R5** - Undertake further research into data gaps on the IMA with the use of a number of case study sites situated in differing environments or ecosystems in order to evaluate the true extent of gaps in the data on the IMA. Also, include surveying of data source stakeholders to allow for improved analysis of the data.**]**

5.2 Synergising Ireland's Marine Atlases

As previously discussed in Chapter 2, there are two marine atlases currently in existence in Ireland – the IMA and MIDA (Marine Irish Digital Atlas). Ireland is one of few countries, possibly the only country, with two active national marine atlases. Both atlases are underpinned by differing goals, therefore it is not expected that they will be combined into one centralised marine atlas. Not only were they established for different means, they also present data in different formats. This creates a problem for the environmental assessment of an offshore wind farm as it is not clear to the user which marine atlas possesses the most relevant data. Furthermore, it questions the integrity of the data if it is displayed elsewhere or if it is inconsistently displayed. A recent study has shown that data integrity can be improved as a result of data centralisation (Merrifield, *et al.,* 2013). Further to this, the quality of the data itself can be enahanced by a common data structure that a combination of the marine atlases could provide (Merrifield, *et al.,* 2013). Such a structure could improve the clarity and availability of data by encouraging data consistency when synergising the marine atlases. **[R6** - Create a greater synergy between the MIDA and the IMA or create a combined national marine atlas that fulfils the objectives of both atlases and includes all available marine data in order to avoid the overlooking of data and general confusion for the user.**]**

5.3 Strengths and Weaknesses of the Data

It is clear from the summary table (Table 3) that the majority of data on the IMA is of good quality which suggests that it could be suitable for use in an environmental assessment of

an offshore wind farm. However, there are a number of deficiencies that need to be addressed with three datasets scoring a rating of 1 which is considered as low quality data. Notwithstanding this, there are a number of deficiencies with a portion of the data assessed as good quality data.

Data under both the human environment and ornithology themes displayed both low data quality and a number of data gaps, deficiencies and limitations. The 'ornithology' data consistently displayed attributes of low quality data. Therefore, 'ornithology' data can be considered the biggest weakness in the IMA data. Although data under the human environment theme includes data of low quality, it also included the data of the highest quality such as the 'weather station' and 'ferry route' data (see Section 5.1.1). This data represents the strongest IMA data in terms of data quality.

5.4 General Limitations

Limitations in this thesis occurred due to a variety of issues including time constraints, lack of data, resources. There were a number of limitations to this study that were simply beyond the scope of a master's thesis. Due to the large amount of data available for assessment, only the relevant data within the selected site was assessed and evaluated. Normally, an environmental assessment would include data from outside of the site to incorporate the true extent of impact. However, it was simply beyond the scope of this study to include the relevant data outside of the selected site. Subsequently, a full environmental assessment could not be undertaken. Indeed, the intention of this thesis was to identify the gaps in data on the IMA rather than to undertake an environmental assessment. Moreover, a complete environmental assessment would include consultation of the relevant authorities, specialists and the general public which was also beyond the scope of this study.

5.5 Concluding Remarks

We still do not know the full effects of renewables on the marine environment (Sustainable Energy Authority of Ireland, 2010); this, and the effects of many other anthropogenic activities, is highlighted in the literature as a barrier to achieving EBM that supports social and economic objectives. We need to find other non-finite sources of fuel, but at what cost

to the ecosystem? Population-level effects of many impacts from wind farms (e.g. noise exposure and collision risk) can be hard to determine, especially if there is a lack of baseline data. Do we need to know how many fish there are in the ocean to know what proportion died as a result of the development? This ambiguity is one of the main barriers to achieving meaningful EBM through comprehensive environmental assessments. Gathering of baseline data can help reduce these barriers, but their quality or sheer existence is not the main factor limiting the application of EBM.

The IMA is the only tangible representation of marine management efforts in Ireland, to date which is evident from recent efforts to establish a framework for MSP in Ireland (Department of Agriculture, Food and Marine, 2012). Ireland is putting the foundations in place for evidence-based planning and management of marine renewable energy with the launch of Ireland's Marine Renewable Energy Atlas as a subset of the IMA. However, it may not be enough to address EU requirements for renewable energy as it has been recognised that Ireland is likely to miss the deadline for achieving 20% of energy demand from renewable energy by 2020 (Burke-Kennedy, 17 September, 2015).

This study assists in the identification of gaps in marine-related data such as that provided by the IMA which is a recommendation of the Enablers Task Force (Enablers Task Force on Maritime Spatial Planning, 2013). Therefore, this study adds to the knowledge in this field by identifying gaps in the data and associated challenges. Furthermore, the results of this study can help to inform a more detailed assessment of the gaps in the data on the IMA in the future. Whilst the IMA may be a useful tool for general marine management, it still lacks certain information for it to be considered usable in the environmental assessment of offshore wind farms, particularly in the Kish Bank case study site. However, the recommendations put forth in this thesis aim to close those gaps and ensure a more benficial tool for the environmental assessment of offshore wind farms.

6 Recommendations

Listed below are the recommendations in numerical order as attributed in Chapter 5.

Recommendation	Reasoning
R1 - Create regional atlases that can be displayed within the IMA based on the RLG (Regional Locational Guidance) precedent utilised in the Shetlands.	The recent launch of a marine renewable energy atlas as a sub-set of the IMA provides a platform for the further development of regional-scale atlases. The marine renewable energy atlas currently includes data taken from the IMA and does not have a specific RLG focus. The RLG approach can help to inform the environmental assessment of offshore wind farms by clearly delineating constraints and alleviating conflicts of use (Tweddle *et al.,* 2014).
R2 - Undertake a nationwide public engagement process, akin to a roadshow, to facilitate the gathering of local data that can improve the quality of baseline data and the effectiveness of the IMA.	Research has shown that local data can be collected and used through stakeholder engagement which increases the validity and accuracy of the data due to the addition of local knowledge to the process (Tweddle *et al.,* 2014). A nationwide public engagement process can help to garner local knowledge to increase data accuracy and ultimately to inform regional atlases that can inform the environmental assessment of an offshore wind farm.

R3 - Undertake a review of the IMA data to address the data gaps and deficiencies relating to availability, detail, timeliness, accuracy, completeness, clarification and resolution.	Although some of the identified data gaps may be considered localised to the Kish Bank site, there are number of deficiencies and gaps in the IMA data in relation to an environmental assessment of an offshore wind farm. Some of these data gaps were previously identified in 2010 when an SEA of the OREDP (Offshore Renewable Energy Development Plan) was undertaken. As six years have passed since the identification of some of these gaps, and they are still evident in the IMA data; it is considered imperative to conduct a review of the IMA data on this basis.
R4 - Increase investment for research regarding the effects of human activities on the marine environment as it is highlighted as an area where data is lacking.	The literature has suggested that knowledge of the effects of human activities, including generating renewable energy from offshore wind farms, on the marine environment is lacking. It is imperative therefore to invest in increasing knowledge of these effects not just to identify the effects but also to identify where there are no effects. This would prevent the requirement of additional surveys to collect large amounts of data (Sustainable Energy Authority of Ireland, 2010). One of the key findings involved a lack of detail which was identified in all of the data that was assessed as low quality. Therefore, this recommendation helps to address identified data gaps in the IMA.

R5 - Undertake further research into data gaps on the IMA with the use of a number of case study sites situated in differing environments or ecosystems in order to evaluate the true extent of gaps in the data on the IMA. Also, include surveying of data source stakeholders to allow for improved analysis of the data.	As previously stated, this study is prone to localised data due to the case study focus. Further research relating to the IMA data with a broader approach including the context of different ecosystems could eliminate this problem. Surveying of data source stakeholders could allow for improved analysis of the data as they may be able to clarify issues that are not clearly evident from analysis of the data. This is an approach that has successfully been used in a previous study to verify evidence (Shucksmith *et al.,* 2014).
R6 - Create a greater synergy between the MIDA and the IMA or create a combined national marine atlas that fulfils the objectives of both atlases and includes all available marine data in order to avoid the overlooking of data and general confusion for the user.	Availability of data was identified as a data gap in the IMA. This is particularly compounded by the data that was non-downloadable from the IMA (see Appendix A). Although the MIDA atlas was not analysed in this study and was created for educational purposes, it is considered important to create a greater synergy between the MIDA and the IMA. This will help to foster a greater relationship between the two atlases and ultimately improved data availability.

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Appendices

Appendix A: List of Non-Downloadable Datasets from the IMA for the Kish Bank site

- Energy Exploration – Current Authorisations.
- Wind Energy Resource – Wind Turbine Impact Seascape (5-15km, 5-24km, 5-35km).
- Species Distribution Marine Mammals – Harbour Porpoise.
- Species Distribution Marine Mammals – Grey Seal.
- Species Distribution Marine Mammals – Common Dolphin.
- Species Distribution Marine Mammals – Minke Whale.
- Species Distribution Marine Mammals – Humpback Whale.
- Species Distribution Marine Mammals – Fin Whale.
- Species Distribution Marine Mammals – Bottlenose Dolphin.
- Species Distribution Marine Birds – Kittiwake.
- Species Distribution Marine Birds – Common Guillemot.
- Species Distribution Marine Birds – Auk.
- Species Distribution Marine Birds – European Herring Gull.
- Species Distribution Marine Birds – Manx Shearwater.
- Species Distribution Marine Birds – Northern Gannet.
- Species Distribution Marine Birds – Razorbill.

Appendix B: Worked Example of the Application of IEEIM EIA Guidelines to an Offshore Wind farm extracted from (Institute of Ecology and Environmental Management, 2010)

The Project

The application considered in this example relates to a project to develop an offshore wind farm with a capacity of approximately 450 MW. In common with many such applications the project takes the form of an envelope i.e. an area of sea and seabed within which the development is proposed. Specific details of the design will be confirmed when and if consent is granted and subject to a more detailed design exercise. Nevertheless, for the purposes of EIA it has been agreed that likely development scenarios will include either 90 x 5 MW turbines or 150 x 3 MW turbines. The latter is more likely as it is unclear that a commercial case can be made for the use of 5 MW turbines. It is also considered that, from an ecological perspective, many smaller turbines represent the worst-case scenario (more disturbance, greater footprint, etc.). On this basis the EcIA is based on the 150-turbine scenario. The 3 MW turbines proposed are likely to have a maximum (to tip of blade) height of no more than 130 m. Four cables (export cables) will be installed to connect the wind farm to the onshore electricity-generating network.

Scoping Issues for an Offshore Wind Farm

The categories of potential ecological effect arising from offshore wind farms are likely to include:

1. Loss of benthic habitat arising from the installation of turbines foundations and scour protection.

2. Habitat and species disturbance arising from the installation and operation of export and other cabling.

3. Changes to coastal processes resulting in changes to the distribution and composition of sediment types.

4. Noise arising from construction activities and to a lesser extent in operation.

5. Disturbance from construction activities.

6. Disturbance arising from the operation and maintenance of the wind farm.

7. Pollution from accidental release of fuels/oils during construction and during operation.

8. Effects on migratory species.

Loss of habitat is likely to be restricted to the turbine locations around the masts. Temporary disturbance would be along the export cable route, which may extend for some distance inshore, including inter-tidal areas. The potential impacts of 1 and 2 would be on benthic habitats, fish spawning and foraging for birds.

Coastal process effects could manifest over a large region – the extent of which may need to be modelled. There is potential for effects to offshore and coastal sediments and these changes could affect benthic habitats and associated species.

Noise from construction vessels can result in disturbance to bird populations and marine mammals within the wind farm and within access routes. Noise, particularly from piling operations, has the potential to cause lethal and sub-lethal effects to fish, marine mammals and birds and these effects can occur over many kilometres.

During operation, maintenance vessels can disturb bird populations and marine mammals within the wind farm and within access routes.

Operational wind farms may cause ongoing disturbance to bird populations, with some species likely to avoid turbine structures. Some species are also at risk of collision with turbine blades. Electromagnetic fields around export cables have the potential to affect elasmobranchs.

There is some risk of pollution during construction from the release of fuels, oils and sediments (during piling) and during operation from the leakage of oil from turbines or offshore substations.

Setting the baseline

The scope of the EcIA will, therefore, need to include consideration of the effects arising from the construction, operation and decommissioning of the wind farm and its export cables over a typical lifetime of at least 25 years. These effects may impact upon water quality, benthic habitats and species, inter-tidal habitats, fish populations, marine mammals and birds. The zone of influence will vary for each, but will extend from the immediate

location of the turbines and export cables (e.g. habitat loss) to areas many kilometres from the wind farm site (e.g. coastal processes and noise) and the baseline will need to reflect this.

Valuation

Benthic habitat surveys (sidescan sonar and grab sampling) indicate that the wind farm area comprises infralittoral mobile clean sand with sparse fauna (SS.SSa.IFiSa.IMoSa). This biotope comprises medium to fine sandy sediments and typically supports an impoverished fauna. This is a widespread biotope around England that occurs at various locations on the east coast (including Spurn Head and The Wash), the Sussex coast, Start Point (Devon), the Bristol Channel and Morecambe Bay; it is less widely recorded in Scotland, Wales and Ireland. SS.SSa.IFiSa.IMoSa forms part of the Subtidal Sands and Gravel (previously Sublittoral Sands and Gravel) priority habitat listed under the UK Biodiversity Action Plan (BAP).

The surveys indicate that in places SS.SSa.IFiSa.IMoSa grades to SS.SBR.PoR.SspiMx (previously CMX.SspiMx) 'Sabellaria spinulosa on stable circa-littoral mixed sediment'. This biotope is found in the subtidal and lower intertidal/sublittoral fringe and in places S. spinulosa forms biogenic reef structures that support a diverse community of epifauna and infauna. It has a wide but restricted distribution throughout the north-east Atlantic, especially in areas of turbid seawater with high sediment loads. However, records are restricted to the east coast (south of Whitby) and south coast (no further west than Weymouth) of England; it has also been recorded from several locations on the Welsh coast. Biogenic reef is a habitat type listed on Annex I of the EC Habitats Directive and is a priority habitat under the UK BAP. Discussions with relevant experts and SNCO indicate that this biotope is rare within the region where the wind farm is proposed and that the reef is sufficiently extensive to qualify as a SAC (but is not classified as a candidate SAC). Some parts of the area have been proposed for inclusion in the Natura 2000 network.

Boat-based and aerial surveys indicate the presence of 56 species of birds, including lesser black-backed gulls, which were recorded throughout the year. A literature search and discussions with the SNCO indicate that birds recorded within the proposed wind farm

area are likely to include breeding birds from a coastal SSSI. The breeding population of lesser black-backed gulls (~400 pairs) is an interest feature of the SSSI.

Feature	Protection Status	Conservation Status	Distribution	Importance
Subtidal features				
SS.SSa.IFiSa.IMoSa	None	BAP priority habitat	Widespread	National
SS.SBR.PoR.SspiMx (Biogenic reef)	Annex 1	cSAC interest feature BAP priority habitat	Very restricted	International
Birds				
Lesser Black-backed Gulls	General protection under WCA	SSSI interest feature	Common and widespread	National

Impact assessment

For the purpose of this section, two potential impacts arising from the wind farm example are considered in detail. The first relates to habitat disturbance on the SS.SSa.IFiSa.IMoSa and SS.SBR.PoR.SspiMx biotopes. The second is the operational impact of potential collision mortality on the breeding population of lesser black-backed gulls.

Feature1: Habitats

Background

Surveys, initially comprising side-scan sonar and grab analysis both conducted over a coarse sampling grid, have confirmed the presence of the SS.SSa.IFiSa.IMoSa biotope and its spatial extent. It is also known, from historical data (> 5 years old) and side scan sonar that biogenic reefs formed by S. spinulosa are present, although the extent and precise location of individual reefs is less well understood.

Construction Impacts

1. Direct habitat loss

1.1. Proposed activity and its duration biophysical change and relevance to receptor in terms of ecosystem structure and function

Turbine foundations would be installed within SS.SSa.IFiSa.IMoSa biotope, but not within an area known to support biogenic reef. The construction of turbines is expected, to result in the loss of an area of the SS.SSa.IFiSa.IMoSa biotope beneath turbine foundations and the associated scour protection. However, the area affected is not considered likely to significantly damage the ecosystem structure and function.

1.2. Characterisation of unmitigated impact on the feature

Habitat loss arising from the installation of turbine foundations is likely to be restricted to the immediate area of the foundation pile and scour protection (comprising rock armour). The habitat loss associated within each turbine is unlikely to extend over more than 300 m2. As 150 turbines are proposed, the total area affected is unlikely to exceed 4.5 ha. (Out of a total wind farm area of 12,000 ha). Habitat loss is a long-term effect, it will persist until the turbine structures are removed (a 25 year operational lifetime is predicted for the wind farm).

1.3. Rationale for prediction of effect on integrity (of a site or ecosystem) or conservation status (of a habitat or population)
As sublittoral sands and gravels are widespread both within the proposed wind farm area and more widely within Britain, the extent of habitat loss arising from this wind farm construction is considered to be very small at geographical scales.

1.4. Significance without mitigation and confidence in assessment
Although the effect of habitat loss arising from turbine construction is long term (at least 25 years), a significant negative effect is not predicted due to the very small proportion of this habitat affected.

1.5. Mitigation, enhancement and compensation
Although a significant effect is not predicted it is considered good practice to limit the extent of habitat loss arising from construction.

1.6. Residual significance (confidence)
It is certain that the habitat loss arising from turbine construction will not be significant.

2. Habitat disturbance (abrasion and physical damage)
2.1. Proposed activity and its duration, biophysical change and relevance to receptor in terms of ecosystem structure and function
The operation of, and activities associated with, jack-up barges used in turbine erection and the installation of inter-array electrical cables during construction have the potential to cause disturbance to habitats. The use of high pressure water jets to assist in the burial of inter-array cables is known to cause the temporary liberation of sediments, which may

disperse over nearby areas of habitat causing smothering. The extent of 'jetting' is not known in advance, but previous experience shows that it tends to be only occasionally required.

Four cables are proposed, which will be installed sequentially. These export cables from the wind farm will pass through an area where biogenic reefs are known to form. The preferred installation method, ploughing, has the potential to cause direct structural damage to the reefs.

2.2. Characterisation of unmitigated impact on the feature

The extent of any effect arising from construction of the wind farm turbines is not known but it is expected that disturbance will be restricted to localised damage and abrasion of benthic fauna in the area immediately adjacent to turbine foundations. In light of the extent of similar habitat recolonisation, recovery is, however, likely to be rapid and any effect will be fully reversible in the short-term.

The extent of any sediment plume arising from jetting activities is unlikely to extend over more than several hundred square metres and is expected to persist for a timeframe measured in hours rather than days.

The disturbance to the habitat from installing the four proposed export cables will, based on previous experience, be restricted to a corridor of no more than 40 m (10 m maximum per cable). Approximately 1 km of the cable route passes through an area known to support the SS.SBR.PoR.SspiMx community, although the extent of biogenic reef within this area is unknown. Installation of the cables will cause damage to any biogenic reef present. Based on experience in similar developments, these effects are probably reversible but only in the long-term with localised damage expected to persist for several years.

2.3. Rationale for prediction of effect on integrity (of a site or ecosystem) or conservation status (of a habitat or population)

The following are extracts from the Habitat Action Plan (HAP) for Subtidal Sands and Gravel (http://www.ukbap.org.uk/UKPlans.aspx?ID=44):

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'Sand and gravel habitats are subjected to a variety of anthropogenic factors including the influence of pollutants in riverine discharge and physical disturbance by fishing and aggregate dredging activities. The latter two factors probably have the greatest influence on the organisms that inhabit sand and gravel substrata...Many species inhabiting highly perturbed and mobile sediments are relatively unaffected by fishing activities or other anthropogenic physical disturbance. However, large bodied, slow growing fauna such as bivalves are sensitive to fishing disturbances and their populations may be slow to recover. Biogenic reefs and sedentary worm beds may be particularly vulnerable to trawling activity'.

In summary, the biotope is less sensitive to short-lived mechanical impacts than those arising from repeated disturbance or pollution. In contrast the SS.SBR.PoR.SspiMx biotope is considerably more sensitive to even small scale physical disturbance. For example, MarLIN (http://www.marlin.ac.uk/biotopes/SS.SBR.PoR.SspiMx.htm) indicates that: S. spinulosa reefs are particularly affected by dredging or trawling and in heavily dredged or disturbed areas an impoverished community may be left (e.g. SS.SCS.CCS.Pkef) particularly if the activity or disturbance is prolonged. However, it is likely that reefs of S spinulosa can recover quite quickly from short term or intermediate levels of disturbance as found by Vorberg (2000) in the case of disturbance from shrimp fisheries and recovery will be accelerated if some of the reef is left intact following disturbance as this will assist larval settlement of the species.

On this basis it is considered that the SS.SSa.IFiSa.IMoSa biotope is resilient to disturbance effects of low magnitude and can be expected to recover quickly from direct habitat damage and sediment deposition of the magnitude envisaged here. It is probable that the predicted effects on this community arising from habitat disturbance would be insignificant. Biogenic reefs, however, are considerably more sensitive to disturbance which impacts on their physical structure. It is considered probable that damage to reefs arising from cable installation could negatively affect the conservation status of this feature.

2.4. Significance without mitigation and confidence in assessment

The effects of disturbance arising from the installation of turbines and inter-array cables will be temporary and very limited in their spatial extent. It is anticipated that the community affected by this disturbance will rapidly recover from these disturbance effects. A significant negative effect from turbine installation and inter-array cabling is not, therefore, predicted.

A significant negative effect on biogenic reefs, arising from export cable installation, at the international level is probable. The physical disturbance caused by the cable installation process is reversible but only in the long-term. As this is an interest feature of a cSAC, the likelihood of such an effect is sufficient to trigger the requirement for an 'appropriate assessment'.

2.5. Mitigation, enhancement and compensation

Although no significant impacts arising from the installation of turbine foundations and inter-array cables have been identified, it is considered good practice to minimise the extent of any unnecessary habitat disturbance. On this basis it is recommended that the extent of jetting used during inter-array cabling is constrained to those areas where it is essential.

A detailed survey of the proposed export cable route which passes through the SS.SBR.PoR.SspiMx community will be undertaken using remote video surveying techniques to identify the location of individual biogenic reefs. The cable route will be modified to avoid these features.

2.6. Residual significance (confidence)

It is certain that the effects of turbine installation in areas that do not support biogenic reef would not be significant. It is certain that the effects of the installation of export cables in areas that do not support biogenic reef would not be significant. If detailed surveys are undertaken and biogenic reefs are avoided during the installation of export cables then the effect of construction disturbance is unlikely to be significant.

Feature 2: Lesser black-backed gulls

Surveys of the proposed wind farm area indicate occasional use of the site during the breeding season by lesser black-backed gulls. A maximum monthly count of 20 individuals was recorded during a two-year programme of boat surveys, and approximately 25% of all observations were recorded at rotor height (assumed to be between 30 – 150 m above sea level).

Construction Impacts

3. Collision mortality

3.1. Proposed activity, duration of activity, biophysical change and relevance to receptor in terms of ecosystem structure and function

The installation of wind turbines has the potential to be an additional mortality factor for bird populations due to collision with turbine blades; the risk arises when birds fly within the rotor swept area. The project is for 150 turbines in the vicinity of a breeding colony of lesser black-backed gulls (< 10 km). Any birds of this species observed within the wind farm (particularly during the breeding season) are assumed to form a part of the breeding population that is an interest feature of the adjacent SSSI.

3.2. Characterisation of unmitigated impact on the feature

Collision risk modelling (using a method agreed with the SNCO and with appropriately cautious assumptions) indicates that approximately 0.30 – 0.50 birds per year can be expected to collide with turbine blades (it is assumed that any bird colliding with a turbine blade will die). Although there are uncertainties in the collision risk modelling undertaken (including, but not limited to, assumptions about avoidance rates) precautionary assumptions have been agreed with the SNCO and other consultees. In light of these assumptions it is considered that the upper value in this range is the maximum rate of mortality likely to arise during operation.

3.3. Rationale for prediction of effect on integrity (of a site or ecosystem) or conservation status (of a habitat or population)

Without application of methods such as Population Viability Analysis (PVA) it is not known to what extent the breeding population of lesser black-backed gull can sustain additional levels of mortality. It has been agreed, with the SNCO and other consultees, that

any impact not increasing adult mortality by more than 1% of the existing background mortality rate can be considered to be insignificant. Wanless *et al* (1996) indicates that annual adult survival is 93%, which implies a background mortality rate of about 56 birds within a population of 800 (i.e. 400 pairs), therefore, a predicted mortality rate arising from collision of greater than 0.56 birds per year would be considered to be significant.

3.4. Significance without mitigation and confidence in assessment

The predicted annual mortality rate arising from collisions with turbines is less than the threshold agreed with the SNCO and it is considered that it is probable that the impact would not be significant at the national (or any other) level.

3.5. Mitigation, enhancement and compensation

No options for mitigation have been identified.

73.6. Residual significance (confidence)

It is probable that there would not be a significant impact on the lesser black-backed gull arising from collision mortality.

Appendix C: EU and Irish Nature Conservation Legislation

- S.I. No. 356/2015 - Flora (Protection) Order, 2015.
- S.I. No. 520/2013 - Planning and Development (Amendment) (No. 2) Regulations 2013.
- Wildlife (Wild Birds) (Open Seasons) (Amendment) Order 2012.
- Wildlife (Wild Mammals) (Open Seasons) (Amendment) Order 2012
- S.I. No. 477/2011 European Communities (Birds and Natural Habitats) Regulations 2011.
- European Communities (Control of Recreational Activities) Regulations 2010.
- SI No. 481 of 2010 (Restrictions on Use of Poison Bait) Regulations 2010.
- (Birds Directive) Directive 2009/147/EC.
- Foyle and Carlingford Fisheries Act 2007.
- Sea-Fisheries and Maritime Jurisdiction Act 2006.
- S.I. No. 550/2005 - Wildlife (Wild Mammals) (Open Seasons) Order, 2005.
- S.I. No. 378/2005 - European Communities (Natural Habitats) (Amendment) Regulations, 2005.
- Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage.
- Fisheries (Amendment) Act 2003.
- European Communities (Water Policy) Regulations 2003 S.I. No. 722 of 2003.
- Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (EU Water Framework Directive).
- Planning and Development Act, 2000.
- Wildlife (Amendment) Act 2000.
- Flora (Protection) Order 1999 S.I. No. 94 of 1999.
- Fisheries and Foreshore (Amendment) Act, 1998.

- European Communities (Conservation of Wild Birds) (Amendment) Regulations, 1998. S.I. No 154/1998.

- S.I. No. 233/1998 - European Communities (Natural Habitats) (Amendment) Regulations, 1998.

- S.I. No. 94/1997 - European Communities (Natural Habitats) Regulations, 1997.

- Regulation (EC) No 938/97 of 26 May 1997 amending Regulation (EC) No 338/97 on the protection of species of wild fauna and flora by regulating trade therein.

- Regulation (EC) No 307/97 of 17 February 1997 amending Regulation (EEC) No 3528/86 on the protection of the Community's forests against atmospheric pollution.

- European Communities (Natural Habitats) Regulations 1997. S.I. No. 94/1997.

- Regulation (EC) No 338/97 of 9 December 1996 on the protection of species of wild fauna and flora by regulating trade therein.

- Directive 95/66/EC of 14 December 1995 amending Directive 92/76/EEC recognising zones exposed to particular plant health risks in the Community.

- Foreshore (Amendment) Act, 1992.

- (Habitats Directive) Directive 92/43/EEC.

- (Wild Birds) (Greenland White-fronted Goose, Shovler and Curlew) Regulations, 1992. Restricts the sale, transport for sale, keeping or offering for sale of the above species.

- Regulation 91/3254/EEC of 4 November 1991 on the use of leghold traps.

- Regulation EEC/2496/89 of 2 August 1989 on a prohibition on importing raw and worked ivory derived from the African elephant into the Community.

- (Quality of Salmonid Waters) Regulations, 1988. S.I. No. 84 of 1988.

- Regulation (EEC) No 3528/86 of 17 November 1986 on the protection of the Community's forests against atmospheric pollution.

- (Wildlife Act 1976) (Amendment) Regulations 1986 (S.I. No. 254 of 1986).

- (Wildlife Act 1976) (Amendment) Regulations 1985 (S.I. No. 397 of 1985).

- (Conservation of Wild Birds) Regulations, 1985 (S.I. No. 291 of 1985).

- (Prohibition of Importation of Skins of Certain Seal Pups and Related Products) Regulations, 1983 (S.I. No. 274 of 1983) implements Directive 83/129/EEC.

- Directive 83/129/EEC of 28 March 1983 concerning the importation into Member States of skins of certain seal pups and products derived therefrom.
- (Wild Birds) (Gadwell and Goldeneye) Regulations, 1982 (S.I. No. 241 of 1982) restricts the sale, transport for sale, keeping or offering for sale of the above species.
- (Cetacean Products) (Regulation of Import) Regulations, 1982 (S.I. No. 7 of 1982) implements Regulation 81/348/EEC.
- Regulation EEC/3626/82 of 3 December 1982 on the implementation in the Community of the Convention on international trade in endangered species of wild fauna and flora.
- Regulation 348/81/EEC of 20 January 1981 on common rules for imports of whales or other cetacean products.
- Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds.
- S.I. No. 192/1979 - Wildlife (Wild Birds) (Open Seasons) Order, 1979.
- Directive 77/93/EEC of 21 December 1976 on protective measures against the introduction into the Member States of harmful organisms of plants or plant products.
- Wildlife Act, 1976.
- Whale Fisheries Act, 1937.
- Foreshore Act, 1933.