Sectoral Marine Plan for Offshore Wind Energy

Strategic Habitat Regulations Appraisal (HRA): Screening and Appropriate Assessment Information Report – Final

December 2019

Scottish Government
Riaghaltas na h-Alba
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For:

Scottish Government
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Draft Sectoral Marine Plan for Offshore Wind Energy consultation

This document forms part of the consultation on the draft Sectoral Marine Plan for Offshore Wind Energy. The draft plan is accompanied by many supporting assessments under a Sustainability Appraisal. These documents are all available online at:

https://consult.gov.scot/marine-scotland/draft-sectoral-marine-plan-for-offshore-wind/

They can also be found individually at the links below:

Draft Sectoral Marine Plan for Offshore Wind Energy
http://www.gov.scot/ISBN/9781839603747

Strategic Environmental Assessment Environmental Report
http://www.gov.scot/ISBN/9781839603761

Social and Economic Impact Assessment
http://www.gov.scot/ISBN/9781839603792

Regional Locational Guidance
http://www.gov.scot/ISBN/9781839603778

Sustainability Appraisal
http://www.gov.scot/ISBN/9781839603785

Strategic Habitat Regulations Appraisal (HRA): Screening and Appropriate Assessment Information Report (this document)
http://www.gov.scot/ISBN/9781839603754

Non-Technical Summary

Introduction

The Scottish Government is currently developing a plan for future commercial offshore wind development in Scottish waters. This new plan builds upon the preceding 2013 draft plan for offshore wind generation and now also seeks to provide opportunities for deep-water wind technologies which may become commercially viable for the period up to 2050.

This new 'Sectoral Marine Plan for Offshore Wind' needs to be accompanied by a Habitats Regulations Appraisal (HRA) process to assess the plan's potential effects on international protected nature conservation sites. This HRA process has been undertaken as a sequence of discrete stages in accordance with established guidance for conducting plan-level HRA that was produced by Scottish Natural Heritage (SNH) in 2015. Further summary details about the scope and methods of the HRA process are presented below.

Scope of the Habitats Regulations Appraisal

The Habitats Regulations implement the EC Habitats and Birds Directives in UK waters and require that an Appropriate Assessment (AA) should be undertaken where a plan or project is not directly connected with or necessary for management of designated European sites or offshore European sites and where the possibility of a likely significant effect (LSE) on these sites cannot be excluded, either alone or in combination with other plans or projects. These sites include the following which comprise the Natura 2000 network:

- Special Areas of Conservation (SACs) designated under the EC Directive on the Conservation of Natural Habitats and of Wild Fauna & Fauna (the Habitats Directive); and
- Special Protection Areas (SPAs) sites classified under the EC Directive on the Conservation of Wild Birds (the Birds Directive).

In the UK, these requirements are also extended to the consideration of effects on:

- Ramsar Sites (listed under the Ramsar Convention on Wetlands of International Importance); and
- sites that are proposed for designation and inclusion in the Natura 2000 network and those sites that are currently in the process of being classified such as: potential SPAs (pSPAs), candidate and possible SACs (cSACs and pSACs) and Sites of Community Importance (SCIs).

As Competent Authority, Marine Scotland is responsible for producing an AA that assesses the impacts of the plan on these sites in fulfilment of the Habitats Regulations obligations. This AA needs to determine whether there will be an 'adverse effect on integrity' (AEOI) on any sites with reference to their conservation objectives.

A major consideration for this HRA process is that the Sectoral Marine Plan for Offshore Wind has many inherent uncertainties associated it. These relate to aspects such as: the detail of the implementation process; future generation capacities; the location, scale and densities of development with the DPOs; the proposed technologies to be used; the scale of the effects arising via some of the defined impact pathways; and the efficacy of some project-level mitigation options.

Although these uncertainties exist, a high level of certainty is required under the Habitats Regulations that AEOI of any European/Ramsar site will be avoided. The HRA has therefore taken account of these issues and, where required, identified relevant mitigation measures to accompany the Plans.

Reporting and Consultation Stages

To assess the effects of the new 'Sectoral Marine Plan for Offshore Wind' on these European/Ramsar sites, the SNH guidance identifies a 13-step plan-level HRAs process. This staged approach and has been adopted, and consulted upon, over three main project phases to ensure there is a high-level of clarity and auditability in the assessment process (an important requirement for strategic-level HRAs an important requirement for strategic-level HRAs which need to be carried out in an iterative, auditable and transparent manner). The findings from each of these phases are presented in the following reports:

- **Phase 1** – Pre-screening Report (HRA Stages 1-3) (Appendix A);
- **Phase 2** – Review of Proposed Assessment Methodology (HRA Stage 4) (Appendix B); and
- **Phase 3** (this document) – Screening and Appropriate Assessment Information Report (AAIR) (HRA Stages 5, 8, 9 and 10).

The pre-screening Report, which was produced by Marine Scotland in June 2018, is the first phase of the HRA process. The report sets out the evidence base and the proposed methods to be applied for the subsequent screening/scoping and assessment stages of the HRA work. The methods proposed were based on available guidance and established best practice that has been developed over the course of multiple preceding plan-level HRAs (and the associated stakeholder and

Project Steering Group discussions which accompanied them) undertaken over the last decade.

In addition to reviewing the screening methods, the pre-screening report also identified an initial list of 652 European/Ramsar sites, and their qualifying interest habitats and species, for which there could be a LSE (or the possibility of LSE could not be excluded at this stage) from the plan. This list encompassed all sites within an objective and quantifiable 'pre-screening buffer zone' which encompassed the Exclusive Economic Zone (EEZ) around Scotland plus a 100 km buffer south of the Scottish border. Since production of the pre-screening report, locations of the Draft Plan Options (DPOs) have been agreed, allowing the initial pre-screening list to be rationalised based on the provision of a 100 km buffer around the DPOs and, as a first step, acknowledging all European/Ramsar sites within this buffer (the screening list).

For the second phase, the Pre-screening Report was consulted upon and the 'Review of Proposed Assessment Methodology' report produced in November 2018. This considered the consultation responses received during Phase 1 (pre-screening report) and, acknowledging the feedback, revisited the proposed HRA scoping and assessment methods where appropriate. It also considered the implications of key EU and UK case-law judgements made during the summer of 2018 (i.e. between the production of the Phase 1 and Phase 2 reports) and how these should be acknowledged within this HRA process.

The second report was discussed at a Project Steering Group meeting on 9 November 2018. During this process the feedback received was generally positive and it was agreed that the methods proposed in the Phase 1 pre-screening report would be applied with some minor changes, as detailed within the Phase 2 report.

This document, the 'Screening and Appropriate Assessment Information' report, presents the outcomes from the third phase of the strategic HRA process. It reviews the impacts of the plan based on the 17 Draft Plan Option areas (DPOs) for potential offshore windfarm development. A summary of the methods and results from this third phase review is presented below.

Screening (HRA Stage 5)

This stage implements a secondary sifting process whereby the pre-screening list of European/Ramsar sites and features are reviewed to identify those sites for which there is the potential for a LSE, (or where one cannot be excluded. It is also an exercise for which sites can be screened out of the assessment where no LSE or impact pathway exists. The screening phase included the following activities:

- Downloading the most recently updated JNCC database of internationally protected nature conservation sites and their associated ecological interest features;
- Provision of an initial screening list encompassing all European/Ramsar sites within 100 km of the DPOs.
- Removal of all Category D sites and features from the screening list.
- Removal of all terrestrial and freshwater interest features that would not be impacted by the Plan
- Literature reviews covering migratory movements and foraging ranges of marine mammals, seabirds and fish.
- Further screening of each interest feature group which included screening in certain bird, marine mammal and fish features beyond the 100 km buffer and screening out certain mobile features where no LSE identified.

A precautionary approach has been adopted to the assessment, as required, in order to ensure that no relevant sites or features are excluded. Therefore, the presumption during this screening process (and throughout the HRA) was to screen sites and interest features into the assessments unless a definitive judgement of no LSE could be made, in which case they could then be excluded.

Screening Results

Following the screening process, a total of 468 European/Ramsar sites were identified that needed to be considered within the assessment. This was reduced from 652 European/Ramsar sites identified at the pre-screening stage, carried out before the 17 DPOs had been confirmed. These European/Ramsar sites include of 267 SACs, 150 SPAs (15 of which were pSPAs) and 51 Ramsar. Of these sites, 121 (112 SACs; 9 SPAs) were represented by non-UK sites, although 14 of these were located within the 100 km screening buffer. These European/Ramsar sites were taken forward into the assessment phase of the HRA.

In order to accommodate project-level case law lessons and the judgements that took place in July and August 2018, it was recommended that Stages 6 and 7, which direct the consideration of mitigation measures at the screening stage, are not

formally considered (see Review of Proposed Assessment Methodology report, Appendix B). Instead the process would move from Stage 5 directly to Stage 8.

Appropriate Assessment (HRA Stages 8 and 9[1])

This section covered Stages 8 and 9 (the AA information and the application of additional measures to ensure no adverse effect). The assessment phase included the following activities:

- Review of the potential impacts on seabed habitat, bird species, marine mammal species; diadromous (migratory) fish and freshwater pearl mussel species and otter (Stage 8 of the Guidance);
- Consideration and a review of in-combination effects
- A concluding review of the potential impacts from the Sectoral Offshore Wind Plan (Stage 8 of the Guidance);
- Consideration and a review of mitigation measures required to ensure that there is no AEOI and a full review of project-level mitigation.

Appropriate Assessment Information Report Results

In advance of considering mitigation measures, it could not be concluded that there will be no AEOI on any European/Ramsar sites. This is because of the inherent uncertainties that exist about future developments. These uncertainties relate to several aspects such as:

- The detail of the Plan implementation process;
- Future generation capacities;
- The location, scale and densities of development;
- The proposed technologies to be used and future advances in these technologies;
- The scale of the effects arising via some of the defined impact pathways; and
- the efficacy of some project-level mitigation options.

Recognising these uncertainties, and the conclusions of Stage 8 (see above), there is clearly a need for appropriate and meaningful mitigation measures to accompany the Plan.

[1] As recommended and agreed in the Phase 2 methods report Stages 6 and 7 of the HRA process were bypassed in light of recent case law judgments (in 2018) which indicate that mitigation measures to reduce adverse effects should not be considered at the screening stage.

Based on current scientific understanding, it was concluded that development of windfarm projects at DPOs E3, NE2, NE3, NE4, NE5 could lead to an AEOI as a result of in-combination effects with other windfarm projects. At this time, an AEOI from in-combination effects was also considered possible if development were to occur at NE6.

Conclusions

Key plan-level mitigation integral to the Draft Plan will be the requirement for project-level HRA and the implementation of the Plan through an iterative and adaptive management process – the Iterative Plan Review (IPR). Project-level assessments and the associated monitoring review work will be linked to (and will inform) regular reviews of the Plan as part of the IPR process.

Further to these mitigation measures, the following plan level mitigation measures were identified as required to avoid AEOI:

- The classification of DPOs E3 and NE2-6 as being 'subject to high levels of ornithological constraint'. It is proposed, therefore, that development will be unable to progress at these DPOs until such time that enough evidence on the environmental capacity for seabirds exists to reduce the risk to an acceptable level. This will involve the resolution of knowledge gaps through potential strategic monitoring; and
- The completion of regional-level survey work to address knowledge gaps regarding potential impacts of development within DPOs E1 and E2.

Based on these measures it is concluded that it would be possible to avoid adverse effects on Natura 2000 features.

In the event that concurrent construction noise in a particular geographical region requires further consideration, then there is potential to implement sequencing of developments within the same broad geographical region. However, such an approach could extend the duration of effects. It is considered that such risks are most appropriately and effectively managed at project level.

This whole document represents Stage 10 of the HRA process – the draft record of the HRA. The final Stages (11-13) will follow consultation and amendments to the document.

How do I respond to the consultation?

We are inviting responses to this consultation by **25 March 2020**.

Please respond to this consultation using the Scottish Government's consultation hub, Citizen Space (http://consult.gov.scot). You can access and respond to this consultation online at https://consult.gov.scot/marine-scotland/draft-sectoral-marine-plan-for-offshore-wind/. You can save and return to your responses while the consultation is still open. Please ensure that consultation responses are submitted before the closing date of **25 March 2020**.

If you are unable to respond using our consultation hub, please complete the Respondent Information Form to:

Sectoral Marine Plan for Offshore Wind Energy Consultation
Scottish Government
Marine Planning and Policy Division
Area GB North
Victoria Quay
Edinburgh EH6 6QQ

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All respondents should be aware that the Scottish Government is subject to the provisions of the Freedom of Information (Scotland) Act 2002 and would therefore have to consider any request made to it under the Act for information relating to responses made to this consultation exercise.

If you are unable to respond via Citizen Space, please complete and return the Respondent Information Form included in this document.

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Next steps in the process
Where respondents have given permission for their response to be made public, and after we have checked that they contain no potentially defamatory material, responses

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Following the closing date, all responses will be analysed and considered along with any other available evidence to help us. Responses will be published where we have been given permission to do so. An analysis report will also be made available.

Comments and complaints
If you have any comments about how this consultation exercise has been conducted, please send them to the contact address above or at SectoralMarinePlanning@gov.scot

Scottish Government consultation process
Consultation is an essential part of the policymaking process. It gives us the opportunity to consider your opinion and expertise on a proposed area of work.

You can find all our consultations online: http://consult.gov.scot. Each consultation details the issues under consideration, as well as a way for you to give us your views, either online, by email or by post.

Responses will be analysed and used as part of the decision making process, along with a range of other available information and evidence. We will publish a report of this analysis for every consultation. Depending on the nature of the consultation exercise the responses received may:

- indicate the need for policy development or review
- inform the development of a particular policy
- help decisions to be made between alternative policy proposals
- be used to finalise legislation before it is implemented

While details of particular circumstances described in a response to a consultation exercise may usefully inform the policy process, consultation exercises cannot address individual concerns and comments, which should be directed to the relevant public body.

Consultation on the draft Sectoral Marine Plan for Offshore Wind Energy
RESPONDENT INFORMATION FORM

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The Scottish Government would like your permission to publish your consultation response. Please indicate your publishing preference:

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Information for organisations:

The option 'Publish response only (without name)' is available for individual respondents only. If this option is selected, the organisation name will still be published.

If you choose the option 'Do not publish response', your organisation name may still be listed as having responded to the consultation in, for example, the analysis report.

We will share your response internally with other Scottish Government policy teams who may be addressing the issues you discuss. They may wish to contact you again in the future, but we require your permission to do so. Are you content for Scottish Government to contact you again in relation to this consultation exercise?

☐ Yes

☐ No

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Abbreviations

AA	Appropriate Assessment
AAIR	Appropriate Assessment Information Report
ABP	Associated British Ports
AC	Alternating Current
ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic Area
AEOI	Adverse Effect on the Integrity (of European/Ramsar Sites)
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
BACI	Before-after control-impact
BD	Biological Disturbance
BERR	Department for Business, Enterprise and Regulatory Reform
BTO	British Trust for Ornithology
CMACS	Centre for Marine and Coastal Studies
COWRIE	Collaborative Offshore Wind Research Into the Environment
CRM	Collision Risk Modelling
cSAC	candidate Special Area of Conservation
DC	Direct Current
DECC	Department of Energy & Climate Change
Defra	Department for Environment Food and Rural Affairs
DG	Directorate General
DO	Dissolved Oxygen
DOENI	Department of Environment for Northern Ireland
DPO	Draft Plan Option
EC	European Commission
ECS	European Cetacean Society
EDPR	EDP Renovaveis (Renewable Energy Company)
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EM	Electromagnetic
EMEC	European Marine Energy Centre
EMF	Electromagnetic Field
EOWDC	European Offshore Wind Deployment Centre
EU	European Union
FAD	Fish Aggregating Device
FAME	Future of the Atlantic Marine Environment
FARL	Fawley Aquatic Research Laboratories Ltd
FTRAG	Forth and Tay Regional Advisory Group
GIS	Geographical Information System
GW	Gigawatts

HDD	Horizontal Direction Drilling
HELCOM	Helsinki Commission
HIE	Highlands and Islands Enterprise
HIT	Humber International Terminal
HPDI	highest posterior density interval
HRA	Habitats Regulations Appraisal
HVDC	High-voltage Direct Current
HWDT	Hebridean Whale and Dolphin Trust
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for Exploration of the Sea
IECS	Institute of Estuarine and Coastal Studies
IH	Inner Hebrides cetacean population area
IMARES	Institute for Marine Resources & Ecosystem Studies
IPF	Draft Initial Plan Framework for Wave and Tidal Energy (see also Draft W&TE Plan)
IPR	Iterative Plan Review
IROPI	Imperative Reasons of Overriding Public Interest
IS	Irish Sea cetacean population area
ISLES	Irish Scottish Links on Energy Study
JNCC	Joint Nature Conservation Committee
KTN	Knowledge Transfer Network
LIMPET	Land Installed Marine Power Energy Transmitter
LSE	Likely Significant Effect
MarLIN	Marine Life Information Network
MCZ	Marine Conservation Zone
MFRAG	Moray Firth Regional Advisory Group
MMO	Marine Management Organisation
MPA	Marine Protected Area
MRIP	Marine Renewables Infrastructure Plan
MSP	Marine Spatial Plan
MU	Management Unit
MUDS	Marine biological underwater Depuration System
MW	Megawatts
NE	North East
NENS	North Eastern North Sea & Skagerrak (harbour porpoise stock)
NERI	National Environmental Research Institute (Denmark)
NF	North France cetacean population area
nm	Nautical Mile
NPD	Non-Physical Disturbance
NPWS	National Parks and Wildlife Service
N-RIP	National Renewables Infrastructure Plan
NS	North Sea cetacean population area
NTC	Non-Toxic Contamination

NWIS	North-west Ireland & West Scotland (harbour porpoise stock)
OBIS	Ocean Biogeographic Information System
ODPM	Office of Deputy Prime Minister
OH	Outer Hebrides (Island of Barra) cetacean population area
ORE	Offshore Renewable Energy
OREDP	Offshore Renewable Energy Development Plan
ORJIP	Offshore Renewables Joint Industry Programmes
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OWE	Offshore Wind Energy
OWiX	Offshore Wind Innovation Exchange
PCB	Polychlorinated biphenyls
PD	Physical Damage
PFOW	Pentland Firth and Orkney Waters (formerly referred to as PFSA)
PFSA	Pentland Firth Strategic Area (now more commonly referred to as PFOW)
PLG	Physical Loss or Gain
PMSS	PMSS Ltd.
PRIMaRE	Partnership for Research in Marine Renewable Energy
pSAC	Possible Special Area of Conservation
PSG	Project Steering Group
pSPA	Potential Special Protection Area
PTS	Permanent Threshold Shift
Ramsar	The Ramsar Convention on Wetlands - the Conservation on Wetlands of International Importance, especially on Waterfowl Habitat
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SAM	Static Acoustic Monitoring
SAMS	Scottish Association for Marine Science
SCI	Site of Community Importance
SCOS	Special Committee on Seals
SDIC	State Development & Investment Corporation
SE	Scottish Enterprise
SEA	Strategic Environmental Assessment
SEIA	Social and Economic Impact Assessment
SEL	Sound Exposure Level
SEPA	Scottish Environment Protection Agency
SG	Scottish Government
SNCB	Statutory Nature Conservation Bodies
SNH	Scottish Natural Heritage
SPA	Special Protection Area

SPL	Sound Pressure Level
SRTP	ScotRenewables Tidal Power Limited
SSE	SSE Renewables
SSMEI	Scottish Sustainable Marine Environment Initiative
TCE	The Crown Estate
TTS	Temporary Threshold Shift
UK	United Kingdom
WDCS	Whale and Dolphin Conservation (formerly WDCS, Whale and Dolphin Conservation Society)
WWT	Wildfowl and Wetlands Trust

1 Introduction

1.1 Report Background

1.1.1 The Scottish Government is developing a Plan for future commercial[2] offshore wind development in Scottish waters in the period to 2050. The plan builds on the previous draft plan for offshore wind published in 2013[3] and seeks to provide opportunities for deep water wind technologies which may become commercially viable over this time period as well as further opportunities for fixed bottom technologies.

1.1.2 The geographical scope of the Plan covers Scottish Waters (0-200 nautical miles) This includes Scottish Territorial Waters (0-12 nautical miles) and the Scottish Marine Area (12-200 nautical miles) which is executively devolved to Scottish Ministers under the Marine and Coastal Access Act 2009.

1.1.3 This new Plan needs to be accompanied by a Habitats Regulations Appraisal (HRA) process. This HRA process is required to assess the Plan's potential effects on international protected nature conservation sites. This HRA process has been undertaken as a sequence of discrete stages in accordance with established guidance for conducting plan-level HRA that was produced by Scottish Natural Heritage (SNH) in 2015. This process also takes account of the guidance produced by the European Commission on the 'Assessment of plans and projects significantly affecting Natura 2000 sites'[4].

1.1.4 The HRA is also being overseen by a Project Steering Group (PSG) which includes representatives from within Scottish Government, The Crown Estate, and Scottish Natural Heritage. Further background details to the plan and details of the Plan development process are set out in the introductory chapter of the preceding HRA Pre-screening report (see Appendix A).

1.1.5 In addition to this plan-level HRA, to support and inform the development of the Sectoral Marine Plan for Offshore Wind a separate Strategic Environmental Assessment (SEA) and Social and Economic Impact Assessment (SEIA) have been produced.

1.1.6 It should be noted that this plan-level HRA is not a substitute for the future requirements of HRAs carried out for individual projects. Such project-level HRA processes will still be required in accordance with the relevant legislation.

1.1.7 Further summary details about the scope of this plan-level HRA process and the work undertaken for the screening and assessment stages of this study are presented below.

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[2] Commercial offshore wind development defined as arrays >100MW installed capacity.

[3] Scottish Government, 2013. Draft Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters; 2013; https://www.gov.scot/publications/draft-sectoral-marine-plans-offshore-renewable-energy-scottish-waters-consultation/PSGes/7/.

[4] European Commission, 2001. Assessment of plans and projects significantly affecting Natura 2000 sites.

1.2 Scope of the Habitats Regulations Appraisals

1.2.1 The Habitats Regulations implement the EC Habitats and Birds Directives in UK[5] waters and require that an Appropriate Assessment (AA) should be undertaken where a plan or project is not directly connected with or necessary for management of designated European sites, or offshore European sites, and where the possibility of a likely significant effect (LSE) on these sites cannot be excluded, either alone or in-combination with other plans or projects. These sites include the following which comprise the Natura 2000 network:

- Special Areas of Conservation (SACs) designated under the EC Directive on the Conservation of Natural Habitats and of Wild Fauna & Fauna (the Habitats Directive); and
- Special Protection Areas (SPAs) sites classified under the EC Directive on the Conservation of Wild Birds (the Birds Directive).

1.2.2 In the UK, these requirements are also extended to the consideration of:

- Ramsar Sites[6] (listed under the Ramsar Convention on Wetlands of International Importance); and
- Sites that are proposed for designation and inclusion in the Natura 2000 network and those sites that are currently in the process of being classified such as: potential SPAs (pSPAs), candidate and possible SACs (cSACs and pSACs) and Sites of Community Importance (SCIs[7]).

1.2.3 As Competent Authority, Marine Scotland is responsible for producing an AA that assesses the impacts of the plan on these sites in fulfilment of the Habitats Regulations obligations. This AA needs to determine whether there will be an 'adverse effect on integrity' (AEOI) at any sites with reference to their conservation objectives.

1.2.4 If it is concluded that the Plan will have an AEOI at a European/Ramsar site (either alone or in-combination with other plans or projects), the Plan can only be adopted if it has been ascertained that there are no alternative solutions and it is necessary for Imperative Reasons of Overriding Public Interest (IROPI), including those of a social or economic nature. In these circumstances, before such a plan can proceed, compensatory measures must be secured to ensure that the overall coherence of the network of Natura 2000 sites is maintained.

1.2.5 A major consideration for this HRA process is that the Sectoral Marine Plan for Offshore Wind (Draft Plan) has many inherent uncertainties associated with it. These relate to aspects such as:

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[5] Each EC Member State is ultimately responsible for implementation of the Directives in their territory and in Scotland, the EC Habitats Directive is transposed through a combination of the Habitats Regulations 2010 (in relation to reserved matters) and the Conservation (Natural Habitats, &c.) Regulations 1994 (as well as Scottish Statutory amendments made between 2004 and 2007).

[6] In Scotland it is also a matter of policy as set out in the February 2010 Scottish Planning Policy document (SG, 2010) that international Ramsar sites are 'also Natura sites and are protected under the relevant statutory regimes'.

[7] Sites that have been adopted by the European Commission but not yet formally designated by the government of each country.

- the detail of the implementation process;
- future generation capacities;
- the location, scale and densities of development with the DPOs;
- the proposed technologies to be used;
- the scale of the effects arising via some of the defined impact pathways;
- the efficacy of some project-level mitigation options.

1.2.6 In addition to the inherent uncertainties about the project details and the impacts arising from the Draft Plan, there will be a high level of uncertainty associated with the future impacts which apply to other plans and projects. Such uncertainty about in-combination effects are typically a characteristic in all strategic coastal and offshore plans where the full extent of future developments cannot be anticipated.

1.2.7 Although these uncertainties exist, a high level of certainty is required under the Habitats Regulations that there will be no AEOI of any European/Ramsar site. The HRA has therefore taken account of these issues and, where required, identified relevant mitigation measures to accompany the Draft Plan. The legislative context for this HRA is also described in Section 2.1 of the pre-screening report (see Appendix A).

1.3 Reporting and Consultation Stages

1.3.1 To assess the effects of the new 'Sectoral Marine Plan for Offshore Wind' on these European/Ramsar sites, the SNH guidance identifies a 13-step plan-level HRAs process (see Figure 1). This staged approach has been adopted, and consulted upon, over three key project phases to ensure there is a high level of clarity and auditability in the assessment process (an important requirement for strategic-level HRAs which need to be carried out in an iterative, auditable and transparent manner). The findings from each of these phases are presented in the following reports:

- **Phase 1** – Pre-screening Report (HRA Stages 1-3) which is included as Appendix A;
- **Phase 2** – Review of Proposed Assessment Methodology (HRA Stage 4) which is included as Appendix B; and
- **Phase 3** – Screening and Appropriate Assessment Information Report (AAIR) (HRA Stages 5 to 10) this document.

1.3.2 The Pre-screening report, encompassing Phase 1, was produced by Marine Scotland in 2018 and sets out the evidence base and the proposed methods to be applied for the subsequent screening/scoping and assessment stages of the HRA work (Appendix A). The methods proposed were based on available guidance and established best practice that has been developed over the course of multiple preceding plan-level HRAs (and the associated stakeholder and Steering Group discussions which accompanied them) that have been carried out over the last decade.

1.3.3 The previous 'case example' plan-level HRAs are listed in Section 2.3 of the Pre-screening report (Appendix A) and include those that were carried out for previous plans in Scottish Waters such as the draft Sectoral Marine Plans for Offshore Renewable Energy[8]; draft plan for the Offshore Wind Energy (OWE)[9] Wave and Tidal Energy (W&TE) generation plans[10]. In addition, during this HRA, consideration has been given to the methods being adopted for new plan-level HRAs that have recently been started to assess The Crown Estate's next round of Offshore Windfarm development (NIRAS in prep.) and Minerals extraction (Marine Space and ABPmer in prep.)

1.3.4 In addition to reviewing the screening methods, the pre-screening report also identified an initial list of 652 European/Ramsar sites, and their qualifying interest habitats and species, for which there could be a LSE (or the possibility of LSE could not be excluded at this stage) from the plan. This list encompassed all sites within an objective and quantifiable 'pre-screening buffer zone' which encompassed the EEZ around Scotland plus a 100 km buffer south of the Scottish border (Figure 5 of Appendix A). Since production of the pre-screening report, locations of the Draft Plan Options (DPOs) have been agreed, allowing the initial pre-screening list to be rationalised based on the provision of a 100 km buffer around the DPOs and, as a first step, acknowledging all European/Ramsar sites within this buffer (the screening list).

1.3.5 To provide a fully auditable trail through the HRA process, the original pre-screening list of European/Ramsar sites is presented (Table A3, Appendix A). However, it is the screening list (Table C1, Appendix C) that provides the starting point for all screening steps and it is this list which has been updated according to the agreed plan-level HRA screening criteria (see Appendix A and B).

1.3.6 For Phase 2, the pre-screening report was consulted upon and a brief 'Review of Proposed Assessment Methodology' report was produced in November 2018 (Appendix B). This considered the consultation responses received on the pre-screening report and revisited the proposed HRA scoping and assessment methods in the light of that feedback. It also considered the implications of key EU and UK case-law judgements made during the summer of 2018 (i.e. between the production of the Phase 1 and Phase 2 reports) and how these should be acknowledged within this HRA process.

1.3.7 To accommodate project-level case law lessons and the judgements that took place in July and August 2018, it was recommended that Stages 6 and 7 of the plan-level HRA process, which direct the consideration of mitigation measures at the screening stage, are not formally considered (see Review of Proposed Assessment Methodology report). Instead the process (as shown in Figure 1) would move from Stage 5 directly to Stage 8 (assessment).

[8] ABPmer, 2017. Habitats Regulations Appraisal of the Draft Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters. Reports for Marine Scotland, ABPmer Report No: R.2121a-c. 5 May 2017.

[9] ABPmer, 2011a. Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Report for the Scottish Government, ABP Marine Environmental Research Ltd, Report No: R.1722a-c. January 2011.

[10] ABPmer, 2013. Habitats Regulations Appraisal of Draft Plan for Wave and Tidal Energy in Scottish Waters. Reports for Marine Scotland, ABP Marine Environmental Research Ltd, Report No: R.1863a-c. January 2013.

1.3.8 The Phase 2 report was also discussed at a PSG meeting on 9 November 2018. Through this process generally positive feedback was received and it was agreed that the methods proposed in the Phase 1 pre-screening report (Appendix A) would be applied with minor changes, as set out in the Phase 2 report (Appendix B).

1.4 Development of Draft Plan Options

1.4.1 The sectoral marine planning process (Figure 1) is an iterative process, informed through stakeholder engagement and evidence from the related social, economic and environmental assessments. All of the information and consultation feedback gathered supports the Scottish Ministers in identifying Draft Plan Options (DPOs) to progress to the next phase of the plan process.

1.4.2 The DPOs have emerged through an examination of spatial data considerations in addition to advice and other related information provided by members of the Steering Groups, as well as stakeholders

1.4.3 The key stages of the planning process in relation to the identification of the Draft Plan Options, described in greater detail below, are:

1. Opportunity and Constraint (O&C) Analysis – Iteration 1
2. Opportunity and Constraint (O&C) Analysis – Iteration 2 - Single Issue Constraint Analysis
3. Scoping Consultation
4. Opportunity and Constraint (O&C) Analysis – Iteration 3
5. Identification of Draft Plan Options
6. Next Steps

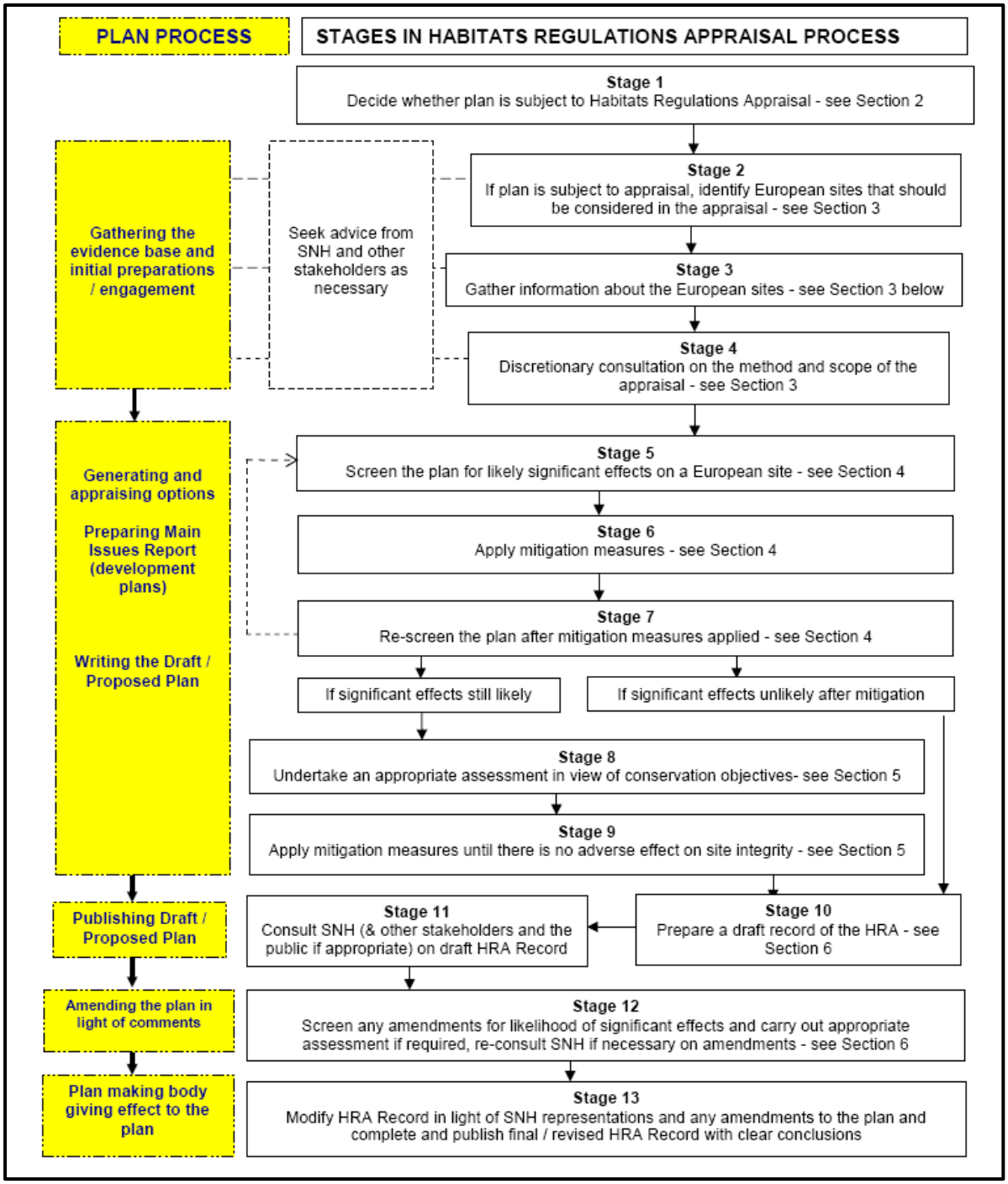

Figure 1. Key stages of plan-level HRA process for plans[11]

11 David Tyldesley and Associates, 2015. Habitats Regulations Appraisal of Plans. Guidance for Plan-making Bodies in Scotland Version 3.0, January 2015 SNH Ref 1739.

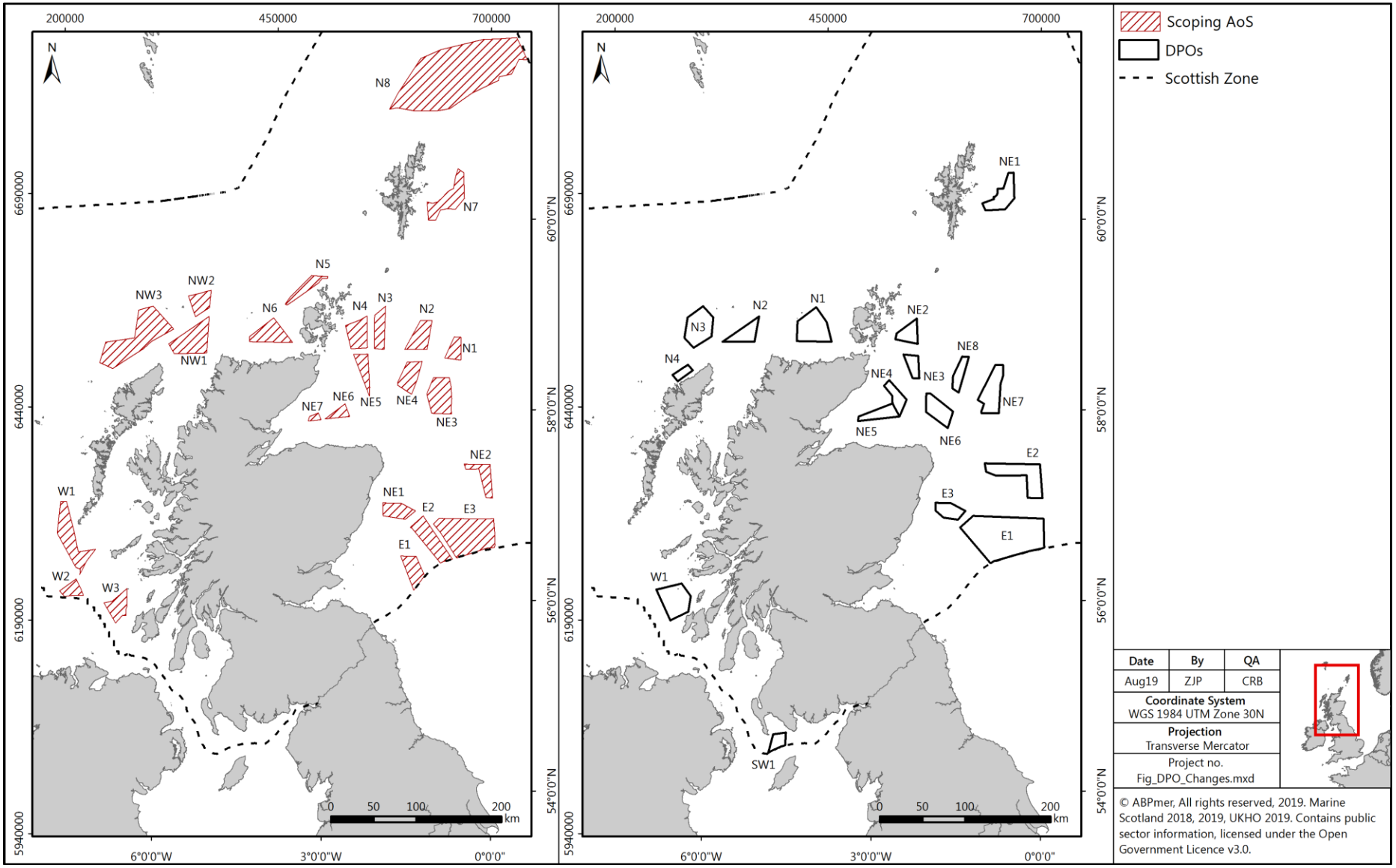

Figure 2. Scoping AoS to DPO

Opportunity and Constraint (O&C) Analysis – Iteration 1

1.4.4 The identification of initial Areas of Search (AoS) was carried out through the use of an O&C analysis.[12] It built upon previous work carried out by Marine Scotland Science in 2011[13] and the production of draft regional locational guidance for potential deep water floating offshore wind test sites in 2014.[14] The analysis was iterative, so updates could be incorporated as required in order to reflect stakeholder feedback.

1.4.5 Full details of the O&C analysis can be found in the AoS scoping report published for consultation in 2018.[15] The O&C analysis sought to identify areas of opportunity for the future development of offshore wind, whilst also identifying areas that minimised potential negative impacts to the environment, other sectors and users of the sea. This analysis was completed through the use of GIS and numerous spatial data resources.

Opportunity and Constraint (O&C) Analysis – Iteration 2

1.4.6 Sectoral engagement workshops were held in spring 2018. The AoS were then refined with consideration to specific spatial issues and feedback from the workshops.

This refinement process identified a range of distinct AoS (

1.4.7 Figure 2). As the draft Plan is technology neutral, no commercial or technology specific information was used in this refinement process.

Scoping Consultation – Screening and Scoping Reports

1.4.8 Scottish Ministers then consulted on the screening and scoping stages of the Plan process during June and July 2018. Screening and scoping reports were prepared and published online for the SEA, HRA and SEIA alongside the AoS scoping study.

Opportunity and Constraint (O&C) Analysis – Iteration 3

1.4.9 Iteration 3 of the O&C analysis was undertaken, which considered the responses received during the Scoping Consultation. For more details see the Consultation Analysis.

1.4.10 The AoS were refined with consideration to the outputs of the Iteration 3 O&C Analysis. As a result, certain AoS were either removed or refined to avoid/incorporate certain areas of Scottish Waters.

1.4.11 This stage also considered the areas of seabed proposed by stakeholders via the scoping consultation. A number of the areas proposed overlapped with existing AoS, while others overlapped with areas with higher levels of

[12] https://www.gov.scot/publications/scoping-areas-search-study-offshore-wind-energy-scottish-waters-2018/
[13] Davies, I. M. and Watret, R. (2011) Scoping Study for Offshore Wind Farm Development in Scottish Waters. Scottish Marine and Freshwater Science Vol 2 No 13. Available at: www.gov.scot/Publications/2011/11/28104658/0
[14] https://www2.gov.scot/Topics/marine/marineenergy/Planning/DRLG
[15] https://www.gov.scot/publications/scoping-areas-search-study-offshore-wind-energy-scottish-waters-2018/

constraint or entirely new areas. This information was provided to Scottish Ministers to inform their decision on the selection of DPOs.

1.4.12 Upon review of the above information, Scottish Ministers identified areas to move forward in the plan process. It should be noted that some additional areas were included at this stage, where there was significant stakeholder interest, but also increased constraint. The Sustainability Appraisal stage will assess these areas in greater detail.

Identification of Draft Plan Options

1.4.13 The 22 revised Areas of Search were made available to the Sectoral Marine Plan Project Board and two Project Steering Groups for consideration and comment.[16]

1.4.14 Responses from both the Board and Steering Groups, together with the outputs of the initial assessments, were presented to Scottish Ministers to inform their decision on which AoS should progress to the Sustainability Appraisal for more detailed assessment.

Seventeen revised AoS were selected as DPOs (

1.4.15 Figure 2).

Next Steps

1.4.16 Following the statutory consultation, the responses received will be subject to consultation analysis. This analysis will be considered by Scottish Ministers' and inform their decision on which Options to take forward in the Final Plan.

1.4.17 It should be noted that if significant changes are required as a result of the consultation feedback, further assessment and consultation may be required prior to adoption and publication of the Final Plan. The Post Adoption Statement (to be published with the Final Plan) will detail any changes made to the Plan as a result of consultation feedback.

1.4.18 The Phase 3 report, this report, details the outcome of the 'Screening and Appropriate Assessment Information' phase of the process including consideration of in-combination effects and mitigation (Stages 5, 8 and 9).

1.4.19 This report initially presents the list of 'screened in' sites that have been taken forward i.e. those European/Ramsar sites contained within a 100 km buffer zone around the DPOs. The concluding outputs from the subsequent screening steps for each of the feature groups are then provided.

1.4.20 Stage 8 (assessment) is then detailed including consideration of potential in-combination effects with known plans and projects. Suitable plan-level mitigation is then provided along with strategic recommendations.

1.4.21 Hence, this report encompasses Stage 5 (screening), Stage 8 (assessment), Stage 9 (mitigation) and Stage 10 (draft HRA record) (see Figure 1). To cover Stages 11 to 13, this report will be forwarded for consultation and a final assessment document produced which acknowledges the consultation

[16] Further detail regarding the cross sectoral Steering Groups is provided in the Statement of Public Participation

and any amendments required. The final AA will be produced by Marine Scotland as the Competent Authority.

1.5 Report Structure

1.5.1 The report has been structured as follows:

Summary: **Non-Technical Summary** a summary and overview of this report.

Section 1: **Introduction** provides background to plan and the HRA together with details of the scope of the documents and the report structure;

Section 2: **Screening/Scoping** presents a review of the approach and outcomes of the Screening/Scoping Process as Stage 5 of the HRA process.

Section 3: **Screening summary** providing results of Stage 5.

Section 4-10: **Appropriate Assessment Information** presents a review of the approach and outcome of the Assessment Process as represented by Stage 8 of the HRA process.

Section 11: **Mitigation** presents detail of the proposed plan-level mitigation measures encompassing Stage 9 of the HRA-process.

Section 12: Conclusion

1.5.2 The following supporting information is provided in the appendices:

Appendix A: Pre-screening Report (HRA Stages 1-3)

Appendix B: Review of Assessment Methodology (HRA Stage 4);

Appendix C: Screening Table (Table C1)

Appendix D **Screening Schedules** for each DPO (Tables D1-D17);

Appendix E **DPO Screening Maps** for each of the 17 DPOs (Figures E1-E17);

Appendix F **>100 km Screening Maps** of European/Ramsar sites supporting features occurring outside of 100 km buffer;

Appendix G **Seabirds Literature Review** describing the baseline environment conditions for foraging seabirds to inform the screening process;

Appendix H **Marine Mammals Literature Review** describing the baseline environment conditions for marine mammals and otters to inform the screening process; and

Appendix I **Fish Literature Review** describing the baseline environment conditions for migratory fish to inform the screening process.

Appendix J **Project Level Mitigation** measures for all identified impact pathways for offshore wind developments.

2 Screening/Scoping (Stage 5)

2.1 Introduction and Scope

2.1.1 The screening or 'scoping' stages of the plan-level HRA process involve a secondary sifting process whereby the list of European/Ramsar sites and features which was identified during the pre-screening are reviewed to identify those sites for which there is the potential for a LSE (or where the likelihood of a LSE cannot be excluded) from the plan. These sites and features are then taken forward in the assessment stage. At the same time those sites and features for which there is no LSE or relevant impact pathway from the plan can be 'screened out' and do not need to be considered further within the assessment.

2.1.2 Proposed methods for making this Stage 5 LSE screening judgement were set out within the Phase 1 Pre-screening report and then updated, following consultation and agreement with the PSG, in the Phase 2 methods review report (see Appendices A and B respectively). These methods were informed by initial literature reviews and by the advice received from stakeholders, and screening principles applied, during previous plan-level HRAs. Based on these methods and advice from the PSG, this section of the report sets out the final list of 'screened in' sites that have been taken forward into the assessment.

2.1.3 The DPOs had not been agreed at the time of writing the Phase 1 and 2 reports. Hence, a precautionary 'pre-screening buffer zone' was adopted in these stages which encompassed the EEZ around Scotland plus a 100 km buffer south of the Scottish border (see Figure 5 of Appendix A). These resulted in a large number of European/Ramsar sites (652) being encompassed by the extensive geographical area covered by the 'pre-screening buffer zone'.

2.1.4 It was recognised in the pre-screening report (Appendix A) that a more detailed consideration of LSE on European/Ramsar sites and interest features would be carried out in the following screening stage (Stage 5). To provide a fully auditable trail through the HRA process, the original pre-screening list of European/Ramsar sites is provided (Table A3, Appendix A); however, appreciating that many of these sites are beyond the 100 km buffer, a rationalised list of sites was established as the 'initial screening list' (Table C1, Appendix C). This initial list encompassed all sites within 100 km of the DPOs as its starting point. It is to this screening list (Table C1, Appendix C) that all updates were made throughout the screening process.

2.1.5 During the pre-screening phase, consideration was given to bat interest features. However, as no bat interest features were within the extensive pre-screening buffer zone, these were not considered further within the HRA (see Appendix A).

2.1.6 In making judgement about the potential for a LSE on designated sites and features, interlinked factors were considered such as the impacts arising from DPO areas, the distance from the sites to features as well as current

scientific understanding (and gaps in that understanding) about the ecology, behavioural characteristics and 'sensitivities' of the interest features.

2.1.7 It was also necessary at screening (and throughout the HRA process) for a precautionary approach to be adopted and to ensure that no relevant sites or features were excluded. Full consideration was given to the definitions and interpretations of the LSE judgement. Under the Habitats Regulations, LSE is defined as a more than '*de minimis*' change. In other words, a plan would not be considered to have a LSE on a European/Ramsar site if "any potential effects are trivial, or '*de minimis'* or so restricted or remote from the site that they would not undermine the conservation objectives for the site in combination"[17].

2.1.8 Several initial steps to the screening were carried out before a further review of each of the key interest feature groups (i.e. coastal, intertidal and subtidal habitats and associated species; bird species; marine mammal species; migratory fish and freshwater pearl mussel; otter) was done. These steps, as outlined below, were captured in the screening table (see Table C1).

2.1.9 Since finalising the Phase 1 and Phase 2 reports, the DPOs have now been agreed. Subsequently, as an initial step to the screening, a 100 km buffer zone was applied to all the DPOs. A 100 km screening boundary has been applied for previous plan-level HRAs and is used because it defines a quantifiable and objective area that is likely to encompass many of the mobile species interest features (fish, seabirds and mammals) within European/Ramsar sites which could be indirectly affected by the Draft Plan. However, it has not been used to limit further review of more distant locations or to presume that all relevant features within this area for which impact pathway exists are necessarily affected. In particular, it is recognised that impacts (especially to migratory bird species) may extend to sites beyond this 100 km boundary and this aspect has been considered within the review of the key interest feature groups that encompass mobile features that range beyond 100 km i.e. birds, marine mammals and migratory fish (Sections 2.3, 2.4 and 2.5).

2.1.10 During Stage 4 of the HRA process, SNH advised that Category D sites and features which are a 'non-significant presence' and of 'little conservation value' do not need to be considered within the HRA process (see Appendix B). Sites and features identified as Category D have therefore been removed during the initial screening. This included removal of habitats with a 'non-significant presence' and species identified as a 'non-significant population' from several SACs.

2.1.11 To ensure the most up-to-date information was used, the latest version of the JNCC Natura features database (17th September 2018) was downloaded and the data interrogated for the screening process. Similarly, all GIS shapefiles of the European/Ramsar sites were obtained from the most recent updates available on the JNCC website and NPWS website (as at 19/07/19).

2.1.12 Terrestrial/freshwater habitats and associated species interest features for which there will be no LSE on the basis that there is definitely no impact

[17] David Tyldesley and Associates, 2015. Habitats Regulations Appraisal of Plans. Guidance for Plan-making Bodies in Scotland Version 3.0, January 2015 SNH Ref 1739.

pathway (i.e. no potential physical or ecological connectivity with any marine activities resulting from the Plan) have been removed during initial screening[18]. Details of this step are provided in Appendix A.

These steps are presented in the updated screening table (Table C1) and

2.1.13 Figure 3 to Figure 5 which show all European/Ramsar sites that were screened in following these initial screening steps. A further review of each of the key interest feature groups was then carried out as detailed within Section 4 of the pre-screening report (Appendix A). A set of individual screening schedules were then prepared for each of the DPOs (Appendix D, D1-D17) along with maps showing those sites screened in (Appendix E, Figures E1 to E17).

2.1.14 Other sites outside the 100 km buffer have also been screened in for foraging bird interest feature species, marine mammals and migratory fish. These are reviewed in Sections 2.3 to 2.5. Appendix F presents screening maps of European/Ramsar sites supporting features occurring outside of 100 km buffer.

2.1.15 To underpin the screening steps, reviews of the baseline conditions for birds, mammals and fish were carried out (Appendices G, H and I).

2.1.16 The screening methods recognised the need to consider the likely cable alignments and landfall positions in order to help define areas of potential effects especially within the coastal zone (Section 4 of Appendix A). While the DPOs define the areas for potential wind energy generation, at this time there remains a high level of uncertainty concerning the possible location and number of power export cables associated with potential developments. Therefore, the possibility of the remaining sites and their relevant interest features being directly or indirectly affected cannot be excluded. Consequently, all European/Ramsar sites that occurred within 100 km buffer of the DPOs remained screened into the HRA. The exception to this is where marine sites were located well seaward of any DPO and therefore definitively beyond any potential cable alignment activity associated with the Plan.

2.1.17 The following sections present an outline of the screening process and the summary findings for each marine interest feature group. In each case the methods are not repeated in detail but the relevant section of the pre-screening report (Appendix A) which describes these methods is referenced.

2.2 Habitats and Associated Species

2.2.1 The methods for screening habitats and their associated species were set out in Section 4.3 of the pre-screening report (see Appendix A). Summary details about how these methods were applied and the results of their application are set out below.

2.2.2 From the pre-screening, all relevant SACs/SCIs and Ramsar sites that were within the pre-screening buffer zone (see Section 2.1.3) were included. Following agreement of the DPOs, this list was rationalised in the initial

[18] To ensure full auditability, both now and in the future, where any site is removed from the assessment scope this is indicated on the screening tables (as shown in Table C1) but these sites are not deleted.

screening by first adopting a 100 km buffer zone around each of the DPOs and then removing all Category D sites and features.

2.2.3 Terrestrial/freshwater habitats, along with their associated species, that would not be affected by the Draft Plan were also screened out. Further consideration of the screening process for freshwater pearl mussels outside the 100 km buffer is provided in Section 2.5.

2.2.4 All the European/Ramsar sites and features that are screened in according to the initial steps are presented in the updated screening table (Table C1, Appendix C) and are shown in

2.2.5 Figure 3 to Figure 5. A separate map of sites has not been prepared which specifically identifies those sites for which habitats are a qualifying interest feature. This is because it is expected that the habitats within all the sites will be important for supporting relevant interest features (e.g. as foraging grounds for feeding birds species) irrespective of whether they are qualifying features in their own right.

2.2.6 While the DPOs are known, there are no definitive locations for the positioning of devices within these areas and no details about the alignments and location of cabling to landside grid connections.

2.2.7 This initially resulted in almost all European/Ramsar sites that lie within 100 km of the DPOs remaining screened in. The exception are those sites that are clearly seawards of any DPO or beyond the route of any potential cable alignment (e.g. Darwin Mounds SAC). These sites are screened out from the HRA (Table C1, Appendix C). During this screening step there were several coastal sites identified which were within 100 km but located in Northern Ireland or Ireland. Given that the location of the nearest DPOs to these sites were either SW1 or W1, the assumption was made that the cable alignment and landfall for these DPOs would be towards Scotland (or potentially northern England from, for example, SW1), not towards Ireland or Northern Ireland. Hence, relevant interest features were screened out for SACs or Ramsar sites. For example, Murlough SAC (Northern Ireland) and Sheephaven SAC (Ireland) were screened out from the overall assessment based on this assumption.

2.2.8 The areas over which activities within the DPO could have an indirect effect on seabed habitats and non-mobile species were then identified. This was done by using the distance covered by a single tidal excursion around each DPO (Section 4.3.6 to 4.3.8 of Appendix A). The distance over which there could be a potential indirect effect as defined by this tidal excursion length is variable depending upon location. The extent of each tidal excursion in relation to the DPOs is shown in Figure 6 and the DPO screening maps (Figures E1-E17). Where this excursion overlapped with a European/Ramsar site, then this site was screened in.

2.2.9 As almost all European/Ramsar sites within 100 km will be automatically screened in due to uncertainty of cable alignments, it is only those sites which have been screened out, based on their location being definitively outwith the route of any cabling (see Section 2.2) but which are within a single tidal excursion, that were revisited. However, there were no sites which were affected by this screening step.

2.2.10 These screening principles were applied to the individual screening schedules for each of the 17 DPOs (Tables D1 to D17) and the screening maps (Figures E1 to E17).

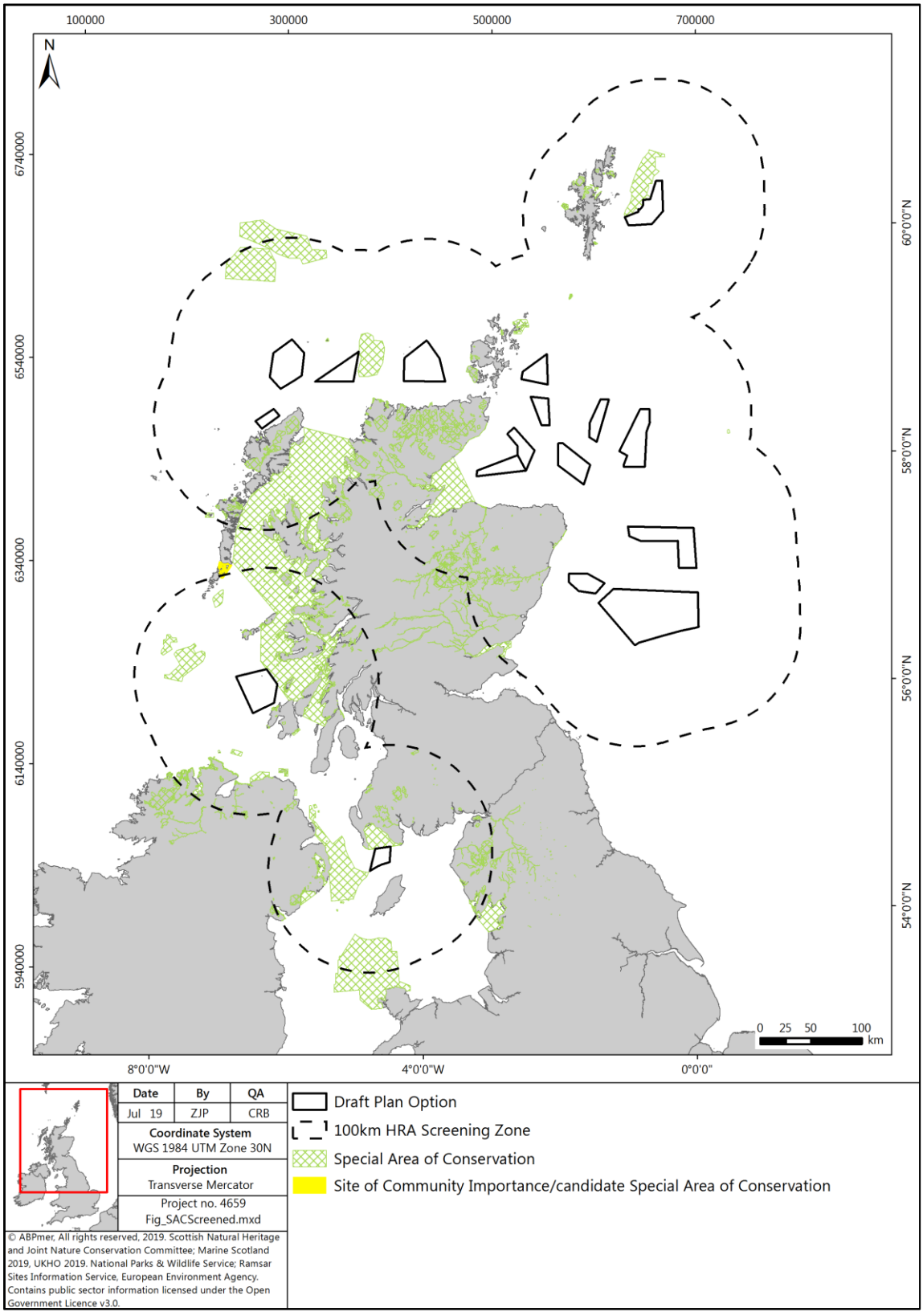

Figure 3. SAC and SCI sites screened into assessment within 100 km of DPOs

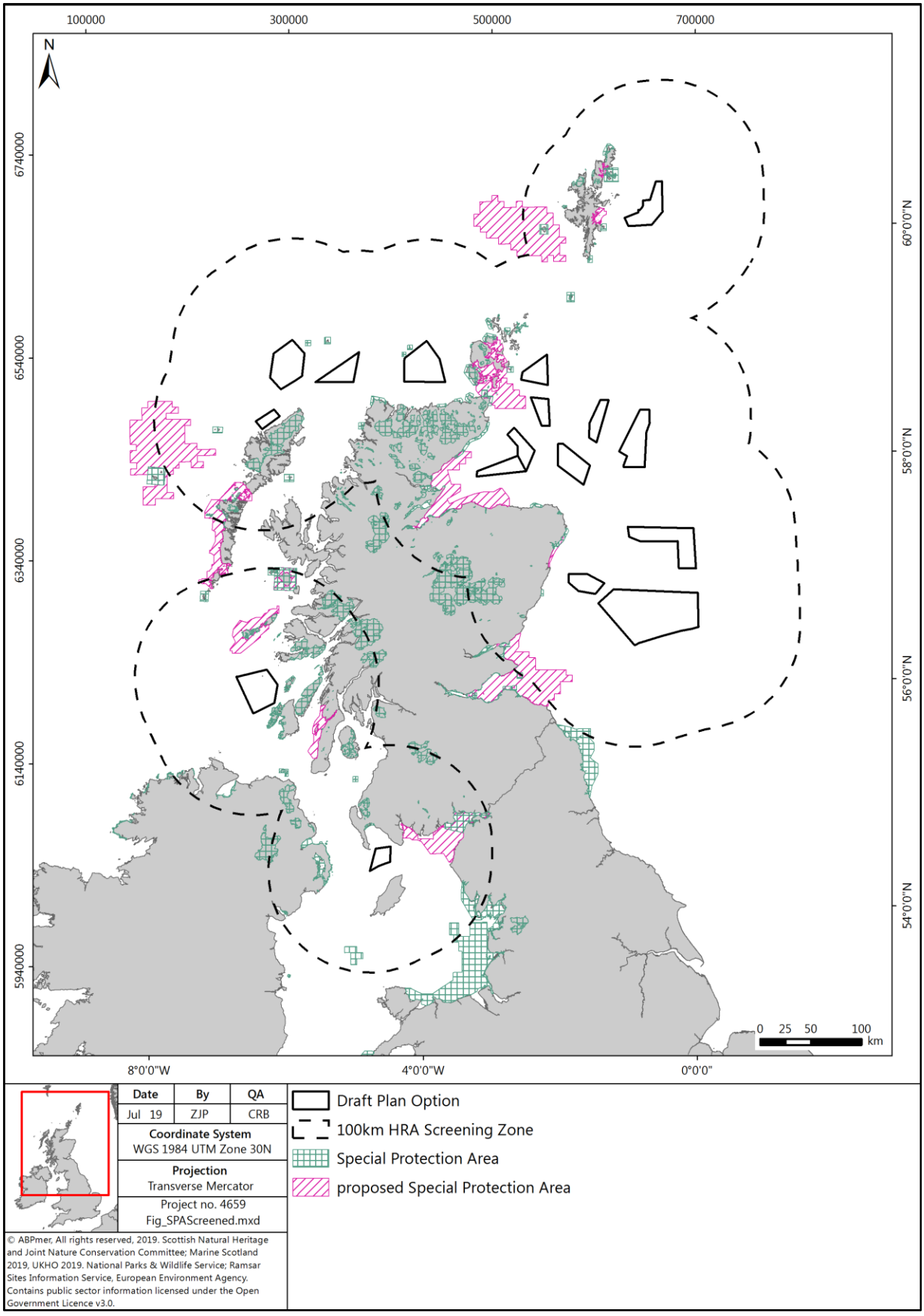

Figure 4. SPA sites screened into assessment within 100 km of DPOs

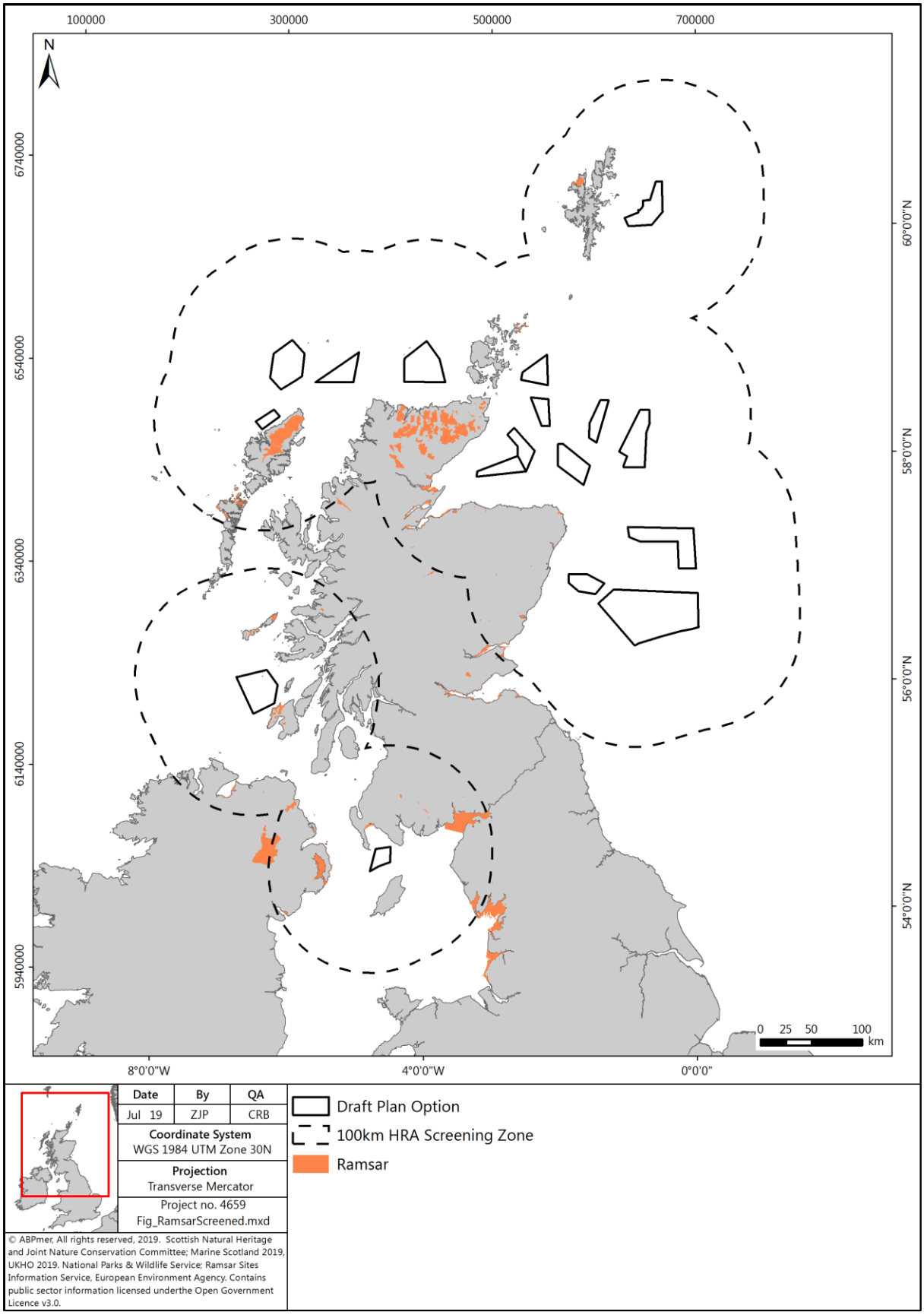

Figure 5. Ramsar sites screened into assessment within 100 km of DPOs

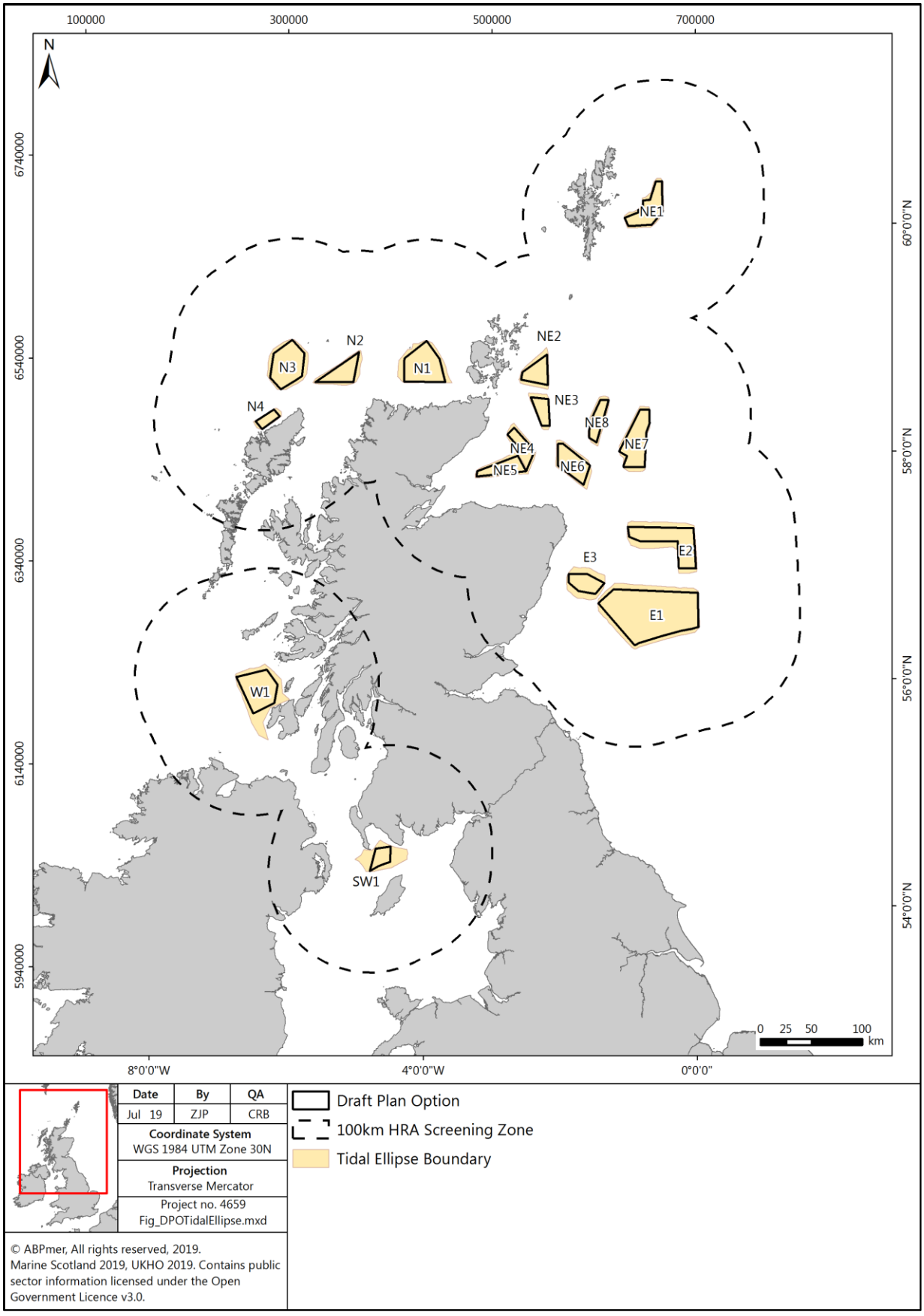

Figure 6. Extents of tidal excursions around each DPO

2.3 Birds

2.3.1 The methods for screening bird species interest features were set out in Section 4.4 of the pre-screening report (Appendix A). Summary details about how these methods were applied and the results of their application are set out below.

2.3.2 For the initial screening, all SPAs and Ramsar sites that lie within 100 km buffer of the DPOs were included (

2.3.3 Figure 4 and Figure 5). The next screening step within the bird interest feature group was screening out all bird species that are entirely resident within terrestrial habitats, do not forage at sea and do not migrate internationally (see Section 4.4.1 to 4.4.3 of Appendix A). A full list of these bird species is included in the pre-screening report (Appendix A).

2.3.4 Where qualifying bird species of UK and Irish European/Ramsar sites were located outside the 100 km buffer zones but identified as having a mean maximum foraging distance of >100 km, these were screened in to the HRA. To inform this process (and also underpin the subsequent assessment), a literature review and a consultation exercise were undertaken to identify the latest scientific understanding about the foraging behaviour distances of coastal waterbirds (overwintering and breeding populations).

2.3.5 This involved updating previous reviews undertaken for past plan-level HRA projects [19] [20] [21] [22] [23] (see Appendix G). During consultation with SNH, it was agreed that incorporation of the mean maximum foraging distance was appropriate for the HRA (see Appendix B).

2.3.6 From the review (Appendix G) and consultation with SNH, the following list of species were confirmed to have mean maximum foraging distances of >100 km (in each case the mean maximum foraging distances are shown in brackets):

- Atlantic Puffin (105 km)
- Lesser Black-backed Gull (141 km)
- Northern Gannet (229 km)
- Manx Shearwater (330 km)
- Northern Fulmar (400 km)

2.3.7 Any SPA or Ramsar sites for which these species are interest features, and which lie outside the 100 km buffer but within these quoted distances, were

[19] ABPmer, 2010a. Screening and Scoping Review for the Pentland Firth Strategic Area (PFSA) Leasing Round Habitats Regulations Assessment. Report for The Crown Estate, ABP Marine Environmental Research Ltd, Report No: R.1601. January 2010.

[20] ABPmer, 2011a. Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Report for the Scottish Government, ABP Marine Environmental Research Ltd, Report No: R.1722a-c. January 2011.

[21] ABPmer, 2011b. Habitats Regulations Appraisal of National Infrastructure Renewables Plan (N-RIP). Report for the Scottish Government, A ABP Marine Environmental Research Ltd, Report No: R.1772a-b. January 2011.

[22] APBmer 2013f. Habitats Regulations Appraisal of Draft Plan for Wave and Tidal Energy (W&TE) in Scottish Waters. Report for Marine Scotland 2013; ABP Marine Environmental Research Ltd, Final Report January 2013 Report Nos. R.1863a (Pre-Screening); R.1863b (Screening); and R.1863c (Report to Inform Appropriate Assessment); and R.1863d (PSG Comments Review).

[23] ABPmer, 2017b. Habitats Regulations Appraisal of the Draft Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters. Reports for Marine Scotland, ABPmer Report No: R.2121b. 5 May 2017.

screened into the assessment for each of the DPOs, as appropriate. In total there were 12 SPAs and 2 Ramsar sites (see Table C1).

2.3.8 The location of screened in sites within and beyond the 100 km buffer is illustrated in Figures F1 to F5 in Appendix F for each of the above species. The screening table (Table C1) and individual DPO schedules (Tables D1-D17) were updated to acknowledge the findings of these screening principles. To maintain suitable resolution the individual DPO screening maps (Appendix E, E1 to E17) do not present many of the sites beyond the 100 km buffer.

2.3.9 Within the pre-screening report (Appendix A) consideration was given to qualifying bird species within non-UK and Irish sites which are not a qualifying interest feature for UK or Irish sites but could forage and/or migrate internationally. The outline review concluded that there was no potential for LSE on these bird species (Section 4.4.8 of Appendix A). The findings of this review remain appropriate and these species are not considered further.

2.3.10 It is recognised that updates to the above quoted foraging ranges are currently under review, following commission of a package of work by The Crown Estate. Whilst not available for inclusion within the HRA process undertaken to date, consideration of any updates will be incorporated into the iterative project review cycle discussed below.

2.4 Marine Mammals

The methods for screening marine mammal species interest features (cetaceans and pinnipeds) were set out in Section 4.5 of the pre-screening report (Appendix A). For the initial screening, all the relevant SACs and Ramsar sites that are located within the 100 km buffer of the DPOs were included (

2.4.1 Figure 3 and Figure 5). There are four marine mammal species which are qualifying features of UK SACs: grey seal *Halichoerus grypus*, common (harbour) seal *Phoca vitulina*, bottlenose dolphin *Tursiops truncatus* and harbour porpoise *Phocoena phocoena*.

2.4.2 Previous literature reviews carried out for plan-level HRA projects were updated with more recent scientific evidence to investigate whether any potential exists for an LSE on marine mammal interest features within transnational sites (Appendix H). Following advice from SNH (see Appendix B) the screening buffer for seals was revised from 100 km for both species to 50 km and 20 km for common and grey seals, respectively. Hence, the 100 km buffer around the DPOs captured all relevant SAC and Ramsar sites with seal interest features. However, during the screening step applied to European/Ramsar sites that were clearly seaward of a given DPO, seal interest features were screened out from several designated sites if they were more than 50 km (common seal) or 20 km (grey seal) seaward from a DPO e.g. North Rona SAC; Sound of Barra SAC.

2.4.3 Transnational sites were considered for harbour porpoise and bottlenose dolphin as these species range beyond 100 km and, as done with other plan-level HRAs, all UK and non-UK European/Ramsar sites with qualifying

bottlenose dolphin or harbour porpoise interest features located within the appropriate Management Units (MUs) (as defined by the UK Inter-Agency Marine Mammal Working Group[24], where these MUs also contained DPOs, were screened in (Section 4.5, Appendix A).

2.4.4 On this basis, a total of 71 non-UK designated sites, for which harbour porpoise or bottlenose dolphin are a qualifying interest feature species and which lie outwith the 100 km buffer boundary and within a relevant MU, have been screened in.

2.4.5 The location of screened in sites within and beyond the 100 km buffer is illustrated in Figure F6 (harbour porpoise) and Figure F7 (bottlenose dolphin) in Appendix F. The screening table (Table C1) and individual DPO schedules (Tables D1-D17) were updated to acknowledge the findings of these screening principles. To maintain suitable resolution the individual DPO screening maps (Figures E1 to E17) do not present many of the additional screened in sites which are located beyond the 100 km buffer.

2.5 Migratory Fish and Freshwater Pearl Mussel

2.5.1 The methods for screening migratory fish and freshwater pearl mussel sites were set out in Section 4.6 of the pre-screening report (Appendix A). During the initial screening, all relevant SACs and Ramsar sites (those with migratory fish or freshwater pearl mussel qualifying interest features) located within a 100 km buffer of the DPOs remained screened in.

2.5.2 The next step was to ensure that all European/Ramsar sites from within the 'West', 'North West', 'North', 'Shetland' and 'North East' regions that support migratory fish and/or freshwater pearl mussel interest features (as detailed within Section 4.6 of the pre-screening report (Appendix A) were screened in.

2.5.3 The sites that were screened in for migratory fish or freshwater pearl mussel are provided in Figure F8 in Appendix F. The screening table (Table C1) and individual DPO schedules (Tables D1-D17) were updated to acknowledge the findings of these screening principles.

2.6 Otter

2.6.1 The methods for screening otter are set out in Section 4.6 of the pre-screening report (Appendix A). During the initial screening, all relevant SACs and Ramsar sites (those with otter as qualifying interest features) located within a 100 km buffer of the DPOs remained screened in.

2.6.2 Following the initial screening steps, any European/Ramsar sites that support otter and are more than 10 km from the coastline were screened out.

2.6.3 The sites that were screened in for otter are provided in Figure F9 of Appendix F. The screening table (Table C1) and individual DPO schedules

[24] IAMMWG, 2015. Management Units for cetaceans in UK waters (January 2015).

(Tables D1-D17) were updated to acknowledge the findings of these screening principles.

3 Summary of Stage 5

3.1.1 At the pre-screening stage a total of 652 European/Ramsar sites were presented for potential consideration. However, following agreement of the DPO locations, a rationalised screening list based solely on the inclusion of all European/Ramsar sites within a 100 km buffer of the DPOs resulted in 329 sites (Table C1). Additional sites were added or removed according to the screening methodologies, resulting in a total of 468 European/Ramsar sites being taken forward to the assessment.

Table 1. Screening summary

Site	Initial screening list (within 100 km buffer)	Total screened in following further steps
SAC*	142	267
SPA**	138	150
Ramsar	49	51
Total	329	468
*includes all cSACs and SCIs **includes all pSPAs		

3.1.2 Of the 468 sites a total of 107 non-UK sites were screened in due to the presence of features (cetaceans or birds) with ranges that regularly exceed 100 km.

4 Assessment Information (Stage 8)

4.1 Introduction

4.1.1 Acknowledging case-law judgements that took place in 2018, it was recommended that Stages 6 and 7 of the plan-level HRA process were not formally considered (see Section 1.3). Instead the process (as shown in Figure 1) moves from Stage 5 directly to Stage 8 (assessment), followed by consideration of mitigation (Stage 9). Stage 10 encompasses the provision of the draft HRA record (this document) (see Section 1.3).

4.1.2 The following sections of the report (Sections 4 to 10) encompass the assessment of the screened in European/Ramsar sites and the relevant interest features (see Table C1) (Stage 8). This includes consideration of in-combination effects (Section 10) before discussing mitigation and the application of suitable measures at a plan-level (Section 11).

4.1.3 The assessment methodology is detailed within the pre-screening report (Section 4.9, Appendix A). A summary of the key steps is outlined below:

- Step 1: Impact pathways review - Identification of the impact pathways that are relevant for offshore wind development;
- Step 2: Identify activities to which features are sensitive - A review of the activities involved in offshore wind development, and the environmental changes arising, which could have an impact on European/Ramsar sites or interest features via the identified impact pathways;
- Step 3: Activity-based screening of European/Ramsar Sites – Identification (screening) of those European/Ramsar sites and their relevant interest features for which there is a LSE, or for which a LSE cannot be excluded, from the activities and impact pathways;
- Step 4: Detailed pathway-feature sensitivity review - A review of the sensitivities of the relevant interest features to the identified impact pathways and activities; and
- Step 5: Assessment of the potential effects on European/Ramsar sites - Assessment of impacts via each of the activities associated with offshore wind development both alone and in-combination with other extant plans or projects. This is followed by the identification of available plan-level mitigation measures which ensure that the Sectoral Offshore Wind Plan activities have no AEOI.

4.1.4 Steps 1-3 were carried out during the pre-screening (steps 1 and 2) (Appendix A) and screening (step 3) stages (see Sections 2 and 3; and Appendices C and D). The relevant generic impact pathways are as identified in the pre-screening (see Table A1 in Appendix A), as are the individual activities to which features are sensitive (see Table A2 in Appendix A). These tables have been referred to during subsequent steps; however, to facilitate cross-referral the generic impact pathways identified are provided below (Table 2).

Table 2. Generic impact pathways associated with the Draft Plan

Pathway Ref No.	Potential Issue/Sensitivity Category		Impact Pathway	Impact Summary
	Categories to Deterioration or Disturbance	Code	Impacts arising from Plan Activity (Summary Impact Pathway Description)	
1	**Physical Loss/Gain of habitat** (loss of habitat in development footprint)	PLG	Loss of coastal and offshore habitat due to installation of devices, cables and cable armouring from the installation, operation and decommissioning of these structures.	Loss of coastal/offshore seabed within development footprint
2	**Physical Loss/Gain of habitat** (direct change to habitat around the development footprint)	PLG	Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside these areas from associated scour and indirectly from changes to the hydrodynamic regime, as well as from chains anchoring devices disturbing seabed habitat during operation.	Loss of coastal/offshore foraging areas within development footprint
3	**Physical Loss/Gain of habitat** (direct change to habitat around the development footprint)	PLG	Presence of structures on or above seabed for the duration of the project resulting in changes to prey and species behaviour (e.g. acting as FAD (Fish Aggregating Device), artificial reef or bird roost).	Loss or gain of habitat from introduced structures causing species change

Pathway Ref No.	Potential Issue/Sensitivity Category		Impact Pathway	Impact Summary
	Categories to Deterioration or Disturbance	Code	Impacts arising from Plan Activity (Summary Impact Pathway Description)	
4	**Physical Damage to habitat** (indirect and temporary damage to marine habitat)	PD	Changes to coastal and offshore habitat as result of damage from baseline surveys (e.g. boreholes/trawls); from equipment use causing abrasion, damage or smothering during installation and from maintenance and removal of cables/devices (e.g. jack-up legs, vessels, anchors, mooring chain).	Damage to coastal/offshore seabed during all project phases
5	**Physical Damage to habitat** (indirect and longer-term damage to habitat)	PD	Changes to coastal and offshore habitat as a result of alterations to the wave climate or hydrodynamic regime from the presence of devices, power cables or cable armouring causing physical changes (including changes to sediment transport and/or sediment scour.	Damage to coastal/offshore seabed from hydrodynamic changes

Pathway Ref No.	Potential Issue/Sensitivity Category		Impact Pathway	Impact Summary
	Categories to Deterioration or Disturbance	Code	Impacts arising from Plan Activity (Summary Impact Pathway Description)	
6	**Physical Damage to habitat** (indirect and temporary damage to habitat)	PD	Reduction in quality of foraging areas as result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during installation; from maintenance and removal of cables/devices or from scour, sediment transport and hydrodynamic change, and damage from chains anchoring devices during operation.	Damage to coastal/offshore foraging areas during all project phases
7	**Physical Damage to species** (direct and temporary damage to habitat)	PD	Damage to seal haul out locations during the installation, decommissioning and operation of the cables and cable armouring.	Damage to seal haul out from cables or pipelines
8	**Physical Damage to species** (direct damage to species from collision risk)	PD	Collision risk and possible mortality of species due to the presence of devices or from vessels travelling to and from the site (including above and below water collision risk and the influence of lighting); risk of entanglement following a collision with power cables or mooring elements.	Damage to species from collision, entanglement or disorientation

Pathway Ref No.	Potential Issue/Sensitivity Category		Impact Pathway	Impact Summary
	Categories to Deterioration or Disturbance	Code	Impacts arising from Plan Activity (Summary Impact Pathway Description)	
9	**Non-Physical disturbance** (barrier to species movement)	NPD	Presence of structures or disturbance (noise or visual) resulting in a barrier to movement, migratory pathways and/or access to feeding grounds depending on array design.	Disturbance from introduced structures causing barrier to mobile species movement
10	Non-Physical disturbance (disturbance to species)	NPD	Visual disturbance and exclusion from areas as a result of surveying, cable and device installation/operation and decommissioning activities and movements of vessels.	Disturbance (visual) from activities during all project phases
11	Non-Physical disturbance (disturbance to species)	NPD	Noise/vibration disturbance and exclusion from areas as a result of vessels and other activities during survey work (e.g. seismic exploration and geophysical surveys), construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning.	Disturbance (noise) from activities during all project phases
12	Non-Physical disturbance (disturbance to species)	NPD	Impacts from Electromagnetic Fields (EMF) and thermal emissions on benthic invertebrates and electromagnetically sensitive fish and cetaceans interfering with prey location and mate detection in some species and creating barriers to migration.	Disturbance (EMF and thermal emissions) from activities during all project phases

Pathway Ref No.	Potential Issue/Sensitivity Category		Impact Pathway	Impact Summary
	Categories to Deterioration or Disturbance	Code	Impacts arising from Plan Activity (Summary Impact Pathway Description)	
13	**Non-Physical disturbance** (exclusion/ displacement of species)	NPD	Presence of structures resulting in an exclusion/displacement of a species from the area.	Disturbance from introduced structures causing exclusion/ displacement of species
14	**Toxic Contamination** (reduction in water quality)	TC	Spillage of fluids, fuels and/or construction materials during installation or removal of structures (devices and cables) or during survey/maintenance.	Contamination during surveys or maintenance activities
15	**Toxic Contamination** (reduction in water quality)	TC	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (devices and cables).	Contamination during installations/removal of structures
16	Non-Toxic Contamination (elevated turbidity)	NTC	Increase in turbidity (and possibly reduced dissolved oxygen) associated with the release of suspended sediments during installation or removal of structures (devices and cables).	Non-toxic contamination from increases in turbidity
17	**Biological Disturbance** (introduction of non-native species)	BD	Introduction of new structures on the seabed providing new substratum that facilitates the colonisation and ingress of invasive non-native species.	Biological disturbance from non-native species on substratum

Pathway Ref No.	Potential Issue/Sensitivity Category		Impact Pathway	Impact Summary
	Categories to Deterioration or Disturbance	Code	Impacts arising from Plan Activity (Summary Impact Pathway Description)	
18	**Biological Disturbance** (introduction of non-native species)	BD	Introduction and ingress of invasive non-native species as biofouling species on the surfaces of vessels or construction plant.	Biological disturbance from non-native species on vessels

4.1.5 Step 4 considers those relevant project-level activities associated with the Draft Plan that have been screened into the assessment (see Section 4.13, Appendix A). The results are presented in a series of 'pathway-sensitivity' tables, within the main body of this document, for each key interest feature group. During this process, acknowledgement is given to the latest scientific evidence to understand the likely sensitivity of a feature to a specific impact pathway.

4.1.6 The 'pathway-sensitivity' tables are structured according to the standard Natura 2000 sensitivity categories (see Section 3.2.3, Appendix A):

- **Physical Loss/Gain** of habitats from removal or smothering;
- **Physical Damage** of habitats and species from siltation, erosion or physical injury/death;
- **Non-Physical (Indirect) Disturbance** from noise or visual presence and reduced availability or exclusion/displacement of species, including prey;
- **Toxic Contamination** from the introduction of synthetic compounds, introduction of non-synthetic contaminants;
- **Non-Toxic Contamination** from nutrient enrichment, organic enrichment, changes in suspended sediment and turbidity, changes in salinity or changes to the thermal regime; and
- **Biological Disturbance** from introduction of microbial pathogens, the introduction of invasive non-native species and translocation, or from selective extraction of selected species.

4.1.7 The tables indicate which project phases the impact pathways are relevant to (i.e. survey, construction, operation or decommissioning) and the sensitivity levels (high, medium or low) associated with each of these phases. The impact pathway reference numbers are included within each pathway-sensitivity table, these numbers relating to the generic impact pathways identified in Step 1 (see Table 2).

4.1.8 The determination of the sensitivity of a feature to a given impact pathway has considered both the function of the sensitivity to the pressure and also the likely level of exposure. In the case of mobile features an individual may have a high sensitivity to a pressure but exposure to the pressure may be minimal, especially at the population level.

4.1.9 Impact pathways arising as a result of the development footprint are considered to occur in the operational rather than construction phase, reflecting the longer-term nature of the impact.

4.1.10 Step 5 assessed the impacts that could occur via each of the identified pathways against the European/Ramsar site's conservation objectives. However, given the large number of sites screened into the assessment, a series of generic conservation objectives were applied across all sites (see Section 4.14.2, Appendix A).

4.1.11 Based on these generic conservation objectives, the potential effects on the European/Ramsar sites via each of the relevant impact pathways were reviewed. An initial view was then taken about the effect on site integrity of

the Sectoral Offshore Wind Plan both alone and in-combination (Section 10) with other extant plans or projects.

4.1.12 It has already been agreed through discussion with the PSG (Section 2.2.3, Appendix B) that because of the uncertainties associated with the Draft Plan (including the scale and location of future developments within the DPOs and the nature of the future technologies that will be used), it will not be possible to definitively conclude that there will be no AEOI from the Plan. Therefore, there will be a need for appropriate and meaningful mitigation measures to accompany the Draft Plan.

4.1.13 Accordingly, plan-level mitigation measures were identified to avoid an AEOI (Section 11), in fulfilment of Stage 9 of the HRA process (Figure 1). The Draft Plan was then re-assessed following the application of these mitigation measures and the conclusions provided (Section 12).

4.2 Key Issues

4.2.1 For plan-level assessments, it is recognised that there is often limited information on the precise location and scale of development or about the relevant construction methods and associated activities. This is typically the case at a plan-level and while the 17 DPOs have been agreed and their locations are indicated (e.g. see Figure 3), no project-level details are currently available for these DPOs. The uncertainty about project level details has duly been recognised throughout the screening and assessment stages.

4.2.2 The assessment has, therefore, taken account of the likely range of development options and activities based on previous wind energy projects that have been carried out or are proposed. It also acknowledges the potential for floating turbine structures to allow exploitation of deep-water sites.

4.2.3 The Sectoral Marine Plan for Offshore Wind has a relatively broad spatial scope and a long-term temporal component which can each influence the range of potential impacts. The temporal aspects of the Draft Plan's implementation, and the scale of the impacts associated, will also be influenced by technological advances that take place over time with respect to wind energy developments. These will influence the scale of potential impacts as well as the distances offshore that developments can be undertaken while remaining commercially viable. It will also influence the needs for future upgrading of wind generating technologies in established areas. In this context, therefore, it has been essential for these assessments that no specific assumptions about project-level activities (e.g. device type or generation capacity) are made in the absence of available information and that the potential impacts that are identified encompass the full envelope of potential change (through the application of a precautionary approach).

4.2.4 This potential envelope of change has therefore been determined to identify the potential effects on features. On this basis, screening matrices and maps for the individual DPOs (see Appendices D and E) have identified where features within individual sites are at risk of LSE (or where the risk of LSE cannot be excluded). The detailed assessment presented in this report has

built on this screening process by considering the particular environmental pressures/changes that give rise to these risks and then providing a generic assessment of the impact having regard to the typical conservation objectives (see Section 4.14.2, Appendix A).

4.2.5 Based on the approaches adopted for previous plan-level HRA work, the results of this phased assessment work have been presented in a series of tables/matrices throughout the following sections (Section 5 to 9).

5 Potential for Adverse Effects on Habitat Features

5.1 Sites Considered

5.1.1 Following the screening process, a total of 468 European/Ramsar sites were identified for which there is a LSE (or the potential for a LSE cannot be excluded) (Table C1). This large number of European/Ramsar sites were identified as it was not possible to conclude that there would be no LSE from the Draft Plan for some, or all, of the qualifying interest features.

5.1.2 In total there were 267 SACs, SCIs and cSACs, 150 SPAs and pSPAs and a further 51 Ramsar sites with qualifying interest features that were screened in. The relevant qualifying features within these sites included a range of coastal, intertidal and sublittoral habitats (see Section 2.2).

5.1.3 The habitats within SPAs also warrant consideration and they are encompassed within Section 6 (dealing with the impacts to seabird qualifying features).

5.1.4 Given the broad area covered by the Draft Plan and the large number of sites screened into these assessments, the same method as agreed in previous HRAs [25] [26] [27] has been used where it is not necessary to individually review the full list of all sites and the qualifying seabed interest features that they support within the plan-level HRA. However, the individual European/Ramsar sites that were screened in for each of the 17 DPOs are shown in the screening tables (schedules) (Table D1-D17) and individual maps (Figures E1-E17). The locations of qualifying habitats screened in (either directly as features in their own right or because they support other qualifying species, notably seabirds) during the initial screening stages are provided in Figure 3 to Figure 5.

5.1.5 Some of the SAC and Ramsar sites also contained other interest features (i.e. not habitat) for which it could not be concluded that there was no LSE (e.g. bottlenose dolphin or freshwater pearl mussel). These interest features are reviewed separately within the relevant feature group sections.

5.2 Interest Features Summary

5.2.1 In summary, the screening phase concluded that there is a possibility of a LSE (or that it was not possible to conclude no LSE) for a range of Annex I qualifying habitat features which are listed below. For the purposes of this review they have been divided into five broad categories as follows:

[25] ABPmer, 2011a. Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Report for the Scottish Government, ABP Marine Environmental Research Ltd, Report No: R.1722a-c. January 2011.
[26] ABPmer, 2013. Habitats Regulations Appraisal of Draft Plan for Wave and Tidal Energy in Scottish Waters. Reports for Marine Scotland, ABP Marine Environmental Research Ltd, Report No: R.1863a-c. January 2013.
[27] ABPmer, 2017. Habitats Regulations Appraisal of the Draft Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters. Reports for Marine Scotland, ABPmer Report No: R.2121a-c. 5 May 2017.

1) Morphological features encompassing a range of habitats:

- Estuaries (1130) which will encompass sub-feature habitats such as saltmarsh, eelgrass, mussel beds as well as many of the other Annex I habitats that are cited separately below; and
- Large shallow inlets and bays (1160) which, as with estuaries, encompass a range of other feature and sub-feature habitats.

2) Subtidal habitats with typically soft-sediment habitat:

- Subtidal sandbanks (i.e. 'Sandbanks which are slightly covered by seawater at all time' 1110).

3) Subtidal habitats with typically hard-substratum habitat:

- Reefs (1170);
- Submarine structures made by leaking gases (1180); and
- Submerged or partially submerged sea caves (8330).

4) Intertidal habitats (including saltmarshes):

- Intertidal mudflats and sandflats (i.e. 'Mudflats and sandflats not covered by seawater at low tide' 1140);
- Annual vegetation of drift lines (1210);
- *Salicornia* and other annuals colonising mud and sand (1310);
- Spartina swards (1320);
- Atlantic salt meadows (1330); and
- Mediterranean and thermo-Atlantic halophilous scrubs.

5) Supralittoral habitats:

- Coastal lagoons (1150);
- Supralittoral dune habitats encompassing the following
  - 2130 Fixed dunes with herbaceous vegetation (`grey dunes`);
  - 2150 Atlantic decalcified fixed dunes *Calluno-Ulicetea*;
  - 2170 Dunes with Salix repens spp. argentea Salicion arenariae;
  - 2250 Coastal dunes with *Juniperu*s spp;
  - 2120 Shifting dunes along the shoreline with *Ammophila arenaria* (`white dunes`);
- Perennial vegetation of stony banks (1220); and
- Vegetated sea cliffs (1230).

5.2.2 In addition to these habitats, there are individual habitats that are identified within Ramsar citations (e.g. "sand and shingle spit") although these individual features are not listed. There are also sub-features of SACs which include a range of habitats and fish species, see below, which have not been cited as qualifying features:

- Rocky shore communities;
- Kelp forest communities;

- Sublittoral faunal turf communities;
- Mussel bed communities;
- Eelgrass communities;
- Intertidal sea cave communities;
- Subtidal sea cave communities;
- Rocky and coarse sediment shores;
- Extensive reedbeds in the inner Firth of Tay;
- A population of the nationally rare fish 'smelt' (or sparling) in the Firth of Tay;
- Rocky scar communities; and
- Infralittoral gravel and sand communities.

5.2.3 The impact pathways for these supporting features are considered to be the same as for the qualifying habitat interest features with particular distinctions being possible between soft sediment, hard substratum, intertidal and supralittoral categories as identified above. Therefore, the impacts to these specific habitats were not considered separately as part of this assessment.

5.2.4 To assess whether there is any adverse effect on the integrity of the European/Ramsar sites that were identified, the following sections review the sensitivities of these habitat features. Section 1.1 then identifies the conservation objectives for these features and assesses, in tabular format, the effects arising in the context of the proposed additional plan-level mitigation measures. These plan-level mitigation measures are considered in detail within Section 11.

5.2.5 For the purpose of these reviews the qualifying habitat features and sub-features that are listed above have been divided into four distinct categories (reefs, subtidal sandflats, intertidal (including saltmarsh) and supralittoral habitats) which encompass the impact pathways that are relevant for each of the above-listed qualifying habitat features and sub-features. Accordingly, the Annex I habitats 'estuaries' and 'large shallow inlets and bays' are not considered separately as these habitats encompass a range of component features (e.g. saltmarsh, intertidal mudflats, reefs etc.). Hence, the sensitivities of 'estuaries' and' large shallow inlets and bays' are captured through the consideration of these component features

5.3 Sensitivities of Habitat Interest Features to Sectoral Offshore Wind Plan Activities

5.3.1 This section reviews the sensitivities that are relevant for the habitat interest features. Initially a generic review of the sensitivities is presented under each of the following impact pathways identified during the screening phase (see Table 2):

- **Physical Loss/Gain of Habitat** (loss of onshore or offshore habitat);
- **Physical Damage to Habitat** (damage of onshore or offshore habitat);
- **Toxic Contamination** (contamination and spillages);

- **Non-Toxic Contamination** (elevated turbidity); and
- **Biological Disturbance** (introduction of non-native species).

5.3.2 Following this review, the individual characteristics and sensitivities for each of the habitat interest features are presented and reviewed against the relevant Draft Plan activities that could cause a LSE. Information on the relative sensitivities of habitat features have been based on professional judgment and sensitivity assessments available for relevant habitat biotopes on the Marine Life Information Network (MarLIN) website and as presented within the sensitivity matrix that was prepared for Marine Protected Areas and wider marine spatial planning[28]. The interest feature reviews are set out in sections which are representative of the broad categories identified above. The reviews have been used to understand the impact pathways and sensitivities that are pertinent to the full list of habitats screened into this assessment:

- Reefs (hard-substratum);
- Subtidal sandbanks (soft subtidal substratum)
- Intertidal habitats (including mudflats and saltmarshes)
- Supralittoral habitats

5.4 Physical Loss/Gain of Habitat (Loss of Onshore or Offshore Habitat; Impact Pathway 1)

5.4.1 Intertidal, subtidal and supralittoral interest feature habitats are sensitive to a physical loss or gain of habitat at locations where new structures are introduced to, or removed from, the sea bed or coastal habitats (i.e. within the development 'footprint' of these structures). Thus, the key activities that are relevant are those which introduce permanent or temporary structures that lie on or protrude from the seabed and cause a direct loss (whether permanent or temporary) of habitat. For the Draft Plan, one of the main activities causing habitat loss or gain would be the installation, presence and then removal of the foundations for the wind devices on the sea bed where these are located within the area of an interest feature habitat. The selection of DPO locations considered direct footprint with designated sites and although several DPOs abut European/Ramsar sites, none have a direct overlap.

5.4.2 Beyond the DPOs consideration needs to be given to the alignment, installation or removal of cables or cable armouring areas which may also result in direct loss (whether permanent or temporary) of offshore or coastal habitat through excavations. However, the alignments of the cables are not known at this stage and therefore it is unclear which cable routes, if any, will pass through the boundaries of a European/Ramsar site. For this reason, all European/Ramsar sites which support coastal or marine habitat features and

[28] Defra, 2010. Accessing and developing the required biophysical datasets and data layers for Marine Protected Areas network planning and wider marine spatial planning purposes Report No 22 Task 3 Development of a Sensitivity Matrix (pressures-MCZ/MPA features) Final September 2010.

lie within 100 km of each DPO were initially screened in (see Figure 3 to Figure 5).

5.4.3 However, several SAC sites will clearly not have cable alignments passing through them as a result of a DPO (i.e. because they lie well to seaward of a DPO). It was therefore possible to screen out these sites from the HRA. This process screened out SAC sites such as St Kilda; Pisces Reef Complex; North Rona, Darwin Mounds and Wyville Thomson Ridge.

5.4.4 It is recognised that direct loss of habitat can be mitigated, where required, by avoiding habitat interest features within a European/Ramsar site at the project planning and design phase although specific plan-level mitigation measures will be needed to be assured that the relevant considerations are made at a project level (see Section 11).

5.4.5 The sensitivity of the habitats from direct effects (whether from device placement or cabling work) and the magnitude of any effects are dependent on a range of factors such as the habitat type, the extent of habitat affected, the location and the nature of activities (e.g. whether invasive or non-invasive Horizontal Direction Drilling (HDD) approaches can be adopted) and whether the activities are temporary or permanent. In the future, it will also be dependent on technological advances affecting device or cable installation.

5.4.6 It is recognised that the bases for devices or the armouring of cable, provides potential structures for the settlement of reef forming species and thus there could be impacts from both the initial installation and at the removal phase. During a review of offshore windfarms, Wilson *et al.*[29] notes that the marine system is able to adjust to new structures in the sea, with these structures even having the potential to benefit their receiving environment. Work has shown how scour protection and towers may create hard substrata and thus act as artificial reefs, thereby increasing production on these 'reefs' and creating organic material as enrichment for the local marine environment. However, this potential effect needs to be studied in greater detail, as it may be beneficial or adverse depeding on the receiving ecosystem, in order for it to be taken into consideration when undertaking impact assessments on the benthic community.

5.5 Physical Damage to Habitat (Changes to Coastal and Offshore Habitat; Impact Pathways 4 and 5)

5.5.1 Intertidal and subtidal habitats are sensitive to physical damage from a range of activities associated with turbine and cable installation and removal activities. Damage can also occur during baseline survey work, if activities take place in the vicinity of European/Ramsar site interest features and where they involve the physical retrieval of samples or bed materials, such as borehole surveys or ecological trawl sampling. Where devices require piling, surveys to assess subsurface geological structure and suitability for installation can involve the collection of many cores and the use of drilling

[29] Wilson, J.C., Elliott M., Cutts N.D, Mander L., Mendão V., Perez-Dominguez 1 R., and Phelps, A. 2010. Coastal and Offshore Wind Energy Generation: Is It Environmentally Benign? Energies, Vol 3, pp. 1383-1422.

equipment from jack-up barges; this all being in addition to activities associated with the installation of the device.

5.5.2 The construction activities will cause damage to the seabed outwith the direct footprint. Such activities could include the use of jack-up legs, piling, and activities involved in cable installation. They can also include the clearance of algae from areas of the seabed to allow for the construction work.

5.5.3 During the operational phase, the presence of the structures (turbine base, cable armouring, anchorages etc.) have the potential to cause scour effects in soft sediment systems. The mooring chains associated with anchored turbines also have the potential to cause abrasion of the adjacent substratum. The magnitude of the scour effects will depend on the size of the structures and the associated risk will depend upon the composition of the seabed substratum, the hydrodynamic conditions, and the distance of the structures from European/Ramsar site interest feature habitats.

5.5.4 A distance of one tidal ellipse away from a DPO (see Section 2.2 and Figure 6) was used to determine the maximum likely distance that water, or any material in suspension or solution it may contain, might be tidally transported from a given location. Evidence from plume studies indicates that even fine particles mobilised from the seabed settle out again to a large extent within the distance of one tidal excursion. Hence, the tidal excursion zone around the DPOs illustrates an area that may be indirectly affected by changes to hydrodynamics and sediment transport, this in turn potentially leading to changes in suspended sediment concentrations and water quality.

5.5.5 The tidal ellipse boundary extends from the edge of a DPO and is shown on the individual figures for each DPO (Figures E1-E17). Due to the uncertainties of cable alignments, only those sites which have been screened out, based on their location being definitively outwith the route of any cabling (see Section 2.2), yet were still within a single tidal excursion, would be screened back in. However, this did not apply to any European/Ramsar sites.

5.5.6 There are also sensitivities to activities associated with maintenance visits because the vessels used may cause small-scale localised damage from shipwash or from chains and anchors. The magnitude of effects will be dependent upon the amount of vessel activity as well as the size and speed of the vessels with the risk being dependent upon the distance of such activities from the European/Ramsar site interest features (which will determine the extent of exposure to any change).

5.5.7 For all the above activities, the rate at which habitats recover from damage will also be a key factor influencing the magnitude of any effects. Reef features for instance are likely to be more sensitive to impacts and take longer to recover than subtidal sandflats.

5.6 Toxic Contamination (Contamination and Spillages; Impact Pathways 14 and 15)

5.6.1 Intertidal and subtidal interest feature habitats are sensitive to toxic contamination i.e. where concentrations of contaminants exceed sensitivity thresholds for a given feature. Contamination can occur from the release of fuels, oils, construction material into the environment during construction or decommissioning. Where contaminated sediment is released or disturbed during development activities there is also the potential for toxic effects on ecological features.

5.6.2 Spillage of oils and fluids from construction vessels and machinery into the marine environment could adversely affect sediment or water quality potentially impacting upon benthic communities. In addition, areas of sediment being excavated or disturbed for the installation/removal of turbines or cables will cause an increase in suspended sediment concentrations over the period of the activity. Where this release of suspended sediments occurs then the potential also exists for the release of sediment-bound contaminants in areas where such contaminants are present. Sediment contamination is most likely to occur inshore, in the vicinity of ongoing or historic industrial locations, particularly within estuaries. For offshore activities, then sediment -bound contaminants are less likely to be an issue, therefore disturbance of sediment has less potential to lead to a LSE on relevant interest features.

5.6.3 The likelihood of mobilising sediments and contaminated sediments and the magnitude of any effect is dependent upon the level of contamination; the proximity of the windfarm activity to the European/Ramsar site(s); the type of activity occurring; the manner in which that activity is pursued (including the extent and duration); the particle size of the disturbed sediments and the hydrodynamic conditions.

5.6.4 It has been indicated that settlement of sediment is most likely to occur within 20-200 m of a cable for a wind farm[30]. However, contaminants are almost always associated with fine sediments which could travel further than 200 m in areas where there is a large tidal excursion and strong tidal flows. However, over greater distances, concentrations of contaminants are less likely to be significant due to increased dilution.

5.7 Non-Toxic Contamination (Elevated Turbidity; Impact Pathway 16)

5.7.1 Increases in suspended sediment concentrations, from construction and decommissioning activities, are typically expected to result in short-term, localised changes in the marine environment. In the event of substantial sediment resuspension, then the potential exists for consequent sediment settlement to cause a smothering effect upon the seabed. In particular, dredging related activities (excavation and disposal) are likely to cause

[30] BERR, 2008. Review of cabling techniques and environmental effects applicable to the offshore wind farm industry - Technical Report. BERR. [cited in Entec UK Ltd, 2009a].

smothering effects seabed features. Settlement of coarse material is most likely to occur within 20-200 m from the point of resuspension[31]. Therefore, the potential for significant smothering effects will reduce at distances beyond 200 m.

5.8 Biological Disturbance (Introduction of Non-Native Species; Impact Pathways 17 and 18)

5.8.1 The introduction of new surfaces such as turbine bases, cable armouring or anchorages (or the clearing of seabed habitats to allow the introduction of these components) has the potential to facilitate the establishment of invasive non-native species through the colonisation of these surfaces. This assumes that the current spread of such invasive species is limited by the prevailing physical regime and lack of new and suitable substrata for colonisation. Therefore, any development which causes changes in physical processes, provides new space for colonisation or vectors for transportation of non-native species has the potential to result in biological disturbance from this impact pathway. This impact has the greatest potential to occur during the construction and decommissioning phases, where movement of vessels may provide a suitable vector for transportation of invasive non-native species.

5.9 Reef Sensitivity Review

5.9.1 Reefs can be either biogenic concretions or of geogenic origin[32]. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions of corallogenic organisms. The sensitivities of this Annex I habitat to the relevant draft Plan activities that might affect it are shown in Table 3. The highest sensitivity relates to direct habitat loss because, in instances where turbines or cables are placed on qualifying reef feature habitats, then an effect must occur.

[31] BERR, 2008. Review of cabling techniques and environmental effects applicable to the offshore wind farm industry - Technical Report. BERR. [cited in Entec UK Ltd, 2009a].

[32] EC, 2007. Interpretation Manual of European Union Habitats (EUR27) Appendix 1 http://ec.europa.eu/environment/nature/natura2000/marine/docs/appendix_1_habitat.pdf.

Table 3. Potential sensitivities of reef features to the Draft Plan. Pathway ref no. relates to Table 2.

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PLG	Physical Loss/Gain of habitat	1	Loss of coastal and offshore habitat under the footprint of turbines, cables and cable armouring from the installation, operation and decommissioning of these structures.	No Impact	No Impact	HS	No Impact
PD	Physical Damage to habitat	4	Changes to coastal and offshore habitat as a result of damage from baseline surveys (e.g. boreholes/trawls); from equipment use causing abrasion, damage or smothering during installation and from maintenance and removal of cables/devices (e.g. jack-up legs, vessels, anchors, mooring chain).	LS	MS	LS	LS
PD	Physical Damage to habitat	5	Changes to coastal and offshore habitat as a result of alterations to the wave climate or hydrodynamic regime from the presence of devices or cable armouring causing physical changes (including changes to sediment transport and/or sediment scour).	No Impact	No Impact	LMS	No Impact

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
TC	Toxic Contamination (Reduction in water quality)	14	Spillage of fluids, fuels and/or construction materials during installation or removal of structures (turbines and cables) or during survey/maintenance.	LS	LS	LS	LS
TC	Toxic Contamination (Reduction in water quality)	15	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (turbines and cables).	No Impact	LS	No Impact	LS
NTC	Non-Toxic Contamination (Elevated turbidity)	16	Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (turbines and cables).	No Impact	LMS	No Impact	LMS
BD	Biological Disturbance (Introduction of non-native species)	17	Introduction of new structures providing new substratum that facilitates the colonisation and ingress of invasive non-native species.	No Impact	No Impact	LMS	No Impact
BD	Biological Disturbance (Introduction of non-native species)	18	Introduction and ingress of invasive non-native species as biofouling species on the surfaces of vessels or construction plant.	LS	LS	LS	LS
In this table, only the estimated sensitivity levels are shown. The level of risk will be dependent upon exposure. For instance, there would be a high degree of exposure for European/Ramsar site habitats were a development to occur within							

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
	or near to a European/Ramsar site. However, at the present time, there is uncertainty regarding the degree of exposure and a worst-case assumption has been made.						
	LS: Low Sensitivity						
	LMS: Low to Medium Sensitivity						
	MS: Medium Sensitivity						
	HS: High Sensitivity						

5.10 Subtidal Sandbanks Sensitivity Review

5.10.1 Sandbanks are defined as elevated, elongated, rounded or irregular topographic features, permanently submerged and predominantly surrounded by deeper water[33]. They consist mainly of sandy sediments, but larger grain sizes, including boulders and cobbles, or smaller grain sizes including mud may also be present on a sandbank. Banks where sandy sediments occur in a layer over hard substrata are classed as sandbanks if the associated biota are dependent on the sand rather than on the underlying hard substrata. "*Slightly covered by sea water all the time*" means that above a sandbank the water depth is seldom more than 20 m below chart datum. Sandbanks can, however, extend beneath 20 m below chart datum. It can, therefore, be appropriate to include in designations such areas where they are part of the feature and host its biological assemblages. The sensitivities of this Annex I feature to particular activities that it might be affected by are shown in **Table 4**.These are very much the same as for reef features although there is a recognition that soft sediment habitats will have a lower sensitivity to sediment smothering events during construction work.

[33] EC, 2007. Interpretation Manual of European Union Habitats (EUR27) Appendix 1 http://ec.europa.eu/environment/nature/natura2000/marine/docs/appendix_1_habitat.pdf.

Table 4. Potential sensitivities of the subtidal sandbank feature to the Draft Plan. Pathway ref no. relates to Table 2.

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PLG	Physical Loss/Gain of habitat	1	Loss of coastal and offshore habitat under the footprint of turbines, cables and cable armouring from the installation, operation and decommissioning of these structures.	No Impact	No Impact	HS	No Impact
PD	Physical Damage to habitat	4	Changes to coastal and offshore habitat as result of damage from baseline surveys (e.g. boreholes/trawls); from equipment use causing abrasion, damage or smothering during installation and from maintenance and removal of cables/devices (e.g. jack-up legs, vessels, anchors, mooring chain).	LS	LS	LS	LS
PD	Physical Damage to habitat	5	Changes to coastal and offshore habitat as a result of alterations to the wave climate or hydrodynamic regime from the presence of devices or cable armouring causing physical changes (including changes to sediment transport and/or sediment scour).	No Impact	No Impact	LS	No Impact
TC	Toxic Contamination (Reduction in water quality)	14	Spillage of fluids, fuels and/or construction materials during installation or removal of	LS	LS	LS	LS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
			structures (turbines and cables) or during survey/maintenance.				
TC	Toxic Contamination (Reduction in water quality)	15	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (turbines and cables).	No Impact	LS	No Impact	LS
NTC	Non-Toxic Contamination (Elevated turbidity)	16	Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (turbines and cables).	No Impact	LS	No Impact	LS
BD	Biological Disturbance (Introduction of non-native species)	17	Introduction of new structures providing new substratum that facilitates the colonisation and ingress of invasive non-native species.	No Impact	No Impact	LMS	No Impact
BD	Biological Disturbance (Introduction of non-native species)	18	Introduction and ingress of invasive non-native species as biofouling species on the surfaces of vessels or construction plant.	LS	LS	LS	LS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
In this table, only the estimated sensitivity levels are shown. The level of risk will be dependent upon exposure. For instance, there would be a high degree of exposure for European/Ramsar site habitats were a development to occur within or near to a European/Ramsar site. However, at the present time, there is uncertainty regarding the degree of exposure and a worst-case assumption has been made.							
LS: Low Sensitivity							
LMS: Low to Medium Sensitivity							
MS: Medium Sensitivity							
HS: High Sensitivity							

5.11 Intertidal Habitats (Including Saltmarshes) Sensitivity Review

5.11.1 Intertidal mudflats and sandflats are defined as the sands and muds of the coasts of the oceans, their connected seas and associated lagoons, not covered by sea water at low tide, devoid of vascular plants, usually coated by blue-green algae and diatoms[34]. They are of particular importance as feeding grounds for wildfowl and waders. Saltmarshes occur in stable intertidal environments typically with fine sediment above the mean high-water neap level where vascular plants can survive and can further stabilise the habitat[35]. Once a cover of vegetation has become established the rate of sedimentation (accretion) often increases as more of the incoming sediment is intercepted and trapped by the increased surface roughness. In addition, the vegetation also reduces the resuspension of deposited material and, at the same time, organic matter is added to the marsh surface.

There is a range of Annex I saltmarsh habitats depending upon the tidal height and vegetation type and these are as listed in Section 2.2. The sensitivities of these habitats to the activity that might affect it are shown in **Table 5.** This sensitivities table is similar to those for soft sediment sandbank habitats with the impacts being associated principally with the laying of cables across the intertidal areas. Again, the highest sensitivity relates to direct habitat loss because, in instances where devices or cables are placed on qualifying intertidal habitats, then an effect must occur.

[34] EC, 2007. Interpretation Manual of European Union Habitats (EUR27) Appendix 1 http://ec.europa.eu/environment/nature/natura2000/marine/docs/appendix_1_habitat.pdf.

[35] Boorman, L.A. 2003. Saltmarsh Review. An overview of coastal saltmarshes, their dynamic and sensitivity characteristics for conservation and management, JNCC, Peterborough.

Table 5. Potential sensitivities of intertidal habitats to the Draft Plan. Pathway ref no. relates to Table 2.

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PLG	Physical Loss/Gain of habitat	1	Loss of coastal and offshore habitat under the footprint of turbines, cables and cable armouring from the installation, operation and decommissioning of these structures.	No Impact	No Impact	HS	No Impact
PD	Physical Damage to habitat	4	Changes to coastal and offshore habitat as result of damage from baseline surveys (e.g. boreholes/trawls); from equipment use causing abrasion, damage or smothering during installation and from maintenance and removal of cables/devices (e.g. jack-up legs, vessels, anchors, mooring chain).	LS	MS	LS	MS
PD	Physical Damage to habitat	5	Changes to coastal and offshore habitat as a result of alterations to the wave climate or hydrodynamic regime from the presence of devices or cable armouring causing physical changes (including changes to sediment transport and/or sediment scour).	No Impact	No Impact	LS	No Impact
TC	Toxic Contamination (Reduction in water quality)	14	Spillage of fluids, fuels and/or construction materials during installation or removal of	LS	LS	LS	LS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
			structures (turbines and cables) or during survey/maintenance.				
TC	Toxic Contamination (Reduction in water quality)	15	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (turbines and cables).	No Impact	LS	No Impact	LS
NTC	Non-Toxic Contamination (Elevated turbidity)	16	Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (turbines and cables).	No Impact	LS	No Impact	LS
BD	Biological Disturbance (Introduction of non-native species)	17	Introduction of new structures providing new substratum that facilitates the colonisation and ingress of invasive non-native species.	No Impact	No Impact	LS	No Impact
BD	Biological Disturbance (Introduction of non-native species)	18	Introduction and ingress of invasive non-native species as biofouling species on the surfaces of vessels or construction plant.	LS	LS	LS	LS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
In this table, only the estimated sensitivity levels are shown. The level of risk will be dependent upon exposure. For instance, there would be a high degree of exposure for European/Ramsar site habitats were a development to occur within or near to a European/Ramsar site. However, at the present time, there is uncertainty regarding the degree of exposure and a worst-case assumption has been made.							
LS: Low Sensitivity							
LMS: Low to Medium Sensitivity							
MS: Medium Sensitivity							
HS: High Sensitivity							

5.12 Supralittoral Habitat Sensitivity Review

5.12.1 Coastal habitat interest features were scoped into the assessment because they could be affected by cable laying operations or other landside works such as an onshore hydroelectric plant. The relevant qualifying habitat features include dune habitats, vegetated cliffs and coastal lagoons (see Section 2.2). The sensitivities of these habitats to the activity that might affect them are shown in Table 6. In each case issues such as the impacts associated with surveys or hydrodynamic effects are not relevant and it is mainly the potential habitat loss/damage from cabling installations. The potential for a construction spillage is relevant at all cable laying locations while the issue of sediment resuspension will also be pertinent for lagoonal habitats.

Table 6. Potential sensitivities of supralittoral habitats to the draft Plan. Pathway ref no. relates to Table 2

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommissi on
PLG	Physical Loss/Gain of habitat	1	Loss of coastal and offshore habitat under the footprint of turbines, cables and cable armouring from the installation, operation and decommissioning of these structures.	No Impact	No Impact	HS	No Impact
PD	Physical Damage to habitat	4	Changes to coastal and offshore habitat as result of damage from baseline surveys (e.g. boreholes/trawls); from equipment use causing abrasion; damage or smothering during installation and from maintenance and removal of cables/devices (e.g. jack-up legs, vessels, anchors, mooring chain).	No Impact	MS	LS	MS
TC	Toxic Contamination (Reduction in water quality)	14	Spillage of fluids, fuels and/or construction materials during installation or removal of structures (turbines and cables) or during survey/maintenance.	LS	LS	LS	LS
TC	Toxic Contamination (Reduction in water quality)	15	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (turbines and cables).	No Impact	LS	No Impact	LS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommissi on
NTC	Non-Toxic Contamination (Elevated turbidity)	16	Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (turbines and cables).	No Impact	LS	No Impact	LS
In this table, only the estimated sensitivity levels are shown. The level of risk will be dependent upon exposure. For instance, there would be a high degree of exposure for European/Ramsar site habitats were a development to occur within or near to a European/Ramsar site. However, at the present time, there is uncertainty regarding the degree of exposure and a worst-case assumption has been made.							
LS: Low Sensitivity							
LMS: Low to Medium Sensitivity							
MS: Medium Sensitivity							
HS: High Sensitivity							

5.13 Potential Effects on European/Ramsar Sites from the Draft Plan

5.13.1 On the basis of the sensitivities of the relevant interest features the following sections review the generic conservation objectives for these features and the potential effects arising for each of the European/Ramsar sites.

5.13.2 The conservation objectives for the qualifying habitats that are relevant to this HRA will be very similar and in many instances identical for all European/Ramsar sites that have been screened in. The relevant objectives seek to avoid deterioration of the qualifying habitats, ultimately ensuring that the integrity of the site is maintained, and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features. As discussed in Section 2.2, it is appropriate to apply generic objectives for this plan-level HRA.

5.13.3 The conservation objectives ensure that for qualifying habitats the following are maintained in the long term:

- Extent of the habitat within the site;
- Distribution of the habitat within the site;
- Structure and function of the habitat;
- Processes supporting the habitat;
- Distribution of typical species of the habitat;
- Viability of typical species as components of the habitat; and
- No significant disturbance of typical species of the habitat.

5.13.4 Taking account of these conservation objectives and the plan-level activities to which the key interest features are sensitive, this section reviews the effects of the draft Plan on the integrity of the European/Ramsar sites. The results are presented in Table 7.

Table 7. Assessment of the potential effects of the Draft Plan on habitat features of relevant European/Ramsar sites

Screened-in sites with these qualifying features are provided in Table C1				**Is There an Adverse Effect on Integrity on any European/Ramsar sites**	**Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?**
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Morphological Features encompassing a range of habitats ▪ Subtidal habitats with typically soft-sediment habitat ▪ Subtidal habitats with typically hard-substratum habitat (Reefs) ▪ Intertidal habitats (including saltmarshes) ▪ Supralittoral habitats	**Physical Loss/Gain of habitat** Loss of coastal and offshore habitat under the footprint of devices, cables and cable armouring from the installation, operation and decommissioning of these structures.	1	**Sensitivity Level(s)** maximum considered to be high (see Tables 3-6 for detail and colour code) Commentary/ Review None of the DPOs directly overlap with European/Ramsar sites so there would be no direct habitat loss from development within the boundaries of the DPOs. However, it is assumed that cable alignment and landfall have the potential for LSE, as a result of physical loss/gain of qualifying habitat features. It is expected, however, that during the early stages in the design of any development, a primary consideration will be to try and avoid habitats within a European/Ramsar site and minimise exposure and risk. Effects can be mitigated through careful routeing of cables and choice of landfalls as well as using installation methods such as HDD at the landfall. **Relevant Conservation Objectives** (see Section 5.13) Of the 7 objectives, the majority are considered to be relevant to impacts from the loss/gain during the operational phase of the project with only the objective relating to the processes affecting habitats being less pertinent. Therefore, the following 6 objectives all need to be considered. Extent of the habitat on site; Distribution of the habitat within site; Structure and function of the habitat; Distribution of typical species of the habitat; Viability of typical species as components of the habitat; and No significant disturbance of typical species of the habitat.	Possibility of an adverse effect on integrity Further work would be required at project-level to ascertain LSE. However, in advance of considering mitigation measures, it cannot be concluded that there will be no AEOI on any European/Ramsar sites. This is because of the inherent uncertainties such as: • the detail of the Plan implementation process; • future generation capacities; • the location, scale and densities of development; • the proposed technologies to be used and future advances in these technologies; • the scale of the effects arising via some of the defined impact pathways; and • the efficacy of some project-level mitigation options.	No adverse effect on integrity With the application of appropriate and meaningful mitigation measures to accompany the Plan (see Section 11), there will be no AEOI.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity on any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Morphological Features encompassing a range of habitats ▪ Subtidal habitats with typically soft-sediment habitat ▪ Subtidal habitats with typically hard-substratum habitat (Reefs) ▪ Intertidal habitats (including saltmarshes) ▪ Supralittoral habitats	**Physical Damage to habitat** Changes to coastal and offshore habitat as result of damage from baseline surveys (e.g. boreholes/trawls); from equipment use causing abrasion, damage or smothering during installation and from maintenance and removal of cables/devices (e.g. jack-up legs, vessels, anchors, mooring chain).	4	**Sensitivity Level(s)** maximum considered to be medium (see Tables 3-6 for detail and colour code) **Commentary/ Review** During the survey phases of a development, for the most part, any changes are likely to be localised and of short-term consequence due to the small amount of material extracted for research and the short duration of activity compared to construction. The developmental works during installation, maintenance and decommissioning are likely to be more significant but in general, most of the construction activities of concern, such as the use of jack-up legs, piling and activities involved in cable installation, are still likely to result in short-term, localised changes to the marine environment (e.g. increased suspended sediments and turbidity, disturbance of contaminated sediments and direct disturbance). The disposal of construction material from shoreline installations and piled devices also has the potential to damage habitats if, for example, sediment deposition occurs on habitat features. The effects of the main construction activities and the cable routeing are likely to be temporary and localised and with careful alignment of cables, unlikely to have any adverse effect on the integrity of a European/Ramsar site. Relevant Conservation Objectives (see Section 5.13) Of the 7 objectives, the majority are considered to be relevant to impacts from physical damage during construction and decommissioning work however the following 4 are most pertinent because they relate to the composition and distribution of the habitats and species present rather than the broader extent, structure, function of the habitats and the processes affecting them: Distribution of the habitat within site; Distribution of typical species of the habitat; Viability of typical species as components of the habitat; and No significant disturbance of typical species of the habitat.	As above	As above
▪ Morphological Features	**Physical Damage to habitat**	5	**Sensitivity Level(s)** maximum considered to be low-medium (see Tables 3-6 for detail and colour code)	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity on any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
encompassing a range of habitats ▪ Subtidal habitats with typically soft-sediment habitat ▪ Subtidal habitats with typically hard-substratum habitat (Reefs) ▪ Intertidal habitats (including saltmarshes)	Changes to coastal and offshore habitat as a result of alterations to the wave climate or hydrodynamic regime from the presence of devices or cable armouring causing physical changes (including changes to sediment transport and/or sediment scour).		**Commentary/ Review** The extent of the effects arising will be greatly influenced by the type and location of the devices that are introduced. Deposition of fine sediments may occur in areas of reduced tidal flow and scouring of benthic communities may result on the seabed around the base of turbines. Cumulative impacts from multiple devices are likely to be additive. The extent of this effect has been defined within this HRA (based on past work for the R3OWF) as the area that extends to one tidal excursion distance from the DPO. The effects of scour around devices and their associated moorings is generally of low significance and would be highly localised and therefore unlikely to result in any changes to European/Ramsar sites. Resultant changes in coastal processes and, potentially, sediment transport are likely to have the greatest risks of impact in areas of medium to high energy. Consideration of the potential changes to processes would need understanding during project level HRAs.		
			Relevant Conservation Objectives (see Section 5.13) Of the 7 objectives the majority are considered are considered to be relevant to impacts from hydrodynamic changes during the operational phase of the project because the potential exists to alter the balance extent and functionality of habitats and species. Therefore, all objectives need to be considered: ▪ Extent of the habitat on site; ▪ Distribution of the habitat within site; ▪ Structure and function of the habitat; ▪ Processes supporting the habitat; ▪ Distribution of typical species of the habitat; ▪ Viability of typical species as components of the habitat; and ▪ No significant disturbance of typical species of the habitat.		
▪ Morphological Features encompassing a range of habitats	**Toxic Contamination** (Reduction in water quality)	14	**Sensitivity Level(s)** maximum considered to be low (see Tables 3-6 for detail and colour code)	As above	As above
			Commentary/ Review For all stages of the work from the construction to decommissioning and including operational/maintenance works, there is the potential for accidental discharges/spillages from machinery and vessels associated with the development,		

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity on any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Subtidal habitats with typically soft-sediment habitat ▪ Subtidal habitats with typically hard-substratum habitat (Reefs) ▪ Intertidal habitats (including saltmarshes) ▪ Supralittoral habitats	Spillage of fluids, fuels and/or construction materials during installation or removal of structures (devices and cables) or during survey/maintenance.		although the likelihood of spillages occurring is comparatively low. This is because there are several standard navigational safety measures employed within the marine environment which reduce the likelihood of spillages occurring and limit the effects should they occur. Given the above and acknowledging that none of the DPOs overlap with European/Ramsar sites, with development within European/Ramsar sites limited to cable routeing and landfall activities, the risk from this impact pathway is considered low. **Relevant Conservation Objectives** (see Section 5.13) The conservation objectives are designed to avoid deterioration of the qualifying habitats thus ensuring that the integrity of the site is maintained. As they are broad-ranging and generic in their scope most activities have the potential to lead to a failure of most, if not all, objectives. Of the 7 generic objectives listed, the following are considered to be most relevant to impacts from toxic contamination/spillage events because they relate to the composition and distribution of the species present rather than the broader extent, distribution and functionality of habitats and the processes affecting them: Distribution of typical species of the habitat; Viability of typical species as components of the habitat; and No significant disturbance of typical species of the habitat.		
▪ Morphological Features encompassing a range of habitats ▪ Subtidal habitats with typically soft-sediment habitat	**Toxic Contamination** (Reduction in water quality Release of contaminants associated with the dispersion of suspended sediments during	15	**Sensitivity Level(s)** maximum considered to be low (see Tables 3-6 for detail and colour code) **Commentary/ Review** There is a low likelihood of contaminated sediments occurring within the DPOs as these are generally sited away from industrial inputs. The receiving waterbody will also provide high levels of dilution to any contaminants at locations away from the coast. Inshore cable routes and landfalls may be located in areas of finer sediments which could have elevated levels of contaminants. Risks can be effectively mitigated through careful routeing of cables and choice of landfalls as well las using installation methods such as HDD at the landfall.	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity on any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Subtidal habitats with typically hard-substratum habitat (Reefs) ▪ Intertidal habitats (including saltmarshes) ▪ Supralittoral habitats	installation or removal of structures (devices and cables).		**Relevant Conservation Objectives** (see Section 5.13) Of the 7 objectives, the following are considered to be most relevant to impacts from toxic contamination events because they relate to the composition and distribution of the species present rather than the broader extent, distribution and functionality of habitats and the processes affecting them: Distribution of typical species of the habitat; Viability of typical species as components of the habitat; and No significant disturbance of typical species of the habitat.		
▪ Morphological Features encompassing a range of habitats ▪ Subtidal habitats with typically soft-sediment habitat ▪ Subtidal habitats with typically hard-substratum habitat (Reefs) ▪ Intertidal habitats (including saltmarshes)	**Non-Toxic Contamination** (Elevated turbidity) Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (devices and cables).	16	**Sensitivity Level(s)** maximum considered to be low-medium (see Tables 3-6 for detail and colour code) **Commentary/ Review** Any excavation work associated with the installation of turbines or cables has the potential (depending on the *in-situ* sediment type) to cause redistribution of sediment and potentially adverse effects on surrounding habitats. The extent of this effect has been defined within this HRA (based on past plan-level HRA work) as the area that extends to one tidal excursion distance of the DPO. None of the DPOs overlap with European/Ramsar sites, with development within European/Ramsar sites limited to cable routeing and landfall activities. However, the tidal excursion of several DPOs extends into a European/Ramsar site. The disposal of construction material from installations and piled devices also has the potential to increase turbidity levels. The effects from this impact pathway will be temporary and localised and with appropriate site selection unlikely to have any adverse effect on the integrity of a European/Ramsar site. **Relevant Conservation Objectives** (see Section 5.13) Of the 7 objectives, the following are considered to be most relevant to impacts from non-toxic contamination events because they relate to the composition and distribution of the species present rather than the broader extent, distribution and functionality of habitats and the processes affecting them: ▪ Distribution of typical species of the habitat; ▪ Viability of typical species as components of the habitat; and ▪ No significant disturbance of typical species of the habitat.	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity on any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Morphological Features encompassing a range of habitats ▪ Subtidal habitats with typically soft-sediment habitat ▪ Subtidal habitats with typically hard-substratum habitat (Reefs) ▪ Intertidal habitats (including saltmarshes)	**Biological Disturbance** (Introduction of non-native species) Introduction of new structures providing new substratum that facilitates the colonisation and ingress of invasive non-native species.	17	**Sensitivity Level(s)** maximum considered to be low-medium (see Tables 3-6 for detail and colour code) **Commentary/ Review** None of the DPOs overlap with European/Ramsar sites, with development within European/Ramsar sites limited to cable routeing and landfall activities. The placement of structures underwater introduces new, and initially barren, surfaces which have the potential to facilitate the spread of invasive non-native species where, in the absence of competition from indigenous species they are potentially able to colonise these structures. It is difficult to quantify the risk of introduction of invasive non-native species. On the assumption that the current spread of such species is limited by the prevailing physical regime and the lack of new colonizing substrate, the options which cause the greatest change in physical processes and provide the greatest colonizing space would be expected to pose the greatest risk. **Relevant Conservation Objectives** (see Section 5.13) Of the 7 objectives listed, the following 3 are considered to be most relevant to impacts from invasive species introductions because they have the potential to affect the balance of species within the habitats: ▪ Distribution of typical species of the habitat; ▪ Viability of typical species as components of the habitat; and ▪ No significant disturbance of typical species of the habitat.	As above	As above
▪ Morphological Features encompassing a range of habitats ▪ Subtidal habitats with typically soft-sediment habitat ▪ Subtidal habitats with typically hard-	**Biological Disturbance** (Introduction of non-native species) Introduction and ingress of invasive non-native species as biofouling species on the surfaces of vessels or construction plant.	18	**Sensitivity Level(s)** maximum considered to be low (see Tables 3-6 for detail and colour code) **Commentary/ Review** The possibility also exists that invasive non-native species could be introduced on the vessels and equipment that are used to construct, maintain or decommission the turbines. The likelihood of this occurrence is considered to be low because all such equipment is expected to be efficiently maintained and cleaned at regular intervals. However, it will be dependent upon this inspection regime being in place and on the provenance of the vessels and equipment being used. Any development will require a biosecurity plan which will outline measures to reduce the risk of introduction and spread of invasive non-native species. **Relevant Conservation Objectives** (see Section 5.13)	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity on any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
substratum habitat (Reefs) ▪ Intertidal habitats (including saltmarshes)			Of the 7 objectives listed, the following 3 are considered to be most relevant to impacts from invasive species introductions because they have the potential to affect the balance of species within the habitats: ▪ Distribution of typical species of the habitat; ▪ Viability of typical species as components of the habitat; and ▪ No significant disturbance of typical species of the habitat.		

6 Potential for Adverse Effects on Bird Features

6.1 Introduction

6.1.1 Following the screening process, a total of 468 European/Ramsar sites was identified for which there is a LSE (or the potential for a LSE cannot be excluded). Of these sites, a large number of European/Ramsar sites were identified at which it was not possible to conclude that there would be no LSE from the Draft Plan for some, or all, of the qualifying bird interest features. In total there were 135 SPAs, 15 pSPAs and a further 51 Ramsar Sites with qualifying bird or habitat interest features that were screened in.

6.1.2 Given the broad area covered by the Draft Plan and the large number of sites screened into these assessments, the method adopted aligns with that carried out in previous HRAs (e.g. [36] [37] [38]). Essentially an individual review of the full list of screened in sites and the qualifying bird interest features that they support, has not been done. However, acknowledging recent consultation responses to project level HRAs for offshore wind development in Moray, Forth and Tay regions issued in 2018, consideration at a regional level has been given to the potential for cumulative effects on identified seabird species of concern (see Section 11).

6.1.3 The individual sites that were screened in for each of the 17 DPOs are shown in the screening tables (schedules) and maps (Tables D1-D17; Figures E1-E17). The locations of the SPA and Ramsar sites which were screened in are also provided in Figure 4 and Figure 5.

6.1.4 The SPA and Ramsar sites also contained other interest features for which it could not be concluded that there was no LSE (e.g. eelgrass) and/or the habitats within them are an important component of the functionality of the European/Ramsar sites (e.g. because they provide foraging ground for bird species) and therefore have assigned conservation objectives. The effects on these other features are reviewed separately under the relevant assessment section(s) of this report that deal with these other habitat/species groups.

6.1.5 In summary, the screening phase concluded that there is a possibility of a LSE (or that it was not possible to conclude no LSE) to qualifying bird interest features. To assess whether there is any adverse effect on the integrity of relevant European/Ramsar sites, the following sections review the sensitivities of the associated bird features, identify the conservation

[36] ABPmer, 2013f. Habitats Regulations Appraisal of Draft Plan for Wave and Tidal Energy (W&TE) in Scottish Waters. Report for Marine Scotland 2013; ABP Marine Environmental Research Ltd, Final Report January 2013 Report Nos. R.1863a (Pre-Screening); R.1863b (Screening); and R.1863c (Report to Inform Appropriate Assessment); and R.1863d (PSG Comments Review).

[37] ABPmer, 2011a. Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Report for the Scottish Government, ABP Marine Environmental Research Ltd, Report No: R.1722a-c. January 2011.

[38] ABPmer, 2017. Habitats Regulations Appraisal of the Draft Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters. Reports for Marine Scotland, ABPmer Report No: R.2121a-c. 5 May 2017.

objectives and assess, in tabular format, the effects arising in the context of the proposed plan-level mitigation measures.

6.2 Sensitivities of Bird Interest Features to the Sectoral Offshore Wind Plan Activities

6.2.1 This section reviews the sensitivities that are relevant for the qualifying bird interest features. A generic review of the sensitivities of relevant bird features is presented under the impact pathways identified during the screening phase (see Table 2):

- Physical Loss/Gain of Habitat (Foraging and Onshore Habitat Loss);
- Physical Loss/Gain of Habitat (Fish Aggregation or Artificial Reef);
- Physical Damage to Habitat (Reduction in Habitat Quality);
- Physical Damage to Species (Collision Risk);
- Non-Physical Disturbance (Noise/Visual Disturbance Causing Exclusion Effects);
- Toxic Contamination (Contamination and Spillages); and
- Non-Toxic Contamination (Increased Turbidity).

6.2.2 Following this review, the general characteristics and sensitivities of relevant bird interest features are presented and reviewed against the Draft Plan activities that could cause a LSE.

6.2.3 It should be noted throughout this section that different species will have different sensitivities to effects according to several factors including:

- Whether they forage by diving or at the surface;
- Whether they forage nocturnally/crepuscularly or diurnally; and
- Whether they are ground/burrow/crevice-nesting species or cliff-nesters.

6.2.4 A categorisation of species, taken from Garthe, S. & Hüppop, O.[39] is summarised in Table 8. Recent discussion in Furness *et al*[40], has recognised that in some cases there may be a lack of evidence regarding nocturnal activities, therefore any future project level HRAs should consider individual species behaviour and current research.

[39] Garthe, S. & Hüppop, O. 2004 Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology, 41, 724 - 734.

[40] Furness, Robert & Garthe, Stefan & Trinder, Mark & Matthiopoulos, Jason & Wanless, Sarah & Jeglinski, Jana. (2018). Nocturnal flight activity of northern gannets Morus bassanus and implications for modelling collision risk at offshore wind farms. Environmental Impact Assessment Review. 73. 1-6. 10.1016/j.eiar.2018.06.006.

Table 8. Breeding/foraging parameters of breeding seabirds which influence sensitivities

Breeding Receptors	Foraging Mode	Nocturnal Flight/Diving Activity	Nesting Location
Red-throated Diver	Pursuit-diver	No	Ground
N. Fulmar	Surface feeder	Yes	Cliff
Manx Shearwater	Surface/Pursuit-diver	Yes	Burrow/crevice
Storm Petrel	Surface feeder	Yes	Burrow/crevice
Leach's Petrel	Surface feeder	Yes	Burrow/crevice
Gannet	Plunge/Pursuit-diver	No	Ground/cliff
Cormorant	Pursuit-diver	No	Cliff/above ground
Shag	Pursuit-diver	No	Cliff
Common Scoter	Diver/Pursuit-diver	No	Ground
Arctic Skua	Surface feeder	No	Ground
Great Skua	Surface feeder	No	Ground
Herring Gull	Surface feeder	Yes	Ground
Great B-b Gull	Surface feeder	Yes	Ground
B. L. Kittiwake	Surface feeder	Yes	Cliff
Arctic Tern	Surface feeder	No	Ground
Guillemot	Pursuit-diver	Crepuscular	Cliff
Razorbill	Pursuit-diver	Crepuscular	Cliff
A. Puffin	Pursuit-diver	Crepuscular	Burrow/crevice

(Sources: Gaston and Jones[41]; Garthe and Hüppop[42])

6.3 Physical Loss/Gain of Habitat (Foraging and Onshore Habitat Loss; Impact Pathway 2)

6.3.1 Seabed habitat important for foraging seabirds and their prey may be lost as a result of the installation of cables and devices. Similar temporary losses of habitat will also occur during decommissioning. The risk and magnitude of such direct effects on the seabed habitats will be dependent on a range of factors such as the habitat type, the extent of habitat affected, the location and the nature of activities and whether they are temporary or permanent.

6.3.2 Although the direct loss of terrestrial habitats as a result of cable installation or any landside infrastructure works also poses a risk, the potential effects

[41] Gaston, A.J. & Jones, I.L. 1998. The Auks. Oxford University Press, Oxford, New York.
[42] Garthe, S. & Hüppop, O. 2004 Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology, 41, 724 - 734.

from terrestrial development are outside the scope of the plan level HRA. Loss of breeding habitat within any European/Ramsar site would result in a significant effect likely to be more detrimental than any loss of foraging habitat. Wintering waterbird species (such as Bar-tailed Godwit, Purple Sandpiper, Turnstone, Ringed Plover and Sanderling) may also be affected by any loss of intertidal habitat due to onshore activities, such as cable routeing, associated with the scheme.

6.3.3 The direct loss of seabed habitat may affect all seabird species considered in this assessment due to effects on the availability of their prey; seabirds will be affected most during construction and operation phases. In advance of any details about exposure levels, birds are considered to have a high sensitivity during these phases.

6.3.4 However, while all species are considered to be of high sensitivity to this risk, sites would only occupy a small proportion of foraging ranges and avoid key feeding areas, therefore the residual significance of such effects would likely be at most medium.

6.4 Physical Loss/Gain of Habitat (Fish Aggregation or Artificial Reef; Impact Pathway 3)

6.4.1 The installation of devices on the seabed, could generate localised new habitat for fish and benthic communities i.e. Fish Aggregation Devices (FADs) or artificial reefs. This in turn could affect the prey availability in the immediate vicinity of the devices and create new foraging opportunities for diving species. The extent of this effect is unknown, though it is likely to be small for all species and if it attracts seabirds there may be an increased risk of collision (see Section 6.5). Structures may provide habitat for seabirds, such as gulls and terns, to perch or rest on, or even potential breeding locations. Species are considered to have a low sensitivity to the creation of new habitat in this manner.

6.5 Physical Damage to Habitat (Reduction in Habitat Quality; Impact Pathway 6)

6.5.1 The potential exists for damage to occur on intertidal and offshore habitats with implications for breeding sites, overwintering areas or foraging habitats. In advance of any details about the exposure levels the sensitivities of seabirds are considered to be medium to such effects especially during the construction and decommissioning phases when activities on site will be greatest.

6.6 Physical Damage to Species (Collision Risk; Impact Pathway 8)

6.6.1 Seabirds could potentially collide with structures both above and below the sea-surface during surveying, construction, operation and decommissioning of wind turbines. Collision risk and mortality will depend on a range of factors related to bird species, abundance, foraging modes (e.g. locations and methods), foraging timings (e.g. day or night), topography, weather conditions the value of the area as a feeding ground, the consistency with which it is used for foraging and the nature (especially the underwater mobility) of the structures themselves including the use of lighting for above-surface components[43]. The following sections consider collision risk during the surveying, construction and decommissioning phases and then the operational phase.

6.6.2 Collisions underwater could occur during baseline surveys involving the physical retrieval of samples or bed materials, including borehole surveying or ecological trawl sampling. There is also a risk of birds colliding above the water with machinery and vessels during the construction phase of all energy sectors, and whilst birds are generally manoeuvrable, they are nonetheless at risk, especially during the night. Although many breeding birds remain at their nest sites on land at night, some may roost at sea [44]. However, the collision risk with vessels is thought to be minimal, and operational construction vessels pose less threat than commercial shipping due to slow travelling speeds. The sensitivity of seabirds to collision risk during the surveying, construction and decommissioning is considered to be low.

6.6.3 A number of studies have investigated the collision risks to birds from offshore wind turbines [45] [46] [47] [48] [49] [50] [51]. Many of these studies agree that

[43] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.
[44] Gaston, A.J. 2004. Seabirds: A Natural History. Christopher Helm A & C Black, London, UK.
[45] Krijgsveld, K.L., R. Lensink, H. Schekkerman, P. Wiersma, M.J.M. Poot, E.H.W.G. Meesters & S. Dirksen, 2005. Baseline studies North Sea wind farms: fluxes, flight paths and altitudes of flying birds 2003 - 2004. Report 05-041. Bureau Waardenburg, Culemborg.
[46] Krijgsveld, K.L., R.C. Fijn, M. Japink, P.W. van Horssen, C. Heunks, M.P. Collier, M.J.M. Poot, D. Beuker & S. Dirksen, 2011. Effect studies Offshore Wind farm Egmond aan Zee: Final report on fluxes, flight altitudes and behaviour of flying birds. Report 10-219. Bureau Waardenburg, Culemborg
[47] Cook, A.S., Johnston, A., Wright, L.J., and Burton, N.H. 2012. A review of flight heights and avoidance rates of birds in relation to offshore wind farms. Strategic Ornithological Support Services: Project SOSS-02. BTO and The Crown Estate.
[48] Furness, R.W., Wade, H.M., & Masden E.A. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management. 119; 56-66.
[49] Bradbury, G., Trinder, M., Furness, B., Banks, A.N., Caldow, R.W.G., Hume, D. 2014. Mapping Seabird Sensitivity to Offshore Wind Farms. PLoS ONE 9(9): e106366. https://doi.org/10.1371/journal.pone.0106366.
[50] Johnston, A., Cook, A., Wright, L., Humphreys, E., Burton, N. 2014. Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology 51, 31–41.
[51] Cook, A.S., Ward, R.M., Hansen, W.S., Larsen, L., 2018. Estimating Seabird Flight Height using LiDAR Scottish Marine and Freshwater Science Vol 9 No 14, 59pp. DOI: 10.7489/12131-1.

collision risk is influenced by various factors but is largely driven by the proportion of birds flying at collision risk height [52].

6.6.4 Some bird species are considered to be at a lower risk of collision as they typically fly at low altitudes (above the sea surface and below the swept area of the turbines)[53]. However, other bird species (such as large gulls and Gannets) have a higher potential collision risk, as they typically fly at higher altitudes and travel large distances between breeding and wintering grounds. For example, 35% of Herring Gull flights have been recorded at blade height[54].

6.6.5 Cook *et al.*[55] found the following species to be particularly prone to collisions with turbines: Northern Gannet, Black-legged Kittiwake, Lesser Black-backed Gull, Herring Gull and Great Black-backed Gull. The Offshore Renewables Joint Industry Programme (ORJIP) study recorded up to six bird species that collided with turbines: Black-legged Kittiwake, Lesser/Great Black-backed Gull, unidentified large gull and other unidentified gulls[56]. Furness *et al.*[57], considering both collision and displacement risk, suggested that the key seabird species most affected by offshore windfarm developments included Red-throated Diver, Northern Gannet, Manx Shearwater, Arctic Skua, Great Skua, Lesser-black Backed Gull, Herring Gull, Great Black-backed Gull, Black-legged Kittiwake, Sandwich Tern, Common Tern, Common Guillemot, Razorbill, Atlantic Puffin.

6.6.6 Studies often disagree about the proportions of each species time spent at the 'collision risk height'. These discrepancies reflect the varying sampling methods used (such as LiDAR and bird tagging) and the factors impacting flight height. Flight height is influenced by various criteria, such as wind speed, wind direction, precipitation, time of the day, season, distance to coast, foraging, habitat type and spatial arrangement, migration, offshore wind farms. Flight height also varies between species and is dependent on a bird's activity and life-history stage[58].

6.6.7 The other factors that are considered to be important in predicting collision rates include manoeuvrability, bird density, flight speed and flight height distribution [59]. McGregor *et al.* [60] accounted for dynamic bird speeds

[52] Furness, R.W., Wade, H.M., & Masden E.A. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management. 119; 56-66.
[53] Jongbloed, R.H. 2016. Flight height of seabirds. A literature study IMARES. Report C024/16.
[54] Furness, R.W., Wade, H.M., & Masden E.A. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management. 119; 56-66.
[55] Cook, A.S., Humphreys, E.M., Masden, E.A., Burton, N.H. 2014. The Avoidance Rates of Collision Between Birds and Offshore Turbines. Scottish Marine and Freshwater Science Volume 5 Number 16.
[56] Bowgen, K., and Cook, A. 2018. Bird collision avaoidance: Empirical evidence and impact assessments. JNCC Report No. 614, JNCC, Peterborough, ISSN 0963-8091.
[57] Furness, R.W., Wade, H.M., & Masden E.A. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management. 119; 56-66.
[58] Jongbloed, R.H. 2016. Flight height of seabirds. A literature study IMARES. Report C024/16.
[59] Masden, E. 2015. Scottish Marine and Freshwater Science Vol 6 No 14: Developing an avian collision risk model to incorporate variability and uncertainty. Published by Marine Scotland Science. DOI: 10.7489/1659-1. http://www.scotland.gov.uk/Resource/0048/00486433.pdf.
[60] McGregor, R., King, S., Donovan, C., Caneco, B., Webb, A. 2018. A Stochastic collision risk model for seabirds in flight.

(affected by avoidance behaviour) and turbine speeds to enable improved stochastic collision risk models.

6.6.8 Models (in particular the Band model) [61] have been used to estimate collision risk, however, as more empirical datasets have become available, both assumptions and these parameters have been tested. The recent ORJIP study[62], was set up to collect data on seabird collision and avoidance rates at an operational wind farm. The study concluded that collision risk is likely to be lower than some previous studies and models have estimated.

6.6.9 Other research concurs with the ORJIP study, suggesting that birds adapt their flight paths to avoid collision with turbines[63] with generally very high avoidance of turbines exhibited by seabirds [64]. WWT [65] have shown that most seabirds are not expected to be at risk because of these avoidance rates. While work by Cook *et al.*[66] suggested that birds rarely pass close to the rotor blades.

6.6.10 However, changing behaviour presents other challenges and risks to birds, in the following ways: firstly, by avoidance (of the area covered by windfarms, turbines or blades) birds are displaced from their normal habitat (habitat loss), and secondly, by barrier effects, where they adapt their behaviour, thus increasing flight times and losing energy[67]. The potential effects from these non-physical impacts are considered below.

6.6.11 At this time the sensitivity of seabirds to collision risk during the operational phase is considered to be medium; however, it is acknowledged that this is a developing area of research with several recent studies indicating a much greater avoidance behaviour than has previously been assumed and/or modelled. In addition, further details on exposure levels will be needed to fully understand site-specific risk levels. Sensitivities at a population-level are also likely to be inherently lower than for individuals.

Species sensitivities to collision risk

6.6.12 All species scoped into this assessment are at some risk of collision during the survey, construction, operation, and decommissioning phases but this will vary according to the nature of the environment, and species foraging modes.

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[61] Band, B. 2012. Using a collision risk model to assess bird collision risks for offshore windfarms. Project SOSS-02. Report to the Crown Estate. pp62.

[62] Bowgen, K., and Cook, A. 2018. Bird collision avaoidance: Empirical evidence and impact assessments. JNCC Report No. 614, JNCC, Peterborough, ISSN 0963-8091.

[63] Jongbloed, R.H. 2016. Flight height of seabirds. A literature study IMARES. Report C024/16.

[64] Skov, H., Heinänen, S., Norman, T., Ward, R.M., Méndez-Roldán, S., Ellis, I. 2018. ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust. 247 pp.

[65] WWT, 2014. Strategic assessment of collision risk of Scottish offshore wind farms to migrating birds. Scottish Marine and Freshwater Science Report Vol 5 No 12.

[66] Cook, A.S., Humphreys, E.M., Masden, E.A., Burton, N.H. 2014. The Avoidance Rates of Collision Between Birds and Offshore Turbines. Scottish Marine and Freshwater Science Volume 5 Number 16.

[67] Furness, R.W., Wade, H.M., & Masden E.A. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management. 119; 56-66.

6.6.13 Those species which forage during dusk/dawn or at night are possibly at a greater risk from collision with wind turbines than those who forage during daylight hours, albeit that the impact of foraging period on sensitivity is less than the impact of flight height (Table 8). Shag, for example, forage only during daylight, whereas a proportion of foraging activity of Guillemots and Razorbills occurs around dawn and dusk [68] [69] [70] [71]. Manx Shearwaters and both UK petrel species arrive at breeding burrows overnight, thus travelling at sea overnight, and potentially increasing collision risk. This may be further exacerbated by their low flight height.

6.6.14 Overall, it is generally agreed that the large gulls such as Great Black-Backed Gull, Herring Gull and Lesser Black-Backed Gull as well as Northern Gannet and Black-legged Kittiwake are the most sensitive to the risk of collision mortality [72] [73]. These species all tending to spend a comparatively higher proportion of their flying time at an altitude that overlaps with blade height [74].

6.6.15 Collision rates are variable and while an accurate quantitative understanding about the impacts is not possible, Collision Risk Modelling (CRM) tools (e.g. Band model) have been extensively used for both onshore and offshore sites globally, including a range of UK offshore developments e.g. DECC[75]. These models can provide useful numerical predictions but as they are dependent on the parameters and avoidance rate for individual species, they need to be specific to developments. The models are also highly sensitive to assumptions on avoidance rates which, as some recent studies suggest, may be higher than previously thought [76] [77].

6.6.16 Avoidance can occur at various stages of the flightpath, including macro, meso or micro scales: Macro-scale responses are behavioural responses to the presence of the windfarm, occurring at distances greater than 500 m

[68] Daunt, F., Camphuysen, C.J., Humphreys, E.M., Hamer, K.C., Wanless, S. and Skov, H. 2005. Local/daily scale hydrography, prey and seabird interactions. In Understanding Marine Food-web Processes: an Ecosystem Approach to Sustainable Sandeel Fisheries in the North Sea: IMPRESS Final Report (e.d. C.J. Camphuysen), pp 163-180. NIOZ-rapport, 2005-5, NIOZ, Texel, Netherlands.

[69] Daunt, F., Wanless, S., Peters, G., Benvenuti, S., Sharples, J., Grémillet, D. and Scott, B. 2006. Impacts of oceanography on the foraging dynamics of seabirds in the North Sea. In Top Predators in Marine Ecosystems: Their Role in Monitoring and Management (eds I. Boyd, S. Wanless & C.J. Camphuysen), pp 177-190. Cambridge University Press, Cambridge, UK.

[70] Thaxter, C.B., Daunt, F., Hamer, K.C., Watanuki, Y., Harris, M.P., Grémillet, D., Peters, G., Wanless, S. 2009. Sex-specific food provisioning in a monomorphic seabird, the Common Guillemot Uria aalge: nest defence, foraging efficiency or parental effort? Journal of Avian biology 40:75-84.

[71] Thaxter, C.B., Wanless, S., Daunt, F., Harris, M.P., Benvenuti, S., Watanuki, Y., Grémillet, D., Hamer, K.C. 2010. Influence of wing loading on trade off between pursuit-diving and flight in Common Guillemots and razorbills. J.Exp. Biol. 213: 1018-1025.

[72] Marine Scotland. 2012. Vulnerability of Scottish Seabirds to Offshore Wind Turbines. Prepared by MacArthur Green Ltd (Furness and Wade).

[73] Furness, R.W., Wade, H.M., & Masden E.A. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management. 119; 56-66.

[74] Marine Scotland. 2012. Vulnerability of Scottish Seabirds to Offshore Wind Turbines. Prepared by MacArthur Green Ltd (Furness and Wade).

[75] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.

[76] Bowgen, K., and Cook, A. 2018. Bird collision avaoidance: Empirical evidence and impact assessments. JNCC Report No. 614, JNCC, Peterborough, ISSN 0963-8091.

[77] Skov, H., Heinänen, S., Norman, T., Ward, R.M., Méndez-Roldán, S., Ellis, I. 2018. ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust. 247 pp.

from the base of the outermost turbines. Meso-scale responses are responses to individual turbines occurring between the base of each turbine and the windfarm perimeter (defined as 500 m from the base of the outermost turbines). Micro-scale avoidance is the 'last-second' action taken to avoid collision, which is considered to occur within 10 m of the turbine rotor blades[78].

6.6.17 Bird avoidance is mainly thought to occur at the meso-scale[79] [80]. In contrast, very few birds are thought to fly close enough to turbines to require micro-avoidance behaviour [81] [82] [83] [84].

6.6.18 Whilst Bowgen and Cook [85] have recommended updated collision factors to the Band model, they also suggest that the best model available is still the Band model. This is because the impact of windfarms varies according to such factors as the different seabird species present, their distribution, the geographical area and the time of year, in addition to many other variables.

6.6.19 Bowgen and Cook [86] emphasise the importance of site-specific data (e.g. distribution of key species) and behaviours exhibited during the breeding season in determining the true risk to bird species. It has been suggested that bird avoidance rates may be lower during the breeding season[87].

6.6.20 The distribution of seabird species is determined by density-dependent competition, habitat accessibility and coastal geometry, and habitat availability. For example, Kittiwakes are generally found in offshore waters, tending to forage over long distances (tens to hundreds of kilometres from their colonies) [88].

6.6.21 Vanermen *et al.*[89] showed how seabirds react differently to windfarms: BACI studies in a Belgian offshore windfarm suggest that Northern Gannet,

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[78] Cook, A.S., Humphreys, E.M., Masden, E.A., Burton, N.H. 2014. The Avoidance Rates of Collision Between Birds and Offshore Turbines. Scottish Marine and Freshwater Science Volume 5 Number 16.

[79] ibid

[80] Bowgen, K., and Cook, A. 2018. Bird collision avaoidance: Empirical evidence and impact assessments. JNCC Report No. 614, JNCC, Peterborough, ISSN 0963-8091.

[81] Krijgsveld, K.L., R.C. Fijn, M. Japink, P.W. van Horssen, C. Heunks, M.P. Collier, M.J.M. Poot, D. Beuker & S. Dirksen, 2011. Effect studies Offshore Wind farm Egmond aan Zee: Final report on fluxes, flight altitudes and behaviour of flying birds. Report 10-219. Bureau Waardenburg, Culemborg

[82] Thaxter, C.B., Ross-Smith, V.H., Bouten, W., Masden, E.A., Clark, N.A., Conway, G.J., Barber, L., Clewley, G., Burton, N.H.K., 2018. Dodging the blades: new insights into three-dimensional area use of offshore wind farms by lesser black-backed gulls *Larus fuscus*. Marine Ecology Progress Series 587, 247-253.

[83] Mendel, B., J. Kotzerka, J. Sommerfeld, H. Schwemmer, N. Sonntag & S. Garthe. 2014. Effects of the offshore test site Alpha Ventus on distribution patterns, behaviour and flight heights of seabirds. Chapter in StUK-plus publication.

[84] Bowgen, K., and Cook, A. 2018. Bird collision avoidance: Empirical evidence and impact assessments. JNCC Report No. 614, JNCC, Peterborough, ISSN 0963-8091.

[85] ibid

[86] Bowgen, K., and Cook, A. 2018. Bird collision avoidance: Empirical evidence and impact assessments. JNCC Report No. 614, JNCC, Peterborough, ISSN 0963-8091.

[87] Cook, A.S., Humphreys, E.M., Masden, E.A., Burton, N.H. 2014. The Avoidance Rates of Collision Between Birds and Offshore Turbines. Scottish Marine and Freshwater Science Volume 5 Number 16.

[88] Wakefield, E., Owen, E., Baer, J., Carroll, M., Daunt, F., Dodd, S., Green, J., Guilford, T., Mavor, R., Miller, P., Newell, M., Newton, S., Robertson, G., Shoji, A.,
Wardle, C.S. 1986. Fish behaviour and fishing gear. In: Pitcher T.J. (ed) The behaviour of Teleost fishes. Croom Helm Ltd, London, UK, p 463-495.

[89] Vanerme, N., Onkelinx, T., Courtens, W., Van de walle, M., Verstraete, H., Stienen, E. 2015. Seabird avoidance and attraction at an offshore wind farm in the Belgian part of the North Sea, Hydrobiologia 756, 51-61.

Common Guillemot and Razorbill avoid the windfarm area whereas, Lesser Black-backed Gull and Herring Gull were attracted to the windfarm and their abundance increased. Similarly, the Common Gull, Black-legged Kittiwake and Great Black-backed Gull also frequented the wind farm.

6.6.22 The migratory and foraging behaviour of many bird species makes assessment of collision risk difficult. Identifying distinct flyway paths is complex both because of the nature and limitations of available information and because movements are likely to occur across broad fronts rather than along clearly definable routes. Variables involved in flight direction include:

- Spatial variation in food abundance (including anthropogenic factors such as fishing vessels);
- The risk of predation/kleptoparasitism by other bird species;
- The importance of nest attending to incubate eggs and protect the nest from predators; and
- Weather and climatological factors.

6.6.23 The RSPB is currently progressing research to map the variation in seabird collision risk around the UK for at least one priority seabird species (Kittiwake). The project will take account of how behaviour affects collision risk and combine this with population modelling to estimate which seabird colonies within SPAs are most at risk from existing developments. Also, those areas where new development would have the greatest (and lowest) impacts on the species in question will be identified. Although the RSPB project is not due for completion until autumn 2019, the RSPB will seek to provide relevant outputs from their study to assist with the plan-level HRA as it progresses through the Iterative Plan Review process (see Section 11).

6.6.24 A literature review encompassing *inter alia* foraging behaviour, was carried out (Appendix G). The results of the FAME (The Future of the Atlantic Marine Environment) study programme indicate the variability of foraging routes and feeding sites. For example, Northern Gannets have been observed repeatedly foraging over a narrow range of bearings in the North Sea. Conversely, in the Celtic Sea birds from a smaller site did not exhibit this behaviour. It was concluded that differences in the consistency of foraging locations were mainly related to differences in the spatial and temporal predictability of prey resources in the two study areas [90].

6.6.25 As highlighted by Bowgen and Cook[91], a fuller understanding of bird collision risk requires site-specific data to inform models and the assessment. Although generic data on bird sensitivities provides a starting point, the potential collision risk to seabirds cannot be fully realised without additional baseline data specific to the proposed location.

[90] Hamer, K. C., Humphreys, E. M., Garthe, S., Hennicke, J., Peters, G., Grémillet, D., Phillips, R. A., Harris, M. P., & Wanless, S. (2007). Annual variation in diets, feeding locations and foraging behaviour of gannets in the North Sea: flexibility, consistency and constraint. Mar Ecol Prog Ser 338: 295-305.

[91] Bowgen, K., and Cook, A. 2018. Bird collision avoidance: Empirical evidence and impact assessments. JNCC Report No. 614, JNCC, Peterborough, ISSN 0963-8091.

Lighting

6.6.26 Lighting has the potential to influence the risk of seabird collision with devices. In particular, this issue has been given a lot of consideration as part of investigations into the collision risk posed by tall wind turbines (>200m) where the above-water collision risk is clearly much greater. Early work carried out by [92] found that lights on tall communication towers attracted migratory birds which often resulted in collision. A more recent study also found strong positive link between lighting and collision rate [93]. Therefore, it has been concluded that offshore wind turbines, when lit at night, could pose a risk that is similar to communication towers [94].

6.6.27 Navigational lighting has also been identified as having the potential to increase collision risk. Studies of different species have indicated that altering the type of lighting (e.g. flashing/strobing) and/or the light's colour spectrum can reduce the risk of attracting birds and therefore reduce such collision risks.

6.7 Non-Physical Disturbance (Noise/Visual Disturbance Causing Exclusion Effects; Pathways 9, 10,11 and 13)

6.7.1 Wind turbines could create a barrier effect to birds, resulting in deviations in their flight route to avoid the structures [95]. Griffin *et al.* [96] observed birds apparently exhibiting avoidance behaviour near operational wind farms at Robin Rigg and Barrow by increasing flight height.

6.7.2 At Nysted offshore wind farm in the western Baltic, radar studies have indicated a high degree of avoidance by Eider and other large waterbirds during migration[97].

6.7.3 An output from this work is shown below (Image 1), the black lines indicate migrating waterbird flocks and the red dots indicate the wind turbines. There was a significant reduction in migration tracking densities within the wind farm area post-construction [98]. During this study avoidance response differences were also observed during daylight and at night. Nocturnally migrating waterfowl over Denmark and the Netherlands have also been

[92] Cochran, W.W., and Graber, R.R. 1958. Attraction of nocturnal migrants by lights on a television tower. Wilson Bulletin, 70: 378-380.
[93] Evans, W. R. and Manville, A. M. 2000. Avian mortality at communication towers. Ithaca, New York: Cornell University.
[94] Ecology Consulting 2001 Assessment of the effects of offshore wind farms on birds. ETSU W/13/00565/1434 http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file20258.pdf
[95] Desholm, M and Kahlert, J. 2005. Avian Collision Risk at an Offshore Wind Farm. Biology Letters 1: 296-298.
[96] Griffin L., Rees E., and Hughes B. 2010. The Migration of Whooper Swans in Relation to Offshore Wind Farms Final Report to COWRIE Ltd. March 2010 (COWRIE Project Code: SWAN-06-08).
[97] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.
[98] Desholm, M and Kahlert, J. 2005. Avian Collision Risk at an Offshore Wind Farm. Biology Letters 1: 296-298.

observed to detect and avoid turbines, with avoidance distances greater during darker nights [99] [100].

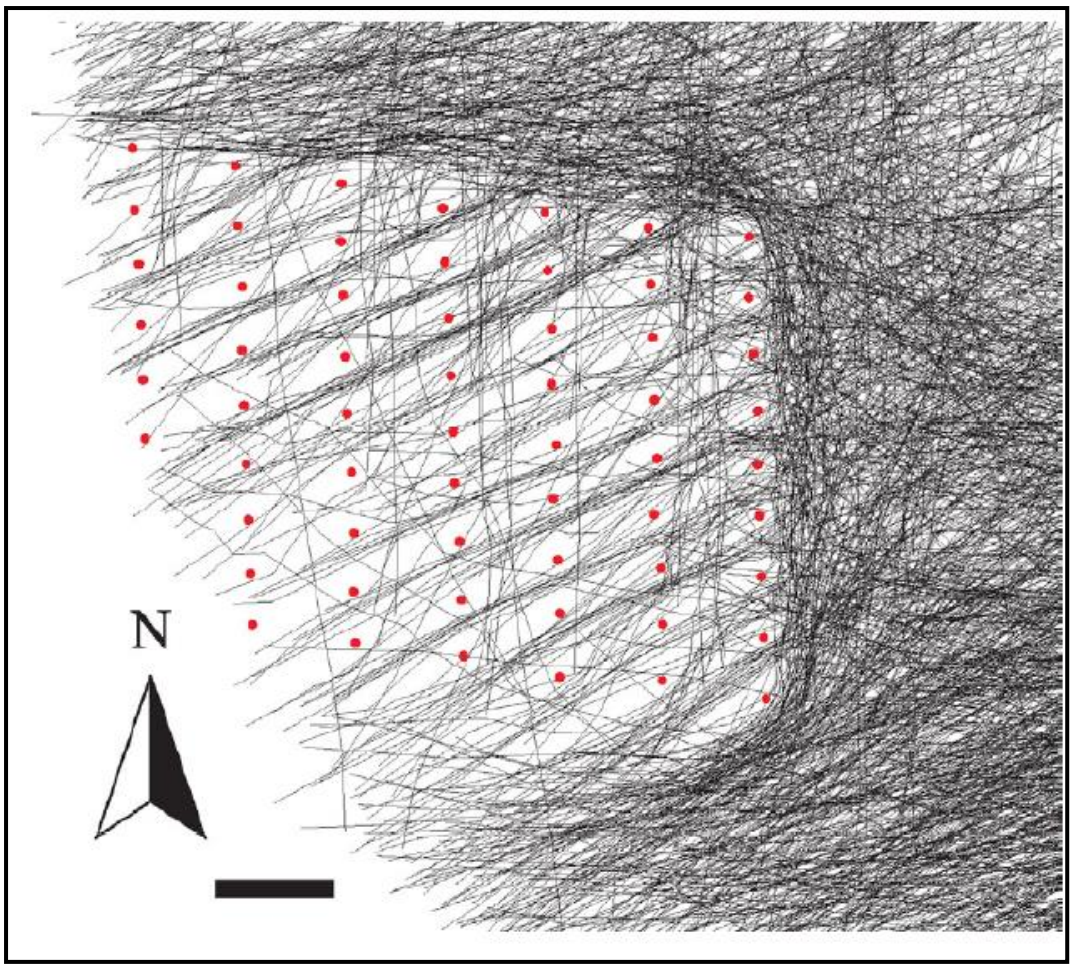

Image 1. Westerly oriented flight trajectories during the initial operation of the wind turbines at Nysted Offshore Wind Farm (scale bar indicates a distance of 1km). Source: Desholm and Kahlert[101]

6.7.4 Following construction of an offshore wind farm site at Tunø Knob in the Danish Kattegat, the number of Common Scoters and Eiders decreased in the two years following construction. However, Eider numbers subsequently increased, possibly due to birds habituating to the wind farm or as a result of the increased abundance of mussels [102]. Later work found that Eider reacted

[99] Dirksen S., Van der Winden J. and Spaans A.L. 1998. Nocturnal collision risks of birds with wind turbines in tidal and semi offshore areas. In Ratto CF and Solari G (eds). Wind Energy and Landscape. Rotterdam: Balkema, 99-108pp.
[100] Dirksen S., Spaans A.L. and Van der Winden J. 2000. Studies on Nocturnal Flight Paths and Altitudes of Waterbirds in Relation to Wind Turbines: A Review of Current Research in the Netherlands. In Proceedings of the National Avian-Wind Power Planning Meeting III, San Diego, California, May 2000. Prepared for the National Wind Coordinating Committee. Ontario: LGL Ltd.
[101] Desholm, M and Kahlert, J. 2005. Avian Collision Risk at an Offshore Wind Farm. Biology Letters 1: 296-298.
[102] Drewitt A.L. and Langston R.H. 2006. Assessing the impacts of wind farms on birds. Ibis 148, 29-42.

strongly to the presence of wind turbines, interpreted to be a consequence of this species' high-flying speed and low manoeuvrability [103].

6.7.5 Following construction of Horns Rev Offshore Wind Farm aerial surveys found that divers, Guillemots, Gannets, Razorbills and Common Scoters all occurred in lower numbers than expected in the wind farm area following construction. Conversely, gulls and terns showed a preference for the wind farm area following construction [104]. Again, it is recognised that these changes may reflect habituation to wind turbine presence or may be as a result of changes in food availability rather than displacement by disturbance [105].

6.7.6 Little is known about the sensitivity of bird species to barrier effects and their ability to alter flight heights. However, avoidance behaviour may lead to the possibility of increased energy expenditure when birds fly further or higher to avoid large turbines. This may potentially disrupt linkages between distant feeding, breeding, moulting and roosting areas which otherwise would be unaffected.

6.7.7 Noise disturbance may occur during the pre-construction survey work (seismic exploration, geophysical surveys), construction/decommissioning (installation/removal of cables and turbines, vessel movements) and turbine operation. The extent to which birds are affected by sources of noise and visual disturbance has been the subject of a lot of previous research and monitoring work;

6.7.8 Studies generally show that birds are disturbed by a sudden large noise but have the ability to habituate (become accustomed) to regular noises. For instance, with respect to piling specifically, it has been concluded that although piling is often the noisiest construction activity, it often consists of rhythmic "bangs", which, after a short period, birds can become accustomed to [106]. Other research has also indicated that in general, birds appear to habituate to continual noises as long as there is no large amplitude 'startling' component [107].

6.7.9 The ABP Teignmouth Quay Development estimated an approximate zone within which birds may be affected by disturbance from construction works (piling and dredging) to be typically about 200m [108]. The startling effects of sudden noise were quantified, based on published research, by the

[103] Larsen, J. K., and Guilemette, M. 2007. Effects of wind turbines on flight behaviour of wintering Common Eiders: implications for habitat use and collision risk. Journal of Applies Ecology 44:516-522.

[104] Petersen, I.K., Clausager, I., and Christensen, T.J. 2004. Bird numbers and distribution on the Horns Rev. offshore windfarm area. Annual Status Report 2003. Report commissioned by Elsam Engineering A/S 2003. Rønde, Denmark: National Environmental Research Institute, 34pp.

[105] Petersen, I.K., Fox, A.D., and Clausager, I. 2003. Distribution and numbers of birds in Kattegat in relation to the proposed offshore wind farm south of Læsø –Ornithological impact assessment. Department of Wildlife Ecology and Biodiversity. National Environmental Research Institute, Ministry of Environment, Denmark.

[106] ABP Research & Consultancy Ltd. 2001. Immingham Outer Harbour, Environmental Statement, August 2001, ABP Research & Consultancy Ltd, Research Report No. R.903.

[107] Hockin, D., Ounsted, M., Gorman, M., Keller, V., and Barker, M.A. 1992. Examination of the effects of disturbance of birds with reference to its importance in ecological assessments. Journal of Environmental Management, 36:253-286.

[108] ABPmer, 2002. ABP Teignmouth Quay Development Environmental Statement. ABP Marine Environmental Research Ltd, Report No. R.984a.

Environment Agency for the Humber Estuary Tidal Defences scheme. It was concluded that a sudden noise in the region of 80dB appears to elicit a flight response in waders up to 250m from the source, with levels below this of approximately 70dB causing flight or anxiety behaviour in some species.

6.7.10 Drilling/piling activity during preliminary surveys and construction could disrupt seabird foraging and directly affect the senses of species diving underwater for prey. Seabirds hunt visually underwater, but evidence from on land suggests they may also have acute hearing, and thus marine noise could potentially disorientate and upset foraging rhythms and even damage hearing.

6.7.11 Little is known concerning the sensitivity of species to marine noise and thus it is not fully possible to assess the likelihood or magnitude of noise effects at any phase of the scheme. However, diving species are probably at greater risk and hence provisionally considered to be of medium sensitivity as compared to a lower sensitivity for surface-feeders.

6.7.12 As a result of disturbance, birds may avoid habitat during the pre-construction survey, construction, operation and decommissioning phases of a wind farm development. Exclusion from habitats essentially prevents access to prey sources. Such exclusion could reduce other effects, notably collision mortality. However, reductions in the availability of habitat and access to prey could lead to many changes in the way individuals forage, including increased individual stress levels and alterations to individual time budgets owing to further foraging distances [109].

6.7.13 Although alternative foraging areas may exist, the quality of the foraging habitat that species are forced to use may be lower, as well as more distant, thus increasing foraging time required to meet energetic needs. Species may have little flexibility to alter their time budgets to encompass extra foraging/travel to destinations. Species may also be reliant on a particular prey source at a location and may have less ability to switch to a different prey source. Effects at the colony and nest sites would be experienced through a reduced attendance time (due to lower feeding rates of chicks and longer foraging trips), possibly with increased neglect of chicks increasing predation risk or attacks from conspecifics. Furthermore, reduction in available habitat can generate increased competition to find food with knock-on implications for neighbouring areas (i.e. not included in the assessment). These disturbances may, therefore, cause a reduction in foraging success, decreases in breeding success, and effects on individual fitness.

6.7.14 All seabird species screened into the assessments are at some risk of disturbance from the indirect loss of foraging habitat although it is clearly the case that this is dependent upon foraging locations used by different species (i.e. whether they feed on intertidal or offshore locations) and the area of development activity. In general, the effects will be temporary during initial survey phases, causing minimal disruption. However, more significant

[109] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave

effects may occur in the construction, operation and decommissioning phases.

6.7.15 The effect that these changes have on birds will depend on how flexible the species are at coping with changes, those species that tend to feed on very specific habitat features will be the most sensitive. For instance, Garthe and Hüppop [110], and more recently Marine Scotland [111], evaluated the sensitivity of species to offshore wind farms, and their score for flexibility in habitat use provides a useful measure to the sensitivity of species to this effect. As suggested by evidence from offshore wind farms, Red-throated Divers and Common Scoters (both diving species) may be particularly sensitive to disturbance and thus the effects of indirect habitat loss.

6.7.16 The breeding success of some surface-feeding species, such as Terns and Kittiwakes, is negatively affected by changes in food availability due to reliance of prey brought to the sea surface [112]. This indirect effect has been presented in Perrow *et al.* [113], which suggests that Little Tern breeding success at a colony in Norfolk may have been reduced by a shortage of young herring around Scroby Sands offshore wind farm; considered a result of monopile installation affecting local fish reproduction.

6.7.17 Those species with higher energy cost burdens of flight and foraging (such as auks) may find it harder to increase foraging ranges to more distant prey resources, as compared to species such as Gannets that are generally less sensitive to natural changes in the availability of food and can forage over a much wider area. Diving species with high wing loading have high energetic costs during flight, thought to be linked with adaptation of wings for underwater locomotion [114] [115]. Thus, while they have the potential to forage far from colonies, their typical ranges may be smaller than those of other species, i.e. 20-40 km [116] [117], and may be less flexible in making changes in the event of reduced prey availability [118]. In summary, seabirds are

[110] Garthe, S. & Hüppop, O. 2004 Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology, 41, 724 - 734.

[111] Marine Scotland. 2012. Vulnerability of Scottish Seabirds to Offshore Wind Turbines. Prepared by MacArthur Green Ltd (Furness and Wade).

[112] Furness, R.W. & Tasker, M.L. 2000. Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. Marine Ecology Progress Series 202: 253-264.

[113] Perrow, M.R., Gilroy, J.J., Skeate, E.R. and Tomlinson, M.L. 2011. Effects of construction of Scroby Sands offshore wind farm on the prey base of little tern Sternula albifrons at its most important UK colony. Marine Pollution Bulletin 62: 1661-1670.

[114] Gaston, A.J. & Jones, I.L. 1998. The Auks. Oxford University Press, Oxford, New York.

[115] Thaxter, C.B., Wanless, S., Daunt, F., Harris, M.P., Benvenuti, S., Watanuki, Y., Grémillet, D., Hamer, K.C. 2010. Influence of wing loading on trade off between pursuit-diving and flight in Common Guillemots and razorbills. J.Exp. Biol. 213: 1018-1025.

[116] Thaxter, C.B., Daunt, F., Hamer, K.C., Watanuki, Y., Harris, M.P., Grémillet, D., Peters, G., Wanless, S. 2009. Sex-specific food provisioning in a monomorphic seabird, the Common Guillemot Uria aalge: nest defence, foraging efficiency or parental effort? Journal of Avian biology 40:75-84.

[117] Thaxter, C.B., Wanless, S., Daunt, F., Harris, M.P., Benvenuti, S., Watanuki, Y., Grémillet, D., Hamer, K.C. 2010. Influence of wing loading on trade off between pursuit-diving and flight in Common Guillemots and razorbills. J.Exp. Biol. 213: 1018-1025.

[118] Enstipp, M.R., Daunt, F., Wanless, S., Humphreys, E.M., Hamer, K.C., Benvenuti, S. and Grémillet, D., 2006. Foraging energetics of North Sea birds confronted with fluctuating prey availability. Top Predators in Marine Ecosystems: Their Role in Monitoring and Management (eds I. Boyd, S. Wanless & C.J. Camphuysen), pp 191-210. Conservation Biology 12. Cambridge University Press, Cambridge, UK.

considered to have a medium sensitivity to the effects of exclusion from feeding areas.

6.7.18 The effect of disturbance and habitat exclusion during construction will depend on the extent of construction, as well as the time of year; a potential mitigation measure is to avoid construction at key times of year (i.e. immediately before and during the breeding season) when prey is needed by adult birds and their young.

6.7.19 In general, disturbance to birds can affect feeding and roosting behaviour, with possible long-term effects of repeated disturbance including loss of weight, condition and a reduction in reproductive success. The effect of such disturbance is linked to the number of disturbance occurrences and the status of the conditions that are prevalent.

6.8 Toxic Contamination (Contamination and Spillages; Pathways 14 and 15)

6.8.1 Spillage of oils and fluids from construction vessels and machinery into the marine environment could adversely affect sediment or water quality during all phases of wind farm development. Marine birds are particularly sensitive to contamination by oil [119], as the oil can cause considerable damage to water-proofing and affect flight [120], as well as additional physiological damage if ingested.

6.8.2 The sensitivity of species to oil contamination is considered to be medium during construction, operation, and decommissioning, but a lower risk during pre-construction surveys, and is dependent on the general behaviour and distribution of species (e.g. the proportion of time spent on the sea surface relative to flying or feeding locations). Auks, in particular, may spend a considerable amount of time on the sea surface or foraging [121], and thus have a higher risk of being adversely affected by 'at sea' spillages of contamination events [122]. By contrast waders would only be affected by contamination events that affect their intertidal foraging zones.

6.8.3 Ingestion of contaminated sediments either through direct poisoning or bio-magnification of pollutants as a result of ingestion of contaminated prey would increase the probability of mortality of all species being considered. The precise risk would again depend on the use of the area by foraging seabirds. All species are potentially sensitive to this effect, but it is

[119] Votier, S.C., Birkhead, T.R., Oro, D., Trinder, M., Grantham, M.J., Clark, J.A., McCleery, R.H. and Hatchwell, B.J., 2008. Recruitment and survival of immature seabirds in relation to oil spills and climate variability. Journal of Animal Ecology, 77, 974-983.

[120] Wernham, C.V., Peach, W.J. and Browne, S.J., 1997. Survival rates of rehabilitated guillemots. BTO Research Report 186. British Trust for Ornithology, Thetford.

[121] Thaxter, C.B., Wanless, S., Daunt, F., Harris, M.P., Benvenuti, S., Watanuki, Y., Grémillet, D., Hamer, K.C. 2010. Influence of wing loading on trade off between pursuit-diving and flight in Common Guillemots and razorbills. J.Exp. Biol. 213: 1018-1025.

[122] Votier, S.C., Birkhead, T.R., Oro, D., Trinder, M., Grantham, M.J., Clark, J.A., McCleery, R.H. and Hatchwell, B.J., 2008. Recruitment and survival of immature seabirds in relation to oil spills and climate variability. Journal of Animal Ecology, 77, 974-983.

considered most relevant to diving birds. The overall sensitivity to toxic contamination is low during the construction and decommissioning phases.

6.9 Non-toxic Contamination (Increased Turbidity; Impact Pathway 16)

6.9.1 Activities involved during the construction and decommissioning of wind devices and associated cabling (e.g. use of jack-up legs, piling activities and cable installation) may result in an increase in suspended sediments and turbidity, potentially leading to effects on (diving) seabird foraging success and predator-prey interactions. The extent of any effect will be determined by the environment itself, i.e. by the strength of currents dispersing the sediment and background suspended sediment levels. The nature, scale and location of the structures will be the key determinants of the risk and magnitude of the effect.

6.9.2 In addition to changes in turbidity, there will also be a change in hydrodynamic regime around any device that may affect diving seabirds. Fish are attracted to areas of high flow gradients and fronts. Thus, a change in local turbidity and flow of currents during all phases of construction may influence the distribution of prey resources for all diving seabird species resulting in change of use of an area.

6.9.3 Species diving underwater are at greatest risk of having foraging activity disrupted by sediment mobilisation and suspension, and this is most likely to occur during the construction and decommissioning phases. Diving species such as Auks, Shags and Cormorants use much of the water column and thus are considered to have a medium sensitivity to this effect, whereas surface-feeding seabirds are considered to have a low sensitivity. All species, however, are at risk of disruption due to likely prey avoidance of areas that have been disturbed. All species are also at medium risk from changes to prey distribution areas associated with changes in hydrodynamics. Nevertheless, given the dispersive nature of the marine environment in areas where offshore wind development will occur, the sensitivities of species to this effect are considered to be low.

6.10 Bird Sensitivity Review

6.10.1 **Table 9** shows the sensitivities of qualifying bird interest features species to the activities associated with the draft Plan. Some of the highest risks are associated with habitat loss, reduced foraging area and disturbance. The levels of risk will be different depending upon the life history and foraging behaviour of the species in questions. This level of risk for different species is indicated within **Table 9.**

6.10.2 To provide an indication of which bird species are at risk from different project components, the screening schedules for each of the 17 DPOs (Tables D1-D17) include a reference to the general location of key species (i.e. whether they are landward, intertidal or offshore).

Table 9. Potential sensitivities of bird interest features to the draft Plan

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PLG	Physical Loss/Gain of habitat	2	Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside these areas from associated scour and indirectly from changes to the hydrodynamic regime as well as from chains anchoring devices disturbing seabed habitat during operation. [Applies to all seabirds]	No impact	No impact	LMS	No impact
PLG	Physical Loss/Gain of habitat	3	Presence of structures on seabed for the duration of the project resulting in changes to prey and species behaviour (e.g. acting as FAD (Fish Aggregating Device), artificial reef or bird roost). [Diving birds and surface feeding birds are most sensitive]	No impact	No impact	LS	No impact
PD	Physical damage to habitat	6	Reduction in quality of foraging areas as result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during installation; from maintenance and removal of cables/devices or from scour, sediment	LS	MS	LS	MS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
			transport and hydrodynamic change during operation. [Applies to all seabirds]				
PD	Physical damage to species	8	Collision risk and possible mortality of seabird species due to the presence of devices or from vessels travelling to and from the site ((including above and below water collision risk and the influence of lighting) [Nocturnal seabird species especially sensitive]	LS	LS	MS	LS
NPD	Non-physical disturbance	9	Presence of structures or disturbance (noise or visual) resulting in a barrier to movement, migratory pathways and/or access to feeding grounds depending on array design [Applies to all seabirds]	No impact	No impact	LMS	No impact
NPD	Non-physical disturbance	10	Visual disturbance and exclusion from areas as a result of surveying, cable and device installation/operation and decommissioning activities and movements of vessels. [Applies to all seabirds although surface feeding and diving birds most sensitive to at-sea activities]	LS	MS	LMS	LMS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
NPD	Non-physical disturbance	11	Noise/vibration disturbance and exclusion from areas as a result of vessels and other activities during survey work (e.g. seismic exploration and geophysical surveys), construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning.[Applies to all seabirds]	LS	LMS	LMS	LMS
NPD	Non-physical disturbance	13	Presence of structures resulting in an exclusion/displacement of a species from the area. [Applies to all seabirds]	No impact	LS	MS	LS
TC	Toxic Contamination (Reduction in water quality)	14	Spillage of fluids, fuels and/or construction materials during installation or removal of structures (devices and cables) or during survey/maintenance. [Highest sensitivities for diving seabirds]	LS	MS	LMS	LMS
TC	Toxic Contamination (Reduction in water quality)	15	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (devices and cables). [Highest sensitivities for diving seabirds]	No impact	LS	No impact	LS
NTC	Non-toxic Contamination (Elevated turbidity)	16	Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (devices	No impact		No impact	

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommissi on
			and cables). [Highest sensitivities for diving seabirds]				
In this table, only the estimated sensitivity levels are shown. The level of risk will be dependent upon exposure. For instance, there would be a high degree of exposure for seabirds were a development to occur within or near to a European/Ramsar site. However, at the present time, there is uncertainty regarding the degree of exposure and a worst-case assumption has been made.							
LS: Low Sensitivity							
LMS: Low to Medium Sensitivity							
MS: Medium Sensitivity							
HS: High Sensitivity							

6.11 Potential Effects on European/Ramsar Sites from the Sectoral Offshore Wind Plan

6.11.1 On the basis of the sensitivities of the relevant interest features the following sections review the typical conservation objectives for these features and the potential effects arising for each of the European/Ramsar sites. Although conservation objectives for yet to be designated pSPAs have still to be agreed, the draft objectives available indicate that the generic objectives outlined below would encompass these sites. It is, however, recognised in the case of Seas off Foula pSPA and Seas off St Kilda pSPA that the function of the pSPAs as foraging areas means that consideration of foraging distances from the sites is not required (i.e. foraging distances are only required when considering sites designated for bird colonies).

6.11.2 The conservation objectives for the qualifying bird interest features seek to avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring the integrity of the site. The conservation objectives are to ensure for the qualifying habitats that the following are maintained in the long term:

- Population of the species as a viable component of the site;
- Distribution of the species within site;
- Distribution and extent of habitats supporting the species;
- Structure, function and supporting processes of habitats supporting the species; and
- No significant disturbance of the species.

6.11.3 Taking account of the conservation objectives and the plan-level activities to which the key interest features (all bird qualifying features within the SPA/Ramsar sites) are sensitive, this section reviews the potential effects of the draft Plan on the integrity of the European/Ramsar sites. The results are presented in Table 10.

Table 10. Assessment of the potential effects of the Sectoral Offshore Wind Plan on the bird features of relevant European/Ramsar sites

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ All seabird species	**Physical loss/gain of habitat** Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside these areas from associated scour and indirectly from changes to the hydrodynamic regime as well as	2	**Sensitivity Level(s)** maximum considered to be low to medium (see Table 9for detail and colour code) **Commentary/ Review** All seabird species are considered sensitive to this effect over the operational phase of the wind farm. However, the effect will depend on the quality and location of habitat that might be affected e.g. loss of sandy sediments found within the DPOs may have the greatest effect on seabirds due to their importance for sandeels, and loss of intertidal habitat due to cable installation works could potentially affect foraging areas for over-wintering birds. **Relevant Conservation Objectives** (see Section 6.11	**Possibility of an adverse effect on integrity** Further work would be required at project-level to ascertain LSE. However, in advance of considering mitigation measures, it cannot be concluded that there will be no AEOI on any European/Ramsar sites. This is	**No adverse effect on integrity** With the application of appropriate and meaningful mitigation measures to accompany the Plan (see Section 11), there will be no AEOI.

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	from chains anchoring devices disturbing seabed habitat during operation.		All of the 5 objectives are pertinent of which the following are considered to be most relevant: ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.	because of the inherent uncertainties such as: • the detail of the Plan implementation process; • future generation capacities; • the location, scale and densities of development; • the proposed technologies to be used and future advances in	

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
				these technologies; • the scale of the effects arising via some of the defined impact pathways; and • the efficacy of some project-level mitigation options.	
▪ All seabird species	**Physical Loss/Gain of habitat** Presence of structures on seabed for the duration of the project resulting	3	**Sensitivity Level(s)** considered to be low (see Table 9 for detail and colour code) **Commentary/Risk Review** Underwater structures may provide new foraging opportunities for diving species. Construction of wind farm arrays and structures above water that have a stable	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	in changes to prey and species behaviour (e.g. acting as FAD (Fish Aggregating Device), artificial reef or bird roost).		platform may serve as additional resting and/or breeding habitat especially for gulls and terns. The extent of this (positive) effect and the degree to which it then has consequences for increased risk through collision etc is unknown, though sensitivity likely to be low. **Relevant Conservation Objectives** (see Section 6.11 All of the 5 objectives are pertinent of which the following are considered to be most relevant: ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species		
▪ All seabird species	**Physical damage to habitat**	6	**Sensitivity Level(s)** considered to be low or medium (see see Table 9for detail and colour code)	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	Reduction in quality of foraging areas as result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during installation; from maintenance and removal of cables/ devices or from scour, sediment transport and hydrodynamic change during operation.		**Commentary/ Review** All species are considered to be of low or medium sensitivity with the higher sensitivities occurring during the construction and decommissioning phases. However, the effect will depend on the quality and location of habitat that might be affected e.g. loss of sandy sediments found within the DPOs may have the greatest effect on seabirds due to their importance for sandeels, and loss of onshore habitat due to cable installation works could potentially affect breeding and/or wintering birds. **Relevant Conservation Objectives** (see Section 6.11 All of the 5 objectives are pertinent of which the following are considered to be most relevant: ▪ Distribution and extent of habitats supporting the species; and		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ Structure, function and supporting processes of habitats supporting the species		
▪ All seabird species	**Physical damage to species** Collision risk and possible mortality of species due to the presence of devices or from vessels travelling to and from the site ((including above and below water collision risk and the influence of lighting)	8	**Sensitivity Level(s)** considered to be medium (see Table 9for detail and colour code) **Commentary/ Review** Wind turbines can create a barrier effect with birds potentially deviating their flight route to avoid the structures. Evidence of birds exhibiting avoidance behaviour by increasing flight height has been obtained near operational wind farms at Robin Rigg and Barrow. Those seabirds that fly and forage during the night are considered to have a medium sensitivity to collision risk. Diurnally foraging species can be considered to have a low sensitivity to the risk of collision mortality **Relevant Conservation Objectives** (see Section 6.11	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			For the purposes of this assessment, the overarching conservation objective for all the SPAs and Ramsar sites reviewed and all the impact pathways/activities assessed is to "maintain specific reference populations for feature species, as provided in the relevant citations". This has been applied because it covers impacts to both the species and the habitats that support them, and it encompasses all of the five 5 conservation objectives that are common to all SPAs.		
▪ All seabird species	**Non-physical disturbance** Presence of structures and disturbance (noise or visual) associated with devices presenting a barrier	9	Sensitivity Level(s) considered to be low to medium (see see Table 9 for detail and colour code) **Commentary/Risk Review** Little is known about the sensitivity of bird species to barrier effects and their ability to alter flight heights. However, avoidance behaviour may lead to increased energy expenditure when birds fly further or higher to	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	to movement and block migratory pathways or access to feeding grounds depending on array design		avoid turbines, which may potentially lead to the disruption of linkages between distant feeding, breeding, moulting and roosting areas which otherwise would be unaffected. **Relevant Conservation Objectives** (see Section 6.11 All of the 5 objectives are pertinent to the potential effects; however, the following are considered to be most relevant: ▪ Distribution of the species within site; ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ All seabird species	**Non-physical disturbance** Visual disturbance and exclusion from areas as a result of surveying, cable and device installation/operation and decommissioning activities and movements of vessels.	10	**Sensitivity Level(s)** considered to be low to medium (see see Table 9 for detail and colour code) **Commentary/Risk Review** There are potential effects during surveying and cable and device installation, lesser effects are likely during operation and decommissioning. The greatest disturbance is likely to be caused by human presence. These disturbance effects can lead to displacement of seabirds. **Relevant Conservation Objectives** (see Section 6.11 All of the 5 objectives are pertinent to the potential effects; however, the following are considered to be most relevant: ▪ Distribution of the species within site; and ▪ No significant disturbance of the species;	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ All seabird species	**Non-physical disturbance** Noise/vibration disturbance and exclusion from areas as a result of vessels and other activities during survey work (e.g. seismic exploration and geophysical surveys), construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning	11	**Sensitivity Level(s)** considered to be low to low/medium (see see Table 9for detail and colour code) **Commentary/Risk Review** There are potential effects during cable and device installation, operation and decommissioning with lesser effects during the pre-construction survey phase. The sensitivity of birds to airborne noise during construction is considered to be low/medium given their ability to habituate to continual noises (e.g. piling). The sensitivity of species to underwater marine noise is unknown, but likely to be greater for diving species and sea surface foragers. There is potential for displacement of sea birds as a result of noise/vibration disturbance. **Relevant Conservation Objectives** (see Section 6.11	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			All of the 5 objectives are pertinent to the potential effects; however, the following are considered to be most relevant: ▪ Population of the species as a viable component of the site; ▪ Distribution of the species within site; ▪ No significant disturbance of the species; and ▪ Structure, function and supporting processes of habitats supporting the species.		
▪ All seabird species	**Non-physical disturbance** Presence of structures resulting in an exclusion/displacement of a species from the area.	13	**Sensitivity Level(s)** considered to be medium (see see Table 9 for detail and colour code) **Commentary/Risk Review** Exclusion/displacement from foraging areas may result in increased energy burdens on seabirds. It is considered that surface feeding species will have a low sensitivity as compared to a medium sensitivity for diving birds.	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			Relevant Conservation Objectives (see Section 6.11 All of the 5 objectives are pertinent to the potential effects; however, the following are considered to be most relevant: ▪ Distribution of the species within site; ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.		
▪ All seabird species	**Toxic Contamination (Reduction in water quality)** Spillage of fluids, fuels and/or construction	14	**Sensitivity Level(s)** considered to be low to medium (see see Table 9 for detail and colour code) **Commentary/ Review** For all stages of the work from the construction to decommissioning and including operational/maintenance works, there is the potential for accidental discharges/spillages	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	materials during installation or removal of structures (devices and cables) or during survey/maintenance.		from machinery and vessels. All species, including those using intertidal habitats have a medium sensitivity to the effects from this impact pathway. However, adoption of standard safety measures would be employed throughout all phases of the project to reduce likelihood of this occurring. **Relevant Conservation Objectives** (see Section 6.11 All of the 5 objectives are pertinent to the potential effects; however, the following are considered to be most relevant: ▪ Distribution of the species within site; ▪ No significant disturbance of the species; and ▪ Structure, function and supporting processes of habitats supporting the species.		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Diving Species	**Toxic Contamination** (Reduction in water quality) Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (devices and cables) .	15	**Sensitivity Level(s)** considered to be low (see see Table 9 for detail and colour code) **Commentary/Risk Review** Where cable routeing passes through areas of contaminated sediment, remobilisation of contaminants may occur. This impact pathway is considered a low risk to seabirds with the potential to occur during the construction and decommissioning phases. **Relevant Conservation Objectives** (see Section 6.11 All of the 5 objectives are pertinent to the potential effects; however, the following are considered to be most relevant: ▪ Distribution of the species within site; ▪ No significant disturbance of the species. and ▪ Structure, function and supporting processes of habitats supporting the species.	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/ Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ All seabird species	**Non-toxic Contamination** (Elevated turbidity) Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (devices and cables).	16	**Sensitivity Level(s)** The risks are considered to be low (see see Table 9 for detail and colour code) **Commentary/ Review** Increases in suspended sediment during the construction and decommissioning phases may disrupt foraging and predator-prey interactions. **Relevant Conservation Objectives** (see Section 6.11 All of the 5 objectives are pertinent to the potential effects; however, the following are considered to be most relevant: ▪ Distribution of the species within site; ▪ No significant disturbance of the species; and ▪ Structure, function and supporting processes of habitats supporting the species.	As above	As above

7 Potential for Adverse Effects on Marine Mammal Features

7.1 Introduction

7.1.1 Following the screening process, a total of 468 European/Ramsar sites were identified for which there is a LSE (or the potential for a LSE cannot be excluded) (Table C1). These European/Ramsar sites were identified as it was not possible to conclude that there would be no LSE from the Sectoral Offshore Wind Plan on qualifying marine mammal interest features.

7.1.2 In total there were 99 SACs with qualifying marine mammal interest features that were screened in. This large number of sites resulted from the broad scope of the Draft Plan and the extensive ranges of some marine mammals.

7.1.3 Given the broad area covered by the draft Plan and the large number of sites screened into these assessments, the same method as agreed in previous HRAs [123] [124] [125] has been used where it is not necessary to individually review the full list of all sites and the qualifying marine mammal interest features that they support within this report. The individual sites that were screened in for each of the 17 DPOs are shown in the screening tables (Tables D1-D17) and maps (Figures E1-E17). The locations of screened in SAC and Ramsar sites with qualifying marine mammal features beyond the 100 km buffer are provided in Appendix F (Figures F6 and F7).

7.1.4 Some of these SACs also contained other interest features for which it could not be concluded that there was no LSE (e.g. subtidal sandbanks) and these are reviewed separately under the relevant section(s) of this report. In addition, where there are interest features at these sites which have been 'screened out' as there will be no LSE these are also recorded (Table C1).

7.1.5 In summary, the screening phase concluded that there was a possibility of a LSE (or that it was not possible to conclude no LSE) for the following qualifying marine mammal interest features:

- Common (Harbour) seal (1365);
- Grey seal (1364);
- Bottlenose dolphin (1349); and
- Harbour porpoise (1351).

7.1.6 To assess whether there is any adverse effect on the integrity of relevant European/Ramsar sites, the following sections review the sensitivities of marine mammal features, identify the conservation objectives and assess

[123] ABPmer, 2011a. Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Report for the Scottish Government, ABP Marine Environmental Research Ltd, Report No: R.1722a-c. January 2011.
[124] ABPmer 2013f. Habitats Regulations Appraisal of Draft Plan for Wave and Tidal Energy (W&TE) in Scottish Waters. Report for Marine Scotland 2013; ABP Marine Environmental Research Ltd, Final Report January 2013 Report Nos. R.1863a (Pre-Screening); R.1863b (Screening); and R.1863c (Report to Inform Appropriate Assessment); and R.1863d (PSG Comments Review).
[125] ABPmer, 2017. Habitats Regulations Appraisal of the Draft Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters. Reports for Marine Scotland, ABPmer Report No: R.2121a-c. 5 May 2017.

the effects arising in the context of the proposed plan-level mitigation measures.

7.2 Sensitivities of Marine Mammal Interest Features to the Sectoral Offshore Wind Plan Activities

7.2.1 This section reviews the sensitivities that are relevant for the marine mammal interest features. A generic review of the sensitivities of relevant bird features is presented under the impact pathways identified during the screening phase (see Table 2):

- Physical Loss/Gain of Habitat (Loss of Foraging area);
- Physical Loss/Gain of Habitat (Fish Aggregating Effects);
- Physical Damage to Habitat (Reduction in Foraging Habitat Quality);
- Physical Damage to Species (Damage to Seal Haul-Outs);
- Physical Damage to Species (Collision Risk);
- Non-Physical Disturbance (Noise/Visual Disturbance causing Barrier and Exclusion effects);
- Non-Physical Disturbance (Electromagnetic Fields);
- Toxic contamination (Contamination and Spillages); and
- Non-toxic contamination (Increased Turbidity).

7.2.2 Following this review, the individual characteristics and sensitivities for each of the relevant qualifying marine mammal interest features are presented and the activities that could cause an impact are identified and tabulated. These interest feature reviews are set out in the following sections:

- Pinnipeds (grey and common seals) (Section 7.12); and
- Cetaceans (bottlenose dolphin and harbour porpoise) (Section 1.1).

7.3 Physical Loss/Gain of Habitat (Loss of Foraging Area; Impact Pathway 2)

7.3.1 Marine mammals have extensive ranges and cover very large distances to forage in the pelagic environment. Critical (key) habitats for marine mammals are those that are essential for day-to-day well-being and survival, as well as for maintaining population growth. Areas that are regularly used for feeding, breeding, raising calves and socialising, as well as, sometimes, migrating, are the key components of critical habitat [126]. In addition to places used regularly for feeding, breeding, raising calves and socialising, locations where associated and supporting activities such as hunting, courtship, singing, calving, nursing, resting, playing and communication take place are important to consider. For a complete consideration of critical habitat, it should also extend to the critical habitat of marine mammal prey and areas where important ecosystem processes occur such as productive upwellings

[126] WDCS, 2010. Toward Marine Protected Areas for Cetaceans in Scotland, England and Wales. A scientific review identifying critical habitat and key recommendations.

and fish spawning grounds. These critical habitat areas will be the most sensitive parts of a marine mammal's range to any developments that cause loss (or gain) of habitat.

7.4 Physical Loss/Gain of Habitat (Fish Aggregating Effects; Impact Pathway 3)

7.4.1 Marine mammals feed on a variety of pelagic and demersal prey. The diet of seals, bottlenose dolphin and harbour porpoise species around Scotland and the North Sea is summarised below (**Table 11**).

Table 11. Prey species commonly consumed by the marine mammals around Scotland and the North Sea

Species	Diet
Common Seal	Sandeels with octopus, gadoids and clupeids also consumed.
Grey Seal	Sandeels, gadoids (particularly cod), flatfish (particularly plaice) and sculpins.
Harbour Porpoise	Sandeels, gadoids such as whiting and clupeids (herring and sprats).
Bottlenose Dolphin	Primarily feed on gadoids such as cod, saithe and whiting as well as Atlantic salmon and cephalopods.

(Based on information from DECC[127], Reid *et al.*[128], Santos *et al.*[129], MacLeod *et al.*[130]

7.4.2 Fish are attracted to solid man-made structures placed on the seabed and artificial reefs are often deployed to enhance fisheries [131]. These structures modify the habitat and provide food and shelter for fish and invertebrate species leading to increased fish abundance and enhancement of the local seabed habitat [132]. A study by Raoux *et al.* [133] recorded an increase in biomass on piles and turbine scour protections post construction of a wind farm, suggesting that fish, marine mammals and seabirds responded positively to the increase in biomass.

[127] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.
[128] Reid JB, Evans PGH, Northridge SP. 2003. Atlas of Cetacean distribution in north-west European waters, 76 pages, colour photos, maps. Paperback, ISBN 1 86107 550 2.
[129] Santos, M.B., Pierce, G.J., Learmonth, J.A. 2004. Variability in the diet of harbour porpoises *Phocoena phocoena* in Scottish waters 1992-2003. Marine mammal science 20, 1-27.
[130] MacLeod, C. D., Begoña Santos, M., Reid, R.J., Scott, B.E and Pierce G.J. 2007. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? Biol. Lett.3, 185-188.
[131] Sayer, M.D.J., Magill, S.H, Pitcher, T.J., Morissette, L and Ainsworth C. 2005. Simulation-based investigations of fishery changes as affected by the scale and design of artificial habitats. Journal of Fish Biology 67: 218-243.
[132] Wilhelmsson, D., Malm, T., and Öhman, M., 2006. The influence of offshore wind power on demersal fish. ICES Journal of Marine Science 63, 775-784.
[133] Raoux, A., Tecchio, S., Pezy, J., Lassalle, G., Degraer, S., Wilhelmsson, D., Cachera, M., Ernande, B., Guen, C., Haraldsson, M., Grangeré, K., Le Loc'h, F., Dauvin, J., Niquil, N. 2017. Benthic and Fish Aggregation Inside an Offshore Wind Farm: Which Effects on the Trophic Web Functioning? Ecological Indicators, 72, 33-46.

7.4.3 Structures can change local abiotic conditions allowing species assemblages to form that are different from natural communities present [134]. Therefore, the potential for prey items of marine mammals to be attracted to underwater structures which could act as a Fish Aggregating Device (FAD) will largely be dependent on the habitat preference of specific species. For example, pelagic species such as salmon, which undertake large migrations and seasonal movements, are less likely to aggregate around structures than demersal species such as gadoids which show a greater association with the seabed.

7.5 Physical Damage to Habitat (Reduction in Foraging Habitat Quality; Impact Pathway 6)

7.5.1 Foraging areas are a critical habitat for marine mammals. ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area) described critical habitat as 'a place or area regularly used by a cetacean group, population or species to perform tasks essential for survival and equilibrium maintenance' [135]. Marine mammals have very large ranges, typically to undertake foraging, but mammals can often be aggregated in 'hotspot' areas where key prey resources are found in high densities. For example, important foraging habitat for harbour porpoises includes areas of strong tidal currents, usually near islands or headlands, where the currents combine with the seafloor topography and seem to create conditions where a higher abundance of prey are recorded [136] [137] [138]. Spawning and nursery sites for prey species will be particularly sensitive to any environmental change.

7.6 Physical Damage to Species (Damage to Seal Haul-Outs; Impact Pathway 7)

7.6.1 Impacts to intertidal areas from cable laying or other infrastructure could affect established seal haul out location. Seals use haul-outs for resting between foraging trips, giving birth (pupping) in the moulting season and also as a nursery for pups [139]. In the UK, grey seals typically breed on remote uninhabited islands or coasts and in small numbers in caves. Harbour seals come ashore in sheltered waters, typically on sandbanks and in estuaries, but also in rocky areas. Harbour seals haul out on land in a pattern that is often related to the tidal cycle. In general, both grey and

[134] ibid.

[135] WDCS, 2010. Toward Marine Protected Areas for Cetaceans in Scotland, England and Wales. A scientific review identifying critical habitat and key recommendations.

[136] Pierpoint, C. 2008. Harbour porpoise *Phocoena phocoena* foraging strategy at a high energy, near-shore site in south-west Wales, UK. Journal of the Marine Biological Association of the UK, 2008, 88(6) 1167-1173.

[137] Marubini, F., Gimona, A., Evans, P.G.H., Wright, P.J. and Pierce, G.J. 2009 Habitat preferences and interannual variability in occurrence of the harbour porpoise *Phocoena phocoena* in the north-west of Scotland. Marine Ecology Progress Series, 381: 297-310.

[138] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.

[139] SCOS, 2009. Scientific advice on matters related to the management of seal populations: 2009. Special Committee on Seals, 100pp.

harbour seals are highly sensitive to disturbance by humans hence their preference for remote breeding sites [140].

7.6.2 Grey seals in the UK spend longer hauled out during their annual moult (between December and April) and during their breeding season (between August and December). Harbour seals give birth to their pups in June and July and moult in August. At these times of the year seals will be the most susceptible to human disturbance at haul out sites.

7.7 Physical Damage to Species (Collision Risk; Impact Pathway 8)

7.7.1 Marine mammals have quick reflexes, good sensory capabilities and fast swimming speeds (over 6 m/s for harbour porpoise). These qualifying species are also considered to be very agile [141] [142]. These are all attributes which increase the chance of close-range evasion with an object. However, marine mammal collisions with anthropogenic structures, such as fishing gear and ships, are well documented [143] [144]. Reduced perception levels of a collision threat through distraction, whilst undertaking other activities such as foraging and social interactions, are possible reasons why collisions are recorded in marine mammals [145]. Young grey seal pups, which are inexperienced at sea, could be particularly vulnerable to collision risk. Dive patterns of juvenile grey seal pups have shown that the majority of their time is spent either at the surface or close to the maximum dive depth, which is usually the seabed. Results show that they swim directly to the bottom and so, spend little time in mid water.

7.7.2 Marine mammals can also be very curious of new foreign objects placed in their environment and so curiosity around an object could also increase the risk of collision. Marine mammals are relatively robust to potential strikes as they have a thick sub-dermal layer of blubber which would defend their vital organs from the worst of any blows [146]. Nevertheless, a direct collision still has the potential to cause injury to marine mammals.

7.7.3 For offshore wind farm projects, the underwater structures are essentially static (either fixed or floating) therefore, collision risk during operational phases to these structures is considered low. There is an additional risk of collision with vessels associated with the various phases of the development; however, these vessels will be carrying out activities at low speeds and the risk is therefore minimal.

7.7.4 Marine mammals have the potential to become entangled with rope and/or lines. There are a number of risk factors associated with entanglement including biological characteristics of marine mammals and the physical

[140] ibid
[141] Carter, C. 2007. Marine Renewable Energy Devices: A Collision Risk for Marine Mammals? MSc thesis University of Aberdeen.
[142] Hoelzel, R.A (ed). 2002. Marine Mammal Biology: An evolutionary approach. Blackwell Publishing. 452pp.
[143] Pace D.S. Miragliuolo A., and Mussi B. 2006. Vessels and dolphins: scars that tell stories. Fins, p 19-2.
[144] Zollett E.A., and Rosenberg A.A., 2005. A review of cetacean bycatch in trawl fisheries of New Hampshire. Literature review.
[145] Wilson, B.; Batty, R.; Daunt, F.; Carter, C. 2007. Collision Risk Between Marine Renewable Energy Devices and Mammals, Fish and Diving Birds. Report by Centre for Ecology & Hydrology and Scottish Association for Marine Science (SAMS). pp 110.
[146] ibid

features of the mooring themselves [147]. Biological factors include body size, flexibility, ability to detect mooring lines, and mode of feeding. However, pinnipeds, harbour porpoise and bottlenose dolphins are considered to have comparatively small risk of entanglement as they are small and agile and are able to detect objects in the water from tens of metres away [148].

7.7.5 The echo locating ability of cetaceans, such as the bottlenose dolphin and harbour porpoise, allows them to detect small objects at these distances. The narrow bisonar beam of harbour porpoise uses a very high peak frequency (~130 kHz) and is able to detect small objects such as fishing nets mesh and floats [149].

7.7.6 Pinnipeds have the ability to detect objects through acute mechanosensitivity through their vibrissae or whiskers [150] [151].

7.7.7 Marine mammals may become entangled with a rope or line if the animal's ability to detect the object is compromised under particular environmental conditions such as low light conditions, or during storms. Marine mammals may also be distracted while feeding on mobile prey species and so not detect the hazard [152].

7.7.8 In addition, large whales have been anecdotally seen seeking out cables in search of a surface to scratch themselves [153] [154]. If pinnipeds or cetaceans were to show this behaviour, it could increase the risk of entanglement. Entanglement in mooring lines is unlikely to be an issue given the latest available evidence [155]. If necessary, however, potential entanglement in mooring lines can be mitigated by using high visibility mooring lines.

7.8 Non-Physical Disturbance (Noise/Visual Disturbance Causing Barrier and Exclusion Effects; Impact Pathways 9 to 11)

Visual

7.8.1 Disturbance caused by an external visual influence can cause marine mammals to stop feeding, resting, travelling and/or socialising, with possible

[147] Benjamins, S., Harnois, V., Smith, H.C.M., Johanning, L., Greenhill, L., Carter, C. and Wilson, B. 2014. Understanding the potential for marine megafauna entanglement risk from renewable marine energy developments. Scottish Natural Heritage Commissioned Report No. 791.
[148] ibid
[149] Miller, L., Wahlberg, M., 2013. Echolocation by the harbour porpoise: life in coastal waters. Frontiers in Physiology. doi: 10.3389/fphys.2013.00052.
[150] Dehnhardt, G., Mauck, B., Hanke, W. & Bleckmann, H. 2001. Hydrodynamic trail-following in harbor seals *Phoca vitulina*. Science, 293, 102-104.
[151] Hanke, W., Wieskotten, S., Marshall, C. & Dehnhardt, G. 2013. Hydrodynamic perception in true seals (Phocidae) and eared seals (Otariidae). Journal of Comparative Physiology A, 199, 421-440.
[152] Benjamins, S., Harnois, V., Smith, H.C.M., Johanning, L., Greenhill, L., Carter, C. and Wilson, B. 2014. Understanding the potential for marine megafauna entanglement risk from renewable marine energy developments. Scottish Natural Heritage Commissioned Report No. 791.
[153] Gentle Giants. 2012. Top Encounter 2012. Gentle Giants - Visit the Gentle Giants of Husavik- Probably the best place in Iceland for whale watching - NEWS [Online]. Available from: http://www.gentlegiants.is/news/nr/658/top-encounter-2012/.
[154] Benjamins, S., Harnois, V., Smith, H.C.M., Johanning, L., Greenhill, L., Carter, C. and Wilson, B. 2014. Understanding the potential for marine megafauna entanglement risk from renewable marine energy developments. Scottish Natural Heritage Commissioned Report No. 791.
[155] ibid

long-term effects of repeated disturbance including loss of weight, condition and a reduction in reproductive success [156] [157]. The group which are most at risk from visual disturbance are seals (when they are resting or breeding on land). In general, ships more than 1,500 m away from grey seal haul out areas are unlikely to evoke any reactions from grey seals. Between 900 m and 1,500 m, grey seals could be expected to detect the presence of vessels and at closer than 900 m a flight reaction could be expected [158].

7.8.2 In the UK, there are currently no good-practice guidelines for minimisation of disturbance by shipping or commercial vessels [159]. However, the *Scottish Marine Wildlife Watching Code* that was designed for recreational water users advises that the minimum approach distance for vessels to avoid visual and noise disturbance to dolphins and porpoises is 50 m (200-400 m for mothers and calves, or for animals that are clearly actively feeding or in transit). The code however isn't necessarily appropriate for repeated commercial activities.

Noise

7.8.3 Marine mammals (particularly cetaceans) are sensitive to acoustic disturbance in the marine environment, due to their use of echolocation and vocal communication[160]. In comparison to fish, marine mammal species are sensitive to a very broad bandwidth of sound (being responsive at frequencies from 100 Hz to 170 kHz and possessing sensitive hearing over the frequency range from 20 kHz to 150 kHz). The hearing sensitivity and frequency range of marine mammals varies between different species and is dependent on their physiology. For example, odontocete cetaceans (toothed whales, porpoises and dolphins) are particularly sensitive to high frequencies.

7.8.4 The impacts of noise on marine mammals can broadly be split into lethal and physical injury, auditory injury and behavioural response. Chronic stress related disorders can also occur with long-term, repeated exposure to a noise source. These responses are discussed in more detail below.

7.8.5 At very high exposure levels, such as those typical close to underwater explosive operations or offshore impact piling (pile driving) operations, the possibility exists for lethality and physical damage to occur. As the time period of the exposure increases (represented by the impulse), there is also an increase in likelihood of fatality. A permanent threshold shift (PTS) is permanent hearing damage caused by very intensive noise or by prolonged exposure to noise. A temporary threshold shift (TTS) involves a temporary reduction of hearing capability caused by exposure to underwater noise.

[156] ABPmer, 2009. Wet Renewable Energy and Marine Nature Conservation: Developing Strategies for Management. ABP Marine Environmental Research Ltd, Report No. R.1451.
[157] JNCC, 2008. The deliberate disturbance of marine European Protected Species: Interim guidance for English and Welsh territorial waters and the UK offshore marine area.
[158] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave

[159] JNCC, 2008. The deliberate disturbance of marine European Protected Species: Interim guidance for English and Welsh territorial waters and the UK offshore marine area.
[160] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.

The level of PTS or TTS will depend on the hearing sensitivity of marine mammals at different frequencies and the overall tolerance of their auditory systems to intense noise. Lucke *et al.* [161], for example, undertook an auditory study to derive data on TTS induced by single impulses for harbour porpoise after exposure to seismic airgun stimuli. At 4 kHz the predefined TTS criterion was exceeded at a received sound pressure level of 199.7 dBpk-pk re 1 µPa and a sound exposure level (SEL) of 164.3 dB re 1 µPa2 s.

7.8.6 At lower Sound Pressure Levels (SPLs), it is more likely that behavioural responses to underwater sound will be observed in marine mammals. These reactions may include the animals leaving the area for a period of time, or a startle reaction may be observed. Interference with the detection of biologically relevant communication signals such as echolocation clicks or social signals (masking) may also occur at lower levels of noise. Masking has been shown in acoustic signals used for communication among marine mammals (see Clark *et al.* [162]). Masking may in some cases hinder echolocation of prey or detection of predators. If the signal-to-noise ratio prevents detection of subtle or even prominent pieces of information, inappropriate or ineffective responses may be shown.

7.8.7 NOAA [163] provides technical guidance for assessing the effects of underwater anthropogenic (human-made) sound on the hearing of marine mammal species. Specifically, the received levels, or acoustic thresholds, at which individual marine mammals are predicted to experience changes in their hearing sensitivity (either temporary or permanent) for acute, incidental exposure to underwater anthropogenic sound sources are provided. These thresholds update and replace the previously proposed criteria in Southall *et al.* [164] for preventing auditory/physiological injuries in marine mammals.

7.8.8 The NOAA [165] thresholds are categorised according to marine mammal hearing groups. According to NOAA [166], harbour porpoise is categorised as a high-frequency (HF) cetacean, bottlenose dolphin as a mid-frequency (MF) cetacean, and grey seal and common seal are categorised as a phocid pinniped (PW). The acoustic thresholds for the onset of TTS and PTS due to impulsive sound sources (e.g. percussive piling) for these marine mammal groups are presented in Table 12.

7.8.9 Behavioural reactions to acoustic exposure are less predictable and difficult to quantify than effects of noise exposure on hearing or physiology as

[161] Lucke, K., Siebert, U., Lepper, P.A. and Blanchet, M.A. 2009. Temporary shift in masked hearing thresholds in a harbour porpoise *Phocoena phocoena* after exposure to seismic airgun stimuli. Journal of the Acoustical Society of America, 125: 4060 – 4070.

[162] Clark, C. W., Ellison, W. T., Southall, B.L., Hatch, L., Van Parijs, S.M., Frankel, A., and D. Ponirakis, 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series 395: 201-222.

[163] NOAA (2018). 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

[164] Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr, C. R., Kastak, D., Miller, J.H., Nachigall, P.E., Richardson, W,.J., Thomas, J.A and Tyack, P.L., 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33:411–521.

[165] NOAA. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

[166] ibid

reactions are highly variable and context specific [167]. Whilst recognising these limitations, Southall *et al.* [168] reviewed a number of disturbance studies to determine possible behavioural response criteria for individual marine mammals exposed to single pulses. There are no equivalent behavioural response criteria for multiple pulses that would represent percussive piling. The single pulse criteria could be compared to the weighted model outputs for different hearing group categories to provide a high-level indication of the potential scale of disturbance. Another potential approach to assessing the behavioural reaction to noise is through consideration of dose-response curves[169],[170].

7.8.10 New recommendations have recently been published regarding marine mammal noise exposure [171] which complement the NOAA [172] thresholds. Southall *et al.* [173] looks at a wider range of marine mammal species and also consider the hearing sensitivity of amphibious mammals (namely seals and otters) to airborne noise.

Table 12. Marine mammal noise exposure criteria

Hearing group	PTS	TTS
High-frequency cetacean (HF)	202 dB peak SPL 155 dB SEL_{cum}	196 dB peak SPL 140 dB SEL_{cum}
Mid-frequency cetacean (MF)	230 dB peak SPL 185 dB SEL_{cum}	224 dB peak SPL 170 dB SEL_{cum}
Phocid pinniped (PW)	218 dB peak SPL 185 dB SEL_{cum}	212 dB peak SPL 170 dB SEL_{cum}
Peak SPL has a reference value of 1 µPa. SEL_{cum} denotes cumulative SEL with a reference value of 1 μPa^2 s over a 24-hour period.		

[167] Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr, C. R., Kastak, D., Miller, J.H., Nachigall, P.E., Richardson, W,.J., Thomas, J.A and Tyack, P.L., 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33:411–521.

[168] ibid

[169] Rebecca A. Dunlop, Michael J. Noad, Robert D. McCauley, Lindsay Scott-Hayward, Eric Kniest, Robert Slade, David Paton, Douglas H. Cato, 2017, Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity, Journal of Experimental Biology 2017 220: 2878-2886; doi: 10.1242/jeb.160192.

[170] Gomez, Catalina & Lawson, Jack & Wright, Andrew & Buren, Alejandro & Tollit, Dominic & Lesage, Véronique. 2016. A systematic review on the behavioural responses of wild marine mammals to noise: The disparity between science and policy. Canadian Journal of Zoology. 94. 10.1139/cjz-2016-0098.

[171] Southall, B.L., Finneran, J.J., Reichmuth, C., Nachtigall P.E., Ketten, D.R., Bowles, A.E., Ellison, W.T., Nowacek, D.P., Tyack, P.L., 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 45 (2): 125 DOI: 10.1578/AM.45.2.2019.125.

[172] NOAA. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

[173] Southall, B.L., Finneran, J.J., Reichmuth, C., Nachtigall P.E., Ketten, D.R., Bowles, A.E., Ellison, W.T., Nowacek, D.P., Tyack, P.L., 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 45 (2): 125 DOI: 10.1578/AM.45.2.2019.125.

7.8.11 Dähne *et al*, [174] monitored the response of harbour porpoise during percussive piling for the foundations of 12 wind turbines at the first offshore wind farm in Germany, 'Alpha Ventus'. Visual monitoring was carried out prior to and during construction by 15 aerial transects from 2008-2010. In addition, Static Acoustic Monitoring (SAM) with echolocation click loggers was deployed at 12 locations between 1 and 50 km from the centre of the wind farm between 2008-2011. The results suggest a pile driving related behavioural reaction at much larger distances than just an avoidance radius would suggest [175].

7.8.12 A more recent study by Graham *et al.* [176] studied responses of bottlenose dolphins and harbour porpoises to two types of pile driving: impact and vibration during harbour construction in northeast Scotland. Both species were not excluded from the area during both piling activities, however, Bottlenose dolphins spent less time in the area (under both piling activities), which may be attributable to the strongly pulsed sound signature from the vibration piling. Whilst vibration piling is considered as a mitigation measure because it is a quieter alternative to impact piling, the study advised that caution should be granted to its efficacy as a mitigation measure as vibration piling exhibited greater impacts on behavioural responses on the two species, than originally anticipated.

7.8.13 Long-term, repeated exposure to a noise source can cause chronic stress in marine mammals. A range of issues may arise from the extended stress response including accelerated ageing, slow disintegration of body condition, sickness symptoms and suppression of reproduction (physiologically and behaviourally) [177] [178]. Wright *et al.* [179] found that young animals may be particularly sensitive to stressors for a number of reasons including the sensitivity of their still-developing brains.

7.8.14 One of the greatest potential impacts on marine mammals from offshore wind farm development is from the noise during construction activities such as impact piling [180] [181]. A number of studies have investigated the distances at which marine mammals may be disturbed as a result of piling and blast noise associated with offshore wind farms (Table 13). Based on the findings from these studies it is apparent that, although hearing injuries from construction are only likely to occur within several hundred metres of pile driving activity, strong avoidance responses could occur several kilometres from the piling with masking of vocalization and mild behavioural changes

[174] Dähne, M., Gilles, A., Lucke, K., Peschko, V., Adler, S., Krügel, K., Sundermeyer, J. and Siebert, U. 2013. Effects of pile-driving on harbour porpoises (Phococena phocoena) at the first offshore wind farm in Germany. Environmental Research Letters: 8 doi:10.1088/1748-9326/8/2/025002.

[175] ibid

[176] Graham, I., Pirotta, E., Merchant, N., Farcas, A., Barton, T., Cheney, B., Hastie, G., Thomson, P. 2017. Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction. Ecosphere, 8(5):e01793.10.1002/ecs2.1793.

[177] Wright et al 2007a. Do Marine Mammals Experience Stress Related to Anthropogenic Noise?, International Journal of Comparative Psychology, 20, 274-316.

[178] ibid

[179] ibid

[180] Bailey, H., Brookes, K.L., Thompson, P.M. 2014. Assessing Environmental Impacts of Offshore Wind Farms: Lessons Learned and Recommendations for the Future. Aquatic Biosystems. 10:8.

[181] Thompson, D., Hall, A. J., McConnell, B. J., Northridge, S. P. & Sparling, C. 2015. Current state of knowledge of effects of offshore renewable energy generation devices on marine mammals and research requirements. Sea Mammal Research Unit, University of St Andrews, Report to Scottish Government, no. MR 1 & MR 2, St Andrews, 55pp.

(e.g. change in swimming direction) occurring as far away as 50km or more from a wind farm development.

7.8.15 Presence of sub-surface structures may present a barrier to movement and migratory pathways depending on array location. Cetaceans are highly mobile, pelagic species which can undergo large seasonal movements and migrations [182] [183]. They can therefore be vulnerable to any structures which could act as a barrier, preventing movement to foraging or nursery grounds. However, the presence of offshore wind turbines is unlikely to prevent movement for these highly mobile species which could circumvent the arrays if required.

7.8.16 Seals are also highly mobile and as with bottlenose dolphin and harbour porpoise, the sensitivity to this impact pathway (barrier to movement) is considered to be low.

7.8.17 Prolonged disturbance in an area has the potential to displace marine mammals from critical habitat (key sites used for important life processes such as feeding, breeding and raising young) [184]. For some species, areas of critical habitat can be difficult to define, particularly for pelagic species which are often highly dispersed and have large ranges. However, studies have also shown that relatively localised areas may be particularly important for some species in certain areas [185].

[182] Reid JB, Evans PGH, Northridge SP. 2003. Atlas of Cetacean distribution in north-west European waters, 76 pages, colour photos, maps. Paperback, ISBN 1 86107 550 2.

[183] Learmonth, J.A., Macleod, C.D., Santos, M.B., Pierce, G.J., Crick, H.Q.P and Robinson, R.A. 2006. Potential effects of climate change on marine mammals. Oceanography & Marine Biology: An Annual Review, 44, 431-464.

[184] WDCS, 2010. Toward Marine Protected Areas for Cetaceans in Scotland, England and Wales. A scientific review identifying critical habitat and key recommendations.

[185] Harwood, J. 2001. Marine Mammals and their Environment in the Twenty-First Century. Journal of Mammalogy 82, 630–640.

Table 13. Summary of research on the spatial extent of piling noise impacts on marine mammals

Activity	Study	Background Information	Reference
Pile driving	Empirical study on underwater noise levels during pile-driving at turbines in NE Scotland and potential effects on marine mammals.	Pile-driving noise was measured at distances of 0.1 to 80km (when background noise was no longer distinguishable above ambient). The study concluded that for bottlenose dolphins auditory injury would only have occurred within 100m of the pile-driving and behavioural disturbance (defined as modifications in behaviour) could have occurred up to 50km away.	Bailey *et al.* (2010)[186].
	Empirical studies of porpoise behaviour during construction of offshore wind farms at Horns Rev (North Sea) and Nysted (Baltic).	At the wind farms, acoustic activity of porpoises decreased shortly after each pile-driving event and returned to baseline conditions after 3-4h. This effect was not only observed in the direct vicinity of the construction site but also at monitoring stations approximately 15km away. Behavioural observations showed that during pile-driving, porpoises exhibited relatively more directional swimming patterns. This effect was found at distances of more than 11km, and possibly also up to 15km from the construction site.	Tougaard *et al.*, (2003a[187], 2003b)[188].
	Assessment of the likely sensitivity of bottlenose dolphins to pile-driving noise.	Research concluded that at 9kHz, masking of strong vocalisations could potentially occur within 10 to 15km. The potential masking radius was predicted to reduce with increasing frequency to 6km at 50kHz and 1.2km at 115kHz.	David (2006)[189].
	Attenuation of modelled pile-driving noise at	Study concluded that pile-driving noise, under realistic North Sea conditions, would be audible to harbour porpoises and seals over	Thomsen *et al.* (2006)[190].

[186] Bailey, H., Brookes, K.L., Thompson, P.M. 2014. Assessing Environmental Impacts of Offshore Wind Farms: Lessons Learned and Recommendations for the Future. Aquatic Biosystems. 10:8.
[187] Tougaard, J., Ebbesen, I., Tougaard, S., Jensen, T., Teilmann, J. 2003a. Satellite tracking of Harbour Seals on Horns Reef. Technical report to Techwise A/S, Biological Papers from the Fisheries and Maritime Museum, Esbjerg. No. 3.
[188] Tougaard, J, Carstensen, Jakob, Damsgaard Henriksen, O, and Teilmann, J. Short-term effects of the construction of wind turbines on harbour porpoises at Horns Reef. Denmark: N. p., 2003b. Web.
[189] David, J. 2006. Likely sensitivity of bottlenose dolphins to pile-driving noise. Water and Environment Journal. doi:10.1111/j.1747-6593.2005.00023
[190] Thomsen, F., Lüdemann, K., Kafemann, R., Piper W. 2006. Effects of offshore wind farm noise on marine mammals and fish. Biola, Hamburg, Germany on behalf of COWRIE Ltd. 62pp.

Activity	Study	Background Information	Reference
	different distances from the source levels.	distances of at least 80km. The dBht metric was applied which indicated that mild behavioural reactions (e.g. subtle change in swimming direction) in harbour porpoises might occur between 7 and 20km distance from the pile-driving source.	
	A two-zone model of effect from pile-driving noise based on measurements from North Hoyle, Scroby Sands, Kentish Flats, Barrow and Burbo Bank.	A Noise Injury Zone, bounded by the 130dBht contour, defines the area in which hearing injury can occur, and, in addition, the areas in which lethal and physical injury could occur, since the ranges at which these will occur are much less than those for hearing injury. This area typically extends to a few hundred metres from pile driving. The Behavioural Effect Zone is bounded by the 90dBht level contour. Within this area, the modelling suggested that harbour porpoise show strong avoidance within ranges of a few kilometres. Milder behavioural effects could occur at ranges of the order of 10 km or more. Noise from pile driving operations can remain above the background underwater noise to ranges of 25 km or more.	Nedwell *et al.*, (2003a)[191]; Nedwell *et al.*, (2007a)[192].
	Assessment of lethal and physical injury of marine mammals and requirements for Passive Acoustic Monitoring.	The estimated likely impact ranges from a 4.7m diameter pile (252 dB re: 1 µPa source level) were predicted to be 4m for lethal range and 81m for injury range. A 6m diameter pile (260 dB re: 1 µPa source level) had a lethal range of 65m and an injury range of 530m.	Parvin *et al.* (2007)[193].

[191] Nedwell, J., Landworthy, J., Howell, D. 2003a. Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore windfarms, and comparison with background noise. Report No. 544 R 0424.

[192] Nedwell, J. R, Parvin, S. J., Edwards, B., Workman, R., Brooker, A.G and Kynoch, J. E. 2007a. Measurement and interpretation of underwater noise during construction and operation of offshore wind farms in UK waters. Subacoustech Report No. 544R0738 to COWRIE Ltd. ISBN: 978-0-9554279-5-4.

[193] Parvin, S.J., Nedwell, J.R and Harland, E. 2007. Lethal and physical injury of marine mammals, and requirements for Passive Acoustic Monitoring. Subacoustech Report No.565R0212.

Activity	Study	Background Information	Reference
	Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea.	Porpoise acoustic activity was reduced by 100% during 1 hr after pile driving and stayed below normal levels for 24 to 72 hrs at a distance of 2.6 km from the construction site. This period gradually decreased with increasing distance. A negative effect was detectable out to a mean distance of 17.8 km. At 22 km it was no longer apparent. Out to a distance of 4.7 km, the recovery time was longer than most pauses between pile driving events. Porpoise activity and possibly abundance were reduced over the entire 5-month construction period. The behavioural response of harbour porpoises to pile driving lasted much longer than previously reported.	Brandt *et al*. (2011)[194]
	Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany.	Found a clear gradient in the decline of porpoise detections after piling, depending on noise level and distance to piling. Declines were found at sound levels exceeding 143 dB re 1 µPa2s and up to 17 km from piling. When only considering piling events with noise mitigation system (NMS), the maximum effect distance was 14 km. Compared to 24-48 h before piling, porpoise detections declined more strongly during unmitigated piling events at all distances: at 10-15 km declines were around 50% during piling without NMS, but only 17% when NMS were applied. Within the vicinity (up to about 2 km) of the construction site, porpoise detections declined several hours before the start of piling and were reduced for about 1-2 d after piling, while at the maximum effect distance, avoidance was only found during the hours of piling.	Brandt *et al*. (2018)[195]

[194] Brandt, M. J., Diederichs, A., Betke, K., Nehls, G. 2011. Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. Mar Ecol Prog Ser. 421: 205-216.
[195] Brandt, M., Dragon, A., Diederichs, A., Bellmann, M., Wahl, V., Piper, W., Nabe-Nielsen, J., Nehls, G. 2018. Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. Mar Ecol Prog Ser 596:213-232. https://doi.org/10.3354/meps12560

Activity	Study	Background Information	Reference
	Behavioural responses of a harbour porpoise *Phocoena phocoena* to playbacks of broadband pile driving sounds.	In this study, a harbour porpoise was exposed to pile driving sounds. At and above a received broadband SPL of 136 dB re 1 µPa the porpoise's respiration rate increased in response to the pile driving sounds. At higher levels, he also jumped out of the water more often. Wild porpoises are expected to move tens of kilometres away from offshore pile driving locations; response distances will vary with context, the sounds' source level, parameters influencing sound propagation, and background noise levels.	Kastelein *et al.* (2013)[196].
Blasting	Sensitivity of marine mammals to blasting.	In this study, an impulse of 69 Pas is given as leading to a low incidence of trivial blast injuries with no eardrum ruptures. The report found that for a 45 kg charge the blast impulse will fall to this level at a range of about 2.2 km. In addition to these figures, dBht levels were calculated from the standoff distances measurements at 600 metres, these are given as 135 dBht *Phocoena phocoena* harbour seal, 152 dBht (*Phocoena vitulina*) harbour porpoise and 158 dBht (*Orcinus orca*) killer whale. The linear SPL at this range was 217 dB re 1 µPa. These figures are in excess of the 90 dBht reaction threshold.	Nedwell *et al.*, (2007a)[197].
	Assessment of lethal and physical injury of marine mammals and requirements for	Blast source levels were found to have lethal ranges of 6-110m and injury ranges of 48-900m.	Parvin *et al.*, (2007)[198].

[196] Kastelein, R. A., Verboom, W. C., Jennings, N., de Haan, D., & van der Heul, S. (2008). The influence of 70 and 120 kHz tonal signals on the behaviour of harbor porpoises *Phocoena phocoena* in a floating pen. Marine Environmental Research, 66(3), 319-326.

[197] Nedwell, J. R, Parvin, S. J., Edwards, B., Workman, R., Brooker, A.G and Kynoch, J. E. 2007a. Measurement and interpretation of underwater noise during construction and operation of offshore wind farms in UK waters. Subacoustech Report No. 544R0738 to COWRIE Ltd. ISBN: 978-0-9554279-5-4.

[198] Parvin, S.J., Nedwell, J.R and Harland, E. 2007. Lethal and physical injury of marine mammals, and requirements for Passive Acoustic Monitoring. Subacoustech Report No.565R0212.

Activity	Study	Background Information	Reference
	Passive Acoustic Monitoring.		

7.9 Non-Physical Disturbance (Electromagnetic Fields; Impact Pathway 12)

7.9.1 The risk to cetacean species of being affected by electromagnetic fields is considered to be low. These fields arise from electricity transmission power cables, resulting from the current passing along the conductor and the voltage differential between the conductor and earth ground, which is nominally at zero volts. The nature and strength of the fields produced, depends on the system voltage and the current (AC or DC) passing through. The effects on the surrounding environment depend on the cable construction, configuration and orientation in space.

7.9.2 In order to standardise terminology, Gill *et al*. [199] proposed the term EMF should be used to describe the direct electromagnetic field. The two constituent fields of the EMF should be clearly defined as the E (Electric) field and the B (Magnetic Field) field, whilst the induced electric field should be labelled the iE field.

7.9.3 Magnetic Fields are produced from AC or DC current passing through the conductor and these emanate outwards from the cable in a circular plane, perpendicular to its longitudinal axis. The field strength produced as a result of the operation of electricity transmission (AC or DC) decreases rapidly with distance away from the source (the decay curve follows the inverse square law). The magnetic field around an AC cable is constantly changing at the same frequency as the alternating current that is producing it, which means that the modulation it produces in the Earth's field will also be constantly variable.

7.9.4 Marine mammals are not considered to be electrosensitive species [200]. For magnetosensitive species, sensitivity to the geomagnetic field is associated with a direction-finding ability e.g. migration. Gill *et al*. [201] lists cetaceans including the harbour porpoise as magnetosensitive. It is therefore considered that anthropogenic sources of EMF have the potential to affect spatial orientation[202] . No evidence has been found to suggest that pinnipeds are magnetoreceptive [203].

7.9.5 The underlying assumption that cetaceans have ferromagnetic organelles capable of determining small differences in relative magnetic field strength remains, however unproven and is based on circumstantial information. There is also no apparent evidence that existing cables have influenced migration of cetaceans. Migration of the harbour porpoise in and out of the Baltic Sea necessitates several crossings over operating subsea HVDC

[199] Gill A.B., Gloyne-Phillips, I.T., Neal, K.J and Kimber J.A., 2005. The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms - a review. Report to COWRIE, London, 90pp.

[200] Gill A.B., Gloyne-Phillips, I.T., Neal, K.J and Kimber J.A., 2005. The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms - a review. Report to COWRIE, London, 90pp.

[201] ibid

[202] NIRAS, 2015. Subsea cable interactions with the marine environment. Expert review and recommendations report.

[203] Gill A.B., Gloyne-Phillips, I.T., Neal, K.J and Kimber J.A., 2005. The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms - a review. Report to COWRIE, London, 90pp.

cables in the Skagerrak and western Baltic Sea without any apparent effect on their migration pattern [204]. The current evidence on the potential effects of EMF (if any) originating from subsea cables remains unclear, with no significant impacts found to date[205].

7.10 Toxic Contamination (Contamination and Spillages; Pathways 14 and 15)

7.10.1 Spillage of oils and fluids from construction vessels and machinery into the marine environment could adversely affect sediment or water quality during all phases of a wind farm development.

7.10.2 Leaching of toxic compounds from sacrificial anodes, antifouling paints or leakage of hydraulic fluids (if present) from the device is a potential effect during device operation. Seals and cetaceans in the study area generally have a low sensitivity to contamination, although the level of sensitivity increases to medium around seal breeding sites [206].

7.10.3 Marine mammals are also exposed to a variety of anthropogenic contaminants, through the consumption of prey. As top predators, they are at particular risk from contaminants which biomagnify through the food chain (i.e. are found at increasing concentrations at higher trophic levels). Most research has focused on two main groups of contaminants: the persistent organic pollutants (POPs) and the heavy metals. However, there is some information on other contaminants including polyaromatic hydrocarbons (PAHs), butyl tins and perfluorinated chemicals[207].

7.10.4 POPs accumulate in fatty tissues, are persistent and commonly resistant to metabolic degradation; they are often found in high concentrations in marine mammal blubber. They may affect the reproductive, immune and hormonal systems which can eventually lead to mortality. For example, Jepson *et al.* [208] suggested a possible link between high levels of PCB (polychlorinated biphenyls) recorded in the blubber of stranded dead bottlenose dolphins in the UK with the decline in bottlenose dolphins observed in this region between 1960s and 1990s. A strong association has also been found between poor health status (mortality due to infectious disease) and PCB chemical contamination for a large sample of UK-stranded harbour porpoises collected since 1990 [209].

7.10.5 Cadmium, lead, zinc and mercury are the heavy metals of greatest importance in marine mammals. They are frequently present in the highest concentrations in the liver, kidney and bone, with levels varying considerably

[204] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave

[205] NIRAS, 2015. Subsea cable interactions with the marine environment. Expert review and recommendations report.

[206] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave

[207] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.

[208] Jepson, P.D., Tregenza, N and Simmonds, M.P. 2009. Disappearing bottlenose dolphins *Tursiops truncatus*.

[209] ibid

with the geographic location of the species. Marine mammals are able to produce certain proteins (metallothioneins) which can sequester certain metal ions into less toxic complexes; this enables many species to cope with relatively high dietary exposures to certain metals. Whilst there are few studies that show major impacts of heavy metals, it is possible that they may have combined effects as they often co-occur with the persistent organic contaminants[210].

7.11 Non - Toxic Contamination (Increased Turbidity; Pathway 16)

7.11.1 Increased turbidity could affect foraging, social and predator/prey interactions of marine mammals, although marine mammals around the UK are regularly recorded foraging in highly turbid environments such as estuaries and tidal streams.

7.11.2 All UK marine mammals use vision to navigate in their environment, avoid obstacles and forage. Marine mammals can forage throughout the diurnal cycle, in very turbid waters and therefore are able to function as predators in very low light levels. Marine mammals are also known to have acute hearing capabilities. Seals just use passive listening while Odontocetes are known to use both passive and active listening when navigating and foraging (echolocation). This also helps marine mammals operate in low visibility, turbid conditions [211].

7.12 Grey and Common Seals (Pinnipeds) Sensitivity Review

7.12.1 Table 14 shows the sensitivities of qualifying seal interest features to the activities associated with the draft Plan. The level of sensitivity is low for all impact pathways with the exception of noise/vibration disturbance which is considered high.

[210] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.
[211] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave

Table 14. Potential sensitivities of seal features from the Sectoral Offshore Wind Plan

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PLG	Physical Loss/Gain of habitat	2	Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside these areas from associated scour and indirectly from changes to the hydrodynamic regime, as well as from chains anchoring devices disturbing seabed habitat during operation.	No impact	No impact	LS	No impact
PLG	Physical Loss/Gain of habitat	3	Presence of structures on seabed for the duration of the project resulting in changes to prey and species behaviour (e.g. acting as FAD (Fish Aggregating Device), artificial reef or bird roost).	No impact	No impact	LS	No impact
PD	Physical Damage to habitat	6	Reduction in quality of foraging areas as result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during installation; from maintenance and removal of cables/devices or from scour, sediment transport and	LS	LS	LS	LS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
			hydrodynamic change, and damage from chains anchoring devices during operation.				
PD	Physical Damage to habitat	7	Damage to seal haul out locations during the installation, decommissioning and operation of the cables and cable armouring.	No impact	LS	LS	LS
PD	Physical Damage to species	8	Collision risk and possible mortality of species due to the presence of devices or from vessels travelling to and from the site (including above and below water collision risk and the influence of lighting); risk of entanglement following a collision with power cables or mooring elements.	LS	LS	LS	LS
NPD	Non-physical disturbance	9	Presence of structures or disturbance (noise or visual) resulting in a barrier to movement, migratory pathways and/or access to feeding grounds depending on array design.	No impact	No impact	LS	No impact

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
NPD	Non-physical disturbance	10	Visual disturbance and exclusion from areas as a result of surveying, cable and device installation/operation and decommissioning activities and movements of vessels.	LS	LS	LS	LS
NPD	Non-physical disturbance	11	Noise/vibration disturbance and exclusion from areas as a result of vessels and other activities during survey work (e.g. seismic exploration and geophysical surveys, UXO clearance), construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning.	LS	HS	LS	MS
TC	Toxic Contamination (Reduction in water quality)	14	Spillage of fluids, fuels and/or construction materials during installation or removal of structures (devices and cables) or during survey /maintenance.	LS	LS	LS	LS
TC	Toxic Contamination (Reduction in water quality)	15	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (devices and cables).	No impact	LS	No impact	LS
NTC	Non-toxic Contamination (Elevated turbidity)	16	Increase in turbidity (and possibly reduced dissolved oxygen) associated with the release	No impact	LS	No impact	LS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
			of suspended sediments during installation or removal of structures (devices and cables).				
In this table, only the estimated sensitivity levels are shown. The level of risk will be dependent upon exposure. For instance, there would be a high degree of exposure for marine mammals were a development to occur within or near to a European/Ramsar site. However, at the present time, there is uncertainty regarding the degree of exposure and a worst-case assumption has been made.							
LS: Low Sensitivity							
LMS: Low to Medium Sensitivity							
MS: Medium Sensitivity							
HS: High Sensitivity							

7.13 Bottlenose Dolphin and Harbour Porpoise (Cetaceans) Sensitivity Review

7.13.1 Table 15 shows the sensitivities of qualifying cetacean interest features (namely bottlenose dolphin and harbour porpoise) to the activities associated with the Sectoral Offshore Wind Plan.

Table 15. Potential sensitivities of cetacean features from the Sectoral Offshore Wind Plan.

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PLG	Physical Loss/Gain of habitat	2	Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside these areas from associated scour and indirectly from changes to the hydrodynamic regime, as well as from chains anchoring devices disturbing seabed habitat during operation.	No impact	No impact	LS	No impact
PLG	Physical Loss/Gain of habitat	3	Presence of structures on seabed for the duration of the project resulting in changes to prey and species behaviour (e.g. acting as FAD (Fish Aggregating Device), artificial reef or bird roost).	No impact	No impact	LS	No impact

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PD	Physical Damage to habitat	6	Reduction in quality of foraging areas as result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during installation; from maintenance and removal of cables/devices or from scour, sediment transport and hydrodynamic change, and damage from chains anchoring devices during operation.	LS	LS	LS	LS
PD	Physical Damage to species	8	Collision risk and possible mortality of species due to the presence of devices or from vessels travelling to and from the site (including above and below water collision risk and the influence of lighting); risk of entanglement following a collision with power cables or mooring elements.	LS	LS	LS	LS
NPD	Non-physical disturbance	9	Presence of structures or disturbance (noise or visual) resulting in a barrier to movement, migratory pathways and/or access to feeding grounds depending on array design.	No impact	No impact	LS	No impact

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
NPD	Non-physical disturbance	10	Visual disturbance and exclusion from areas as a result of surveying, cable and device installation/operation and decommissioning activities and movements of vessels.	LS	LS	LS	LS
NPD	Non-physical disturbance	11	Noise/vibration disturbance and exclusion from areas as a result of vessels and other activities during survey work (e.g. seismic exploration and geophysical surveys), construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning.	LS	HS	LS	MS
NPD	Non-physical disturbance	12	Impacts from Electromagnetic Fields (EMF) and thermal emissions on benthic invertebrates and electromagnetically sensitive fish and cetaceans interfering with prey location and mate detection in some species and creating barriers to migration	No impact	No impact	LS	No impact

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
TC	Toxic Contamination (Reduction in water quality)	14	Spillage of fluids, fuels and/or construction materials during installation or removal of structures (devices and cables) or during survey /maintenance.	LS	LS	LS	LS
TC	Toxic Contamination (Reduction in water quality)	15	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (devices and cables).	No impact	LS	No impact	LS
NTC	Non-toxic Contamination (Elevated turbidity)	16	Increase in turbidity (and possibly reduced dissolved oxygen) associated with the release of suspended sediments during installation or removal of structures (devices and cables).	No impact	LS	No impact	LS
In this table, only the estimated sensitivity levels are shown. The level of risk will be dependent upon exposure. For instance, there would be a high degree of exposure for marine mammals were a development to occur within or near to a European/Ramsar site. However, at the present time, there is uncertainty regarding the degree of exposure and a worst-case assumption has been made.							
LS: Low Sensitivity							
LMS: Low to Medium Sensitivity							
MS: Medium Sensitivity							
HS: High Sensitivity							

7.14 Potential Effects on European/Ramsar Sites from the Sectoral Offshore Wind Plan

7.14.1 On the basis of the sensitivities of the relevant interest features the following sections review the typical conservation objectives for these features and the potential effects arising for the European/Ramsar sites.

7.14.2 In the UK the conservation objectives for the four qualifying features (grey seal, common seal, bottlenose dolphin and harbour porpoise) are typically the same across different European/Ramsar sites. The UK objectives seek to avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features. The conservation objectives are to ensure for the qualifying species that the following are maintained in the long term:

- Population of the species as a viable component of the site;
- Distribution of the species within site;
- Distribution and extent of habitats supporting the species;
- Structure, function and supporting processes of habitats supporting the species; and
- No significant disturbance of the species.

7.14.3 Taking account of the conservation objectives and the plan-level activities to which the key interest features (all marine mammal qualifying features within the SAC/Ramsar sites) are sensitive, this section reviews the potential effects of the Sectoral Offshore Wind Plan on the integrity of the European/Ramsar sites. The results are presented in Table 16.

Table 16. Assessment of the potential effects of the Sectoral Offshore Wind Plan on the marine mammal features of relevant European/Ramsar sites

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Common seal ▪ Grey seal ▪ Bottlenose dolphin ▪ Harbour porpoise	**Physical Loss/Gain of habitat** Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside these areas from associated scour and indirectly from changes to the	2	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code) **Commentary/Risk Review** Marine mammals are highly mobile and have large foraging ranges. Any loss of habitat because of a wind farm development is likely to only constitute a very small fraction of the total area used by a species for foraging. In addition, a study by Diederichs *et al*. [212] found no significant influence of wind farms on the occurrence of harbour porpoises which were found to be recorded moving through and foraging in two wind farm areas (Horns Rev-North Sea and Nysted-Baltic Sea) almost daily.	Possibility of an adverse effect on integrity Further work would be required at project-level to ascertain LSE. However, in advance of considering mitigation measures, it cannot be concluded that there will be no AEOI on any	No adverse effect on integrity With the application of appropriate and meaningful mitigation measures to accompany the Plan (see Section 11), there will be no AEOI.

[212] Diederichs, A. Grünkorn and Nehls, G., 2008. Offshore windfarms-disturbance or attraction for harbour porpoises? First results of T-pod investigation in horns rev and nysted. In. Proceedings of the ASCOBANS/ECS workshop offshore windfarms and marine mammal. Impacts and methodologies for assessing impacts. Ed. Evans, P.G.H.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	hydrodynamic regime, as well as from chains anchoring devices disturbing seabed habitat during operation.		**Relevant Conservation Objectives** (see Section 7.14) Of the 5 objectives, two are considered to be particularly relevant to impacts from physical loss/gain of habitat during the operational phase of the Sectoral Offshore Wind Plan: ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.	European/Ramsar sites. This is because of the inherent uncertainties such as: the detail of the Plan implementation process; future generation capacities; the location, scale and densities of development; the proposed technologies to be used and future advances in these technologies; the scale of the effects arising via	

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
				some of the defined impact pathways; and the efficacy of some project-level mitigation options.	
▪ Common seal ▪ Grey seal ▪ Bottlenose dolphin ▪ Harbour porpoise	**Physical Loss/Gain of habitat** Presence of structures on seabed for the duration of the project resulting in changes to prey and species behaviour (e.g. acting as FAD (Fish Aggregating Device), artificial reef or bird roost).	3	**Sensitivity Level(s)** considered to be low (see Table 14and Table 15 for detail and colour code) **Commentary/ Review (**see Section 7.14)) The base of wind turbines could potentially act both as artificial reefs and as FADs for prey species of marine mammals. Wilhelmsson *et al.* [213] investigated this potential for wind turbines to function as artificial reefs and FADs. Fish abundance was found to be greater in the vicinity of the turbines than in surrounding areas, while	As above	As above

[213] Wilhelmsson, D., Malm, T., and Ŏhman, M., 2006. The influence of offshore wind power on demersal fish. ICES Journal of Marine Science 63, 775-784.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			species richness and Shannon-Wiener diversity (H′) were similar. A gill netting survey at the Svante Wind Farm, Sweden, found higher numbers of cod within two hundred metres of an operating turbine compared to the surrounding open waters, and higher still when the turbines were not operating [214]. Diver held video surveys of the North Hoyle offshore wind farm piles found extremely high densities of juvenile whiting, apparently feeding on dense populations of amphipods amongst the fouling biota on the piles [215]. Both cod and whiting are prey items for marine mammals such as harbour porpoise and grey seal. Harbour porpoise have also been regularly recorded foraging around wind farm areas which could be		

[214] Westerberg, H. 1999. Impact studies of sea-based windpower in Sweden. lecture held at "Technische Eingriffe in marine Lebensräume“ Bundesamt für Naturschutz .Internationale NaturschutzakademieInsel Vilm 27-29.10.99.

[215] Bunker, F. 2004. Biology and video surveys of North Hoyle wind turbines 11-13th August 2004. A report to CMACS Ltd by Marine Seen, Estuary Cottage, Bentlass, Hundleton, Pembs. SA71 5RN.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			because of an increase in prey species [216]. A study by Raoux *et al.* [217] concluded that increased biomass around offshore wind turbines resulted in positive feeding opportunities for marine mammals. The size of an array will be a key consideration and devices with the highest FAD potential are therefore those with large elements e.g. large mooring points or floating structures. Devices with large moorings may provide additional shelter and food (habitat) for small demersal fish such as territorial blennies and gobies (Love *et al.*, 2000). Increases in demersal fish have been		

[216] Diederichs, A. Grünkorn and Nehls, G., 2008. Offshore windfarms-disturbance or attraction for harbour porpoises? First results of T-pod investigation in horns rev and nysted. In. Proceedings of the ASCOBANS/ECS workshop offshore windfarms and marine mammal. Impacts and methodologies for assessing impacts. Ed. Evans, P.G.H.

[217] Raoux, A., Tecchio, S., Pezy, J., Lassalle, G., Degraer, S., Wilhelmsson, D., Cachera, M., Ernande, B., Guen, C., Haraldsson, M., Grangeré, K., Le Loc'h, F., Dauvin, J., Niquil, N. 2017. Benthic and Fish Aggregation Inside an Offshore Wind Farm: Which Effects on the Trophic Web Functioning? Ecological Indicators, 72, 33-46.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			observed around the piles of off-shore wind farms [218] [219]. However, it is generally agreed that fish aggregation probably represents a very minor effect DECC (2009). Empirical data on the relationship between marine mammals and prey that might be aggregating around wind turbines is currently limited.		
			Relevant Conservation Objectives (see Section 7.14)) Of the 5 objectives, three are considered to be most relevant to impacts from non-physical disturbance as a result of an increase in prey species: ▪ Distribution of the species within site;		

[218] Wilhelmsson, D., Malm, T., and Ŏhman, M., 2006. The influence of offshore wind power on demersal fish. ICES Journal of Marine Science 63, 775-784.

[219] Linley, E.A.S., Wilding, T.A., Black K., Hawkins, A.J.S. and Mangi S, 2007. Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation. Report from PML Applications Ltd and the Scottish Association for Marine Science to the Department for Business, Enterprise and Regulatory Reform (BERR), Contract No: RFCA/005/0029P.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.		
▪ Common seal ▪ Grey seal ▪ Bottlenose dolphin ▪ Harbour porpoise	**Damage to Habitat** Reduction in quality of foraging areas as result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during	6	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code) **Commentary/ Review** Marine mammals are highly mobile and have large foraging ranges. The extent of habitat that might be reduced in quality is only going to constitute a very small fraction of the total area used by a species for foraging making any impact negligible. **Relevant Conservation Objectives** (see Section7.14))	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	installation; from maintenance and removal of cables/devices or from scour, sediment transport and hydrodynamic change during operation.		Of the 5 objectives, two are considered to be particularly relevant to impacts from reduction in the quality of foraging habitat: ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.		
▪ Common seal ▪ Grey seal	**Physical Damage to Habitat** Damage to seal haul out locations during the installation, decommissioning and operation of the	7	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code) **Commentary/ Review** Seals use haul-out sites for a range of purposes including breeding, resting and moulting [220]. Seals generally choose remote areas to haul-out and are generally highly sensitive to damage and disturbance	As above	As above

[220] SCOS, 2009. Scientific advice on matters related to the management of seal populations: 2009. Special Committee on Seals, 100pp.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	cables and cable armouring.		(particularly in the breeding season). Cable routes are most likely to come ashore where infrastructure already exists on the mainland. Most seals haul-out on uninhabited islands, offshore sandbanks and rocky areas. Therefore, any damage to seal haul-outs is considered to be unlikely. **Relevant Conservation Objectives** (see Section 7.14) Of the 5 objectives, two are considered to be particularly relevant to impacts from physical damage of haul-out habitat: ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.		
▪ Common seal ▪ Grey seal	**Damage to Species**	8	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code)	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Bottlenose dolphin ▪ Harbour porpoise	Collision risk and possible mortality of species due to the presence of devices or from vessels travelling to and from the site (including above and below water collision risk and the influence of lighting); risk of entanglement following a collision with power cables or mooring elements.		**Commentary/ Review** Pinnipeds and cetaceans can potentially collide with construction vessel propellers and machinery possibly leading to physical injury and, in the worst case, fatalities. Juvenile grey seal pups, which are inexperienced in the water, are likely to be particularly vulnerable to collision risk. Ships travelling at 14 knots (~7 m/s) or faster are most likely to cause lethal or serious injuries if there is a collision [221]. Vessels involved in the construction phase are either likely to be stationary or travelling at much slower speeds than this, and, therefore, risk of injury by collision would be considerably lower. Marine mammals have the potential to become entangled with ropes and/or lines. Echo locating cetaceans, such as the		

[221] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			bottlenose dolphin and harbour porpoise, will be able to detect the object at a distance of tens of metres [222]. Pinnipeds have the ability to detect objects underwater through acute mechano-sensitivity using their vibrissae or whiskers [223] [224]. There are a number of risk factors associated with entanglement including biological characteristics of marine mammals and the physical features of the mooring themselves [225]. Biological factors include body size, flexibility, ability to detect moorings, and mode of feeding. Pinnipeds, harbour porpoise and bottlenose dolphins are considered to have a low risk of becoming entangled as they are small and agile and are able to detect objects in the water from		

[222] Miller, L., Wahlberg, M., 2013. Echolocation by the harbour porpoise: life in coastal waters. Frontiers in Physiology. doi: 10.3389/fphys.2013.00052.
[223] Dehnhardt, G., Mauck, B., Hanke, W. & Bleckmann, H. 2001. Hydrodynamic trail-following in harbor seals *Phoca vitulina*. Science, 293, 102-104.
[224] Hanke, W., Wieskotten, S., Marshall, C. & Dehnhardt, G. 2013. Hydrodynamic perception in true seals (Phocidae) and eared seals (Otariidae). Journal of Comparative Physiology A, 199, 421-440.
[225] Benjamins, S., Harnois, V., Smith, H.C.M., Johanning, L., Greenhill, L., Carter, C. and Wilson, B. 2014. Understanding the potential for marine megafauna entanglement risk from renewable marine energy developments. Scottish Natural Heritage Commissioned Report No. 791.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			tens of metres away [226]. Marine mammals may become entangled with a rope or line if the animal's ability to detect the object is compromised under particular environmental conditions such as low light conditions, or during storms. Marine mammals may also be distracted while feeding on mobile prey species and so not see the hazard [227]. Entanglement in mooring lines is unlikely to be an issue given the latest available evidence [228]. If necessary, however, potential entanglement in mooring lines can be mitigated by using high visibility mooring lines. Behavioural responses of marine mammals to perceived threats can be broadly		

[226] ibid
[227] ibid
[228] ibid

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			categorized in two ways: avoidance and evasion. Hence with respect to wind farm developments, marine mammals may demonstrate two types of response: long range avoidance (i.e. avoiding the area within the vicinity of the device(s)) or close-range evasion, depending upon the distance at which the device is perceived and the subsequent behavioural response. However, collision risk with wind turbine structures is considered low.		
			Relevant Conservation Objectives (see Section 7.14) Of the 5 objectives, three are considered to be particularly relevant to impacts from physical damage as a result of collision risk during all phases of the Sectoral Offshore Wind Plan:		

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ Population of the species as a viable component of the site; ▪ Distribution of the species within site; and ▪ No significant disturbance of the species.		
▪ Common seal ▪ Grey seal ▪ Bottlenose dolphin ▪ Harbour porpoise	**Non-physical Disturbance** Barrier to movement from the presence of sub-surface structures and disturbance (noise or visual) which may block migratory pathways or access to feeding grounds depending on array design.	9	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code) **Commentary/ Review** The potential for wind turbines to act as a barrier to movement will be partly dependent on the extent that noise and visual cues from the device(s) cause an avoidance response. It is also dependent on the ability of marine mammals to navigate around the devices. The significance of any obstruction will ultimately depend on the spatial confines and size of the array. Considering the highly manoeuvrable nature of the marine mammal interest features and the offshore locations of	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			the DPOs a low sensitivity has been assessed for marine mammals to this impact pathway.		
			Relevant Conservation Objectives (see Section 7.14) The conservation objectives are designed to avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained. All of the 5 objectives are pertinent to the potential effects; however, the following are considered to be most relevant: ▪ Distribution of the species within site; ▪ Distribution and extent of habitats supporting the species; and		

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ Structure, function and supporting processes of habitats supporting the species.		
▪ Common seal ▪ Grey seal ▪ Bottlenose dolphinHarbour porpoise	**Non-Physical Disturbance** Visual disturbance and exclusion from areas as a result of surveying, cable and device installation/ operation and decommissioning activities and movements of vessels.	10	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code) **Commentary/ Review** Visual disturbance from vessels in the different phases of development will generally only be short term. However, the level of impact will be dependent on the distance vessels are away from seal haul out sites and key foraging areas for marine mammals. Overall sensitivities are considered to be low. **Relevant Conservation Objectives** (see Section 7.14) The conservation objectives are designed to avoid deterioration of the habitats of the qualifying species or significant disturbance	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			to the qualifying species, thus ensuring that the integrity of the site is maintained. All of the 5 objectives are pertinent to the potential effects; however, the following are considered to be most relevant: ▪ Distribution of the species within site; ▪ No significant disturbance of the species.		
▪ Common seal ▪ Grey seal ▪ Bottlenose dolphin ▪ Harbour porpoise	**Non-Physical Disturbance** Noise/vibration disturbance and exclusion from areas as a result of vessels and other activities during survey work (e.g. seismic exploration and	11	**Sensitivity Level(s)** maximum considered to be high (see Table 14 and Table 15 for detail and colour code) **Commentary/ Review** The sensitivity of marine mammals is considered to be high during the construction phase (especially where there is a need for piling) but low or medium during other phases of development. Geophysical surveys carried out for installations of marine renewable devices often involve side scan	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	geophysical surveys), construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning.		sonar that may cause acoustic disturbance of marine mammals. Available information on the magnitude impact from side scan sonar indicates that disturbance (for single or multiple devices) of marine mammals is low (MacGillvray *et al*., 2014[229]) in contrast to seismic surveys employed for oil and gas exploration which generate greater source noise levels [230]. The effect on marine mammals from vessel noise is not clear, with both attraction and avoidance reactions having been observed [231]. Noise levels from the ship's echo-sounder or acoustic emissions from a dynamic positioning system would not be expected to cause widespread disturbance to		

[229] MacGillivray, A.O., Racca, R. and Zizheng, L., 2014. Marine mammal audibility of selected shallow-water survey sources. Available at: https://asa.scitation.org/doi/10.1121/1.4838296 (accessed 02/11/2018)
[230] JNCC, 2008. The deliberate disturbance of marine European Protected Species: Interim guidance for English and Welsh territorial waters and the UK offshore marine area.
[231] Nedwell, J. and Howell, D., 2004. A review of offshore wind farm related underwater noise sources. Report No. 544 R 0308.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			marine mammals [232]. For harbour porpoises the zone of audibility of shipping noise ranges from 1-3 km depending on the frequency of noise emitted by the ship [233]. The Scottish Marine Wildlife Watching Code advises that the minimum approach distance for vessels to avoid visual and noise disturbance to dolphins and porpoises is 50m (200-400m for mothers and calves, or for animals that are clearly actively feeding or in transit). The key sources of noise related to construction and device installation are: ▪ Shipping and machinery; ▪ Dredging; and ▪ Pile driving or drilling.		

[232] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave

[233] Thomsen, F., Lüdemann, K., Kafemann, R., Piper W. 2006. Effects of offshore wind farm noise on marine mammals and fish. Biola, Hamburg, Germany on behalf of COWRIE Ltd. 62pp.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			Additionally, cable burial requires the use of trenching or jetting machinery in soft sediments, rock cutting machinery in hard sea-beds, or rock or concrete mattress laying may be used to protect cables in areas where they cannot be buried. **Relevant Conservation Objectives** (see Section 7.14)) Of the 5 objectives, two are considered to be particularly relevant to impacts from non-physical noise and vibration disturbance: ▪ Distribution of the species within the site; and ▪ No significant disturbance of the species.		
▪ Bottlenose dolphin ▪ Harbour porpoise	**Non-Physical Disturbance** Impacts from Electromagnetic	12	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code) **Commentary/ Review**	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	Fields (EMF) on electromagnetically sensitive fish and cetaceans interfering with prey location and mate detection in some species and creating barriers to migration		It is assumed that cetaceans may be sensitive to electromagnetic fields[234]. However, the expected magnetic field from a cable (up to a few micro Tesla (μT) is very small, particularly relative to the Earth's own magnetic field (approximately 50 μT)[235]. Furthermore, no studies have suggested that the electromagnetic fields around cables have a behavioural effect on cetaceans. Hence, the sensitivity of bottlenose dolphins and harbour porpoise to electromagnetic fields is considered to be low and only relevant during the operational phases.		
			Relevant Conservation Objectives (see Section 7.14)		

[234] Fisher C and Slater M (2010) Effects of electromagnetic fields on marine species: A literature review. Report prepared on behalf of Oregon Wave Energy Trust. 26pp. Available at: https://tethys.pnnl.gov/sites/default/files/publications/Effects_of_Electromagnetic_Fields_on_Marine_Species.pdf.

[235] PMSS Ltd, 2007. Wave Dragon Pre-Commercial Wave Energy Device. Environmental Statement. A report for Wave Dragon Wales Ltd.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			Of the 5 objectives, two are considered to be particularly relevant to impacts from non-physical EMF disturbance: ▪ Distribution of the species within site; and ▪ No significant disturbance of the species.		
▪ Common seal ▪ Grey seal ▪ Bottlenose dolphin ▪ Harbour porpoise	**Toxic Contamination** (Reduction in water quality) Spillage of fluids, fuels and/or construction materials during installation or removal of structures (devices and cables)	14	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code) **Commentary/ Review** For all phases of the development, there is the potential for accidental discharges/spillages from machinery and vessels. However, adoption of standard safety measures would be employed throughout all phases of the project to reduce likelihood of accidental spillages occurring.	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	or during survey/maintenance.		The marine renewables SEA [236] identifies a range of optional contamination sources including from anti-fouling paints and sacrificial anodes and the accidental leakage of fluids and/or spillage fuels or cargo from vessels. The quantities and toxicities associated with sacrificial anodes and antifouling coatings are generally expected to be extremely small, and it is therefore considered that this potential effect will be of negligible significance.		
			Relevant Conservation Objectives (see Section 7.14) Of the 5 objectives, two are considered to be most relevant to impacts from toxic contamination due to spillage incidents: ▪ Distribution of the species within site; and		

[236] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave.

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ No significant disturbance of the species.		
▪ Common seal ▪ Grey seal ▪ Bottlenose dolphin ▪ Harbour porpoise	**Toxic Contamination** (Reduction in water quality) Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (devices and cables).	15	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code) **Commentary/ Review** Sediments are generally likely to be low in contaminant levels within DPOs, given the distance away from major coastal development and the inherently dispersive and often dynamic nature of the environment. The characteristically energetic environments in which the devices will be located will also assist in the dispersion of any localised contamination, thus minimising any impacts on water quality. **Relevant Conservation Objectives** (see Section 7.14)	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			The conservation objectives are designed to avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained. In total there are 5 objectives (see Section 7.14.2) and of these the ones that are most relevant to this impact pathway are to maintain the following in the long-term ▪ Population of the species as a viable component of the site; ▪ No significant disturbance of the species; and ▪ Distribution of the species within site		
▪ Common seal ▪ Grey seal	**Non-Toxic Contamination** (Elevated turbidity)	16	**Sensitivity Level(s)** considered to be low (see Table 14 and Table 15 for detail and colour code) **Commentary/ Review**	As above	As above

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ ottlenose dolphin ▪ rbour porpoise	Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (devices and cables).		Local suspended sediment concentrations may increase as a result of drilling of the seabed for the installation of the pile, burial of the power export cables and disposal of drill cuttings. Increased turbidity could affect foraging, social and predator/prey interactions of marine mammals, although marine mammals around the UK are regularly recorded foraging in highly turbid environments such as estuaries and tidal streams. All features of interest have a low sensitivity to this impact pathway.		
			Relevant Conservation Objectives (see Section 7.14)) Of the 5 objectives, two are considered to be particularly relevant to impacts from non-toxic contamination as a result of increased turbidity:		

Screened-in sites with these qualifying features are provided in Table C1				Is There an Adverse Effect on Integrity of any European/Ramsar sites	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ Distribution of the species within the site; and ▪ No significant disturbance of the species		

8 Potential for Adverse Effects on Fish and Freshwater Pearl Mussel Features

8.1 Introduction

8.1.1 Following the screening process, a total of 468 European/Ramsar sites were identified for which there is a LSE (or the potential for a LSE cannot be excluded) (Table C1, Appendix C). Of these sites, a number of European/Ramsar sites were identified as it was not possible to conclude that there would be no LSE from the Sectoral Offshore Wind Plan on qualifying fish or freshwater pearl mussel interest features.

8.1.2 Given the broad area covered by the draft Plan and the large number of sites screened into these assessments, the same method as agreed in previous HRAs [237] [238] [239] has been used where it is not necessary to individually review the full list of all sites and the qualifying fish and freshwater pearl mussel interest features that they support within this report. The individual sites that were screened in for each of the 17 DPOs are shown in the schedules (Tables D1-D17) and maps (Figures E1-E17). The locations of screened in SAC and Ramsar sites with qualifying fish and/or pearl mussel features beyond the 100 km buffer are provided in Appendix F (Figure F8).

8.1.3 European sites support additional fish species as 'typical species of habitat' features; for example, sparling (the European smelt *Osmerus operlanus*). The impact pathways for these supporting features are considered to be the same as for qualifying interest fish features and have, therefore, not been considered separately and specifically as part of this assessment. It is recognised that differences in their life histories may mean they are more (or less) susceptible to impacts than other species and this may in turn influence the levels of risk that are relevant and, at a project-level, the detailed requirements for mitigation. However, the assessment process has been undertaken and the mitigation measures selected such that they encompass all the levels of risk to relevant qualifying species.

8.1.4 Some of these SACs and Ramsar sites also contain other interest features for which it could not be concluded that there was no LSE (e.g. otter) and these are reviewed separately under the relevant section(s) that encompass these other habitat/species groups in this report. In addition, where there are interest features at these sites which have been 'screened out' because there will be no LSE then these are also recorded (Table C1).

[237] ABPmer, 2011a. Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Report for the Scottish Government, ABP Marine Environmental Research Ltd, Report No: R.1722a-c. January 2011.

[238] ABPmer 2013f. Habitats Regulations Appraisal of Draft Plan for Wave and Tidal Energy (W&TE) in Scottish Waters. Report for Marine Scotland 2013; ABP Marine Environmental Research Ltd, Final Report January 2013 Report Nos. R.1863a (Pre-Screening); R.1863b (Screening); and R.1863c (Report to Inform Appropriate Assessment); and R.1863d (PSG Comments Review).

[239] ABPmer, 2017. Habitats Regulations Appraisal of the Draft Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters. Reports for Marine Scotland, ABPmer Report No: R.2121a-c. 5 May 2017.

8.1.5 In summary, the screening phase concluded that there is a possibility of a LSE (or that it was not possible to conclude no LSE) for the following fish and freshwater pearl mussel features:

- Atlantic salmon *Salmo salar* (1106);
- Sea lamprey *Petromyzon marinus* (1095);
- River lamprey *Lampetra fluviatilis* (1099);
- Allis shad *Alosa alosa* (1102);
- Twaite shad *Alosa fallax* (1103); and
- Freshwater pearl mussel *Margaritifera margaritifera* (1029).

8.1.6 To assess whether there is any adverse effect on the integrity of relevant European/Ramsar sites, the following sections review the sensitivities of the associated qualifying fish and freshwater pearl mussel features, identify the conservation objectives and assess, in tabular format, the effects arising in the context of the proposed plan-level mitigation measures.

8.2 Sensitivities of Fish Interest Features to Sectoral Offshore Wind Plan Activities

8.2.1 This section reviews the sensitivities that are relevant for the fish interest features. These reviews focus on the fish species because any effect on freshwater pearl mussel will only arise as an indirect consequence of effects on Atlantic salmon. Initially a generic review of the sensitivities is presented under the impact pathways identified during the screening phase:

- Physical loss/gain of habitat (Loss of Onshore and Offshore Habitat);
- Physical Loss/Gain of Habitat (Fish Aggregation);
- Physical Damage to Habitat (Reduction in Foraging Habitat Quality);
- Physical Damage to Species (Collision Risk);
- Non-Physical Disturbance (Noise Disturbance causing Barrier or Exclusion Effects);
- Non-Physical Disturbance (Electromagnetic field);
- Toxic Contamination (Contamination and Spillages); and
- Non-toxic Contamination (Increased Turbidity).

8.2.2 Following this review, the general sensitivities for the relevant interest features are identified and tabulated in addition to the impact pathways.

8.3 Physical Loss/Gain of Habitat (Damage to Onshore and Offshore Habitat; Impact Pathway 2)

8.3.1 Although the direct loss of freshwater habitats may occur as a result of cable installation or any landside infrastructure works, the potential effects from terrestrial development are outside the scope of the plan level HRA. However, there is potential for loss of migratory fish foraging areas or pearl mussel habitat in marine and estuarine environments. This could be a

habitat that is designated for qualifying features (in which case there would be the highest risk of an effect) or it could be located along the migratory routes of fish.

8.3.2 It is anticipated that any sensitive habitats would be avoided wherever possible and during the construction period that the worst-case scenario would involve temporary effects.

8.3.3 Damage to offshore habitats during the operation phase may influence foraging areas for migratory fish species. However, the high mobility and ranges of this group of fish will enable them to use other offshore foraging areas if required.

8.4 Physical Loss/Gain of Habitat (Fish Aggregation; Impact Pathway 3)

8.4.1 Many fish are attracted to solid man-made structures and artificial reefs are often deployed to enhance fisheries [240]. Structures constructed for other purposes such as oil platforms and breakwaters [241] can also serve as new habitats for fish. However, unlike for some fish species, the presence of windfarm infrastructure is unlikely to result in the direct aggregation of migratory fish such as Atlantic salmon.

8.4.2 Subsea structures can change local abiotic conditions allowing species assemblages to form that are different from the natural communities present. The monopiles of turbines, for example, become encrusted with epibiota such as mussels and barnacles [242]. These modify the habitat and provide food and shelter for fish and invertebrate species leading to increased fish abundance and enhancement of the local seabed habitat [243].

8.4.3 While it is unlikely that the windfarm devices would result in aggregation of migratory fish species, their presence may attract prey species and therefore indirectly attract migratory fish. Wilhelmsson *et al.* [244] investigated this potential for devices to function as artificial reefs and Fish Aggregation Devices (FADs). Fish abundance was found to be greater in the vicinity of the turbines than in surrounding areas, while species richness and Shannon-Wiener diversity (H′) were similar.

[240] Sayer, M.D.J., Magill, S.H, Pitcher, T.J., Morissette, L and Ainsworth C. 2005. Simulation-based investigations of fishery changes as affected by the scale and design of artificial habitats. Journal of Fish Biology 67: 218-243.
[241] Helvey, M., 2002. Are southern California oil and gas platforms essential fish habitat? ICES Journal of Marine Science, 59:
[242] Linley, E.A.S., Wilding, T.A., Black K., Hawkins, A.J.S. and Mangi S, 2007. Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation. Report from PML Applications Ltd and the Scottish Association for Marine Science to the Department for Business, Enterprise and Regulatory Reform (BERR), Contract No: RFCA/005/0029P.
[243] Wilhelmsson, D., Malm, T., and Ŏhman, M., 2006. The influence of offshore wind power on demersal fish. ICES Journal of Marine Science 63, 775-784.
[244] ibid

8.5 Physical Damage to Habitat (Reduction in Foraging Habitat Quality; Impact Pathway 6)

8.5.1 There is potential for damage to migratory fish foraging areas in marine and estuarine environments from cable routeing and at landfall. This could be a habitat that is designated for migratory fish or freshwater pearl mussel qualifying features (in which case there would be the highest risk of an effect) or it could be located along the migratory routes of fish.

8.5.2 In offshore locations, baseline survey work (e.g. boreholes and trawls), installation, maintenance and removal of cables and turbines could all potentially result in a reduction of foraging habitat quality and prey species availability, as a result of physical disturbance.

8.6 Physical Damage to Species (Collision Risk; Impact Pathway 8)

8.6.1 The ability for fish to avoid a potential collision with an object is dependent on sensory capabilities (such as vision and hearing), perception levels and swimming speeds of the species. As lamprey could be attached to a range of different pelagic and demersal species while undertaking the marine phase of the lifecycle, general information on fish sensitivity to collisions is considered.

8.6.2 Marine animals in high latitude coastal areas have to contend with variable and often poor visual conditions, resulting from fluctuations in ambient light levels and in the light transmission properties of the water. Fish have well developed eyes and the variety of colour patterns and specific movements that they display invites comparisons between the most visually orientated species among birds and mammals [245] [246].

8.6.3 Fish have been recorded colliding or becoming entrapped within a range of anthropogenic structures such as fishing nets and power station intakes [247] [248]. The level of light and clarity of water are important factors in fish collision risk. In poor visibility conditions, fish have been observed only just avoiding collision with an obstacle, whereas in good visibility conditions, fish react further away from otter trawl boards and swim over/under/around trawls [249]. More recent experiments quantified the light level thresholds for the visual reactions of mackerel to monofilament netting were -1 log lux and -4 log lux (1 - 0.001 lux) for multifilament [250]. At light levels below these

[245] Guthrie, D.M., and Muntz, W.R.A. 1993. Role of vision in fish behaviour. In Behaviour of teleost fishes. Edited by T.J. Pitcher. Chapman and Hall, London, UK.
[246] Brawn V.M. 1969. Feeding behaviour of cod (Gadus morhua). J. Fish. Res. Board Can 26, 583-596.
[247] Johnson, L., Dorn, P., Muench, K., and Hood, M. 1976. An evaluation of fish entrapment associated with the offshore cooling water intake system at Redondo Beach Steam Generating Station Units 7 and 8. South. Calif. Edison Co. Res. Develop. Ser. 77-RD-12, Rosemead, Calif., 36 p.
[248] Wardle, C.S. 1986. Fish behaviour and fishing gear. In: Pitcher T.J. (ed) The behaviour of Teleost fishes. Croom Helm Ltd, London, UK, p 463-495.
[249] ibid
[250] Cui, G., Wardle, C. S., Glass, C.W., Johnstone, A.D.F and Mojsiewicz, W.R. 1991. Light level thresholds of visual reaction of mackerel, Scomber scombrus L. to coloured monofilament nylon gillnet materials. Fisheries Research 10, 255-263.

thresholds, fish were unaware of the netting barriers and swam straight through them.

8.6.4 Fish may avoid collisions with an object through "startle" (or "C-start") responses. The C-start response can be initiated by transient sound, visual or touch stimuli. For example, herring escape behaviour is a reflex response stimulated by transient sound stimuli, detected in the labyrinth (inner ear) [251]. 'Visually looming' objects will also trigger evasion behaviour in most if not all species, with a greater response rate to edges moving horizontally rather than vertically [252]. The behavioural response to an approaching net is to turn and swim in the direction of the moving net, using the minimum swimming speed to avoid the object (resulting in them 'holding position' at the mouth of the net) whilst reserving energy for an escape response. However, on exhaustion, the fish turn and allow the net mouth to overtake them [253].

8.7 Non-Physical Disturbance (Barrier or Exclusion Effects; Impact Pathway 9)

8.7.1 Salmon and lamprey are highly mobile species that undergo large seasonal movements and migrations to forage and breed [254] [255] [256]. They can, therefore, be particularly vulnerable to any structures which could act as a barrier, preventing movement to key foraging or nursery grounds.

8.7.2 However, the presence of offshore wind turbines is unlikely to prevent movement for these highly mobile and wide-ranging species who could circumvent the arrays if required.

8.8 Non-Physical Disturbance (Noise/vibration Disturbance; Impact Pathway 11)

8.8.1 Sound has two components: sound pressure and particle motion. All fish can sense the particle motion component of an acoustic field via the inner ear as a result of whole-body accelerations [257], and noise detection ('hearing') becomes more specialised with the addition of further hearing structures. Although many fish are also likely to detect sound pressure, particle motion is considered equally or potentially more important [258]. Particle motion is

[251] Blaxter, J. H. S., Gray, J.A.B and Denton, E.J. 1981. Sound and startle responses in herring shoals. J.mar.biol.Ass.UK. 61, 851-869.
[252] Wilson, B.; Batty, R.; Daunt, F.; Carter, C. 2007. Collision Risk Between Marine Renewable Energy Devices and Mammals, Fish and Diving Birds. Report by Centre for Ecology & Hydrology and Scottish Association for Marine Science (SAMS). pp 110.
[253] ibid
[254] Hendry, K and Cragg-Hine D .2003. Ecology of the Atlantic Salmon. Conserving Natura 2000 Rivers Ecology Series No. 7. English Nature, Peterborough.
[255] Maitland. P.S. 2003. Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
[256] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.
[257] Radford, C .A., Montgomery, J. C., Caiger, P. & Higgs, D. M., 2012. Pressure and particle motion detection thresholds in fish: a re-examination of salient auditory cues in teleosts. Journal of Experimental Biology, 215(19), pp.3429-3481.
[258] Hawkins, A., and Popper, A. 2016. A sound approach to assessing the impact of underwater noise in marine fishes and invertebrates. ICES Journal of Marine Science 74, 635-651.

especially important for locating sound sources through directional hearing [259] [260] [261].

8.8.2 From the few studies of hearing capabilities in fishes that have been conducted, it is evident that there are potentially substantial differences in auditory capabilities from one fish species to another [262]. Since it is impossible to determine hearing sensitivity for all fish species, one approach to understand hearing has been to distinguish fish groups on the basis of differences in their anatomy and what is known about hearing in other species with comparable anatomy. Popper *et al.* [263] proposed categories based on anatomical differences:

- Fishes with no swim bladder or other gas chamber – e.g. lamprey. These species are sensitive only to sound particle motion and show sensitivity only to a narrow band of frequencies.
- Fishes with swim bladders in which hearing does not involve the swim bladder or other gas volume – e.g. salmonids, such as Atlantic salmon; European eel. Salmonids are more sensitive to particle motion than sound pressure [264] [265] and European eel is sensitive to both particle motion and sound pressure [266] [267].
- Fishes in which hearing involves a swim bladder or other gas volume – e.g. clupeids such as shad species. These species are primarily sensitive to sound pressure, although they also detect particle motion [268].

8.8.3 Particle motion rather than sound pressure is considered to be potentially more important to fish without swim bladders, salmonids and European eel. However, there is no published literature on the levels of particle motion generated during construction activities (e.g. pile-driving and dredging) and the distance at which they can be detected). This may be due to the fact that there are far fewer devices (and less expertise in their use) for detection and analysis of particle motion compared to hydrophone devices for

[259] Popper A. N., Hawkins A. D., Fay R. R., Mann D. A., Bartol S., Carlson T. J., Coombs S. 2014. Sound Exposure Guidelines. In ASA S3/SC1. 4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI , pp. 33–51. Springer, New York.

[260] Hawkins A. D., Pembroke A., Popper A. 2015. Information gaps in understanding the effects of noise on fishes and invertebrates. Reviews in Fish Biology and Fisheries , 25: 39–64.

[261] Nedelec, S. L., Campbell, J., Radford, A. N., Simpson, S. D., & Merchant, N. D. 2016. Particle motion: The missing link in underwater acoustic ecology. Methods in Ecology and Evolution, 7, 836–842.

[262] Hawkins, A., and Popper, A. 2016. A sound approach to assessing the impact of underwater noise in marine fishes and invertebrates. ICES Journal of Marine Science 74, 635-651.

[263] Popper A. N., Hawkins A. D., Fay R. R., Mann D. A., Bartol S., Carlson T. J., Coombs S. 2014. Sound Exposure Guidelines. In ASA S3/SC1. 4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI , pp. 33–51. Springer, New York.

[264] Popper, A.N. and Fay, R.R. (2014). Perspectives on auditory research. Springer, NY.

[265] Hawkins, A., and Popper, A. 2016. A sound approach to assessing the impact of underwater noise in marine fishes and invertebrates. ICES Journal of Marine Science 74, 635-651.

[266] Popper, A.H. and Fay R.R. (2011). Rethinking sound detection by fishes. Hearing Research 273 (2011) 25-36.

[267] Hawkins, A., and Popper, A. 2016. A sound approach to assessing the impact of underwater noise in marine fishes and invertebrates. ICES Journal of Marine Science 74, 635-651.

[268] Hawkins, A., and Popper, A. 2016. A sound approach to assessing the impact of underwater noise in marine fishes and invertebrates. ICES Journal of Marine Science 74, 635-651.

detection of sound pressure [269]. Direct measurements of particle motion have also been hampered by the lack of guidance on data analysis methods.

8.8.4 Steps that are required to improve knowledge of the effects of particle motion on marine fauna have recently been set out [270]. However, at present there continues to be a lack of particle motion measurement standards, lack of easy to use and reasonably priced instrumentation to measure particle motion, and lack of sound exposure criteria for particle motion. As such, the scope for considering particle motion in underwater noise assessments is currently limited [271]. Hence, this review considers the effects of sound pressure rather than particle motion.

8.8.5 The extent to which intense underwater sound might cause an adverse environmental impact in a particular fish species is dependent upon the level of sound pressure or particle motion, its frequency, duration and/or repetition [272]. The range of potential effects from intense sound sources, such as pile driving, includes immediate death, permanent or temporary tissue damage and hearing loss, behavioural changes and masking effects. Tissue damage can result in eventual death or may make the fish less fit until healing occurs, resulting in lower survival rates. Hearing loss can also lower fitness until hearing recovers.

8.8.6 Behavioural changes can potentially result in animals avoiding migratory routes or leaving feeding or reproduction grounds with potential population level consequences. Biologically important sounds can also be masked where the received levels are marginally above existing background levels [273]. The ability to detect and localise the source of a sound is of considerable biological importance to many fish species and is often used to assess the suitability of a potential mate or during territorial displays and during predator prey interactions.

8.8.7 Published noise exposure criteria for fish are included in Table 17. The Popper *et al.* [274] peak Sound Pressure Level (SPL) and cumulative Sound Exposure Level (SEL) criteria for piling driving can be used to determine the mortality/potential mortal injury and recoverable injury for each of the fish hearing categories described above. These criteria are based on an understanding that fish will respond to sounds and their hearing sensitivity. However, there is a lack of specific data on exposure or received levels that enable guideline thresholds to be provided for all fish hearing categories.

[269] Martin, B., Zeddies, D. G., Gaudet, B., and Richard, J. 2016. Evaluation of three sensor types for particle motion measurement. In The Effects of Noise on Aquatic Life II, pp. 679–686. Ed. by A. N. Popper, and A. D. Hawkins. Springer, New York.

[270] Popper, A., Hawkins, A. 2018. The importance of particle motion to fishes and invertebrates. The Journal of the Acoustical Society of America 143, 470. https://doi.org/10.1121/1.5021594.

[271] Faulkner, R., Farcas, A., Merchant, N. 2018. Guiding principles for assessing the impact of underwater noise. Journal of Applied Ecology 55, 2531-2536.

[272] Hastings, M.C., and Popper, A.N. 2005. Effects of sounds on fish. Report to Jones and Stokes for California Department of Transportation, January 2005. 82pp.

[273] Hawkins, A. D. & Myrberg Jr, A. A., 1983. Hearing and sound communication under water. In: Bioacoustics: A Comparative Approach (Ed. by B. Lewis), pp. 347-405: Academic Press.

[274] Popper A. N., Hawkins A. D., Fay R. R., Mann D. A., Bartol S., Carlson T. J., Coombs S. 2014. Sound Exposure Guidelines. In ASA S3/SC1. 4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI , pp. 33–51. Springer, New York.

8.8.8 While these noise exposure criteria provide thresholds for auditory impairment, there are many data gaps that preclude the setting of specific noise exposure criteria for behavioural responses in fish [275] [276] [277]. The onset of behavioural responses is much more difficult to quantify as reactions are likely to be strongly influenced by behavioural or ecological context and the effect of a particular response is often unclear and may not necessarily scale with received sound level [278] [279] [280]. In other words, behaviour may be more strongly related to the particular circumstances of the animal, the activities in which it is engaged, and the context in which it is exposed to sounds [281] [282]. For example, a startle or reflex response to the onset of a noise source does not necessarily lead to displacement from the ensonified area.

8.8.9 This uncertainty is further compounded by the limitations of observing fish behavioural responses in a natural context. Few studies have conducted behavioural field experiments with wild fish and laboratory experiments may not give a realistic measure of how fish will respond in their natural environment [283] [284] [285]. As a consequence, only hearing data based on behavioural experiments is acceptable for assessing the ability of fish to detect sound [286].

8.8.10 Recent studies have considered approaches to quantify the risk of behavioural responses, for example through dual criteria based on dose-response curves for proximity to the sound source and received sound level [287]. An empirical behavioural threshold could also be adopted using *in situ* observed responses of fish to similar sound sources [288]. A study observing

[275] Popper A. N., Hawkins A. D., Fay R. R., Mann D. A., Bartol S., Carlson T. J., Coombs S. 2014. Sound Exposure Guidelines. In ASA S3/SC1. 4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI , pp. 33–51. Springer, New York.

[276] Hawkins, A., and Popper, A. 2016. A sound approach to assessing the impact of underwater noise in marine fishes and invertebrates. ICES Journal of Marine Science 74, 635-651.

[277] Faulkner, R., Farcas, A., Merchant, N. 2018. Guiding principles for assessing the impact of underwater noise. Journal of Applied Ecology 55, 2531-2536.

[278] Hawkins, A. D., and Popper, A. (2014). "Assessing the impacts of underwater sounds on fishes and other forms of marine life," Acoust. Today 10, 30–41.

[279] Hawkins A. D., Pembroke A., Popper A. 2015. Information gaps in understanding the effects of noise on fishes and invertebrates. Reviews in Fish Biology and Fisheries , 25: 39–64.

[280] Faulkner, R., Farcas, A., Merchant, N. 2018. Guiding principles for assessing the impact of underwater noise. Journal of Applied Ecology 55, 2531-2536.

[281] Ellison, W.T., Southall B.L., Clark C.W., Frankel A.S., 2012. A new context-based approach to assess marine mammal behavioural responses to anthropogenic sounds. Conservation Biology 26: 21 8.

[282] Pena, H., Handegard, N. O., and Ona, E. (2013). Feeding herring schools do not react to seismic air gun surveys. ICES Journal of Marine Science, 70: 1174–1180.

[283] Hastings, M.C., and Popper, A.N. 2005. Effects of sounds on fish. Report to Jones and Stokes for California Department of Transportation, January 2005. 82pp.

[284] Kastelein, R. A., Verboom, W. C., Jennings, N., de Haan, D., & van der Heul, S. (2008). The influence of 70 and 120 kHz tonal signals on the behaviour of harbor porpoises *Phocoena phocoena* in a floating pen. Marine Environmental Research, 66(3), 319-326.

[285] Popper, A.N. and Hastings, M.C. (2009). The effects of anthropogenic sources of sound on fishes. Journal of Fish Biology 75: 455-489.

[286] Sisneros, J. A., Popper, A. N., Hawkins, A. D., and Fay, R. R. (2016). Auditory Evoked Potential audiograms compared to behavioural audiograms in aquatic animals. In The Effects of Noise on Aquatic Life, II, pp. 1049–1056. Ed. by A. N. Popper, and A. D. Hawkins. Springer ScienceþBusiness Media, New York.

[287] Dunlop, R. A., Noad, M. J., McCauley, R. D., Scott-Hayward, L., Kniest, E., Slade, R., Cato, D. H. (2017). Determining the behavioural dose response relationship of marine mammals to air gun noise and source proximity. Journal of Experimental Biology, 220, 2878–2886. https://doi.org/10.1242/jeb.160192

[288] Faulkner, R., Farcas, A., Merchant, N. 2018. Guiding principles for assessing the impact of underwater noise. Journal of Applied Ecology 55, 2531-2536.

the responses of caged fish to nearby air gun operations found that initial increases in swimming behaviour may occur at a level of 156 dB re 1µPa rms [289]. At levels of around 161-168 dB re 1µPa rms active avoidance of the air gun source would be expected to occur [290] [291]. These responses may however differ from those of unconfined fish.

8.8.11 More recent work has been undertaken by Hawkins *et al.* [292] reporting behavioural responses of schools of wild sprat and mackerel to playbacks of pile driving. At a single-pulse peak-to-peak SPL of 163 dB re 1 µPa (equivalent to peak SPL of 157 dB re 1 µPa and SEL of 135 dB re 1 µPa^2 s), schools of sprat and mackerel were observed to disperse or change depth on 50 % of presentations. Sprat and mackerel have specialised hearing structures. This threshold is likely to be an indicator of more subtle behavioural responses in fish without specialised hearing structures (i.e. salmonids, European eel and lampreys).

Table 17 Fish noise exposure criteria

Fish Hearing Group	Mortality/ Potential Mortal Injury	Recoverable Injury	Behaviour/ Displacement
Swim bladder involved in hearing	> 207 dB re 1 µPa > 207 dB SEL_{cum}	> 207 dB re 1 µPa > 203 dB SEL_{cum}	> 157 dB re 1 µPa > 135 dB SEL_{single}
Swim bladder is not involved in hearing (particle motion detection)	> 207 dB re 1 µPa > 210 dB SEL_{cum}	> 207 dB re 1 µPa > 203 dB SEL_{cum}	
No swim bladder (particle motion detection)	> 213 dB re 1 µPa > 219 dB SEL_{cum}	> 213 dB re 1 µPa > 216 dB SEL_{cum}	
SEL_{cum} denotes cumulative SEL with a reference value of 1 µPa^2 s over a 24-hour period. SEL_{single} denotes single pulse SEL with a reference value of 1 µPa^2 s over a 1 second period. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exists [293].			

[289] McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M-N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdoch, J. and McCabe, K. (2000). Marine seismic surveys – A study of environmental implications. Appea Journal, pp. 692-707.
[290] Pearson, W. H., Skalski, J. R. and Malme, C. I. (1992). Effects of sounds from a geophysical survey device on behaviour of captive rockfish (Sebastes spp.). Can. J. Fish. Aquat. Sci., 49, pp. 1343-1355.
[291] McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M-N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdoch, J. and McCabe, K. (2000). Marine seismic surveys – A study of environmental implications. Appea Journal, pp. 692-707.
[292] Hawkins, A.D., Roberts, L. & Cheesman, S., 2014. Responses of free-living coastal pelagic fish to impulsive sounds. The Journal of the Acoustical Society of America 135: 3101-3116.
[293] Popper A. N., Hawkins A. D., Fay R. R., Mann D. A., Bartol S., Carlson T. J., Coombs S. 2014. Sound Exposure Guidelines. In ASA S3/SC1. 4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI , pp. 33–51. Springer, New York.

8.8.12 Potential behavioural effects in the past have also been inferred by comparing the received sound level with the auditory threshold of marine fauna. Richardson *et al*. [294] and Thomsen *et al*. [295], for example, have used received levels of noise in comparison with the corresponding hearing thresholds of marine fauna in order to estimate the range of audibility and zones of influence from underwater sound sources. This form of analysis has been taken a stage further by Nedwell *et al*. [296], where the underwater noise is compared with receptor hearing threshold across the entire receptor auditory bandwidth in the same manner that the dB(A) is used to assess noise sources in air for humans. These include behavioural thresholds, where received sound levels around 90 dB above hearing threshold (dB_{ht}) are considered to cause a strong behavioural avoidance, levels around 75 dB_{ht} a moderate behavioural response and levels around 50 dB_{ht} a minor response.

8.8.13 The dB_{ht} criteria have been applied in a number of offshore renewables EIAs and the Environment Agency has previously recommended it to be used in impact assessments in coastal/estuarine environments [297] [298]. However, it is worth noting that the dB_{ht} criteria have not been validated by experimental study and have not been published in an independent peer-reviewed paper. The dB_{ht} approach does not take into account potential for sound sensitivity to changes with that of the life stage of the organism, time of year, animal motivation, or other factors that might affect hearing and behavioural responses to sound [299]. Furthermore, the dB_{ht} criteria are based on measures of inner ear responses and should rather be based on behavioural threshold determinations [300] [301]. The use of dB_{ht} criteria is therefore not recommended for underwater noise assessments [302].

8.8.14 Disturbance effects on migratory fish from noise are most likely to occur during the construction phase of a wind farm. The potential for activities such as impact piling, means migratory fish are all assessed as highly sensitive to noise during construction.

[294] Richardson, W.J., Green Jr, C.R., Malme, C.I. and Thomson, D.H., 1995. Marine Mammals and Noise. Academic Press, New York.
[295] Thomsen, F., Lüdemann, K., Kafemann, R., Piper W. 2006. Effects of offshore wind farm noise on marine mammals and fish. Biola, Hamburg, Germany on behalf of COWRIE Ltd. 62pp.
[296] Nedwell, J. R, Parvin, S. J., Edwards, B., Workman, R., Brooker, A.G and Kynoch, J. E. 2007a. Measurement and interpretation of underwater noise during construction and operation of offshore wind farms in UK waters. Subacoustech Report No. 544R0738 to COWRIE Ltd. ISBN: 978-0-9554279-5-4.
[297] ABPmer, 2008. Environmental Statement for Port of Southampton: Berth 201/202 Works. ABPmer Report No. R.1494.
[298] URS Scott Wilson (2011). Green Port Hull Environmental Statement.
[299] Hawkins, A., and Popper, A. 2016. A sound approach to assessing the impact of underwater noise in marine fishes and invertebrates. ICES Journal of Marine Science 74, 635-651.
[300] Popper A. N., Hawkins A. D., Fay R. R., Mann D. A., Bartol S., Carlson T. J., Coombs S. 2014. Sound Exposure Guidelines. In ASA S3/SC1. 4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI , pp. 33–51. Springer, New York.
[301] Hawkins, A., and Popper, A. 2016. A sound approach to assessing the impact of underwater noise in marine fishes and invertebrates. ICES Journal of Marine Science 74, 635-651.
[302] ibid

8.9 Non-Physical Disturbance (Electromagnetic Field; Impact Pathway 12)

8.9.1 Power export cables generate an electromagnetic field (EMF) with two components: an electric (E) field contained within the cable by armouring and a magnetic (B) field that can be detected outside of the cable. The magnetic field also produces an induced electric field (iE) outside the cable.

8.9.2 Potential impacts could result from repulsion effects, leading to exclusion of animals from an area of seabed, attraction effects and disruption to migrations for magnetically sensitive species such as eels and salmonids that may use the earth's geomagnetic field for navigational cues[303]. Although Atlantic salmon may be sensitive to the magnetic fields associated with operational cables, their navigation and migration is unlikely to be affected based on existing evidence [304] [305]. For example, Armstrong *et al*.[306] found no significant differences in approach, traverse or departure times of large Atlantic salmon to activated Helmholtz coils and no significant difference in the numbers of small post-smolts passing through the coils, in relation to magnetic field intensity.

8.9.3 River lamprey and sea lamprey are considered to be magnetically and electrically sensitive [307]. However, like most UK species that are EM-sensitive, knowledge of their interaction with anthropogenic EMFs is limited. A recent review by Gill and Bartlett [308] confirmed the limitations of understanding about the effects on fish species. It concluded that, based on current knowledge, Atlantic salmon *S. salar*, Sea trout *S. trutta* or European eel *A. anguilla* may respond to B or iE fields generated from subsea power cables, either by short-term attraction or avoidance. If such behaviour occurs, then they noted that it may waste time and energy for the fish, and perhaps be a causal effect in delayed migration or alterations to movement and distribution. It was also noted that there was an incomplete understanding about how these species move around their environment and interact with natural, anthropogenic and subsea EMF (and noise). However, Gill and Bartlett [309] noted that there was no clear evidence that either attraction or repulsion due to anthropogenic EMFs would have an effect on the fish species which they reviewed.

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[303] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.

[304] CMACS. 2003. COWRIE Phase 1 Report. A Baseline Assessment of Electromagnetic Fields Generated by Offshore Wind farm Cables. Centre for Marine and Coastal Studies (CMACS). COWRIE Report EMF - 01-2002 66.

[305] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC
https://www2.gov.scot/Publications/2007/03/seawave.

[306] Armstrong JD, Hunter DC, Fryer RJ, Rycroft P and Orpwood JE (2015) Behavioural Responses of Atlantic Salmon to Mains Frequency Magnetic Fields. Scottish Marine and Freshwater Science, 6 (9) 22pp

[307] Gill A.B., Gloyne-Phillips, I.T., Neal, K.J and Kimber J.A., 2005. The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms - a review. Report to COWRIE, London, 90pp.

[308] Gill, A.B. & Bartlett, M. 2010. Literature review on the potential effects of electromagnetic fields and subsea noise from marine renewable energy developments on Atlantic salmon, sea trout and European eel. Scottish Natural Heritage Commissioned Report No.401.

[309] ibid

8.9.4 A review by NIRAS on the potential effects of subsea cables, notes how the implications of the potential effects of EMF (if any) originating from subsea cables remain unclear, with no significant impacts found to date[310]. However, much of the literature focuses on elasmobranchs and lampreys with comparatively little understanding on how EMFs can affect other migratory fish or fish species.

8.10 Toxic Contamination (Contamination and Spillages; Pathways 14 and 15

8.10.1 For all phases of the development, there is the potential for accidental discharges/spillages from machinery and vessels. However, adoption of standard safety measures would be employed throughout these phases to reduce the likelihood of accidental spillages occurring.

8.10.2 Leaching of toxic compounds from sacrificial anodes, antifouling paints or leakage of hydraulic fluids (if present) from the device is a potential effect during offshore wind farm operation. Any chemical or microbiological contaminants associated with sediments being resuspended into the water column may be dispersed, redistributed and deposited elsewhere.

8.10.3 There is a risk that some of these contaminants may be temporarily bioaccumulated in the tissues of certain fish prey, such as polychaete worms and marine bivalves, and made available for uptake by feeding fish. The accumulation of moderate or high levels of contaminants in fish can cause or contribute to a range of lethal and sub-lethal effects, including genetic, reproductive and growth changes. There is less information available on the effects of low levels of contaminants. Pelagic fish, including Atlantic salmon, would experience a lower exposure to contaminated sediments than demersal fish species which remain close to the seabed and feed mainly on benthic organisms. Lampreys attach onto a variety of pelagic and demersal fish species in the marine phase of their lifecycle and so their movements and distribution are largely dictated by their host.

8.11 Non-Toxic Contamination (Increased Turbidity; Pathway 16)

8.11.1 Increased turbidity has been reported to affect salmonids; however, their tolerance to naturally high turbidity levels in estuaries is acknowledged. As all migratory fish species have to spend part of their lifecycle either in or navigating through turbid waters it is considered that they have a high tolerance to this impact pathway. For example, salmon and lamprey successfully pass through estuaries with extremely high suspended sediments such as the Severn and its sub estuaries the Wye, Usk and Parrett, which naturally contain up to several thousand milligrams per litre

[310] NIRAS, 2015. Subsea cable interactions with the marine environment. Expert review and recommendations report. Project no. UKNO253

[311], concentrations as high as 9,000 mg/l have been recorded in the path of runs in the Usk Estuary [312].

8.11.2 Where conditions are particularly adverse, the mobile nature of fish species will generally allow them to avoid such areas. Hence, such impacts will be unlikely to significantly affect a population provided such conditions are temporary. In the case of migratory fish species; however, the potential significance of an effect can be greater if the increases to suspended sediment were to constitute a barrier to a fish migratory route.

8.11.3 Such conditions would; however, only be significant if they extended across the entire width of a water body, thus comprising the migration route at any given point. Otherwise fish would be able to circumvent the area, avoiding impacts, and thus not inhibiting migration up (or down) stream. Should significant delay in migration occur, either due to the barrier or as a result of avoidance, these delays may reduce survival rates. Considering the scope of the Plan for offshore wind farm development, this impact pathway is considered a low risk to migratory fish.

8.11.4 Suspended sediment levels also affect the level of dissolved oxygen (DO), with increased suspended sediments concentrations potentially depleting DO concentrations.

8.11.5 The effects of suspended sediment levels on fish have been considered in a number of studies, including that undertaken by the European Inland Fisheries Advisory Commission [313]. Lethal effects were seldom observed, with Pacific salmon and trout juveniles surviving for 3-4 weeks in suspended sediment concentrations of 300-750 mg/l, which were increased to 2300-6500 mg/l for short periods. Sub lethal pathological effects included increased mucus production over the body and gills, and at very high suspended sediments, evidence of abrasion and damage to the gill filaments was noted [314].

8.12 Migratory Fish and Freshwater Pearl Mussel Sensitivity Review

8.12.1 **Table 18** shows the sensitivities of Atlantic salmon (and freshwater pearl mussel by association) as well as river lamprey, sea lamprey and shad species to the activities associated with the Sectoral Offshore Wind Plan.

[311] FARL, 1995. Possible impacts of dredging on salmonids. Research Note for ABP Research. Fawley Aquatic Research Laboratories Ltd.
[312] Alabaster, J.S., 1993. River Usk Barrage Order 1993. Proof of Evidence on Pollution and Fisheries.
[313] FARL, 1995. Possible impacts of dredging on salmonids. Research Note for ABP Research. Fawley Aquatic Research Laboratories Ltd.
[314] ibid

Table 18. Potential sensitivities of Atlantic salmon, lamprey and shad features from the Sectoral Offshore Wind Plan

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PLG	Physical Loss/Gain of habitat	2	Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside these areas from associated scour and indirectly from changes to the hydrodynamic regime, as well as from chains anchoring devices disturbing seabed habitat during operation.	No impact	No impact	LS	No impact
PLG	Physical Loss/Gain of habitat	3	Presence of structures on seabed for the duration of the project resulting in changes to prey and species behaviour (e.g. acting as FAD (Fish Aggregating Device), artificial reef or bird roost).	No impact	No impact	LS	No impact
PD	Physical Damage to habitat	6	Reduction in quality of foraging areas as result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during installation; from maintenance and removal of cables/devices or from scour, sediment transport and hydrodynamic change, and damage from chains anchoring devices during operation.	No impact	LS	LS	LS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PD	Physical Damage to species	8	Collision risk and possible mortality of species due to the presence of devices or from vessels travelling to and from the site (including above and below water collision risk and the influence of lighting); risk of entanglement following a collision with power cables or mooring elements.	LS	LS	LS	LS
NPD	Non-Physical Disturbance	9	Presence of structures or disturbance (noise or visual) resulting in a barrier to movement, migratory pathways and/or access to feeding grounds depending on array design.	No impact	No impact	LS	No impact
NPD	Non-Physical Disturbance	11	Noise/vibration disturbance from vessels and other activities during survey work (e.g. seismic exploration and geophysical surveys), construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning.	LS	HS	LS	MS
NPD	Non-Physical Disturbance	12	Impacts from Electromagnetic Fields (EMF) and thermal emissions on benthic invertebrates and electromagnetically sensitive fish and cetaceans interfering with prey location and mate detection in some species and creating barriers to migration	No impact	No impact	LS	No impact

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
TC	Toxic Contamination	14	Spillage of fluids, fuels and/or construction materials during installation or removal of structures (devices and cables) or during survey/maintenance.	LS	LS	LS	LS
TC	Toxic Contamination	15	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (devices and cables).	No impact	LS	No impact	LS
NTC	Non-Toxic Contamination	16	Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (devices and cables).	No impact	LS	No impact	LS
	In this table, only the estimated sensitivity levels are shown. The level of risk will be dependent upon exposure. For instance, there would be a high degree of exposure for migratory fish and freshwater pearl mussel were a development to occur within or near to a European/Ramsar site. However, at the present time, there is uncertainty regarding the degree of exposure and a worst-case assumption has been made.						
	LS: Low Sensitivity						
	LMS: Low to Medium Sensitivity						
	MS: Medium Sensitivity						
	HS: High Sensitivity						

8.13 Potential Effects on European/Ramsar Sites of the Sectoral Offshore Wind Plan

8.13.1 On the basis of the sensitivities of the relevant interest features the following sections review the typical conservation objectives for these features and the potential effects arising for the screened in European/Ramsar sites

8.13.2 The conservation objectives for the qualifying fish interest features seek to avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features. The conservation objectives are to ensure for the qualifying species that the following are maintained in the long term:

- Population of the species, including range of genetic types for salmon, as a viable component of the site;
- Distribution of the species within site;
- Distribution and extent of habitats supporting the species;
- Structure, function and supporting processes of habitats supporting the species;
- No significant disturbance of the species;
- Distribution and viability of the species' host species (e.g. freshwater pearl mussel); and
- Structure, function and supporting processes of habitats supporting the species' host species.

8.13.3 Taking account of the conservation objectives and the plan-level activities to which the key interest features are sensitive, this section reviews the potential effects of the Sectoral Offshore Wind Plan on the integrity of the European/Ramsar sites. The results are presented in Table 19.

Table 19. Assessment of the potential effects of the Sectoral Offshore Wind Plan on the fish features of relevant European sites

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)					
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**	**Is There an Adverse Effect on Integrity of any European/Ramsar sites?**	**Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?**
▪ Atlantic salmon ▪ Sea lamprey ▪ River lamprey ▪ Allis shad ▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	**Physical Loss/Gain of Habitat** (Direct Change to habitat within the development footprint) Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside	2	**Sensitivity Level(s)** considered to be low (see Table 18 for detail and colour code) **Commentary/Risk Review** Atlantic salmon and shad are highly mobile, migratory species undergoing large shifts in distribution during the marine phase of their lifecycle. Atlantic salmon and shad are also pelagic in lifestyle at sea, having very little association with the seabed. Unlike certain demersal fish species which could be considered 'resident' within the Sectoral Offshore Wind Plan areas, any	Possibility of an adverse effect on integrity Further work would be required at project-level to ascertain LSE. However, in advance of considering mitigation measures, it cannot be concluded that there will be no AEOI on any European/Ramsar sites. This is because	No adverse effect on integrity With the application of appropriate and meaningful mitigation measures to accompany the Plan (see

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	these areas from associated scour and indirectly from changes to the hydrodynamic regime, as well as from chains anchoring devices disturbing seabed habitat during operation.		Atlantic salmon or shad passing through the area can be considered transient. Therefore, any potential damage to the seabed in deployment locations will be of negligible impact to these fish species. Sea lamprey which attach and then feed on a variety of pelagic and demersal fish species in the marine phase of their lifecycle are unusual in that they could be considered to have similar sensitivities to their host. However, as sea lamprey are a highly mobile, migratory species which are widely distributed at sea any potential damage to the seabed in deployment locations will	of the inherent uncertainties such as: • the detail of the Plan implementation process; • future generation capacities; • the location, scale and densities of development; • the proposed technologies to be used and future advances in	Section 11), there will be no AEOI.

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			be of negligible impact to the sea lamprey. River lamprey adults live primarily within estuaries before migrating upstream to spawn in freshwater. There would be no direct overlap of the development footprint with river lamprey habitat and/or foraging areas. **Relevant Conservation Objectives** (see Section 8.13) Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting	these technologies; • the scale of the effects arising via some of the defined impact pathways; and • the efficacy of some project-level mitigation options.	

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			processes of habitats supporting the species.		
▪ Atlantic salmon ▪ Sea lamprey ▪ River lamprey	**Physical Loss/Gain of Habitat (**Direct change to habitat	3	**Sensitivity Level(s)** considered to be low (see Table 18 for detail and colour code)	As above	As above

▪ Allis shad ▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	around the development footprint) Presence of structures on seabed for the duration of the project resulting in changes to prey and species behaviour (e.g. acting as FAD (Fish Aggregating Device), artificial reef or bird roost).		**Commentary/Risk Review** Wilhelmsson *et al.* [315] investigated the potential for wind turbines to function as artificial reefs and FADs. Fish abundance was found to be greater in the vicinity of the turbines than in surrounding areas, while species richness and Shannon–Wiener diversity (*H'*) were similar. On the monopiles of the turbines, fish community structure was different, and total fish abundance was greater, while species richness and diversity (*H'*) were lower than on the surrounding seabed. Blue mussels and barnacles covered most of the submerged parts of the turbines. On the seabed, more blue mussels and less red algae were recorded compared to adjacent areas. A gill netting survey at the Svante Wind Farm, Sweden, found higher numbers of cod within two hundred metres of an operating turbine compared to the surrounding open waters, and higher still when the		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			turbines were not operating [316]. Diver held video surveys of the North Hoyle offshore wind farm piles found extremely high densities of juvenile whiting, apparently feeding on dense populations of amphipods amongst the fouling biota on the piles [317]. However, it is generally agreed that fish aggregation probably represents a very minor effect[318].		
			Relevant Conservation Objectives (see Section 8.13)		

[315] Wilhelmsson, D., Malm, T., and Ŏhman, M., 2006. The influence of offshore wind power on demersal fish. ICES Journal of Marine Science 63, 775-784.
[316] Westerberg, H. 1999. Impact studies of sea-based windpower in Sweden. lecture held at "Technische Eingriffe in marine Lebensräume“ Bundesamt für Naturschutz .Internationale NaturschutzakademieInsel Vilm 27-29.10.99.
[317] Bunker, F. 2004. Biology and video surveys of North Hoyle wind turbines 11-13th August 2004. A report to CMACS Ltd by Marine Seen, Estuary Cottage, Bentlass, Hundleton, Pembs. SA71 5RN.
[318] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			All conservation objectives are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site, including range of genetic types for salmon; ▪ Distribution of the species within site; ▪ Distribution and extent of habitats supporting the species; ▪ Structure, function and supporting processes of habitats		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			supporting the species; ▪ No significant disturbance of the species; ▪ Distribution and viability of freshwater pearl mussel host species; and ▪ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.		
▪ Atlantic salmon ▪ Sea lamprey ▪ River lamprey ▪ Allis shad	**Physical damage to habitat** (indirect and temporary damage to habitat)	6	**Sensitivity Level(s)** considered to be low (see Table 18 for detail and colour code) **Commentary/Risk Review**	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	Reduction in quality of foraging areas as result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during installation; from maintenance and removal of cables/devices or from scour, sediment transport		When considering the impacts on foraging habitat quality, the issues are the same as for foraging habitat quality loss (see Impact pathway 2). Atlantic salmon and shad are highly mobile, migratory species undergoing large shifts in distribution during the marine phase of their lifecycle. Atlantic salmon and shad are also pelagic in lifestyle at sea, having very little association with the seabed. Unlike certain demersal fish species which could be considered 'resident' in DPO locations, any Atlantic salmon or shad passing through the area will be considered transient. Therefore, any potential damage to foraging areas at DPO		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	and hydrodynamic change, and damage from chains anchoring devices during operation.		locations will have a negligible impact on these fish species. Sea lamprey which attach and then feed on a variety of pelagic and demersal fish species in the marine phase of their lifecycle are unusual in that they could be considered to have similar sensitivities to their host. However, as sea lamprey are a highly mobile, migratory species which are widely distributed at sea any potential damage to the seabed in deployment locations will have a negligible impact on this species. River lamprey adults live primarily within estuaries before migrating upstream to spawn in freshwater. There would be		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			minimal overlap of the development activities with river lamprey foraging areas. **Relevant Conservation Objectives** (see Section 8.13) Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ tlantic salmon ▪ Sea lamprey ▪ River lamprey ▪ Allis shad ▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	**Physical Damage** (direct damage to species from collision risk) Collision risk and possible mortality of species due to the presence of devices or from vessels travelling to and from the site (including above and below water collision risk and the influence of lighting); risk of entanglement following a collision	8	**Sensitivity Level(s)** considered to be low (see Table 18 for detail and colour code) **Commentary/Risk Review** Behavioural responses of fish to perceived threats can be broadly categorized in two ways: avoidance and evasion. Hence with respect to wind turbine structures, fish may demonstrate two types of response: long range avoidance (i.e. avoiding the area within the vicinity of the device) or close-range evasion depending upon the distance at which the device is perceived and the subsequent behavioural response.	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	with power cables or mooring elements.		Long range avoidance in the context of this report is considered to be avoidance at distances further away than where a visual response can be undertaken i.e. through noise and vibration cues. Close range evasion is considered to be at distances where the primary stimulus for the response is triggered by a visual reaction to physical characteristics of the device. The essentially static base of a wind turbine (irrespective of technology) means that collision risk is unlikely. Fish have been recorded colliding with anthropogenic structures, but		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			generally only in areas of poor visibility [319].		

[319] Wardle, C.S. 1986. Fish behaviour and fishing gear. In: Pitcher T.J. (ed) The behaviour of Teleost fishes. Croom Helm Ltd, London, UK, p 463-495.

			Relevant Conservation Objectives (see Section 8.13) Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site, including range of genetic types for salmon; ▪ Distribution of the species within site; ▪ No significant disturbance of the species; ▪ Distribution and viability of freshwater pearl mussel host species; and ▪ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)					
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**	**Is There an Adverse Effect on Integrity of any European/Ramsar sites?**	**Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?**
▪ Atlantic salmon ▪ Sea lamprey ▪ River lamprey ▪ Allis shad ▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	**Non-Physical Disturbance** Barrier to movement from the presence of sub-surface structures and disturbance (noise or visual) which may block migratory pathways or access to feeding grounds depending on array design	9	**Sensitivity Level(s)** considered to be low (see Table 18 for detail and colour code) **Commentary/Risk Review** Wind turbine arrays will pose minimal barrier effects to the highly mobile migratory fish species. The significance of any obstruction is partly dependent on the spatial confines and size of the devices and array, e.g. whether it spans across the entire mouth of an estuary, and the functional use of the area by fish. Considering the scope of the Plan the significance of an effect from this impact pathway would be negligible for migratory fish species.	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			Relevant Conservation Objectives (see Section 8.13) Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site, including range of genetic types for salmon; ▪ Distribution of the species within site; ▪ No significant disturbance of the species; ▪ Distribution and viability of freshwater		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ pearl mussel host species; and ▪ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.		
▪ Atlantic salmon ▪ Sea lamprey ▪ River lamprey ▪ Allis shad ▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	**Non-Physical Disturbance** Noise/vibration disturbance from vessels and other activities during survey work (e.g. seismic exploration and geophysical surveys),	11	**Sensitivity Level(s)** maximum considered to be high (see Table 18 for detail and colour code) **Commentary/Risk Review** Noise associated with installation activities might arise from vessel traffic, possible requirements for bed levelling, driving and drilling of piles, and installation of the power export cable (i.e. ploughing through sediment areas, rock cutting in	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning.		hard sea beds, bolting to the sea bed and/or directional drilling). There is an ever-increasing understanding of the source noise levels and frequencies associated with the marine construction activities of offshore wind farms [320] [321]. The impacts from pile driving and the use of explosives are of most concern (IECS, 2007). Studies indicate that some exposures can result in changes or damage to sensory structures and hearing capabilities, with mortality		

[320] Nedwell, J. and Howell, D., 2004. A review of offshore wind farm related underwater noise sources. Report No. 544 R 0308.

[321] Thomsen, F., Lüdemann, K., Kafemann, R., Piper W. 2006. Effects of offshore wind farm noise on marine mammals and fish. Biola, Hamburg, Germany on behalf of COWRIE Ltd. 62pp.

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			even occurring in extreme cases [322] [323]). Behavioural changes can potentially result in animals avoiding migratory routes or leaving feeding or reproduction grounds with potential population level consequences. Biologically important sounds can also be masked where the received levels are marginally above existing background levels [324]. The ability to detect and localise the source of a sound is of considerable		

[322] Hastings, M.C., and Popper, A.N. 2005. Effects of sounds on fish. Report to Jones and Stokes for California Department of Transportation, January 2005. 82pp.
[323] Popper A. N., Hawkins A. D., Fay R. R., Mann D. A., Bartol S., Carlson T. J., Coombs S. 2014. Sound Exposure Guidelines. In ASA S3/SC1. 4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI , pp. 33–51. Springer, New York.
[324] Hawkins, A. D. & Myrberg Jr, A. A., 1983. Hearing and sound communication under water. In: Bioacoustics: A Comparative Approach (Ed. by B. Lewis), pp. 347-405: Academic Press.

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			biological importance to many fish species and is often used to assess the suitability of a potential mate or during territorial displays and during predator prey interactions. Disturbance effects on migratory fish from noise are most likely to occur during the construction phase of a wind farm. The potential for activities such as impact piling, means migratory fish are all assessed as highly sensitive to noise during construction.		
			Relevant Conservation Objectives (see Section 8.13)		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site, including range of genetic types for salmon; ▪ Distribution of the species within site; ▪ No significant disturbance of the species; ▪ Distribution and viability of freshwater pearl mussel host species; and		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.		
▪ Atlantic salmon ▪ Sea lamprey ▪ River lamprey ▪ Allis shad ▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	**Non-Physical Disturbance** Impacts from Electromagnetic Fields (EMF) and thermal emissions on benthic invertebrates and electromagnetically sensitive fish and cetaceans interfering with prey	12	**Sensitivity Level(s)** considered to be low (see Table 18 for detail and colour code) **Commentary/Risk Review** The generated magnetic fields from wind farm developments are likely to be perceived by Atlantic salmon, and other migratory species, as a new localised addition to the heterogeneous pattern of geomagnetic anomalies already occurring naturally and anthropogenically in the sea.	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	location and mate detection in some species and creating barriers to migration		However, the expected magnetic field from a cable (up to a few micro Tesla (μT) is very small, particularly relative to the Earth's own magnetic field (approximately 50 μT) (PMSS Ltd, 2007). The conclusion of most project-specific environmental impact assessments is that whilst there could be an interaction between these species and the subsea cables, the result is unlikely to be of any significance at a population level[325] .		
			Relevant Conservation Objectives (see Section 8.13)		

[325] DECC, 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report.

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site, including range of genetic types for salmon; ▪ Distribution of the species within site; ▪ No significant disturbance of the species; ▪ Distribution and viability of freshwater pearl mussel host species; and		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.		
▪ Atlantic salmon ▪ Sea lamprey ▪ River lamprey ▪ Allis shad ▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	**Toxic Contamination** Spillage of fluids, fuels and/or construction materials during installation or removal of structures (devices and cables) or during survey/maintenance.	14	**Sensitivity Level(s)** considered to be low (see Table 18 for detail and colour code) **Commentary/Risk Review** For all phases of the development, there is the potential for accidental discharges/spillages from machinery and vessels. However, adoption of standard safety measures would be employed throughout all phases of the project to reduce likelihood of accidental spillages occurring.	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			The quantities and toxicities associated with sacrificial anodes and antifouling coatings are generally expected to be extremely small, and therefore this potential effect will be of negligible significance. Should this impact occur it is not possible to make any realistic estimate of the geographical extent of any contamination impact due to the large numbers of variables involved (quantities leaked, metocean conditions, etc) [326]. Accidental leakage of hydraulic fluids may be more significant,		

[326] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave.

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			should they occur through storm damage, device malfunction of, or collision with, navigating vessels. However, the probability of large amounts of oil or hydraulic fluids entering the environment as a result of a major structural failure or spill is very low. **Relevant Conservation Objectives** (see Section 8.13) Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site, including range of genetic types for salmon;		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ Distribution of the species within site; ▪ No significant disturbance of the species; ▪ Distribution and viability of freshwater pearl mussel host species; and ▪ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.		
▪ Atlantic salmon ▪ Sea lamprey ▪ River lamprey	**Toxic Contamination**	15	**Sensitivity Level(s)** considered to be low (see Table 18 for detail and colour code)	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Allis shad ▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	Release of contaminants associated with the dispersion of suspended sediments during installation or removal of structures (devices and cables		**Commentary/Risk Review** Sediments are generally expected to be low in contaminant concentrations within the DPO locations, given the characteristically high-energy environments in which the devices will be located and their offshore localities. The large volumes of water and highly dispersive and diluting nature of the surrounding waters will minimise any effects on water quality should contaminants be resuspended. **Relevant Conservation Objectives** (see Section 8.13)		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site, including range of genetic types for salmon; ▪ Distribution of the species within site; ▪ No significant disturbance of the species; ▪ Distribution and viability of freshwater pearl mussel host species; and		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)					
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**	**Is There an Adverse Effect on Integrity of any European/Ramsar sites?**	**Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?**
			▪ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.		
▪ Atlantic salmon ▪ Sea lamprey ▪ River lamprey ▪ Allis shad ▪ Twaite shad ▪ Freshwater pearl mussel (indirectly)	**Non-Toxic Contamination** Increase in turbidity associated with the release of suspended sediments during installation or removal of structures (devices and cables).	16	**Sensitivity Level(s)** considered to be low (see Table 18 for detail and colour code) **Commentary/Risk Review** Migratory fish regularly transit through estuaries with extremely high suspended sediments and therefore can be considered largely tolerant of turbid conditions. The characteristically high-energy offshore environments in which the devices will be located will assist in the dispersion of any localised	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)					
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**	**Is There an Adverse Effect on Integrity of any European/Ramsar sites?**	**Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?**
			increases in turbidity, thus minimising any impacts on water quality. **Relevant Conservation Objectives** (see Section 8.13) Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site, including range of genetic types for salmon; ▪ Distribution of the species within site;		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity Following Application of Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			▪ No significant disturbance of the species; ▪ Distribution and viability of freshwater pearl mussel host species; and ▪ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.		

9 Potential for Adverse Effects on the Otter Feature

9.1 Introduction

9.1.1 Following the screening process, a total of 468 European/Ramsar sites were identified for which there is a LSE (or the potential for a LSE cannot be excluded) (Table C1). Of these sites, 44 SACs were identified where it was not possible to conclude that there would be no LSE from the Sectoral Offshore Wind Plan for qualifying otter interest features.

9.1.2 Given the broad area covered by the Sectoral Offshore Wind Plan and the large number of sites screened into these assessments, the same method as agreed in previous plan-level HRAs [327] [328] [329] was used i.e. it is not necessary to individually review the full list of all sites and the qualifying otter interest features that they support within this report. The individual sites that were screened in for each of the 17 DPOs are shown in the schedules (Tables D1-D17) and on the maps (Figures E1-E17). Locations of the SAC and Ramsar sites that are screened in for qualifying otter interest features are provided in Appendix F (Figure F9).

9.1.3 Some of the SAC and Ramsar sites also contained other interest features for which it could not be concluded that there is no LSE (e.g. supralittoral habitats) and these are reviewed separately under the relevant section(s) encompassing these other habitat/species groups. Where there were interest features at these sites which have been 'screened out' because there will be no LSE then these were recorded (see Table C1).

9.1.4 In summary, the screening phase concluded that there is a possibility of a LSE (or that it was not possible to conclude no LSE) for otter *Lutra lutra* (1355). To assess whether there is any adverse effect on the integrity of the relevant European/Ramsar sites, the following sections review the sensitivities of the associated otter interest feature, identify the conservation objectives and assess, in tabular format, the effects arising in the context of the proposed plan-level mitigation measures.

[327] ABPmer, 2011a. Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Report for the Scottish Government, ABP Marine Environmental Research Ltd, Report No: R.1722a-c. January 2011.

[328] ABPmer 2013f. Habitats Regulations Appraisal of Draft Plan for Wave and Tidal Energy (W&TE) in Scottish Waters. Report for Marine Scotland 2013; ABP Marine Environmental Research Ltd, Final Report January 2013 Report Nos. R.1863a (Pre-Screening); R.1863b (Screening); and R.1863c (Report to Inform Appropriate Assessment); and R.1863d (PSG Comments Review).

[329] ABPmer, 2017. Habitats Regulations Appraisal of the Draft Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters. Reports for Marine Scotland, ABPmer Report No: R.2121a-c. 5 May 2017.

9.2 Sensitivities of the Otter Interest Feature to Sectoral Offshore Wind Plan Activities

9.2.1 This section reviews the sensitivities that are relevant for the otter interest feature. Initially a generic review of the sensitivities is presented under the impact pathways identified during the screening phase:

- Physical Loss/Gain of Habitat (Loss of Foraging Habitat);
- Physical Damage to Habitat (Damage to Foraging Habitat); and
- Non-Physical Disturbance (Noise/Visual Disturbance causing Barrier and Exclusion effects).

9.2.2 Following this review, the general sensitivities for otter are identified and tabulated in addition to the impact pathways.

9.3 Physical Loss/Gain of Habitat (Loss of Foraging Habitat; Impact Pathway 2)

9.3.1 Based on SNH advice about the impacts of development on otter [330] as well as the relevant advice documents provided by SNH under Regulation 33(2) of the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended), it is evident that otter are vulnerable to the loss of their shelters (including those on the shoreline) and to the loss of habitat which, in turn, can leave them more exposed to disturbance effects. If shore development overlaps with otter habitat it may result in direct loss of foraging habitat, removal of holts and loss of resting places (couches).

9.4 Physical Damage to Habitat (Damage to Onshore Habitat; Impact Pathway 6)

9.4.1 Shore development, including cable alignments and landfall related to the Draft Plan have the potential to damage foraging areas either directly or indirectly.

9.4.2 When assessing the impacts of construction work, the sensitivities of otter to habitat damage are gauged by the presence or absence of otter activity (e.g. spraints) and, in particular, by evidence of otter shelters, as it is usually these which ultimately constrain a development in terms of licensing. The scope of the proposal, allied to the level of otter activity, dictate the potential risks that exist. However, even relatively small-scale developments, such as bridge repairs or bank works, have the potential to damage otter habitat and cause disturbance.

[330] SNH, 2010. Otter and Development- Scottish Wildlife Series. Further information available: https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/protected-species/protected-species-z-guide/protected-species-otters

9.5 Non-Physical Disturbance (Noise/Visual Disturbance Causing Barrier and Exclusion Effects; Impact Pathways 10 and 11)

9.5.1 Otter are sensitive to visual and noise disturbance. They are intolerant of areas subject to intense human activity, such as recreational areas [331]. Noise and visual impacts associated with coastal engineering works may exclude otter from foraging habitat.

9.5.2 Otter move along established routes between open-water habitats, including freshwater sites near the coast, therefore they are sensitive to any proposals that could cause a barrier to their established pathways.

9.6 Otter Sensitivity Review

9.6.1 Table 20 shows the sensitivities of, and the activities that might affect the otter interest feature. The impact pathway descriptions are taken directly from the generic descriptions in Table 2.

[331] ibid

Table 20.Potential sensitivities of otter to the Sectoral Offshore Wind Plan

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
PLG	Physical Loss/Gain of habitat	2	Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside these areas from associated scour and indirectly from changes to the hydrodynamic regime, as well as from chains anchoring devices disturbing seabed habitat during operation.	No impact	No impact	MS	No impact
PD	Physical Damage to habitat	6	Reduction in quality of foraging areas as result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during installation; from maintenance and removal of cables/devices or from scour, sediment transport and hydrodynamic change, and damage from chains anchoring devices during operation.	No impact	LMS	LS	LMS

Sensitivity Category	Sensitivities	Pathway Ref. No.	Leasing Activity as Identified in Sectoral Offshore Wind Plan HRA (Summary Impact Pathway Description)	Survey	Construction	Operation	Decommission
NPD	Non-Physical Disturbance	10	Visual disturbance and exclusion from areas as a result of surveying, cable and device installation/operation and decommissioning activities and movements of vessels.	LS	LS	LS	LS
NPD	Non-Physical Disturbance	11	Noise/vibration disturbance and exclusion from areas as a result of vessels and other activities during survey work (e.g. seismic exploration and geophysical surveys), construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning.	LS	LS	LS	LS
In this table, only the estimated sensitivity levels are shown. The level of risk will be dependent upon exposure. For instance, there would be a high degree of exposure for otter were a development to occur within or near to a European/Ramsar site. However, at the present time, there is uncertainty regarding the degree of exposure and a worst-case assumption has been made.							
LS: Low Sensitivity							
LMS: Low to Medium Sensitivity							
MS: Medium Sensitivity							
HS: High Sensitivity							

9.7 Potential Effects on European/Ramsar Sites of the Sectoral Marine Plan

9.7.1 The following sections review the conservation objectives for this feature and the potential effects arising for each of the European/Ramsar sites.

9.7.2 The conservation objectives for the qualifying otter interest features seek to avoid deterioration of the habitats and significant disturbance to otter, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for this qualifying feature. The conservation objectives are to ensure for the qualifying species that the following are maintained in the long term:

- Population of the species as a viable component of the site;
- Distribution of the species within site;
- Distribution and extent of habitats supporting the species;
- Structure, function and supporting processes of habitats supporting the species; and
- No significant disturbance of the species;

9.7.3 Taking account of the conservation objectives and the plan-level activities to which the otter interest feature is sensitive, this section reviews the effects of the Sectoral Offshore Wind Plan on the integrity of the European/Ramsar sites. The results are presented in Table 21.

Table 21. Assessment of the potential effects of the Sectoral Offshore Wind Plan on the otter interest feature

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity With Additional Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Otter	**Physical Loss/Gain of Habitat** Loss of foraging areas from reduction in coastal and offshore habitat due to installation of devices and cable armouring both at the development footprint and outside these areas from associated scour and indirectly from changes to the hydrodynamic regime, as well as from chains anchoring devices	2	**Sensitivity Level(s)** considered to be medium (see Table 20 for detail and colour code) **Commentary/Risk Review** The potential effects to otter habitat arising from any coastal activities (i.e. cable routeing and landfall) will be highly dependent upon the locations selected, the scale of the work proposed and the proximity of the works to their holts and sheltering grounds. In advance of a full understanding about the exposure levels, the sensitivity of this species to this effect is considered to be medium. **Relevant Conservation Objectives** (see Section 9.7 Of the conservation objectives, the following are particularly relevant to this impact pathway:	Possibility of an adverse effect on integrity Further work would be required at project-level to ascertain LSE. However, in advance of considering mitigation measures, it cannot be concluded that there will be no AEOI on any European/Ramsar sites. This is	No adverse effect on integrity With the application of appropriate and meaningful mitigation measures to accompany the Plan (see Section 11), there will be no AEOI.

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity With Additional Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	disturbing seabed habitat during operation.		▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.	because of the inherent uncertainties such as: • the detail of the Plan implementation process; • future generation capacities; • the location, scale and densities of development; • the proposed technologies to be used and future	

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity With Additional Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
				advances in these technologies; • the scale of the effects arising via some of the defined impact pathways; and • the efficacy of some project-level mitigation options.	
▪ Otter	**Physical Damage** Reduction in quality of foraging areas as	6	**Sensitivity Level(s)** considered to be low to medium (see Table 20 for detail and colour code) **Commentary/Risk Review**	As above	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity With Additional Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	result of damage to coastal and offshore habitat from baseline surveys (e.g. boreholes and trawls); from equipment use causing abrasion, damage or smothering during installation; from maintenance and removal of cables/devices or from scour, sediment transport and hydrodynamic change, and damage from chains anchoring devices during operation.		The extent to which habitat supporting otters will be damaged as a result of cable installation activities is largely dependent on the proximity of the works to their holts and sheltering grounds. In advance of a full understanding about the exposure levels, the sensitivity of this species to this effect is considered to be low to medium. **Relevant Conservation Objectives** (see Section 9.7 Of the objectives, the following are particularly relevant to this impact pathway: ▪ Distribution and extent of habitats supporting the species; and ▪ Structure, function and supporting processes of habitats supporting the species.		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity With Additional Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
▪ Otter	**Non-physical Disturbance** Visual disturbance and exclusion from areas as a result of surveying, cable and device installation/operation and decommissioning activities and movements of vessels	10	**Sensitivity Level(s)** considered to be low (see Table 20 for detail and colour code) **Commentary/Risk Review** The degree to which otters from locations within a European/Ramsar site will be subject to visual disturbance from survey and construction activities will largely be a function of the proximity of such works to their holts and foraging grounds. Most European/Ramsar sites which support otter are inland from the coast and, therefore, the likelihood of visual disturbance is considered to be low. The guidance on undertaking surveys to assess impacts upon this species suggests that distances of 200-250m are appropriate. It is noted [332] that for 'small' schemes such as individual bridges, pipeline crossings, local	As above	As above

[332] SNH, 2010. Otter and Development- Scottish Wildlife Series. Online sites accessed January 2010. http://www.snh.org.uk/publications/on-line/wildlife/otters/default.asp.

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity With Additional Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			bank works and individual houses, a survey of 200-250m both upstream and downstream of the site is recommended, but with particular attention being paid to important riverine features such as in stream islands and reed beds. Beyond about 250m, disturbance from the proposed activity is unlikely to be an issue. It is expected that there are unlikely to be adverse disturbance on otter beyond these distances along the shoreline.		

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity With Additional Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
			Relevant Conservation Objectives (see Section 9.7 Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site; ▪ Distribution of the species within site; and ▪ No significant disturbance of the species.		
▪ Otter	**Non-Physical Disturbance** Noise/vibration disturbance and exclusion from areas as a result of vessels and other activities during survey work (e.g. seismic		**Sensitivity Level(s)** considered to be low (see Table 20 for detail and colour code) **Commentary/Risk Review** The degree to which otters from locations within a European/Ramsar site will be subject to noise disturbance from survey and construction activities will largely be a function of the proximity of such works to their holts and foraging grounds. Most European/Ramsar sites which support otter are inland from the	As above ▪	As above

Screened-in sites with these qualifying features are provided in Table C1 (Appendix C)				Is There an Adverse Effect on Integrity of any European/Ramsar sites?	Is There an Adverse Effect on Integrity With Additional Mitigation Measures?
Qualifying and Supporting Feature	**Summary Impact Pathway**	**Pathway Ref. No.**	**Sensitivity Level(s) Commentary, and Relevant Conservation Objective**		
	exploration and geophysical surveys), construction (e.g. piling, drilling, cable laying), operation (e.g. device noise), maintenance or decommissioning.		coast and, therefore, the likelihood of noise/vibration disturbance is considered to be low. The guidance on undertaking surveys to assess impacts upon this species suggests that distances of 200-250m are appropriate. It is expected that there are unlikely to be adverse disturbance on otter beyond these distances along the shoreline.		
			Relevant Conservation Objectives (see Section 9.7 Of the conservation objectives, the following are particularly relevant to this impact pathway: ▪ Population of the species as a viable component of the site; ▪ Distribution of the species within site; and ▪ No significant disturbance of the species.		

10 In-Combination Effects

10.1 Introduction

10.1.1 The Habitats Regulations require that, in determining whether a plan or project is likely to have a significant effect on a European/Ramsar site, its effects should be considered both alone and in-combination with other plans or projects.

10.1.2 By definition, an in-combination effect within the Draft Plan would be between different DPOs and / or other plans or projects with connectivity to the same qualifying interests of a European/Ramsar site.

10.1.3 To inform this in-combination assessment, a review of existing plans and projects was initially carried out, allowing plans or projects with the potential to affect the same features as the Draft Plan to be identified.

10.2 Key Assumptions

10.2.1 In considering the potential for in-combination effects it has been assumed that windfarm development will occur within each of the 17 DPOs. Hence, the in-combination assessment encompasses those effects which could arise from development at any or all of the DPOs, in tandem with the potential effects that could occur as a result of other plans and projects.

10.2.2 As it is not possible to determine the degree of windfarm development that could occur within a DPO at this point in the Draft Plan process, indicative potential generating capacities have been used based on the overall scale of the draft Plan (as defined within the Offshore Wind Plan SEA). Although windfarm development within any of the DPOs would not fully encompass the extent of any DPO, for the HRA assessment it is assumed that development could potentially occur within any part of a given DPO.

10.3 Relevant Marine Projects and Plans

10.3.1 Initially a full review of extant and relevant plans and projects was carried out. Although a lot of the information on extant marine renewable projects is held by Marine Scotland and The Crown Estate, there is no complete central repository for such information across all the marine renewable sectors.

10.3.2 Proposed and operational offshore renewable energy developments in Scottish waters were first identified (Section 10.4; Table 22). Other plans and projects which could potentially affect the same features as the Draft Plan were also identified (Section 0). Careful consideration was then given to the outcomes of project-level HRAs and EIAs for Scottish windfarm proposals (Section 10.6), including the outcomes of Appropriate Assessments carried out by MS-LOT and MSS on behalf of Scottish Ministers.

10.3.3 Scotland currently has five operational offshore wind sites with a total capacity of 320 MW: the Beatrice demonstrator project (two 5 MW turbines, currently undergoing decommissioning), the Hywind Scotland Pilot Park

project (30 MW capacity), Robin Rigg (180 MW capacity), Levenmouth Demonstration Turbine (one 7 MW turbine) and, during 2018, the European Offshore Wind Deployment Centre (EOWDC) deployed 11 turbines, with a total capacity of 93.2 MW.

10.3.4 While the number of operational windfarms is small within Scottish Territorial Waters, there are currently plans to install up to 1.9 GW capacity of offshore wind in three short-term option sites (Beatrice, Inch Cape and Neart na Gaoithe), together with up to 4.15 GW capacity within two Round 3 sites in offshore waters (Moray Firth (1.7 GW) and Firth of Forth (2.45 GW)). All five of these major offshore wind developments in Scottish waters were consented in 2014. However, applications for revisions to several of these projects (e.g. Inch Cape; Neart na Gaoithe; Moray East) have required new HRAs to support the applications. The Moray West Offshore Wind Farm (up to 85 turbines) was consented in June 2019 following four consultation exercises carried out by Scottish Ministers.

10.3.5 The Beatrice windfarm project is currently under construction and is expected to be fully operational by the end of 2019, with a total capacity of 588 MW.

10.3.6 Although a large number of wave and tidal developments are in development/in planning, particularly associated with the Pentland Firth and Orkney Waters lease areas and lease awards made in relation to the Saltire Prize (see Table 22), relatively few are operational.

10.3.7 The MeyGen tidal stream project is currently under construction in the Pentland Firth. Phase 1 installed four 1.5 MW tidal turbines, now operational, as a precursor to the development of the remaining consented 86 MW project and potential future expansion.

10.3.8 The European Marine Energy Centre (EMEC) provides a range of testing facilities for wave and tidal devices around Orkney. Operational devices are currently being tested at the Billia Croo (wave energy), Scapa Flow (wave energy), Fall of Warness (tidal stream energy) and Shapinsay Sound (tidal stream energy) sites. The Islay LIMPET wave device was the world's first commercial wave power device connected to the United Kingdom's National Grid. Following the construction of a 75-kW prototype in 1991, a 500-kW unit was built in 2000 (later downgraded to 250 kW) and was decommissioned in 2018. The 300 kW (3 x 100 kW turbines) North Yell tidal array was installed and commissioned in early 2014 in the Bluemull Sound in Shetland; the project is 100% owned by the local community, making this the world's first community-owned tidal energy project, and there are plans to double capacity of the site.

10.3.9 The key strategies or planning context for these marine renewable energy projects include:

- National Marine Plan;
- Blue Seas Green Energy – Sectoral Marine Plan for Offshore Wind Energy in Scottish Territorial Waters;
- Scottish Energy Strategy;
- Shetland Marine Plan;

- National Renewables Infrastructure Plan;
- Marine Renewables Infrastructure Plan;
- National Planning Framework 3;
- The pilot Pentland Firth and Orkney Waters Marine Spatial Plan (PFOW MSP);
- Scottish Sustainable Marine Environment Initiative (SSMEI);
- Electricity Ten Year Statement;
- Proposals for additional wave and tidal development lease areas including through the Further Scottish Leasing Rounds;
- Demonstrator wave and tidal energy projects;
- The Northern Ireland strategic wave, wind and tidal energy areas; and
- The R3OWF Plan (e.g. Moray Firth, Firth of Forth).

10.4 HRA Review

10.4.1 As mentioned above, to help inform this in-combination assessment, particular consideration was given to the findings from various EIA reports and HRAs carried out for windfarm projects in Scottish Territorial Waters (see Table 22).All potential impact pathways from windfarm proposals have been previously identified through review of plan and project level HRAs (see Table 2), including those projects listed below (Table 22). In addition, mitigation measures derived from a range of previous strategic assessments and plan-level HRAs for the Marine Renewable Sector have been tabulated (Table J1, Appendix J) against each of the key impact pathways.

10.4.2 These details can be used to inform high-level in-combination effects reviews but, over the longer-term they can also provide a basis for informing the future Iterative Plan Review (IPR) process (see Section 11.4). It is also hoped that this information will provide a useful guide to developers and regulators to identify some of the key impacts of future projects and the mitigation/monitoring requirements that might be relevant.

Table 22. Operational and planned offshore wind, tidal and wave renewable energy projects within Scottish Territorial Waters

Energy Type	Name/ Location	Company (Project Website)	Status	Capacity (MW)
Wind	Robin Rigg	E.ON https://www.eonenergy.com/About-eon/our-company/generation/our-current-portfolio/wind/offshore/robin-rigg	Fully operational since September 2010.	174
Wind	Beatrice Demonstrator	SSE Renewables / Talisman	Entering decommissioning (2024 – 2027)	10
Wind	Levenmouth Turbine	ORE Catapult https://ore.catapult.org.uk/press-releases/levenmouth-turbine-offers-unrivalled-opportunity-for-renewable-energy-rd/	Fully operational	7
Wind	Hywind	Equinor / Masdar http://www.statoil.com/en/environmentsociety/environment/impactassessments/newenergy/intwind/pages/hywindscotland.aspx	Fully operational	30
Wind	Aberdeen Bay (EOWDC)	Vattenfall http://www.statoil.com/en/environmentsociety/environment/impactassessments/newenergy/intwind/pages/hywindscotland.aspx	Fully operational	93.2
Wind	Beatrice	SSE Renewables / SDIC / Copenhagen Infrastructure Partners http://sse.com/whatwedo/ourprojectsandassets/renewables/Beatrice	Fully operational	588

Energy Type	Name/ Location	Company (Project Website)	Status	Capacity (MW)
Wind	Neart na Gaoithe	EDF Renewables http://www.neartnagaoithe.com	Consented December 2018 (Varied June 2019).	450
Wind	Firth of Forth 1 (Seagreen Alpha and Bravo)	SSE Renewables http://www.seagreenwindenergy.com	Consent granted October 2014 (varied August 2018 to remove maximum capacity). Updated application for optimised project submitted September 2018. Construction anticipated to commence by 2022.	1500
Wind	Moray East	EDPR http://www.morayoffshorerenewables.com/Home.aspx	Consent granted in March 2014. Delivery expected early 2020s.	950
Wind	Inch Cape	SDIC http://www.inchcapewind.com	New application submitted August 2018.	700
Wind	Kincardine	Atkins / Pilot Offshore Renewables http://pilot-renewables.com/	Consent received 2017. Currently under construction (one turbine operational)	49.6
Wind	Dounreay Tri Demonstration Project	Hexicon https://www.hexicon.eu/dounreay-tri/	Currently on hold, delivery expected 2020 (company in administration)	12

Energy Type	Name/ Location	Company (Project Website)	Status	Capacity (MW)
Wind	Firth of Forth 2 (Charlie)	SSE Renewables http://www.seagreenwindenergy.com	In planning	1800
Wind	Firth of Forth 3 (Delta)	SSE Renewables http://www.seagreenwindenergy.com	In planning	800
Wind	Moray Firth Western Development Area	EDPR http://www.morayoffshorerenewables.com/Home.aspx	Consented June 2019. Delivery potential in mid 2020s	850
Wind	Forthwind OWF, Methil	Forthwind Ltd	Consented, (Consent varied May 2019 to increase capacity)	29.9
Wind Total				**8209.7**
Tidal Stream	North Yell, Bluemull Sound, Shetland	Nova Innovation (https://www.novainnovation.com/bluemull-sound)	Fully operational since 2017. Expansion to 0.6 MW planned.	0.3
Tidal Stream	Sound of Islay	Scottish Power Renewables (http://www.scottishpowerrenewables.com/pages/sound_of_islay.asp)	Consent granted in March 2011. Pre-construction. (not currently active as a project)	10
Tidal Stream	Ness of Duncansby, Pentland Firth	Scottish Power Renewables (http://www.scottishpowerrenewables.com/pages/ness_of_duncansby.asp)	In early stages of planning. Agreement to lease secured.	95
Tidal Stream	Westray South, Pentland Firth	DP Energy (http://www.dpenergy.com/projects/tidal/westray-south)	In development. Agreement to lease secured. Scoping Report submitted November 2011.	200

Energy Type	Name/ Location	Company (Project Website)	Status	Capacity (MW)
Tidal Stream	Brough Ness, Pentland Firth	Simec Atlantis Energy (https://simecatlantis.com/projects/)	In development.	100
Tidal Stream	Inner Sound, Pentland Firth	Simec Atlantis Energy (https://simecatlantis.com/projects/meygen/)	Phase 1 (6 MW) in operation.	398
Tidal Stream	Mull of Kintyre, Argyll	Argyll Tidal Ltd (http://www.gov.scot/Topics/marine/Licensing/marine/scoping/ArgyllTidalArray)	Consent granted in May 2014 for one demonstration turbine (0.5MW) to be installed. Pre-construction.	0.5
Tidal Stream	Isle of Islay, Islay	DP Marine Energy Ltd (http://www.dpenergy.com/projects)	In development. Agreement to lease secured. Consent received 2017.	30
Tidal Stream	Lashy Sound	Scotrenewables Tidal Power Limited (SRTP) (https://www2.gov.scot/Topics/marine/Licensing/marine/scoping/LashySound)	In development. Agreement to lease secured. Scoping Report submitted in July 2014.	10
Tidal Stream	Brims Tidal Array (formerly Cantick Head)	SSE Renewables and OpenHydro Group Ltd (http://sse.com/whatwedo/ourprojectsandassets/renewables/brims)	In development. Agreement to lease secured. EIA submitted 2016 (company in administration)	200
Tidal Stream	Mull of Galloway	Marine Current Turbines (https://simecatlantis.com/projects/galloway/)	In planning. Agreement to lease secured.	30
Tidal Stream	Fall of Warness	European Marine Energy Centre Ltd	Test site. Operational Feb 2019.	N/A

Energy Type	Name/ Location	Company (Project Website)	Status	Capacity (MW)
Tidal Stream	Shapinsay Sound	European Marine Energy Centre Ltd	Test site.	N/A
Tidal Stream	Islay Demonstration Zone	European Marine Energy Centre Ltd	Test site.	N/A
Tidal Stream	Stronsay Firth	European Marine Energy Centre Ltd	Test site.	N/A
Tidal Total				**1,073**
Wave	Billia Croo	European Marine Energy Centre Ltd	Test site	N/A
Wave	Scapa Flow	European Marine Energy Centre Ltd		N/A
Wave	Scottish Sea Farms (MANTA) - Teisti Geo	Scottish Sea Farms	Marine Licence Granted May 2018 (Operational)	0.262
Wave	WaveNet Mingary	Wavenet Energy Mingary Ltd.	Marine Licence issued – operational	0.45
Wave	Harris Demonstration Zone	European Marine Energy Centre Ltd	Test site	N/A
Wave Total				**0.712**
Hybrid	Katanes Floating Energy Park	Katanes Floating Energy Ltd	Screening opinion issued November 2017	11.6
Hybrid Total				**11.6**

10.5 Other Plans and Projects

10.5.1 In addition to the offshore marine renewable projects, a wide range of other plans and projects are potentially relevant including:

- Marine Renewables Infrastructure Plan (MRIP);
- National Renewables Infrastructure Plan (N-RIP) (e.g. Port of Dundee, Port of Leith);
- The National Planning Framework for Scotland (NPF3);
- The Crown Estate Scotland (ScotWind) Leasing Round;
- The Crown Estate Offshore Wind Leasing – Round 4
- Waterfront regeneration projects (e.g. Helensburgh);
- Harbour expansion projects (e.g. Aberdeen);
- Onshore wind farms;
- Increased vessel activity from all sources (no specific plan), including offshore development and shipping from other ports;
- ISLES project;
- ISLES II project;
- Proposals for the offshore grid and other proposed cable routes;
- Container transhipment hub at Scapa Flow;
- Other proposals included within the pilot Pentland Firth and Orkney Waters Marine Spatial Plan;
- Oil and gas development activities;
- Port and marina developments (e.g. Granton);
- Aquaculture developments;
- Fishing activities;
- Military activities;
- Terrestrial developments potentially affecting Atlantic salmon, freshwater pearl mussel or otter features associated with SAC rivers.

10.5.2 An overarching National Marine Plan was introduced in Scotland through the Marine (Scotland) Act 2010. The plan, adopted in March 2015, is designed to inform decision making in the marine environment by governing more detailed planning at the regional level and informing marine licensing and other decision-making functions. An HRA was carried out for this Plan and following the screening stage of that process it was concluded that an AA was not required. Having followed SNH guidance, this view was taken in respect of both the Plan's 'cross-cutting' and 'sector-specific' policies as follows:

- The cross-cutting policies are general in direction, as they apply to all activities and development in the marine environment. In consequence, no connectivity or direct pathway for impact was identified between these and specific European sites.

- The sector-specific policies are general in direction, as they do not direct development or activities to a particular location and do not have a pathway for impact on specific European sites. For those which could have a significant effect on the integrity of European sites, mitigation measures have been recommended in the form of changes to the wording of the policies.

10.5.3 In conclusion, the National Marine Plan was considered to have no significant effect on the integrity of European sites, and for the same reason there will be no in-combination effects between the Sectoral Offshore Wind Plan and the National Marine Plan. The Sectoral Offshore Wind Plan provides the spatial strategy for developing offshore wind energy at the national and regional level. This spatial strategy has been assessed within this plan-level HRA. Future developments which take place within these areas will be assessed against the proposals and policies contained within the National Marine Plan at the project licensing stage.

10.5.4 It should also be noted that in the coming years regional Marine Plans will be developed (e.g. Clyde Regional Marine Plan). These regional plans will include more focused policies for the coastal regions and, as such, an HRA for these plans may be required.

10.6 Assessment Review

10.6.1 The review of operational and planned marine windfarm projects indicated a high degree of similarity between the impact pathways described. All of the 18 generic impact pathways that have been identified and assessed for the Sectoral Offshore Wind Plan HRA (see Table 2) were considered to some degree within project-level HRAs for the proposed or operational windfarm projects.

10.6.2 Within the windfarm project assessments, the key impact pathways which were consistently considered included:

- Direct and indirect damage to habitats;
- Physical damage and mortality to species, especially birds, due to collision risk;
- Non-physical disturbance to species due to displacement effects, noise and vibration effects and effects from Electromagnetic Fields (EMF); and
- Non-toxic contamination due to elevated turbidity.

10.6.3 It is evident that the main concerns at a project-level for offshore windfarm developments relate to: the direct and indirect damage to habitats within and adjacent to the footprint of the development and the potential impacts to mobile species via collision risks (especially birds), disturbance (visual, noise and vibration) and displacement.

10.6.4 The direct and indirect effects to benthic habitats and species in the vicinity of individual developments is well understood. These relatively localised impacts from future projects are foreseeable and can be addressed/offset through mitigation and or compensation, as required, if they result in an

adverse effect on a European/Ramsar site. Although the DPOs do not directly overlap with any European/Ramsar site, there is potential for direct effects to occur as a result of cable routeing and landfall.

10.6.5 Spatial planning and array design at a project level will be key in contributing towards mitigation of such impacts. However, there also remains an opportunity to reduce the likelihood of adverse effects on designated habitats through spatial planning at a plan-level (see Section 11).

10.6.6 Hence, the greatest risk of an in-combination impact from windfarms is likely to be for mobile interest features, with the potential to adversely affect these receptors through a variety of activities and pathways, during different phases of the development. A high-level review of the potential in-combination effects on mobile features from the Draft Plan with other windfarm developments has been carried out below.

10.6.7 For non-renewable marine projects the range of impact pathways will differ, however, the in-combination effects on mobile features such as marine mammals, fish and birds remain key considerations. Coastal developments such as waterfront enhancements and port expansions could result in prolonged periods of underwater noise (with potential effects on seals and cetaceans) (e.g. the construction phase of Aberdeen Harbour Expansion Project). Terrestrial activities for developments might affect river SACs and could result in in-combination effects for Atlantic salmon, freshwater pearl mussel and otter interest features. Within the offshore environment there are a number of potential developments over a range of sectors (fishing, oil and gas etc.) for which there could be in-combination effects to, for instance, habitats or foraging species.

10.6.8 Although non-renewable and other renewable (tidal stream and wave energy) developments have the potential for in-combination effects with the Draft Plan, the key risks to mobile features will arise from in-combination effects with other offshore windfarm developments. These risks have been explored in the following sections to understand the likelihood of an AEOI, with consideration of appropriate plan-level mitigation (Section 11) to minimise these risks.

10.6.9 It is recognised that seismic surveys associated with oil and gas surveys are generally of greater magnitude than those associated with development under this plan, and therefore there is potential for in-combination effects.

10.7 Mobile Features

10.7.1 The key risks to marine mammals and fish are generally considered to occur during the construction phase (see Table 14, Table 15 and Table 17), thus there is greater opportunity for the application of project-level mitigation (see Table J1 and J2, Appendix J) to minimise the effects of certain activities. Conversely, the key risks to seabirds from windfarm developments will generally occur during the operational phase (Table 9) with more limited options for suitable mitigation outwith design and spatial planning.

10.7.2 Offshore windfarm development (proposed and operational) is comparatively greater along the east and northeast coast of Scotland (i.e. Forth, Tay and

Moray regions). Therefore, the conclusions of HRA in-combination assessments of windfarm proposals from these regions provide a useful indication of the likely effects on mobile qualifying features. Consultation advice, issued in 2018, from SNCBs in relation to commercial windfarm proposals in Scottish waters was reviewed. It is assumed that where an AEOI has been concluded by a SNCB in relation to a mobile feature then there is an increased risk of AEOI in-combination with the Draft Plan. Where available, the conclusions of Appropriate Assessments (e.g. Moray Firth East (2014); Beatrice (2014); Neart na Gaoithe (2018)) carried out by MS-LOT and MSS, have been acknowledged.

10.7.3 Conversely, offshore windfarm development along the southwest, west and north coast of Scotland is minimal; with Robin Rigg in the Solway Firth. The results of a 5-year post-construction monitoring study carried out at Robin Rigg windfarm provide empirical evidence on the utilisation of the area by birds, mammals and fish. These results have been used to inform this assessment review where appropriate.

10.7.4 Birds, marine mammals and migratory fish have been reviewed in turn with reference to regional areas if relevant to further plan-level consideration of the potential for in-combination effects.

Birds

10.7.5 In 2018, project-level HRA consultation advice received from SNCBs in relation to commercial windfarm proposals, along the east and north-east coast of Scotland highlighted the adverse in-combination effects on seabird populations. An AEOI, from in-combination effects on seabirds, by way of collision and/or displacement effects occurring during the operational phase, was identified for several large-scale offshore windfarm proposals in the Forth, Tay and Moray regions (see Table 22).

10.7.6 Since submission of the application for Neart na Gaoithe (revised) windfarm, an Appropriate Assessment carried out by Marine Scotland (01/12/18) concluded that the development would not lead to an AEOI either alone or in-combination with other plans or projects. Neart na Gaoithe was consented in December 2018. Similarly, an Appropriate Assessment carried out by Marine Scotland (26/04/19) concluded that the Moray West wind farm development would not lead to an AEOI either alone or in-combination with other plans or projects.

10.7.7 Given the consistency of HRA consultation responses in relation to in-combination effects on seabirds from offshore windfarms in the Forth, Tay and Moray, the general scientific consensus, based on current available evidence and modelling, suggests that there is little available carrying capacity in these regions for further windfarm development. Hence, at this time, where there is likely to be connectivity to seabird colonies already thought to be affected by ongoing offshore windfarm development, then further windfarm development within the DPO(s) has a greater risk of an AEOI.

Table 23. SNCB advice during 2018 on project level HRAs for large scale commercial wind farm proposals in Forth, Tay and Moray.

Region	Site name	Turbines	Planning phase	SNH consultation response (in summary)
Moray	Moray West	up to 85	Consented June 2019	Object to proposal (07/09/18; 04/01/19; 12/04/19) In-combination with Moray East and Beatrice will have AEOI for: Kittiwake as a qualifying interest of the East and North Caithness Cliffs SPAs (collision risk) Great Black-backed Gull as a qualifying interest of the East Caithness Cliffs SPAs (collision risk)
Forth	Seagreen (Alpha and Bravo phase 1) (revised)	120	Application submitted September 2018	Object to proposal (02/11/18) In-combination with Inch Cape and Neart na Gaoithe likely AEOI for Black-legged Kittiwake and Northern Gannet as qualifying interests of Forth Islands SPA (collision risk) Black-legged Kittiwake as qualifying interests of the Fowlsheugh SPA (collision risk)
Tay	Inch Cape (revised)	72	Application submitted August 2018	Object to proposal (28/09/18) In-combination with Neart na Gaoithe and Seagreen will have AEOI for Black-legged Kittiwake, Northern Gannet (collision risk) and Razorbill (displacement) as qualifying interests of Forth Islands SPA

				Black-legged Kittiwake (collision) and Razorbill (displacement) as qualifying interests of the Fowlsheugh SPA
Tay	Neart na Gaoithe (revised)	54	Consented December 2018	Object to proposal (07/09/18 and 08/10/18) In-combination with Inch Cape and Seagreen will have AEOI for Black-legged Kittiwake, Northern Gannet (collision risk) and Razorbill (displacement) as qualifying interests of Forth Islands SPA Black-legged Kittiwake (collision) and Razorbill (displacement) as qualifying interests of the Fowlsheugh SPA Black-legged Kittiwake (collision) as qualifying interests of the St Abbs Head to Fast Castle SPA

10.7.8 European designated sites highlighted in recent consultations (see Table 22) as adversely affected by proposed and ongoing windfarm developments in Scottish Territorial Waters include:

- Forth Islands SPA
- Fowlsheugh SPA
- St Abbs Head to Fast Castle SPA
- East Caithness Cliff SPA
- North Caithness Cliff SPA

10.7.9 It is acknowledged that the HRA advice for recent commercial windfarm proposals (see Table 23Table 22) is based on current 'worst case scenarios' e.g. the Neart na Gaoithe application (April 2018) considered in-combination effects with the earlier 2014 consented schemes at Inch Cape and Seagreen, and vice-versa. In the case of Neart na Gaoithe (revised) and Moray West, when the appropriate assessments were carried out by Scottish Ministers (December 2018 and April 2019 respectively), acknowledgment was given to the highly precautionary assumptions within the assessments; this contributing to the decision that these proposals would not lead to an AEOI.

10.7.10 Despite the emerging scientific evidence such as species-specific flight speeds recorded at Thanet by Skov *et al.* [333] and the collision avoidance rates recorded in the same study, the assessment of in-combination effects of any additional offshore windfarms in the Forth, Tay and Moray is likely to require more evidence to conclude no AEOI. Accordingly, further high-level consideration is given to the potential in-combination effects of the Sectoral Offshore Wind Plan in the Forth, Tay and Moray regions (Section 10.8 and 10.9).

10.7.11 Concerns have previously been raised in relation to collision risk of windfarms to migrating birds, seabirds and non-seabirds, in particular on the potential effects of multiple windfarms on the migratory passage of Whooper Swan[334];[335],[336]. A key migration flyway for Whooper Swan encompasses the Cumbrian coast, Solway Firth and the North Channel, along the west coast of Scotland. Fifty percent of whooper swans are estimated to fly at collision risk height [337] hence, the in-combination effects of windfarm development along the southwest and west coast of Scotland, when considered with proposed and operational windfarms such as at Robin Rigg, Ormonde, Walney, Barrow and Burbo Bank, may increase collision risk and lead to an AEOI where, for example, Whooper Swan are a qualifying feature of a European/Ramsar site.

[333] Skov, H., Heinänen, S., Norman, T., Ward, R.M., Méndez-Roldán, S., Ellis, I. 2018. ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust. 247 pp.

[334] Griffin, L., Rees, E. & Hughes, B. 2010. Whooper Swan migration in relation to offshore wind farms. BOU Proceedings – Climate Change and Birds. https://tethys.pnnl.gov/sites/default/files/publications/Griffin_et_al_Wooper_Swan_Migration.pdf

[335] Rees, E. 2012. Impacts of wind farms on swans and geese: a review. Wildfowl 62: 37-72.

[336] Wright, L.J., Ross-Smith, V.H., Massimino, D., Dadam, D., Cook, A.S.C.P., and Burton, N.J.K. (2012). Assessing the risk of offshore wind farm development to migratory birds designated as features of UK Special Protection Areas (and Scottish Government Migratory species collision risk modelling assessments Page 147 July 2014 other Annex 1 species). The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-05. BTO and the Crown Estate.

[337] ibid

10.7.12 A focussed study in 2014 looking at the potential impact of operational windfarms on migratory birds concluded that at a strategic level all non-seabirds and almost all seabirds did not appear to be at risk of significant levels of additional mortality due to collisions alone with Scottish offshore windfarms[338]. At Robin Rigg, bird surveys carried out monthly or bimonthly from 2001 to 2011, encompassing baseline, construction and post-construction phases recorded six Whooper Swan in total, two of which were flying[339].

10.7.13 It is realised that future development from TCE Round 4 leasing may lead to additional windfarm development within the key migration flyway for Whooper Swan (see above) and as further detail of the Round 4 leasing emerges then the potential for in-combination effects should be revisited. The proposed plan-level mitigation provides a mechanism for continuous review and updates to the Draft Plan (Section 11.4).

Marine mammals

10.7.14 SNCB consultation responses to project level HRAs at Inch Cape (revised), Moray West, Seagreen (revised), Neart na Gaoithe (revised) and Dounreay Tri Floating project have consistently concluded that compliance with consent conditions would be sufficient to result in no adverse effect on marine mammals as qualifying features of designated sites, either alone or in-combination with other developments. Similarly, the Appropriate Assessments for Beatrice, Moray Offshore East, Neart na Gaoithe (revised) and Dounreay Tri Floating project concluded the same.

10.7.15 Anecdotal evidence from post-consent monitoring at Robin Rigg windfarm suggests that both harbour porpoise and grey seal were present within the survey area within 24 hours of piling events, as has been previously reported at other windfarm sites.

10.7.16 Although it is considered that the adoption of project-level mitigation measures at an individual DPO would avoid an in-combination AEOI, there is scope for an additive cumulative effect from construction (e.g. underwater noise from piling activities) if development at DPOs coincided within a particular area. There is potential for temporal sequencing of DPO development within a particular area to avoid additive effects. However, such an approach could extend the duration of effects. It is considered that such risks are most appropriately and effectively managed at project level.

10.7.17 Furthermore, should development at sites further offshore occur simultaneously with oil and gas survey activities, there is potential for additive in-combination effects on marine mammals to occur. The level of activity in the future from oil and gas survey is uncertain, and therefore it is considered that such risks are most appropriately and effectively managed at project level.

[338] Wildfowl & Wetlands Trust (Consulting) Ltd. 2014. Migratory species collision risk modelling assessments. Strategic assessment of collision risk of Scottish offshore wind farms to migrating birds. Published by Marine Scotland Science. ISSN: 2043-7722.

[339] Walls, R., Canning, S., Lye, G., Givens, L., Garrett, C., Lancaster, J., (2013) Analysis of Marine Environmental Monitoring Plan Data from the Robin Rigg Offshore Wind Farm, Scotland (Operational Year 1) Technical Report, Document ref: 1022038. https://tethys.pnnl.gov/sites/default/files/publications/Walls%20et%20al%202013.pdf

Fish

10.7.18 SNCB consultation responses to project level HRAs at Inch Cape (revised), Moray West, Seagreen (revised), Neart na Gaoithe (revised) and Dounreay Tri Floating project have consistently concluded that compliance with consent conditions would be sufficient to result in no adverse effect on diadromous (migratory) fish and freshwater pearl mussel as qualifying features of designated sites, either alone or in-combination with other developments. Similarly, the Appropriate Assessments for Beatrice, Moray Offshore East, Neart na Gaoithe (revised) and Dounreay Tri Floating project concluded the same.

10.7.19 The post-consent monitoring study at Robin Rigg suggested that the construction and operation of the Robin Rigg Offshore Wind Farm has not had any significant or permanent impact upon the fish and benthic fauna in the immediate or surrounding area of the windfarm[340].

10.7.20 Although it is considered that the adoption of project-level mitigation measures at an individual DPO would avoid an in-combination AEOI; there is scope for an additive cumulative effect from construction (e.g. underwater noise from piling activities) if development at DPOs coincided within a particular area. There is the potential that a commitment to temporal sequencing of DPO development within a particular area would avoid additive effects. However, such an approach could extend the duration of effects. It is considered that such risks are most appropriately and effectively managed at project level.

10.8 Forth and Tay In-combination

10.8.1 SNH has advised that an AEOI for Kittiwake, Northern Gannet and Razorbill from the in-combination effects of proposed offshore windfarms in the Forth and Tay is likely for several designated sites (see Table 23)

10.8.2 Scottish Kittiwake populations have experienced significant declines over the last 30 years, as has been highlighted in advice received from both SNH and RSPB consultation responses (e.g. Neart na Gaoithe Offshore Windfarm consultation responses). The RSPB Kittiwake utilisation distribution map indicates relatively high utilisation of the waters overlapping DPO E3 (Figure 7). This DPO is within 30 km from both the Buchan Ness to Collieston Coast SPA and Fowlsheugh SPA; and approximately 100 km from the Forth Islands SPA. Given that the mean maximum foraging range of Kittiwake is 60 km [341], it is assumed that Kittiwakes from the colonies at Buchan Ness to Collieston Coast SPA and Fowlsheugh SPA would potentially be affected by development at E3, with an increased likelihood of an AEOI, particularly at Fowlsheugh SPA, when considered in-combination with the consented Neart na Gaoithe and the proposals at Inch Cape and Seagreen.

[340] Natural Power Consultants. 2013. Analysis of Marine Environmental Monitoring Plan Data from the Robin Rigg Offshore Wind Farm, Scotland (Operational Year 1 and Year 3). Report nos. 1022038 and 1029455

[341] Thaxter, C. B., Lascelles, B., Sugar, K., Cook, A. S. C. P., Roos, S., Bolton, M., Langston, R. H. W. and Burton, N.H.K. (2012). Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas. Biological Conservation 156: 53-61.

10.8.3 DPOs E1 and E2 are further offshore than E3, approximately 60 km at their nearest point to the Kittiwake colonies at Fowlsheugh SPA and Buchan Ness to Collieston Coast SPA respectively. Kittiwake utilisation within these DPOs is considerably lower than that at E3 (Figure 7).

10.8.4 There is potential for development in E3 to have an effect on Razorbill populations from the Fowlsheugh SPA as a large proportion of E3 is within the foraging range distance from the SPA and RSPB utilisation data (Figure 8) suggests some usage of the western half of E3 by Razorbill. However, the smaller mean maximum foraging range (48 km[342]) of Razorbill compared to Kittiwake reduces the overlap with other Forth and Tay windfarms and therefore subsequently reduces the potential for significant in-combination effects. Both E1 and E2 are beyond the mean maximum foraging range for Razorbill from the Fowlsheugh SPA colony, while E1, E2 and E3 are all beyond the mean maximum foraging ranges for Razorbill from the Forth Islands SPA.

10.8.5 Gannets forage much further than Kittiwake (mean maximum foraging range of 229 km) and therefore individuals from Forth Islands SPA could be affected by development in DPOs E1, E2 and E3.

10.8.6 A recent study by Garthe *et al*.[343] found that gannets largely avoided the windfarm area to the north of Helgoland, implying that Northern Gannets may be more at risk from displacement than collision. Similarly, a five-year post construction monitoring study at Robin Rigg windfarm did not record any flying gannets, possibly indicating macro-avoidance behaviour of the site.

10.8.7 Although the general assumption is that nearer shore windfarm developments are worse for seabirds than those further offshore, this assumption has not yet been tested. However, observations from ship surveys[344] and tagging data[345] seem to indicate that fewer Northern Gannet may utilise the waters around and within DPOs E1 and E2, the most offshore sites, than areas which coincide with proposed windfarm developments (i.e. Seagreen, Inch Cape and Neart na Gaoithe) and DPO E3. For example, results from a Northern Gannet tagging study of the Bass Rock colony showed a greater density of foraging flights nearshore than directly offshore[346].

10.8.8 The Forth Islands SPA, for which Northern Gannets are a qualifying feature, is over 100 km from E1, at its nearest point, and approximately 170 km from E2. Although E3 is approximately the same distance from the Forth Islands SPA as E1, it is much closer inshore than E1 and E2. At a plan-level, acknowledging current scientific evidence, consultation advice issued in 2018 for windfarm proposals in the Forth and Tay and the general

[342] Thaxter, C. B., Lascelles, B., Sugar, K., Cook, A. S. C. P., Roos, S., Bolton, M., Langston, R. H. W. and Burton, N.H.K. (2012). Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas. Biological Conservation 156: 53-61.

[343] Garthe, S., Markones, N. & Corman, AM. J Ornithol (2017) 158: 345. https://doi.org/10.1007/s10336-016-1402-y

[344] Camphuysen, CJ., 2011. Northern gannets Morus bassanus in the North Sea: foraging distribution and feeding techniques around the Bass Rock. British Birds 104(2): 60-76.

[345] Wakefield, ED, Bodey, TW, Bearhop, S et al. (19 more authors) (2013) Space Partitioning Without Territoriality in Gannets. Science, 341 (6141). 68 - 70. ISSN 0036-8075

[346] ibid

consensus that the carrying capacity for several bird interest features of SPAs is close to being reached, the potential in-combination effects from development in E3 with Neart na Gaoithe, Seagreen and Inch Cape will likely lead to an AEOI. The in-combination effects would be compounded by additional development in E1 and E2, if it were to occur.

10.8.9 Development at the more offshore sites, E1 and E2, is less likely to result in an AEOI from in-combination effects, as at their closest points they are at the limits of Kittiwake mean maximum foraging ranges from the nearest SPA colonies.

10.8.10 Recent consultation regarding the effects on gannets in the Forth and Tay regions has highlighted collision risk as the key in-combination impact from proposed windfarms (see Table 23). The large foraging range of Gannets means that individuals from the Forth Islands SPA could be affected by development at DPOs E1 and E2, although considering the distances offshore and from the Bass Rock colony, the risk of an AEOI from in-combination effects with either E1 or E2 would be comparatively less than at E3.

10.8.11 SEANSE (Strategic Environmental Assessment North Sea Energy) is an EU funded project which will produce a regional strategic assessment of the impacts on seabirds from offshore wind development scenarios in the Forth and Tay region. The study will use currently available tools and information to establish an up-to-date baseline of seabird behaviour and habitat use in the Forth and Tay region, and then develop and undertake a strategic ornithology assessment for the region based on different development scenarios. One of the tools that will be used in the newly developed seabird sensitivity mapping tool, which provides spatial information on the sensitivity of seabird populations based on windfarm footprint size and location. Both the seabird sensitivity mapping tool and outputs from the SEANSE project will help support the evidence base for future HRAs. As mentioned previously, the proposed plan-level mitigation provides a mechanism for continuous review and updates to the Draft Plan allowing for new evidence to be acknowledged as it becomes available (Section 11.3).

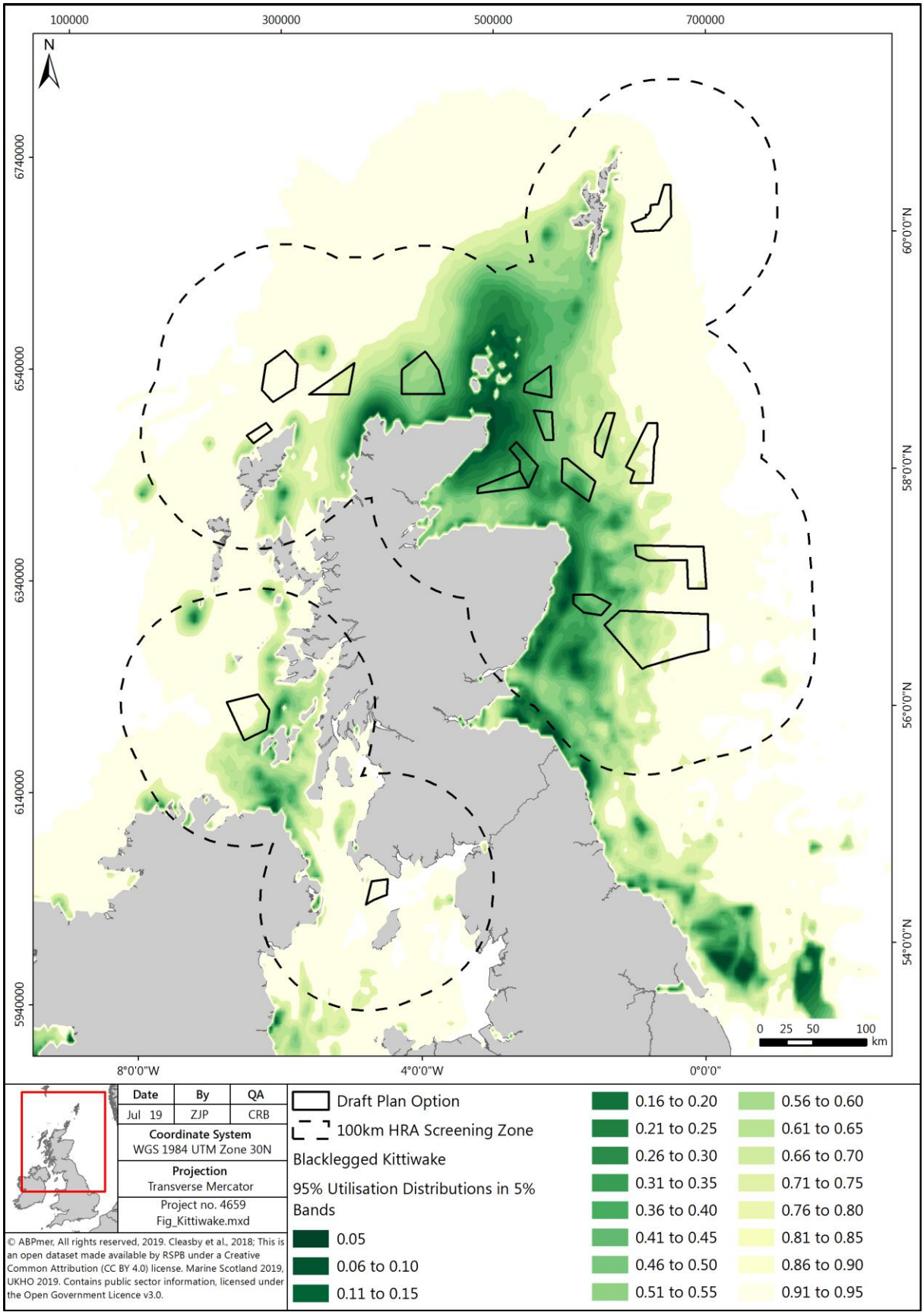

Figure 7. RSPB utilisation distribution data for Black-legged Kittiwake

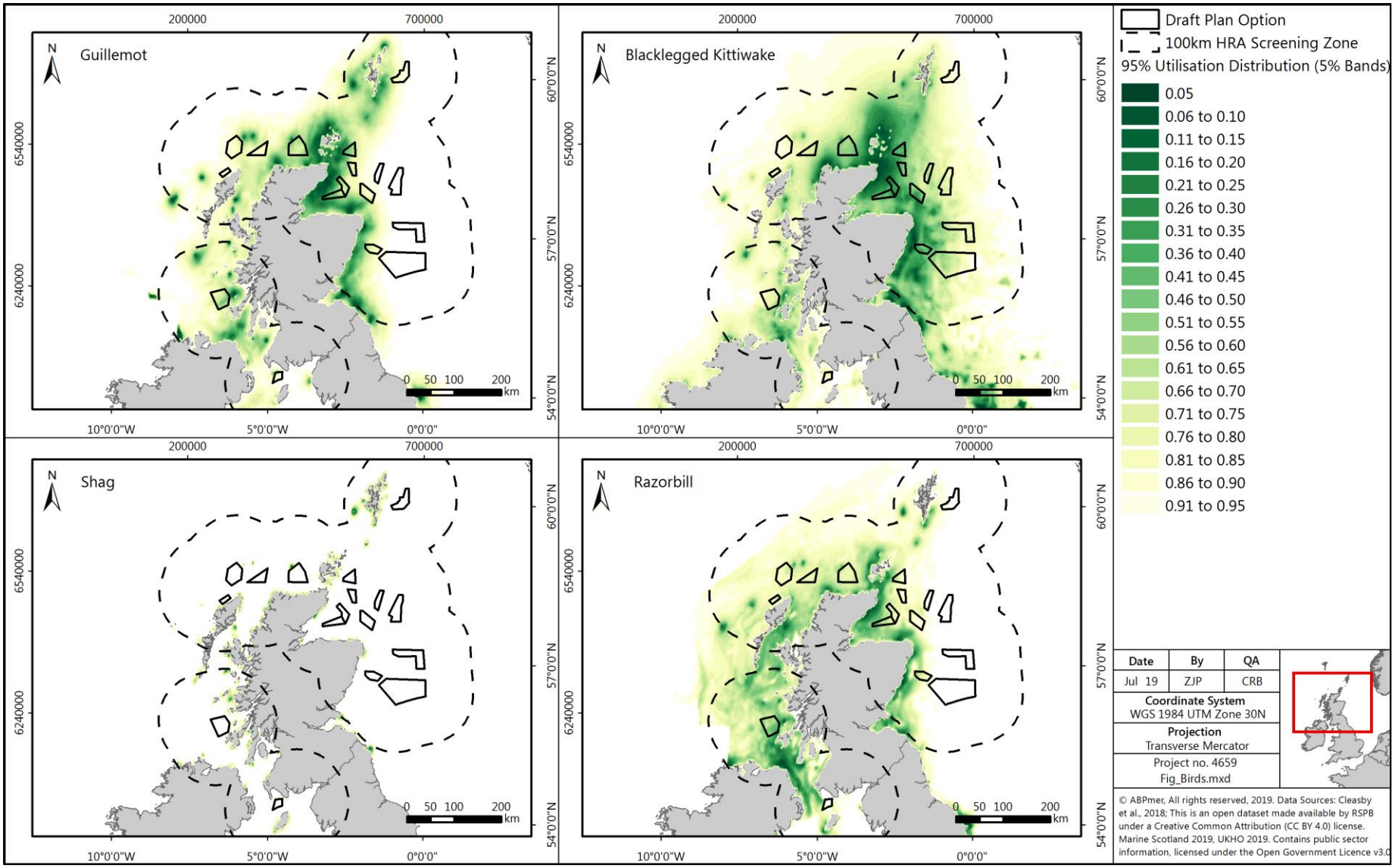

Figure 8. RSPB utilisation distribution data for Kittiwake, Shag, Guillemot and Razorbill

10.9 Moray In-combination

10.9.1 SNH has advised that in-combination effects from the proposed Moray West windfarm with the consented Moray East and Beatrice offshore windfarms will likely lead to an AEOI for Kittiwake as a qualifying feature of East and North Caithness Cliffs SPAs (Table 23). From the RSPB Kittiwake distribution map, relatively high utilisation of the waters overlapping DPOs NE2-NE6 is indicated (Figure 7). NE 2-5 are all located within 60 km of the Kittiwake colonies at the East and North Caithness Cliffs SPAs and are thus within the mean maximum foraging range for this species.

10.9.2 At a plan-level, acknowledging current scientific evidence, consultation advice received for Moray West in 2018 and 2019 (see Table 23) and the general consensus that the carrying capacity for Kittiwake interest features of East and North Caithness Cliffs SPAs is close to being reached, the potential in-combination effects from development at any of the DPOs with connectivity (NE2-5) with the consented Moray East, Moray West and Beatrice offshore windfarms will likely lead to an AEOI. In addition, although less is known about foraging behaviour from Great Black Backed Gulls, there is potential for sites in the NE region to have an effect on the North Caithness Cliffs SPA population, particularly given that large gull species are known to be of higher collision risk[347].

10.9.3 Development at the more offshore Moray sites, NE7 and NE8, would be beyond the Kittiwake mean maximum foraging ranges from the nearest SPA colonies, and are thus less likely to result in an AEOI from in-combination effects. Seabird distribution maps provided by RSPB (see Figure 8) have indicated minimal utilisation in the waters around and within NE7 and NE8 for Kittiwake, Razorbill, Guillemot and Shag.

10.9.4 The DPO NE6 is beyond 60 km from the East and North Caithness Cliffs SPAs and hence the mean maximum foraging distance for Kittiwake; however, it is within 60 km of the Troup, Pennan and Lion's Heads SPA which has Kittiwake as a qualifying feature, as are DPOs NE4 and NE5. Consultation issued by SNH for Moray West and Moray East did not conclude that there would be an AEOI for Kittiwake (or any other feature) as a qualifying feature of the Troup, Pennan and Lion's Heads SPA. However, it is considered that if windfarm development were to occur at all these DPOs (NE4-6) it would potentially lead to an in-combination AEOI on Kittiwake at Troup, Pennan and Lion's Head SPA. The level of cross connectivity between Kittiwake colonies in the Moray region is unknown; however, there is likely to be some connectivity between the East and North Caithness Cliffs SPAs.

10.9.5 As the DPOs NE2 to NE5 are all within 60 km of at least two SPAs which have Kittiwake as a qualifying feature, there is considerable risk of AEOI on these SPAs when considered in-combination with the consented Beatrice, Moray East and Moray West windfarms.

[347] Skov, H., Heinänen, S., Norman, T., Ward, R.M., Méndez-Roldán, S., Ellis, I. 2018. ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust. 247 pp.

11 Plan Impact Evaluation and Mitigation Requirements

11.1 Introduction

11.1.1 The appropriate assessment phase of the HRA (Stage 8) has reviewed the impacts arising from the Sectoral Offshore Wind Plan (Sections 5 to 9). In advance of considering mitigation measures, it could not be concluded that there will be no AEOI on any European/Ramsar sites. This is because of the inherent uncertainties that exist about future developments and the potential in-combination effects (Section 10). These uncertainties relate to several aspects such as:

- the detail of the Sectoral Offshore Wind Plan implementation process;
- future generation capacities;
- the location, scale and densities of development;
- the proposed technologies to be used and future advances in these technologies;
- the scale of the effects arising via some of the defined impact pathways; and
- the efficacy of some project-level mitigation options.

11.1.2 Recognising these uncertainties, and the conclusions of Stage 8, there is clearly a need for appropriate and meaningful mitigation measures to accompany the Draft Plan. The following sections detail the plan-level mitigation required to conclude, with a high degree of certainty, that there will be no AEOI on any European/Ramsar site arising from the Sectoral Offshore Wind Plan, either alone or in-combination, with other known plans or projects. Thus, this section covers Stage 9 of the plan-level HRA process (see Figure 1).

11.2 Mitigation (Stage 9)

11.2.1 Given the inherent uncertainties associated with the Draft Plan (see above), plan-level mitigation measures are required to ensure there is no AEOI. Two mitigation measures were initially identified as integral to the Draft Plan:

- **The legal requirement for individual projects to undergo HRA**. All future developments that are undertaken as part of the individual Sectoral Offshore Wind Plan will be required to undergo an HRA and, wherever the possibility of a LSE on a European/Ramsar site cannot be excluded, a project-level AA will need to be completed.
- **The implementation of the Plan through an iterative management process.** In the future, the project-level assessments and the associated monitoring review work will be linked to (and will inform) regular reviews of the Plan as part of an (IPR) process.

11.2.2 It is important to confirm that this plan-level HRA will not be a substitute for project-level HRAs, where these are required for individual projects. Such project-level HRA processes will still be required in accordance with the legislation. Accordingly, the requirement for a project-level AA, wherever there is possibility of a LSE, is an important mitigation measure for the plan-level HRA to ensure there is no adverse effect on integrity of designated sites once there is the required level of certainty about development location(s) and design.

11.2.3 For individual windfarm projects a range of mitigation measures are applied to help reduce or offset ecological effects where needed. Lists of such measures have been developed during previous strategic assessments including the following: the preceding Scottish Marine Renewables SEA [348]; the HRAs for previous draft OWE and W&TE Plans [349] [350]; the HRA for the East of England Inshore and Offshore Marine Plans [351]; the Northern Ireland Offshore Renewable Energy Strategic Plan 2009-2020 [352]; and most recently the HRA for ORE in Scottish Waters[353].

11.2.4 From these sources, an overall list of project mitigation measures was collected which provides a central 'project-level mitigation options' data table (Table J1, Appendix J). These measures were then compared against the impact matrix within Table J2 (Appendix J) to indicate which measures address which impacts. As these mitigation measures were derived from past strategic assessment and plan-level HRA work, they are comprehensive and cover all of the 18 key impact pathways identified during the pre-screening process (see Table 2). Of these measures, an overarching consideration, and the one that is also most intuitive, is that during the early stages in the design of any development, '*a primary consideration will be to try to avoid habitats within a European/Ramsar site and minimise exposure and risk*'. There are no DPOs which overlap with European/Ramsar sites; however, cable routeing and landfall activities could overlap with designated sites.

11.2.5 While this list demonstrates the range of project-level mitigation measures that are available, they do not, by themselves, provide further certainty that any European/Ramsar site or features will not be affected. This is because they are not a formal requirement of the Sectoral Offshore Wind Plan and they are too generic in nature to be assured that there will be no adverse effects as a result of their application. However, they have been brought

[348] Scottish Executive, 2007. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC https://www2.gov.scot/Publications/2007/03/seawave

[349] ABPmer, 2011a. Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Report for the Scottish Government, ABP Marine Environmental Research Ltd, Report No: R.1722a-c. January 2011.

[350] ABPmer 2013f. Habitats Regulations Appraisal of Draft Plan for Wave and Tidal Energy (W&TE) in Scottish Waters. Report for Marine Scotland 2013; ABP Marine Environmental Research Ltd, Final Report January 2013 Report Nos. R.1863a (Pre-Screening); R.1863b (Screening); and R.1863c (Report to Inform Appropriate Assessment); and R.1863d (PSG Comments Review).

[351] MMO, 2013. East of England Marine Plans Habitats Regulations Assessment. Reports Prepared by ABPmer, Hartley Anderson and Hyder Consulting (UK) Ltd., ABPmer Report No. R.2020a-c. March 2013.

[352] Entec 2011 Department of Enterprise, Trade and Investment Offshore Renewable Energy Strategic Action Plan 2009-2020 Habitats Regulations Assessment - Screening Report and Appropriate Assessment (Final Report) June 2011.

[353] ABPmer, 2017. Habitats Regulations Appraisal of the Draft Sectoral Marine Plans for Offshore Renewable Energy in Scottish Waters. Reports for Marine Scotland, ABPmer Report No: R.2121a-c. 5 May 2017.

together for this HRA in order to provide a basis for understanding the measures that will or may be required for future projects.

11.3 Project-Level HRA

11.3.1 Acknowledgment of this measure is based on a recognition that, as a matter of law, any new project developed under the Draft Plan will be required to undergo a project-level HRA and to produce an AA wherever the possibility of LSE on a European/Ramsar site cannot be excluded. Each individual project will need to review the baseline conditions and undertake work in a manner that does not have an AEOI. As part of this plan-level HRA, information has been provided to aid future project level AAs.

11.3.2 All future project-level HRA work will need to be completed in the context of the latest scientific knowledge and evidence base (relating to the development of offshore wind farms) that is available at the time of the assessment. It will also need to be done to the satisfaction of the consenting body (as competent authority at the project stage), taking account of advice from SNCBs and consultees where appropriate. The pursuance of project-level HRAs (with reference to latest monitoring and scientific understanding) will be a legal requirement in all cases where LSE cannot be excluded as will the application of project-level mitigation (where these are necessary to avoid adverse effects at project level). This work will provide assurances of no adverse effect from individual projects but will also improve understanding of the impacts from key pathways, with updated information fed back into the HRA process i.e. through the IPR process (see Section 11.4). The information that will need to be supplied within the project-level HRAs includes:

- Updates on the location and status of new European/Ramsar designations;
- New information on interest feature sensitivities (in the context of the latest scientific understanding);
- Assessment of effects during survey, construction and operational phases of the project (including the in-combination effects with other plans or projects); and
- Proposed mitigation measures.

11.3.3 It should also be recognised that it may be necessary, as part of the project-level HRAs, to revisit the screening process that was undertaken for the Draft Plan. Depending upon the outcome of the project-level AA, there might be a need for mitigation measures to be implemented to ensure that there is no AEOI.

11.3.4 Overall, it should be emphasised that uncertainties associated with the sensitivities of European/Ramsar site features to individual projects will be addressed through project-level HRA (with the benefit of project specific information), to demonstrate no adverse effect on integrity of these features. The Habitats Regulations and the case-law that informs their implementation place great emphasis on developers demonstrating ‘no adverse effect’ using best available scientific knowledge and beyond reasonable scientific doubt.

The process of ongoing research and feeding the results of targeted monitoring back into the assessment process will address these uncertainties, but it should be noted that there is a process to be followed (see below) which is likely to influence the rate and scale of project-level developments.

11.4 Iterative Plan Review (IPR)

11.4.1 The proposal for an iterative management process, delivered through the IPR, is critical in providing assurance that the Draft Plan will have no AEOI.

11.4.2 The Plan will be implemented as a phased process allowing iterative reviews of the Draft Plan to occur at agreed intervals through consultation with the Advisory Group (which will be formed upon adoption of the final Plan). This will provide a mechanism whereby the project-level assessments and the associated monitoring work of windfarm projects inform regular reviews of the Plan and ongoing decision about project implementation. In particular, as monitoring data is collected (when projects are consented, such as that for Whooper Swan) it will then be used to validate the conclusions that are made as part of successive project level HRAs and, where required, AAs (including in-combination assessments).

11.4.3 To ensure that the process is iterative, the Scottish Government will revisit the Draft Plan every two years. This review process will involve particular consideration of the work undertaken within the DPOs that have been identified within the Draft Plan but will also encompass other individual projects that are prompted by other planning initiatives (such as the work being carried out to support TCE Round 4 offshore wind leasing). To ensure that the IPR is responsive, an annual forum will also be carried out to consider evidence which is potentially pertinent to the Plan. Where there is adequate justification, the Plan may then be revisited within the two-year review cycle.

11.4.4 There is no expectation that the review process will alter commitments for the DPOs, but they will guide the scale, extent and location of developments within the DPO boundaries. Any developments within these DPOs will, though, still be subject to project-level HRA (Section 11.3) and will only go ahead if it can be shown that they have no AEOI (alone or in-combination with other plans or projects).

11.4.5 This process will be overseen by the Advisory Group. They will be linked to, inform and be informed by, the work of other relevant groups and plans such as the Moray Firth Regional Advisory Group (MFRAG), the Forth and Tay Regional Advisory Group (FTRAG) and Marine Planning Partnerships (as appropriate). The PSG will comprise members of the Scottish Government Marine Strategy Forum and include academics with expert knowledge of the key issues. It will also apply and, where needed, take forward the principles of the Scottish Government survey, deploy and monitor licensing policy guidance [354].

[354] Marine Scotland Website. Located at https://www2.gov.scot/Topics/marine/Licensing/marine/Applications/SDM

11.4.6 The mechanism of IPR implementation is itself expected to have some adaptability but the main processes over the initial two-year cycle are summarised below.

11.5 Outline of Proposed IPR Programme (Two-Year Cycle)

11.5.1 The IPR process will begin following the completion of the HRA report (including the AA Information report) and the final HRA record and Appropriate Assessment (to be carried out by the Scottish Government) for the Sectoral Offshore Wind Plan. Once completed there will be a period of consultation on these documents. Then, following this phase and subsequent Plan adoption, the IPR process will operate on a biennial rolling cycle. Work undertaken in the initial phase of Plan implementation (first two-year cycle) will include the following elements:

- **Creating and updating Project Impacts and Mitigation Evaluation Framework.** This step will be facilitated through the Scottish Marine Energy Research (ScotMER) programme. The programme is focussed on carrying out high priority research projects to fill knowledge gaps and further the evidence base. The outputs from this programme will be used to update project level impacts and mitigation measures (see Table 2, Tables J1 and J2 (Appendix J)) as appropriate. The framework will help to identify all extant projects and allow for the compilation of key documents into a single, accessible and regularly reviewed database listing the public-domain assessments, strategic monitoring work, mitigation guidance documents or individual project-level mitigation measures that developers can use to achieve impact reductions. This will assist with the implementation of projects by alerting all interested parties to the issues and opportunities that exist and also can be developed and improved over time as the efficacy of mitigation measures is better understood through monitoring. This will include an updated review of the status of European/Ramsar sites (including the identification of sites that are designated subsequent to the completion of this HRA). On a regular basis this established online framework will be updated based on the following review tasks.
- **Project Assessment and Review (process).** In the early stages there will be a progression, by developers and competent authorities, of EIAs and AAs for initial projects undertaken in response to the Sectoral Offshore Wind Plan. These documents will be collated and reviewed on an ongoing basis. However, acknowledgement will continue to be given to the assessments already carried out for those windfarm projects that are either proposed or consented (see Table 22).
- **Project Monitoring and Review (process).** As offshore renewable energy projects are put in place there will be the completion, collation and dissemination of project-level monitoring. This will include monitoring work on the initial projects undertaken in response to the Sectoral Offshore Wind Plan but also other relevant projects (in UK and

Europe). It is envisaged that there will be collaboration between developers and regulators and that, as often as possible, there would be integrated work undertaken across sectors and between projects. Mechanisms and initiatives for such collaborations already exist such as the Offshore Renewables Joint Industry Programmes (ORJIP); the Knowledge Transfer Network (KTN) for offshore renewables (e.g. Offshore Wind Innovation Hub (including Offshore Wind Innovation Exchange (OWiX)); the Partnership for Research in Marine Renewable Energy (PRIMaRE); the Habitats Directive Implementation Review (England); Marine Scotland's ongoing strategic research.

- **Project Mitigation and Review (process).** Directly accompanying the monitoring review there would be an evaluation of the efficacy of established mitigation measures. Research is currently being undertaken by Marine Scotland, The Crown Estate, MFRAG and FTRAG into the effectiveness of various mitigation measures and such reviews will provide a valuable contribution to this part of the IPR process.
- **Progression of strategic-level monitoring and research (process).** Alongside the project-level survey work, strategic work will continue to fill identified gaps in understanding. Especially to aspects such as seabird and cetacean distributions, collision mortality of seabirds, migratory pathways, seabird behaviour at sea and seabird body-mass survival rates. These topics are being progressed through Marine Scotland research programmes, such as ScotMER.
- **Review Gaps Understanding (workshop/review and Advisory Group meeting).** Building on the above reviews of project-level and strategic monitoring and mitigation, there will be an evaluation of gaps in understanding and of the progress made to address these gaps (e.g. the results of seabird body mass survival rates and how these inform the seabORD tool for estimating the fate of birds displaced by offshore renewable developments).
- **Review status of future projects in the context of research and planning developments (workshop/review and Advisory Group meeting).** Regular reviews will be taken about the future projects to be implemented and the need for Plan revisions. These will be based again on the above information but will also take into consideration emerging marine spatial planning requirements (e.g. Marine Planning Partnerships), ongoing industry led research (e.g. ORJIP and OWSMRF), as well as future marine protected areas.

11.5.2 Linked to these elements will be an annual forum to discuss new evidence, information and research outcomes relevant to the Plan. Where there is adequate justification, this will enable the forum to trigger an earlier review of the Plan (i.e. within the two-year review cycle) in response to new information and as required. Accordingly, this biennial programme of review work may be subject to amendment.

11.5.3 With each of iteration of the Plan, understanding about the relevant issues and risks will be progressively enhanced as ongoing research provides information about species sensitivities and the effectiveness of mitigation measures.

11.5.4 Detail on project implementation, including connection to the national grid and coastal infrastructure will also be better understood at each successive stage.

11.5.5 In addition to this temporal component, this process will require continual consideration of the spatial/regional context (e.g. the effects of those on the east or west coast) for project-level AAs to ensure that there is no AEOI on any European/Ramsar site from projects either individually or in-combination with other plans or projects. It will also need to include regular consultation with other EU Member States to address issues relating to transnational sites.

11.5.6 The IPR process will thus provide the mechanism for updates to the Plan as new information becomes available. This information may be the result of technological advances, scientific evidence, project monitoring and the results of project level assessments.

11.6 DPOs subject to higher levels of ornithological constraint

11.6.1 Review of the in-combination assessment has highlighted the significant concerns raised by SNCBs over further windfarm development in the East (Forth and Tay) and North-East (Moray) regions (see Sections 10.8 and 10.9). Based on modelling (e.g. collision risk) and the best available scientific evidence there are concerns that additional windfarm development would have adverse in-combination effects on seabird populations, in particular from collision risk to Kittiwake.

11.6.2 The SNCB consultation advice provided in 2018 and 2019, in relation to commercial offshore windfarm proposals in these regions, objected to all the proposals on the basis that they would all have or were likely to have an AEOI when considered in-combination with consented windfarm developments (see Table 23). Despite the advice being based on worst case scenarios, with a number of precautionary assumptions, at this time it is reasonable to conclude, based on current evidence, that further development in these regions, as defined within the Sectoral Offshore Wind Plan, could result in an AEOI on Kittiwakes as a qualifying feature of a designated site, if development occurred in any of the following DPOs:

- E3
- NE2
- NE3
- NE4
- NE5

11.6.3 Considering that Kittiwake colonies around Moray will already be affected by the consented windfarm developments, there is an increased risk of an in-combination AEOI on Kittiwake as a qualifying feature of the Troup, Pennan

and Lion's Heads SPA if development occurs at NE6. However, this is assuming that development occurred at NE4 and NE5.

11.6.4 Furthermore, consideration has been given, based on discussion with SNCBs, as to the potential effect of construction within E1 and E2. These sites are generally beyond the mean max foraging ranges for Kittiwake and Razorbill, and therefore a LSE has not been identified. However, if the more precautionary measure of mean max foraging range in addition to one standard deviation is considered this would include more significant areas of the two sites. Based on this, although the extent to which developments in sites E1 and E2 would increase currently assessed cumulative impacts for east coast SPAs is unclear, the sites may overlap with the foraging distribution for some seabird species from east coast SPAs, especially the western parts of E1 and E2 that are more inshore. Therefore, whilst not classed in the same risk category as DPOs E3 and NE2-NE6, there will be a requirement for the collection and assessment of regional-level ornithology survey data (e.g. from digital aerial surveys) in this region. This would improve confidence in assessing the likely level of effects from collision, displacement, and barrier effects from any developments. The potential for LSE on east coast SPAs could be further understood by tracking studies of seabirds from these SPAs. Such information would improve confidence in assessing what proportion of any effects at the two sites should be apportioned to these SPAs and hence support project level HRA.

11.6.5 Currently, as a further mitigation measure, in order to conclude no AEOI, DPOs E3 and NE2-6 have been classed as being subject to high levels of ornithological constraint. It is proposed, therefore, that development will only be able to progress at DPOs E3 and NE2-6 where sufficient scientific evidence can be provided to reduce the risk to an acceptable level (unless it can be determined that there are imperative reasons of overriding public interest that require development to proceed).

11.6.6 In order to address the uncertainties described above, a number of key knowledge gaps (OR[355]) relating to the potential effects of offshore wind farm developments on seabirds have been identified by the ScotMER process. These are:

- Collision mortality and avoidance behaviour of Black-legged Kittiwake, Northern Gannet and Great Black-backed Gull (OR. 17). All three species concerned are of direct relevance to future offshore wind farm development in the Moray Firth region, whilst in the Forth and Tay region Kittiwake and Gannet are the key species of concern in relation to potential collision mortality.
- The consequences of displacement and barrier effects on survival and productivity (OR. 23), and subsequently populations of Atlantic Puffin, Razorbill and Common Guillemot are key constraints in the Forth and Tay region, and to a lesser extent in the Moray Firth region.
- The drivers of any observed changes in distribution and abundance of Black-legged Kittiwake, Northern Gannet, Atlantic Puffin, Razorbill, and

[355] ScotMER (2018). Ornithology Evidence Map https://www2.gov.scot/Topics/marine/marineenergy/mre/research/ornithology

Common Guillemot in and around offshore wind farms (OR. 06, OR. 19, OR. 20, OR. 21).

- The movements of adult birds during the non-breeding season and immature birds during the entire year, and their level of exposure to cumulative effects (OR. 02, OR. 03, OR. 09).

11.6.7 These key knowledge gaps are best addressed via targeted strategic monitoring activities:

- Deployment of collision detection and tracking technologies at operational wind farms to establish interactions and behavioural responses of key species to wind farms, wind turbine generators, and blades, and the estimation of collision mortality. Appropriate technologies may include radar, cameras, thermal imaging, acoustic collision detection systems, GPS tagging of individual birds that pass through operational wind farms etc. Ideally data would be collected from multiple wind farms, multiple years and multiple locations within each wind farm to ensure representativeness. Data collection at wind farm/s in the Forth and Tay and in the Moray Firth regions would be appropriate.
- Tracking of tagged individuals of key species during the breeding season to quantify use of the marine environment, interactions with offshore wind farm/s and linking these data with body condition, survival, and productivity of known individuals would be required. This type of study would be logistically challenging and there are limited colonies where such a study could be undertaken. However, the Forth and Tay region would be a suitable study region, due to the accessibility of the isle of May and the long term research undertaken there providing invaluable baseline data sets.
- Gathering oceanographic and ecological data (ocean mixing, primary productivity, prey species) to better explain the distribution and abundance of the key seabird species, determining which if any wind farm effects are driving observed changes in seabird abundance, distribution, or associated population consequences. Ideally data would be collected from multiple wind farms, multiple years, and multiple locations within each wind farm to ensure representativeness. Data collection at wind farm/s in the Forth and Tay and in the Moray Firth regions would be appropriate.
- Tagging and tracking of key species to provide information on movements, habitat use and energetics during the non breeding season. Tagging would need to be carried out at multiple colonies to fully understand movements and mixing of birds from different source populations. There are a number of existing tracking projects that could be expanded or built upon.

11.6.8 In addition, various monitoring surveys (pre-construction and post-construction) are planned for 2019 and 2020 (e.g. pre-construction for Neart na Gaoithe, Inch Cape, Seagreen and Moray West; post-construction for

Beatrice (including aerial surveys)). Among other things, the seabird monitoring surveys will help to understand small scale displacement due to construction disturbance, connectivity (inferred) and flight heights for comparison inside and outside the wind farm and potential displacement during operation. The results of these surveys, and ongoing research, will provide valuable evidence to support the assessments and assist with understanding the implication of in-combination effects while reducing the level of uncertainty. The findings of the monitoring surveys will feed into the IPR process during the regular reviews of the Draft Plan.

11.7 Additional Considerations

11.7.1 To further reduce consenting risk, consideration could also be given to the extent and boundaries of several DPOs. A number of DPO boundaries are currently located immediately adjacent to designated sites (Table 24). However, it is considered that this risk can best be managed at project level through spatial planning within DPOs to avoid or minimise risks to sensitive features where necessary.

Table 24. DPOs located immediately adjacent to a designated site.

DPO	Adjacent Designated Site	Qualifying Features
SW1	Luce Bay and Sands SAC North Channel SAC	Includes reefs, subtidal sandbanks and intertidal mudflats; Harbour porpoise
W1	Inner Hebrides and the Minches SAC; Gruinart Flats, Islay SPA	Harbour porpoise; Includes Chough, Greenland barnacle goose, Canadian light bellied brent goose
N2	Solan Bank SAC	Reefs
NE1	Pobie Bank SAC	Reefs

11.7.2 Coincident windfarm construction activities at DPOs within the same broad geographical area may increase the risk of an in-combination AEOI on marine mammal and fish qualifying features. For example, in the event that concurrent piling noise in a particular geographical region may increase risk of AEOI, then implementing sequential development of windfarms could help minimise in-combination effects from the construction phase, although such an approach could extend the duration of such effects. It is considered that such risks are most appropriately and effectively managed at project level.

12 Conclusion

12.1.1 Provided that the initial plan-level mitigation (i.e. project-level HRAs and the IPR) and a temporal moratorium on windfarm development within E3 and NE2-6 is applied, it is concluded that the Sectoral Offshore Wind Plan will not lead to an AEOI either alone or in-combination with other plans or projects. In order for these areas to be released for development, a number of knowledge gaps, discussed in Section 11 above will require addressing.

12.1.2 Successful bidders for future lease options will need to re-visit the issues identified within the plan-level HRA; ensuring that they adhere to relevant project-level mitigation measures where necessary to avoid an AEOI.

12.1.3 Developments at some DPOs are likely to pose a greater risk of impact on European/Ramsar sites and features than at other DPOs. Therefore, development at some DPOs will present greater challenges and require more mitigation (at possibly a greater cost) than at others, in order to ensure no AEOI. Similarly, development within some areas of a given DPO will be less likely to result in a significant effect than other areas within the same DPO. Spatial planning at a project level will allow developers to avoid sensitive features and thereby reduce consenting risk.

12.1.4 There is a considerable amount of ongoing strategic research which will help to reduce uncertainty on the predicted impacts of windfarms through the provision of robust evidence. Concurrent to the research, empirical data is being generated through large scale monitoring programmes, such as the coordinated surveys being proposed by the commercial windfarm developers for Inch Cape, Neart na Gaoithe and Seagreen in the Forth and Tay regions.

12.1.5 The conclusions of these studies will be acknowledged within future iterations of the Draft Plan through the IPR process. Hence, as the Draft Plan evolves, the required mitigation (see Section 11) may also change. If, for example, sufficient evidence becomes available to conclude that the in-combination effects from windfarm development at either E3, NE2, NE3, NE4, NE5 or NE6 will not lead to an AEOI, then the conclusions of the Draft Plan will change accordingly. Conversely, new evidence may indicate that additional steps and measures are taken to avoid AEOI, in which case, the recommendations within the Draft Plan will be adapted following the outcomes of Advisory Group meetings. Such recommendations may include:

- Avoidance of certain areas;
- Technology preferences; and
- Further strategic research.

12.1.6 The mitigation requirements will also change during the iterative process, ensuring that project-level measures are reasonable and effective to avoid or reduce effects on an interest feature. These changes will be acknowledged within the Draft Plan, allowing developers to remain abreast of the most recent and applicable evidence.

12.1.7 It is recognised that as the Draft Plan evolves, some of the inherent uncertainties of early iterations will diminish as a greater understanding is

developed (see Section 11). For example, the potential exists for the cable alignments and landfall positions, once identified, of almost all DPOs to directly or indirectly affect European/Ramsar sites. There was no presumption within this plan-level HRA that European/Ramsar sites will not or cannot be directly or indirectly affected in this manner although clearly the risks of impact and requirements for mitigation are likely to be greater where this is the case. However, it is expected that developers will, in the first instance, seek to avoid European/Ramsar sites (as noted above) and address any residual risks associated with cable installation at a project level.

12.1.8 A key assumption of this plan-level HRA is that there is scope for development within the DPOs which avoids AEOI. Therefore, at a high-level there should be certainty that should development occur within a DPO it will not lead to an AEOI. In most cases this level of certainty is not possible without the intervention of project-level HRA; however, it is concluded that any windfarm development in DPOs E3 and NE2-5, could result in an AEOI based on current scientific evidence, with development at NE6 also having the potential to result in an AEOI.

12.1.9 There will be a statutory requirement for future project-level HRAs to accompany any development resulting from the Draft Plan. These HRAs will take account of project level detailed considerations and the content of the plan-level HRA, allowing the planning of windfarms and their cable routes to occur in a manner that does not lead to an AEOI. However, through this high-level assessment, recommendations have been made which will guide regulators and developers to reduce the likelihood of AEOI through the implementation of the Sectoral Offshore Wind Plan.

12.1.10 This document represents Stage 10 of the HRA process – the draft record of the HRA. The final Stages (11-13) will follow consultation and amendments to the document.

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Appendix A.Pre-screening Report

A copy of the pre-screening report can be downloaded from: https://www.gov.scot/publications/sectoral-marine-plan-offshore-wind-energy-encompassing-deep-water-plan-9781788519632/

Appendix B.Review of Assessment Methodology

B.1 Background

The Scottish Government is currently developing a plan for future commercial offshore wind development in Scottish waters for the period up to 2050. This new plan builds on the previous draft plan for offshore wind that was published in 2013. The previous Sectoral Marine Plan considered the opportunities for Offshore Wind Energy generation (as well as Wave and Tidal Energy generation) in Scottish Waters[356]. The new offshore wind plan also seeks to provide opportunities for deep water technologies which may become commercially viable over this time period[357].

The geographical scope of this new 'Sectoral Marine Plan for Offshore Wind Encompassing Deep Water Options' covers Scottish Waters (0-200 nautical miles) This includes Scottish Territorial Waters (0-12 nautical miles) and the Scottish Marine Area (12-200 nautical miles) which is executively devolved to Scottish Ministers under the Marine and Coastal Access Act 2009.

This new plan will need to be accompanied by a Habitats Regulations Appraisal (HRA) process. This process is required to assess the plan's potential effects on international protected nature conservation sites. For the first stage of the HRA work, a 'Pre-screening report' was produced (Marine Scotland, 2018)[358] and consulted upon. This Pre-screening report set out the evidence base and the proposed methods that will be applied for the subsequent scoping and assessment stages of the HRA work.

In response to the consultation process, this brief report has now been produced as an intermediate stage between the completed pre-screening work and the scoping and assessment stages that are to follow. It considers the consultation responses and highlights some minor methodological adjustments to the HRA process that will be made as a result. It also identifies a number of priority considerations and clarifications that will be taken into account during the ongoing HRA process work.

This intermediate review has been prepared to ensure there a high-level clarity and auditability in the assessment process as this is an important requirement for strategic-level HRAs. This report also considers the implications of recent EU and UK case-law judgements (reached during summer 2018) and how these should be taken into account for this HRA process.

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356 Marine Scotland 2013. Planning Scotland's Seas Sectoral Marine Plans for Offshore Wind, Wave and Tidal Energy in Scottish Waters Consultation Draft

357 This encompasses arrays that will have an installed capacity of greater than 100 MW.

358 Marine Scotland, 2018. Sectoral Marine Plan for Offshore Wind Energy (encompassing Deep Water Plan Options). Strategic Habitat Regulations Appraisal: Pre-Screening Report. June 2018.

B.1.1 Report Structure

This interim technical note is structured as follows:

- Section 1: Introduction;
- Section 2: Review of HRA Methods and Issues; and
- Section 3: References.

B.2 Review of HRA Methods and Issues

B.2.1 Pre-Screening Overview

The proposed methods for the HRA work are set out in the Pre-Screening which was completed in June 2018 (Marine Scotland, 2018).

The HRA methods presented in this report are based on available guidance and established best practice. This best practice was developed over the course of multiple preceding plan-level HRAs (and the associated stakeholder and Steering Group discussions which accompanied them) that have been undertaken in Scotland and across the rest of the UK over the last decade. These past HRAs are listed in Section 2.3 of the Pre-Screening report (Marine Scotland, 2018).

The HRA process will follow the 13-step process that is set out in the agreed SNH guidance for undertaking plan-level HRAs in Scotland[359]. This process is shown in Figure B1. From the consultation feedback (in particular views received from SNH) it will be appropriate to adhere to this sequential approach.

It is noted, however, that recent case-law judgements which were reached during 2018 will need to be considered. These judgements relate to the way in which mitigation should be considered when seeking to make screening judgements under the HRA process. The implications of these judgements are considered further in Section 2.3 of this report.

B.2.2 Plan-Level Mitigation and relationship to Project-Level HRA

The consultation responses from SNH and JNCC have highlighted separate but inter-related and important issues in respect of the anticipated Plan-Level Mitigation requirements and the relevance and role of Project-Level HRAs in this context. In response to these comments it is important to confirm firstly (and specifically in response to the JNCC comments) that this plan level work will not be a substitute for the future requirements for HRAs to be undertaken for individual projects. Such project-level HRA processes will still be required in accordance with the legislation and as recommended by JNCC this point will be made clear in the HRA documentation.

[359] David Tyldesley and Associates, 2015. Habitats Regulations Appraisal of Plans. Guidance for Plan-making Bodies in Scotland Version 3.0, January 2015 SNH Ref 1739.

The application of future project-level HRAs, which will be prepared when there is greater certainty about development locations and details, will be vital for ensuring that there is no adverse effect on the integrity of designated sites. Equally though (and in response to the comments raised by SNH as well as the lessons from past strategic marine HRAs prepared by the Marine Scotland) it is recognised that this plan, due to its scale and complexity, should not rely on the requirement for future HRAs at a project-level as a sole mechanism for being assured that the plan as a whole will not have an adverse effect on designated sites.

An important objective for this Plan-level HRA therefore will be to clarify these aspects and the role and mechanisms of future Plan-level mitigation and associated monitoring work and its relationship to project-level HRA responsibilities. It is agreed, in particular, that because of the uncertainties associated with the plan (including the scale and location of future developments within the Areas of Search and the nature of the future technologies that will be used) it will not be possible to definitively conclude that there will be no adverse effect on site integrity (NAESI) from the plan. Therefore, there will be a need for appropriate and meaningful mitigation measures to accompany the Plan with potentially different levels of mitigation required for different scales of development.

The plan-level mitigation measures are expected to include a phased process for implementing the Plan and the adoption of an 'Iterative Plan Review' (IPR) process (or bespoke variant of the same concept). The development of such an IPR process would be in keeping with recommendations developed by Marine Scotland during the preparation of the previous draft Plans. The details of this process and the ways in which it would be pursued, and where needed modified, over time will be developed during the HRA process in consultation with the Project Steering Group. These issues are also considered within Section 2.5 and Paragraph 4.14.6 and 4.14.7 (Section 4.14) of the Pre-Screening Report (Marine Scotland, 2018).

The RSPB consultation response also requests that mechanisms are explored which include robust mitigation and enhancement as well as statutory wind sector investment of enhancement measures to improve the resilience of natural marine wildlife and habitats. This will require consideration during the HRA process and on an ongoing basis as part of the IPR process that is instigated.

B.2.3 Implications of recent Case Law for Mitigation

In recent months there have been some key EU and UK court decisions, and these will need to be taken into account to ensure that the HRA process is compliant with this case law. These judgments are:

- **April 2018** Case C323/17 People over Wind, Peter Sweetman v Coillte Teoranta
- **July 2018** Case C-164/17 - Grace & Sweetman v An Bord Pleanala

- **August 2018** Case EWHC 2190 -Langton v SoS for Environment, Food
- Rural Affairs, Natural England.

The implications of these judgements, and how they influence this HRA will be discussed with the Project Steering Group in the context of the SNH guidance on strategic HRA[360].In simple terms however, a key outcome of these judgments is that there is a need to be careful when considering the influence and benefits of future anticipated mitigation measures during the HRA screening process. The April 2018 case in particular has the effect of directing developers and planners to avoid relying on such future mitigation measures when making decisions about whether a project will have a likely significant effect. Instead mitigation measures should be taken into account after the screening process when the Appropriate Assessment and HRA record are being undertaken.

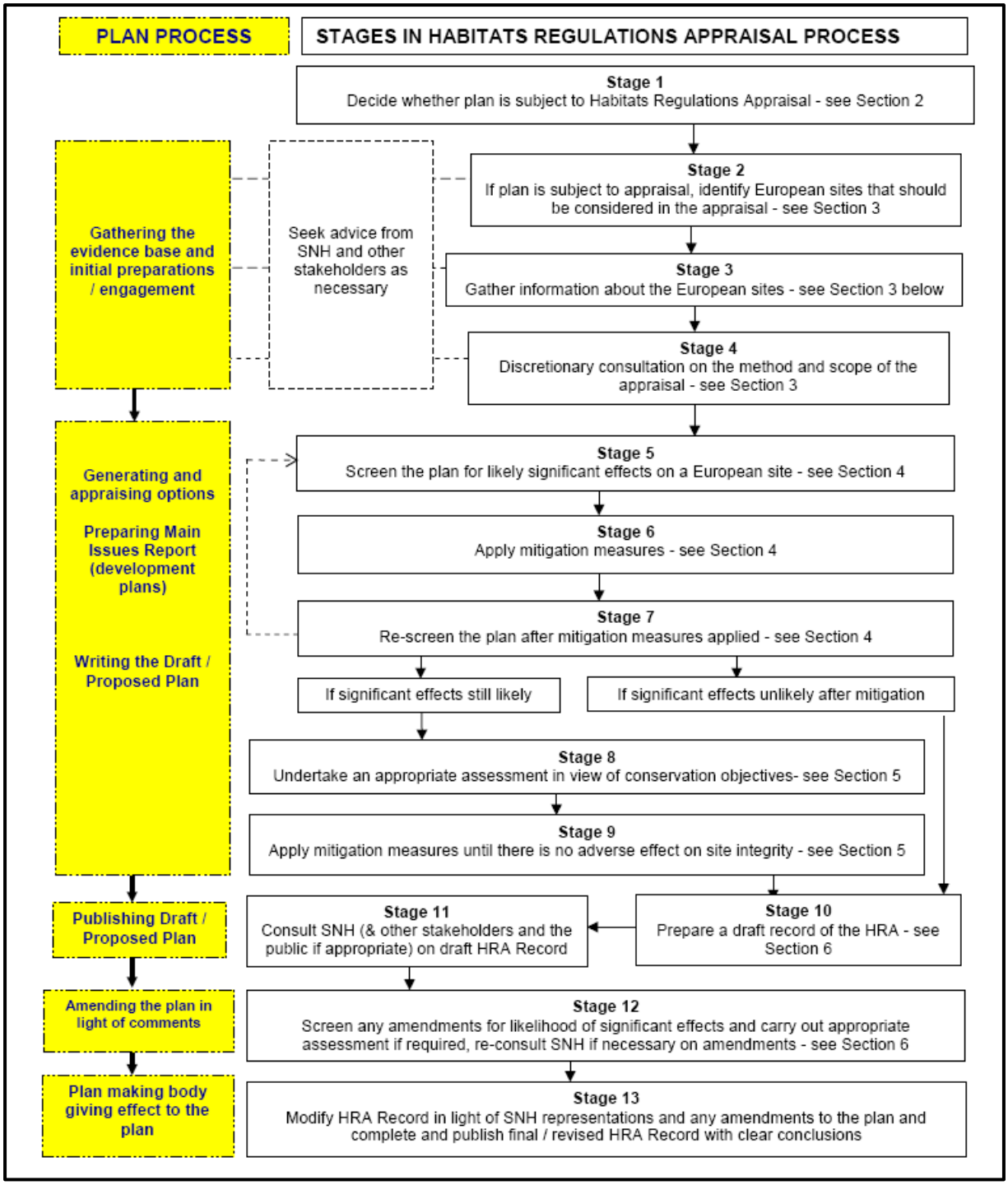
The July and August 2018 judgements have also provided a steer regarding what constitutes mitigation and indicate that a distinction needs to be drawn between:

- measures designed to avoid or reduce any adverse effects and are considered in the Appropriate Assessment under Article 6(3); and
- measures that are undertaken to compensate for negative effects that are required Article 6(4).

In order to accommodate these project-level case law lessons to this strategic HRA, it is recommended that Stages 6 and 7, which direct the consideration of mitigation measures at the screening stage, are not formally considered. Instead the process (as shown in Figure B1) would move from Stage 5 directly to Stage 8.

In terms of how this high-level HRA is progressed, this change is not expected to materially influence the outcome, methodological detail or thoroughness of the process. Indeed, it has been shown during previous strategic HRAs that it has not been possible to use anticipated mitigation measures for the screening process because of the inherent uncertainties that exist at a plan-level and this same situation will also apply for this strategic HRA. It is also expected to add clarity to the process and to the thinking on issues relating to mitigation (as discussed in the preceding section) to move through Stages 5 to 7 in this manner and then solely address the issue of mitigation at Stage 9.

[360] David Tyldesley and Associates, 2015. Habitats Regulations Appraisal of Plans. Guidance for Plan-making Bodies in Scotland Version 3.0, January 2015 SNH Ref 1739.



Source: David Tyldesley and Associates (2015).

Figure B1. Key stages of plan-level HRA process for plans

B.2.4 Project Steering Group

During the consultations SNH confirmed that they would wish to be involved in the Project Advisory/Steering Group. This Steering Group has now been set up and includes Marine Scotland; Scottish Government Energy Representative, SG Strategic Environmental Assessment (SEA) Officer, Scottish Natural Heritage, Historic Environment Scotland, Scottish Environment Protection Agency, Scottish Renewables, Crown Estate Scotland (Interim Management), two representatives from Scottish Environment LINK (RSPB and WWF); Joint Nature Conservation Committee, Scottish Fishermen's Federation, and the Regional Inshore Fisheries Group.

B.2.5 Refinements to the HRA Process

In general, the feedback received from the consultation process has been positive and has verified that the proposed approach to the HRA is appropriate and is in keeping with SNH guidance. However, a few detailed points and areas of clarification have been highlighted in the feedback received. These points, and the way in which they will be addressed, are considered further below:

- **Project Description Update for Future Documents:** JNCC has noted that the 'Background' to the plan of the pre-screening report (Section 1.2 and especially Paragraph 1.2.3, (Marine Scotland, 2018)) should reflect the now broader scope of the plan as opposed to indicating a focus on floating technologies. This will be done for all future documents in the HRA process and will use, as suggested by JNCC, the text within the SEA report as appropriate.
- **Consideration of Bird Foraging Distances**. SNH has confirmed that the use of 'mean maximum' foraging ranges (as proposed in Section 4.4, Paragraph 4.4.5 of the pre-screening report (Marine Scotland, 2018)) is appropriate. JNCC has also offered advice in respect of dealing with foraging distances (both shorter and longer than 100 km buffer zone. The way in which longer-distance foragers are dealt with (and the relevance of the 'mean maximum' distances for these species that is quoted in Paragraph 4.4.4 of the Pre-screening report (Marine Scotland, 2018)) will be discussed further with the Project Steering Group during next stages of the assessment process. The at-sea distribution documents cited by JNCC will be reviewed as part of this process.
- **Consideration of White-Tailed Eagle**: Both SNH and JNCC have highlighted the presence of White-Tailed Eagle now on the west coast as well as the east coast of Scotland (see Paragraph 4.4.7 (Marine Scotland, 2018)). The comments about the vulnerability of this species are noted but, as there are no SPAs or pSPAs for this species in

Scotland, this population will not be considered within the HRA process. It will however need to be addressed within the SEA.

- **Revision to the Seal Screening Distances:** In the pre-screening report a 100 km buffer around the Areas of Search was proposed for 'screening in' grey and common seal species that might be affected by the proposed plan **(**Section 4.5, Paragraph 4.5.3 (Marine Scotland, 2018)). SNH has advised that distances of 20 km and 50 km are appropriate for grey and common seals respectively. These distances will therefore be used for the screening process.
- **Marine Mammal Impact Pathways:** As recommended by JNCC, during the screening and assessment of effects on marine mammals it will be made clear that the direct and indirect effects to Marine Mammal via the features' habitat and prey will be included as impact pathways in Steps 1 and 2 of the process (see Paragraph 4.9.2 of the Pre-screening report (Marine Scotland, 2018)). This approach was anticipated and will be in keeping with past HRAs including the one produced for the 2013 Draft Sectoral Plan (Marine Scotland, 2013);
- **Removal of Category D Sites and Features:** SNH has highlighted that Category D sites and features which are a 'non-significant presence' and of 'little conservation value'[361] do not need to be considered within the HRA process. These sites and features will therefore be removed for the screening and assessment phases of the work. At the start of these next phases, the latest version of the JNCC Natura features database will also be downloaded to ensure that the most up-to-date information is being used. JNCC also identify a number of adjustments that should be made to qualifying the interest features in the pSPA and these will be made as required following the database upload.
- **Responses to Future Plan Change:** In Paragraph 5.2.1 of the pre-screening report (Marine Scotland, 2018), it is noted that if any further detail on the plan emerges (as this HRA is progressed) then the detail and focus of the HRA will be adjusted accordingly. This process will occur within the lifetime of the HRA process. SNH has asked how this thinking will translate to the ongoing process of plan implementation up to 2025 and beyond. This relates to the proposed IPR process as discussed in Section 2.2 which will need to be developed and reviewed during the HRA process in consultation with the Project Steering Group.
- **Introducing Categorisation to the Natura sites list**: To improve the presentation and interpretation of the long list of Natura sites that will inherently be generated by this high-level HRA process, SNH has offered a mechanism for categorising the sites. This categorisation will be adopted for the screening and assessment process.
- **Consideration of available data and tools**. In the correspondence received from SNH, JNCC and the RSPB, there are offers of support and

[361] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011D0484&from=EN

references made to relevant information sources and tools (e.g. the Feature Sensitivity Tool (FeAST) for sensitivity analysis). This support is appreciated, and the relevant tools will be used in consultation with these three organisations and the Project Steering Group.

In addition, SNH offers additional comments in a short Annex to their letter dated 23 July 2018. These comments and the references cited will be considered as part of the screening and assessment work. The following comments have also been received from organisation and individuals. In addition, SNH offers additional comments in a short Annex to their letter dated 23 July 2018. These comments and the references cited will be considered as part of the screening and assessment work. The following comments have also been received from organisation and individuals:

- **Response ID ANON-WYYN-2K2G-A:** Highlights the uncertainties associated with cable landfall arrangements and this will be recognised in the HRA (see also Section 2.5 of the Pre-screening report (Marine Scotland, 2018)). In this communication a request is also made to exclude vessel activities from Impact Pathway 8 in Table A1. However, it is considered that vessel effects must be included as they will represent an essential part of the activities to be undertaken. A request for a table of abbreviations is acknowledged and this will be included in future documentation. Also, it is acknowledged that text is missing at the start of Paragraph 4.3.8. The first word should say ‘For’ rather than ‘or’.
- **Response ID ANON-WYYN-2K2G-D:** Considers that the proposed methods for the HRA are appropriate as it is adheres to established practice and offers no further comment specifically on the HRA
- **Response ID ANON-WYYN-2K2F-C:** This communication emphasises the need to consider cumulative effects from increased numbers of offshore windfarms. It also proposes that the HRA should include a scenario in which all the areas of search are developed. The requirement to address cumulative (or, in this case “in-combination”) effects and the challenges associated with this element of the HRA process are noted and are also highlighted in Section 4.15 of the pre-screening report (Marine Scotland, 2018). The challenges arise in particular because this in-combination element of the assessment process includes further levels of uncertainty in addition to those that are an inherent part of the proposed plan on its own. There is a need, for example, to think about the in-combination effects with other extant and relevant plans and projects. In this case, consideration of evidence, precedents and the development of an appropriate Iterative Plan Review (IPR) process) will be key requirements for ensuring that there are no in-combination effects. It is likely to be unrealistic and misleading though to include a scenario in which all the areas of search are developed as that

eventuality would not be consistence with the likely scale of the development.

- **Response ID ANON-WYYN-2K2H-E**. This consultation response asks that target species for commercial fishing are included. These issues will be addressed within the SEA, but they fall outside the remit of the HRA except in so far as fish species are interest or supporting features of designated sites.
- **Response ID ANON-WYYN-2K21-Q**. Provides support for the assessment methodology but raises a request that the timing of leases in the context of the environmental assessment work being done for the plan. It is envisaged that this subject will be addressed during the development of the proposed plan implementation process (which will be considered further during the assessment work including as part of the HRA process).
- **Response ID ANON-WYYN-2K28-X**. This consultation response determines that the pre-screening report is comprehensive and supports the approach being proposed.
- **Response ID ANON-WYYN-2K99-6**. This response asks that pelagic fish and the value of reefs and fisheries exclusion zones are considered. It also offers information on the subject of windfarm extent. These aspects will be addressed within the HRA process where they could have an effect (including a beneficial effect) on internationally designated sites. However, the fish and fisheries considerations will be largely addressed under the SEA process.
- **Respondent Information Form.** A range of technical comments were provided that will be noted within the HRA process. These included:
- Agreement with the need to be technology neutral (See Paragraph 1.2.5 of the Pre-Screening report (Marine Scotland, 2018));
- It is more accurate to refer to “floating structures” or “floating wind turbines” rather than floating foundation’. This will be done in future;
- It is noted that seabed founded structures such as jackets are suitable for depths up to 55 m (See Paragraph 1.2.1 of the Pre-Screening report (Marine Scotland, 2018)); and
- Identifying cable alignments at this stage appears almost impossible and that frequently, the connection point is some distance from the coast and several landfall locations need to be examined with widely different potential alignments. This point helps to further reaffirm the issues and uncertainties associated with the cable alignments and landfall aspects as noted above.

B.3 References

ABPmer, 2018. Sectoral Marine Plan for Offshore Wind. Strategic Habitat Regulations Appraisal (HRA): Review of Proposed Assessment Methodology. Report prepared for Marine Scotland. November, 2018.

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Marine Scotland 2013. Planning Scotland's Seas Sectoral Marine Plans for Offshore Wind, Wave and Tidal Energy in Scottish Waters Consultation Draft https://beta.gov.scot/binaries/content/documents/govscot/publications/consultation-paper/2013/07/draft-sectoral-marine-plans-offshore-renewable-energy-scottish-waters-consultation/documents/00428241-pdf/00428241-pdf/govscot:document/

Marine Scotland, 2018. Sectoral Marine Plan for Offshore Wind Energy (encompassing Deep Water Plan Options). Strategic Habitat Regulations Appraisal: Pre-Screening Report. June 2018. https://www.gov.scot/Resource/0053/00536718.pdf

David Tyldesley and Associates, 2015. Habitats Regulations Appraisal of Plans. Guidance for Plan-making Bodies in Scotland Version 3.0, January 2015 SNH Ref 1739.

Appendix C. Screening Table

Table C1 provides a list of all European/Ramsar sites (and their interest features) screened in/out of the assessment at all stages of the screening process (provided in an Excel Datasheet). Available at https://www.gov.scot/publications/draft-sectoral-marine-plan-offshore-wind-energy-habitat-regulations-appraisal/

Table C1. European/Ramsar sites (and their interest features) screened in/out of the assessment at all stages of the screening process

Appendix D. DPO Screening Schedules

Tables D1 to D17 provides a list of all European/Ramsar sites (and their interest features) screened in for assessment.for each DPO (provided in an Excel Datasheet). Available at https://www.gov.scot/publications/draft-sectoral-marine-plan-offshore-wind-energy-habitat-regulations-appraisal/

Table D1. SW1: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D2. W1: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D3. N1: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D4. N2: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D5. N3: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D6. N4: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D7. NE1: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D8. NE2: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D9. NE3: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D10. NE4: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D11. NE5: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D12. NE6: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D13. NE7: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D14. NE8: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D15. E1: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D16. E2: European/Ramsar sites (and their interest features) screened in for potential LSE

Table D17. E3: European/Ramsar sites (and their interest features) screened in for potential LSE

Appendix E.DPO Screening Maps

Figure 1. Key stages of plan-level HRA process for plans
Figure 2. Scoping AoS to DPO
Figure 3. SAC and SCI sites screened into assessment within 100 km of DPOs
Figure 4. SPA sites screened into assessment within 100 km of DPOs
Figure 5. Ramsar sites screened into assessment within 100 km of DPOs
Figure 6. Extents of tidal excursions around each DPO
Figure 7. RSPB utilisation distribution data for Black-legged Kittiwake
Figure 8. RSPB utilisation distribution data for Kittiwake, Shag, Guillemot and Razorbill
Figure B1. Key stages of plan-level HRA process for plans
Figure E1. SW1: European/Ramsar sites screened in for potential LSE
Figure E2. W1: European/Ramsar sites screened in for potential LSE
Figure E3. N1: European/Ramsar sites screened in for potential LSE
Figure E4. N2: European/Ramsar sites screened in for potential LSE
Figure E5. N3: European/Ramsar sites screened in for potential LSE
Figure E6. N4: European/Ramsar sites screened in for potential LSE
Figure E7. NE1: European/Ramsar sites screened in for potential LSE
Figure E8. NE2: European/Ramsar sites screened in for potential LSE
Figure E9. NE3: European/Ramsar sites screened in for potential LSE
Figure E10. NE4: European/Ramsar sites screened in for potential LSE
Figure E11. NE5: European/Ramsar sites screened in for potential LSE
Figure E12. NE6: European/Ramsar sites screened in for potential LSE
Figure E13. NE7: European/Ramsar sites screened in for potential LSE
Figure E14. NE8: European/Ramsar sites screened in for potential LSE
Figure E15. E1: European/Ramsar sites screened in for potential LSE
Figure E16. E2: European/Ramsar sites screened in for potential LSE
Figure E17. E3: European/Ramsar sites screened in for potential LSE
Figure F1. Puffin European/Ramsar sites screened in for potential LSE
Figure F2. Northern Gannet European/Ramsar sites screened in for potential LSE
Figure F3. Manx Shearwater European/Ramsar sites screened in for potential LSE
Figure F4. Lesser Black-backed Gull European/Ramsar sites screened in for potential LSE
Figure F5. Northern Fulmar European/Ramsar sites screened in for potential LSE
Figure F6. Harbour porpoise European/Ramsar sites screened in for potential LSE
Figure F7. Bottlenose dolphin European/Ramsar sites screened in for potential LSE
Figure F8 Migratory fish and fresh water pearl mussel European/Ramsar sites screened in for potential LSE
Figure F9. Otter European/Ramsar sites screened in for potential LSE
Figure E1. SW1: European/Ramsar sites screened in for potential LSE

Figure E2. W1: European/Ramsar sites screened in for potential LSE
Figure E3. N1: European/Ramsar sites screened in for potential LSE
Figure E4. N2: European/Ramsar sites screened in for potential LSE
Figure E5. N3: European/Ramsar sites screened in for potential LSE
Figure E6. N4: European/Ramsar sites screened in for potential LSE
Figure E7. NE1: European/Ramsar sites screened in for potential LSE
Figure E8. NE2: European/Ramsar sites screened in for potential LSE
Figure E9. NE3: European/Ramsar sites screened in for potential LSE
Figure E10. NE4: European/Ramsar sites screened in for potential LSE
Figure E11. NE5: European/Ramsar sites screened in for potential LSE
Figure E12. NE6: European/Ramsar sites screened in for potential LSE
Figure E13. NE7: European/Ramsar sites screened in for potential LSE
Figure E14. NE8: European/Ramsar sites screened in for potential LSE
Figure E15. E1: European/Ramsar sites screened in for potential LSE
Figure E16. E2: European/Ramsar sites screened in for potential LSE
Figure E17. E3: European/Ramsar sites screened in for potential LSE

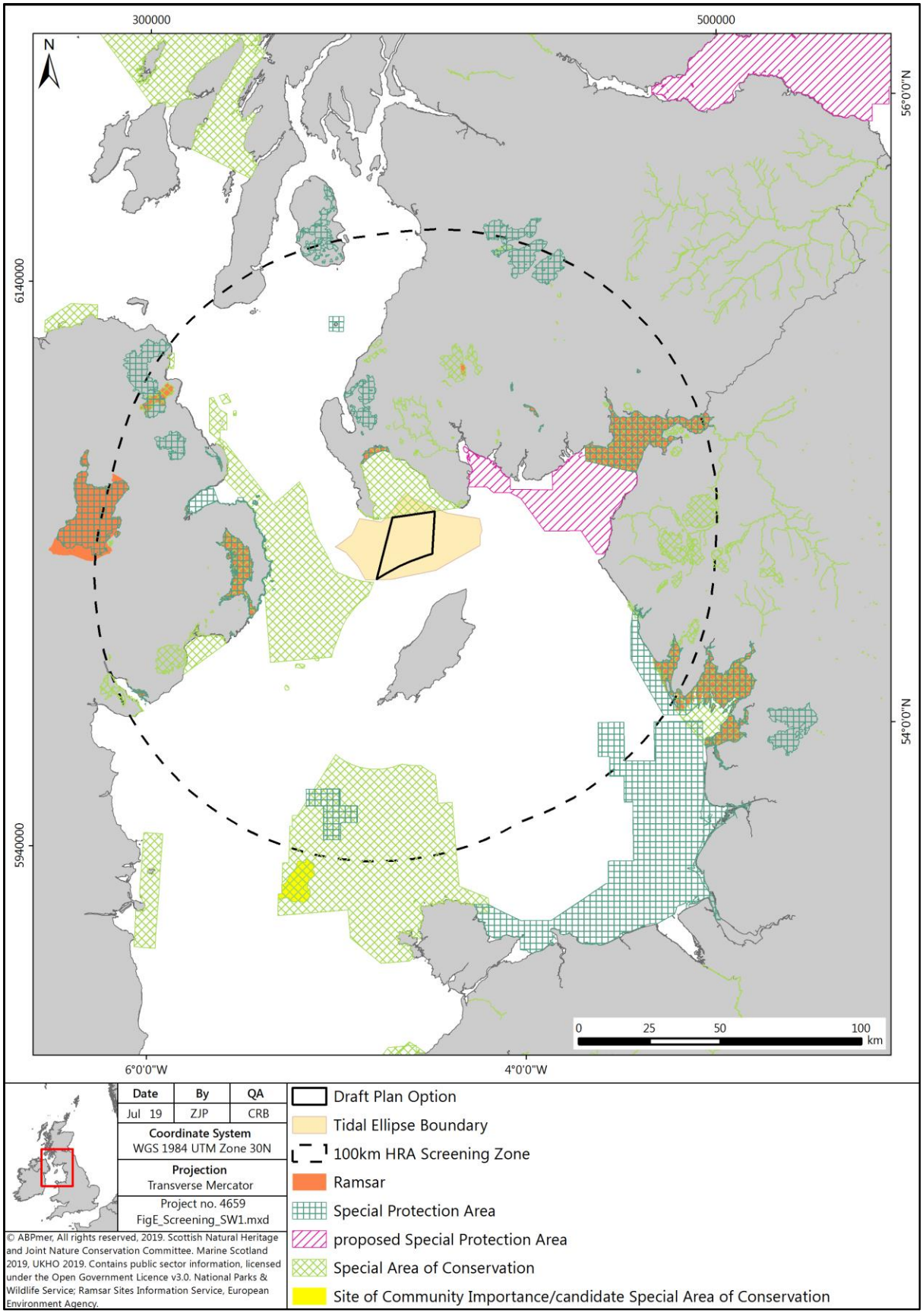


Figure E1. SW1: European/Ramsar sites screened in for potential LSE

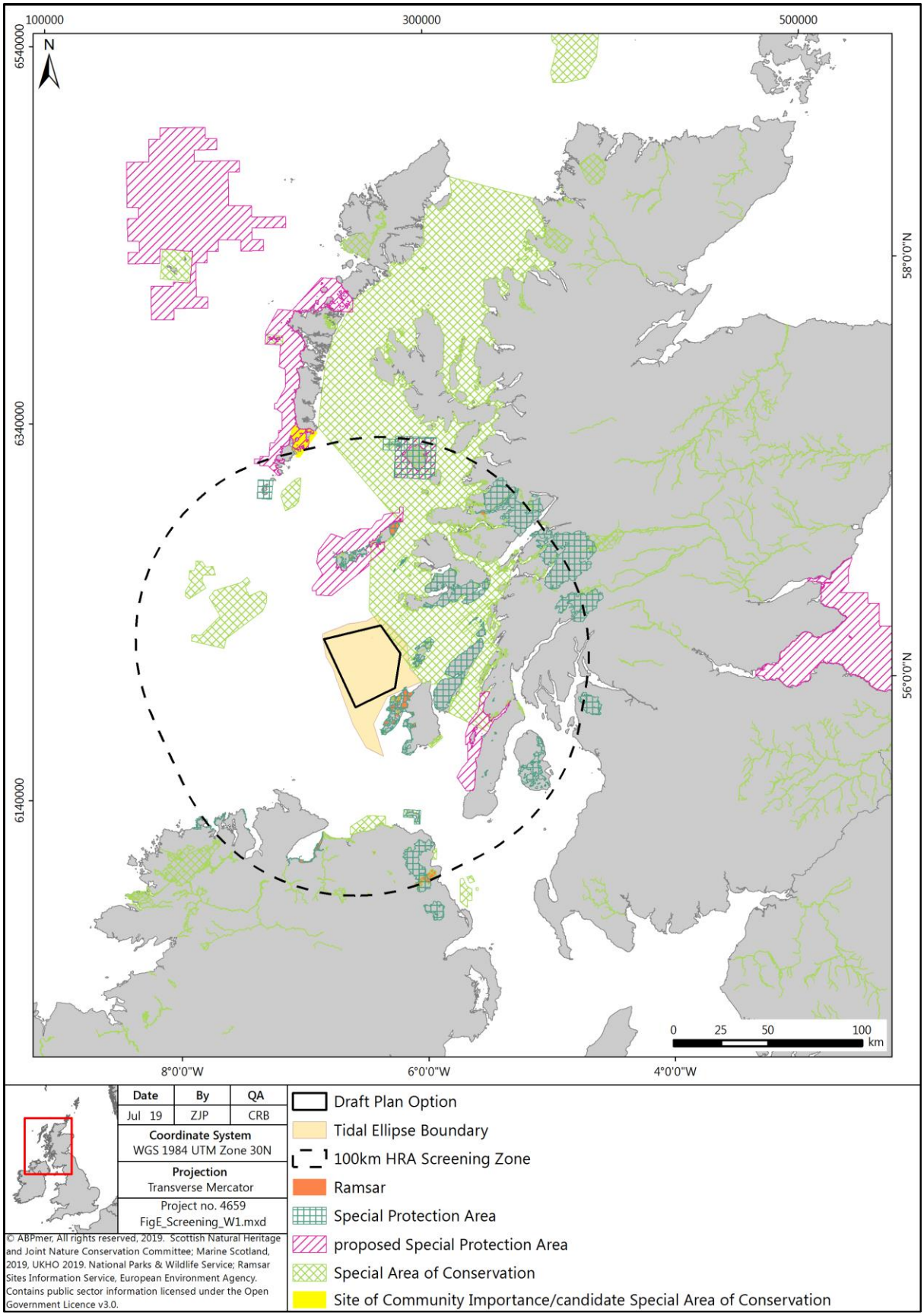


Figure E2. W1: European/Ramsar sites screened in for potential LSE

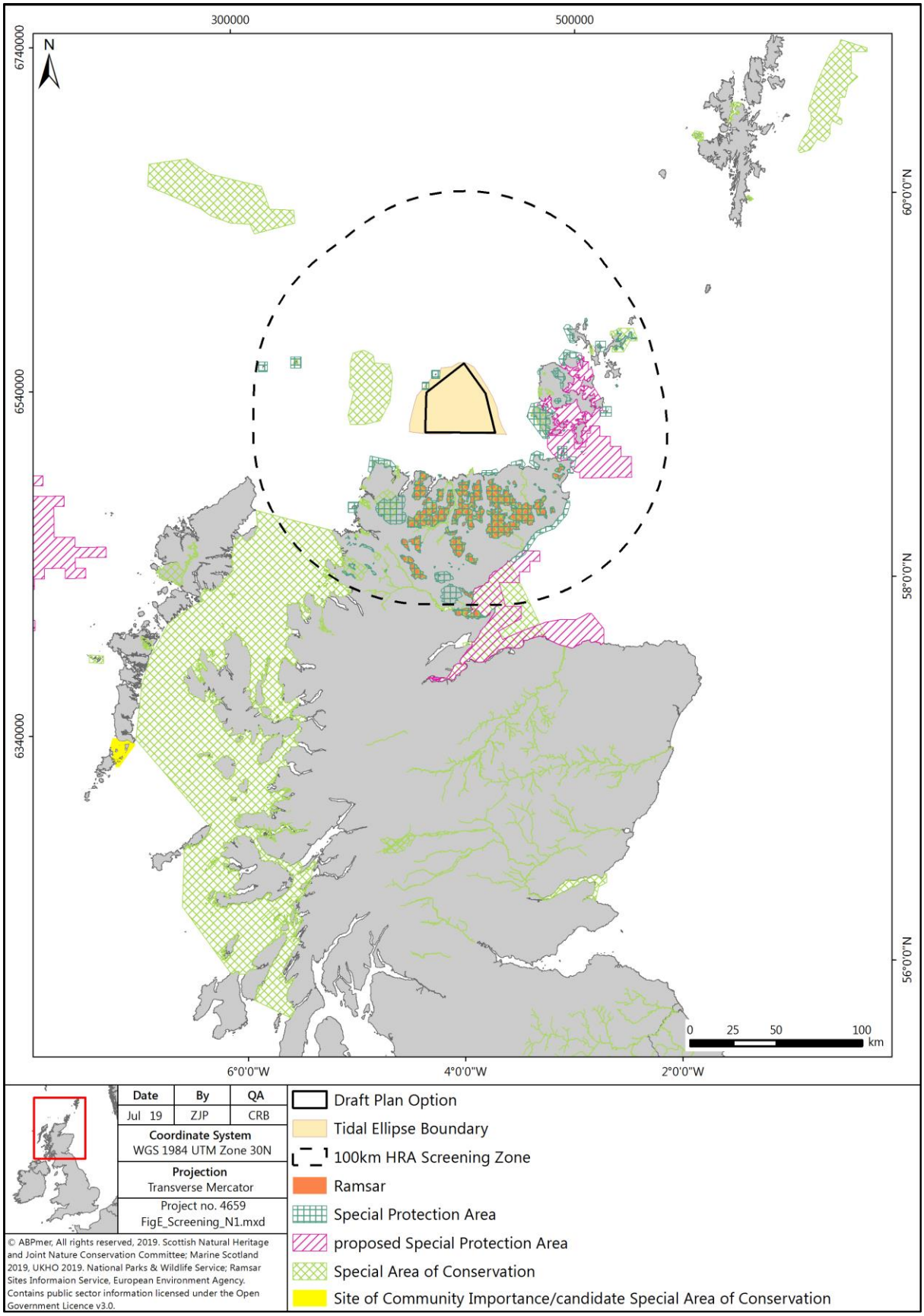


Figure E3. N1: European/Ramsar sites screened in for potential LSE

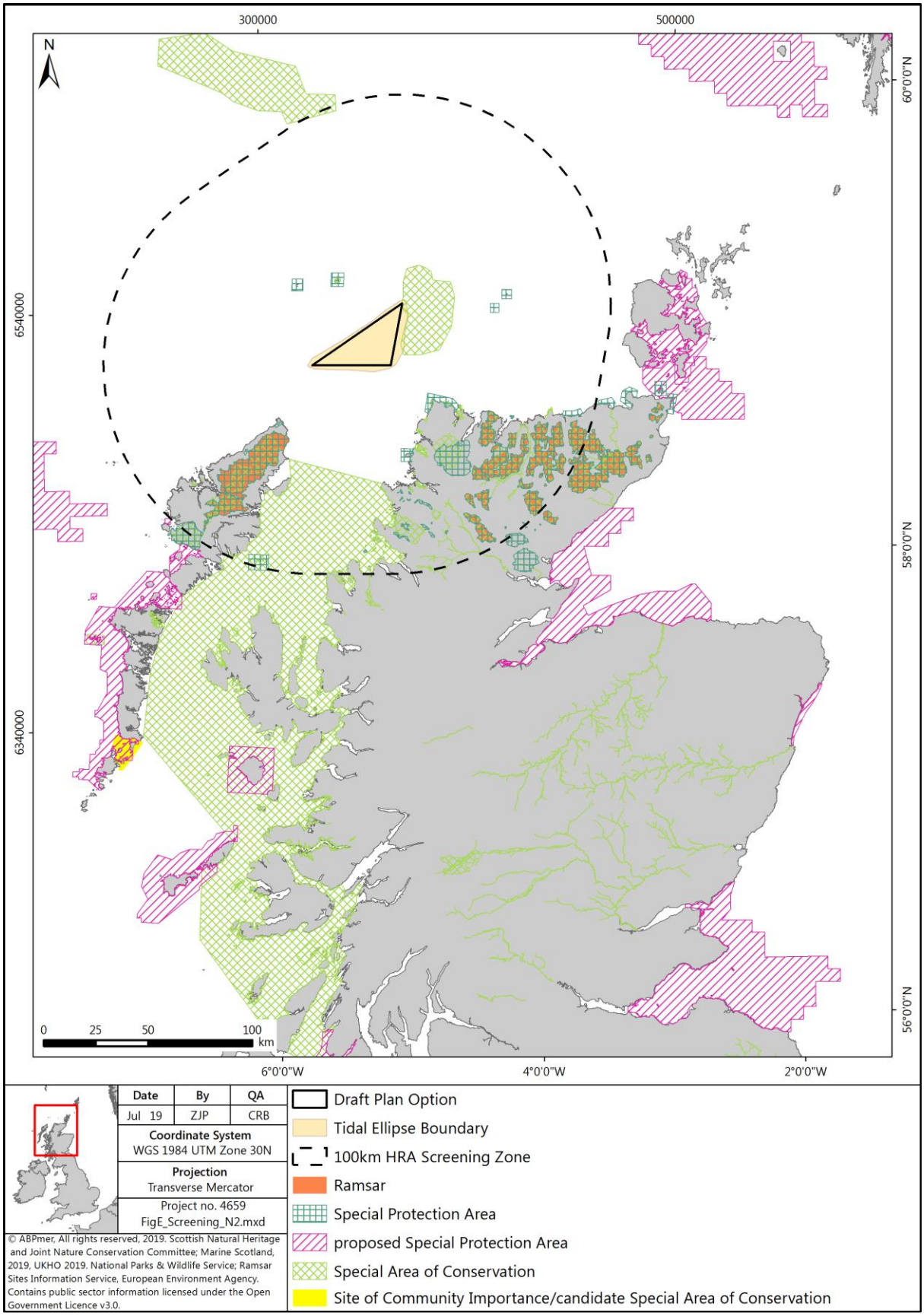


Figure E4. N2: European/Ramsar sites screened in for potential LSE

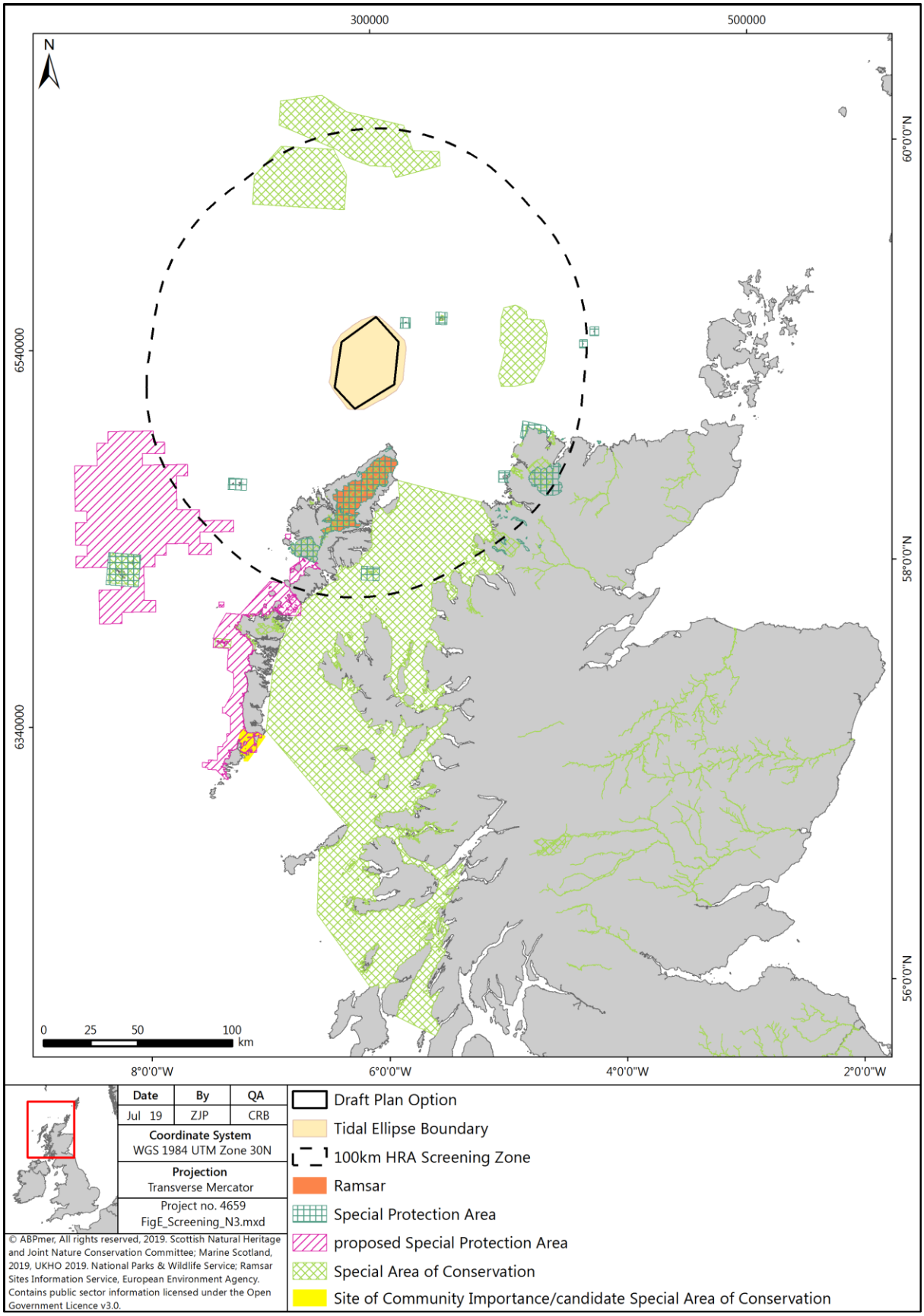


Figure E5. N3: European/Ramsar sites screened in for potential LSE

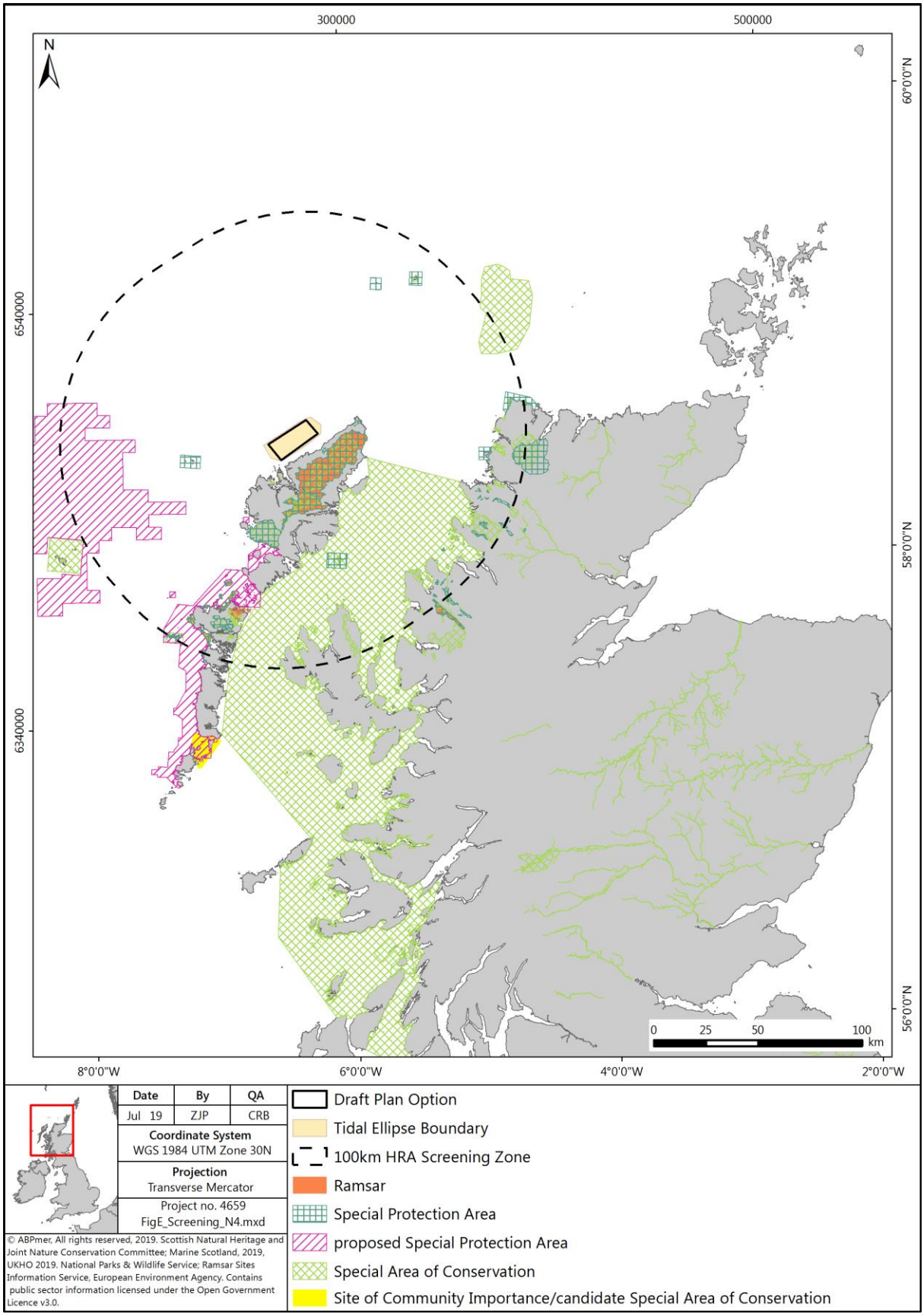


Figure E6. N4: European/Ramsar sites screened in for potential LSE

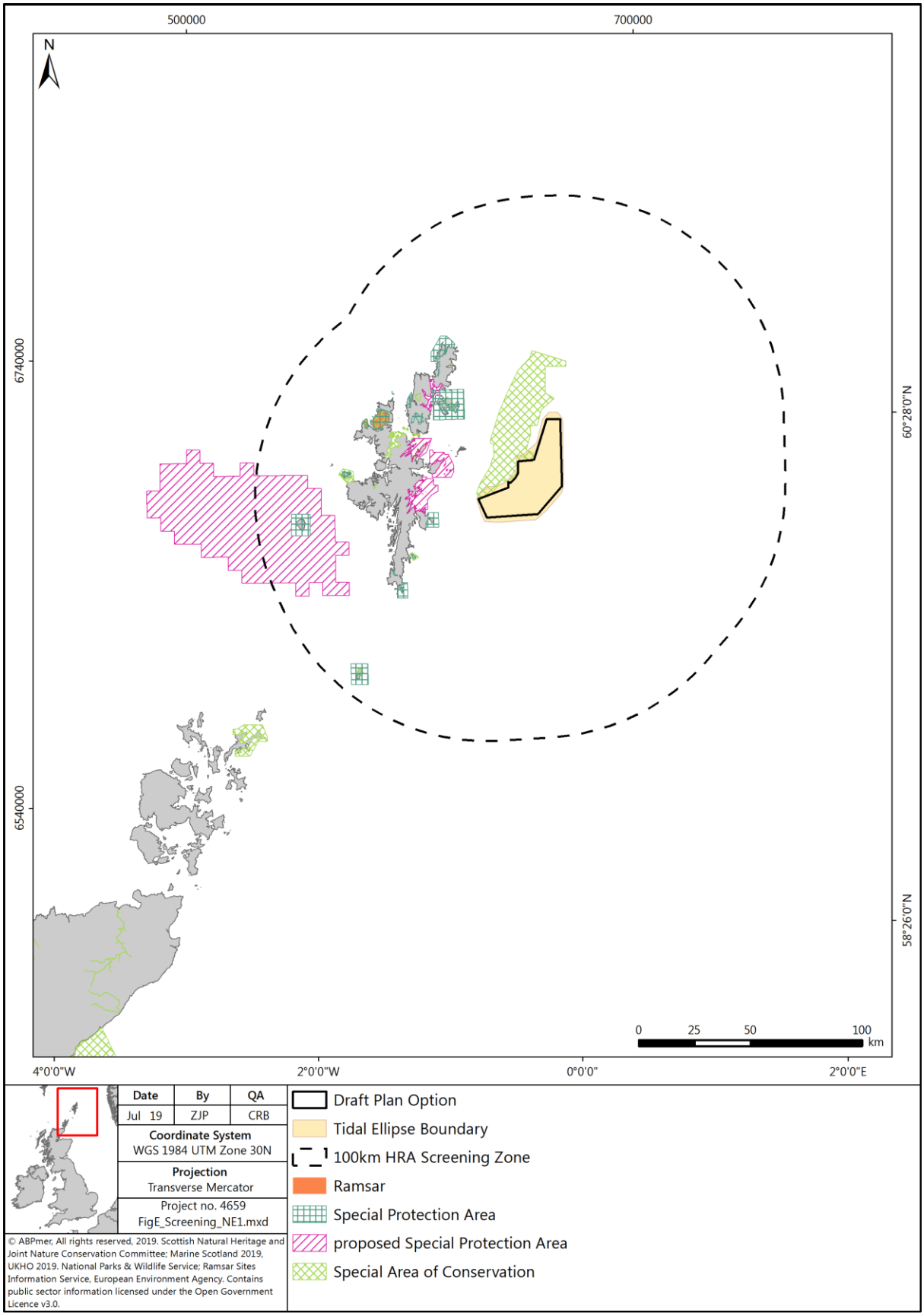


Figure E7. NE1: European/Ramsar sites screened in for potential LSE

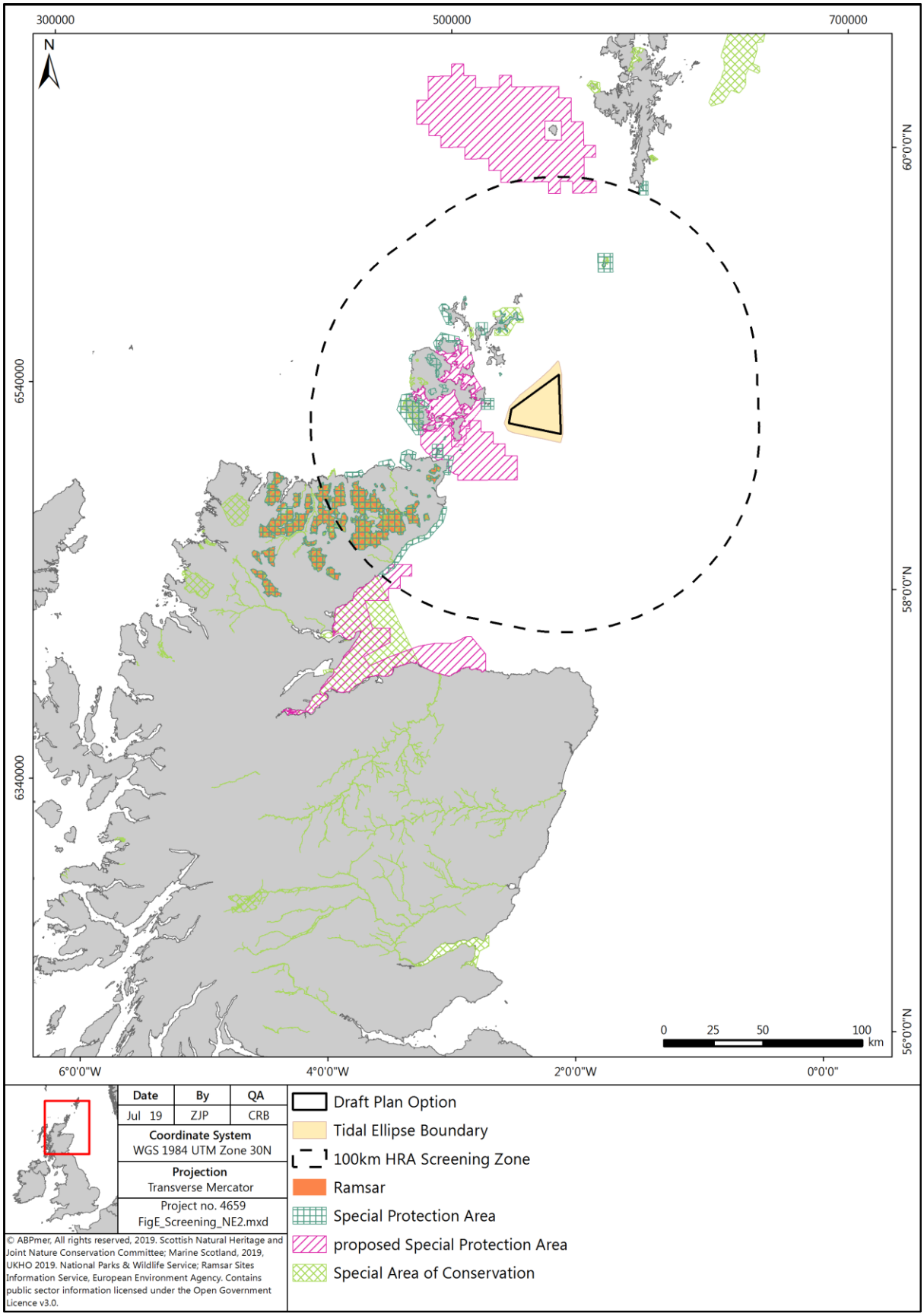


Figure E8. NE2: European/Ramsar sites screened in for potential LSE

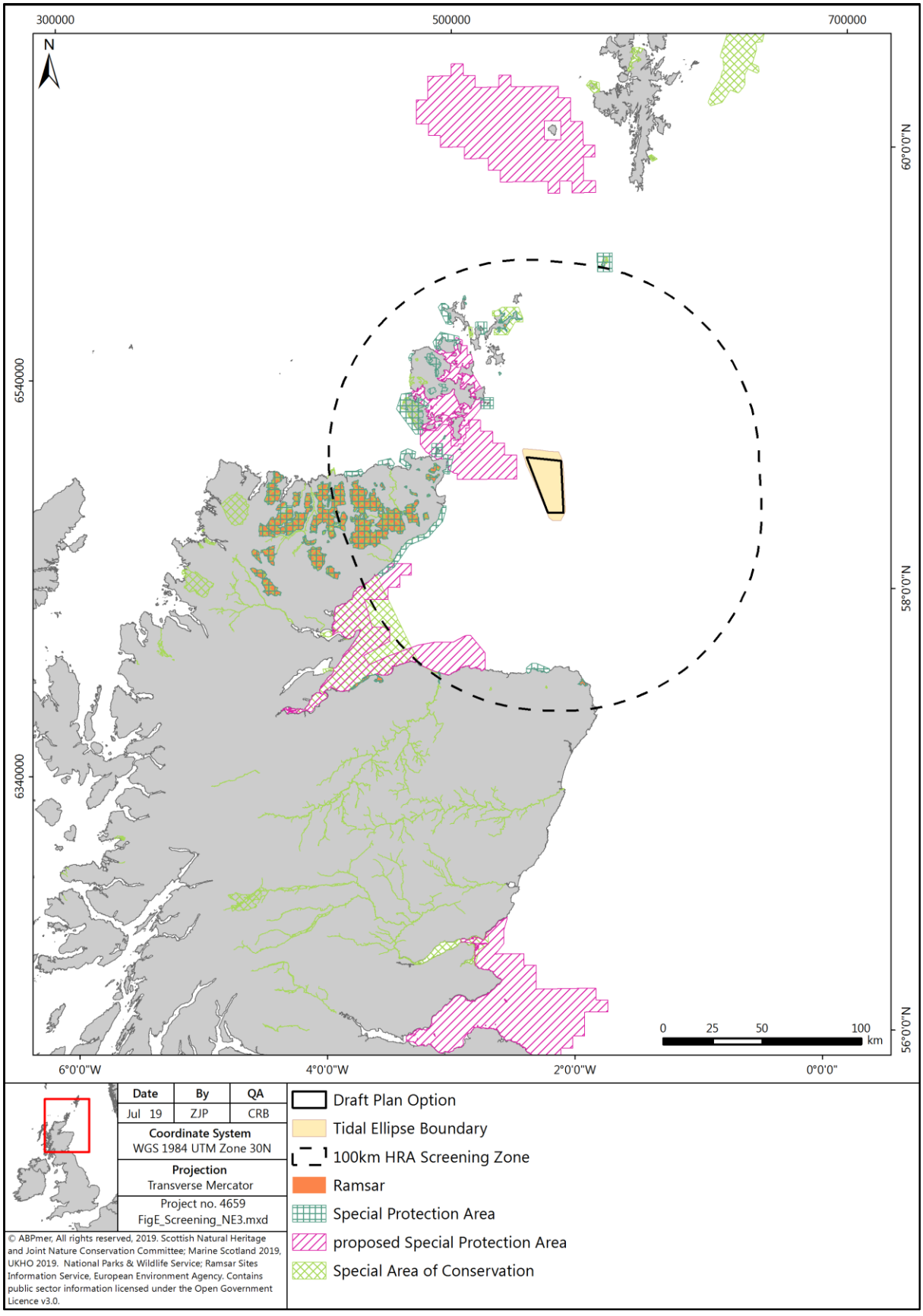


Figure E9. NE3: European/Ramsar sites screened in for potential LSE

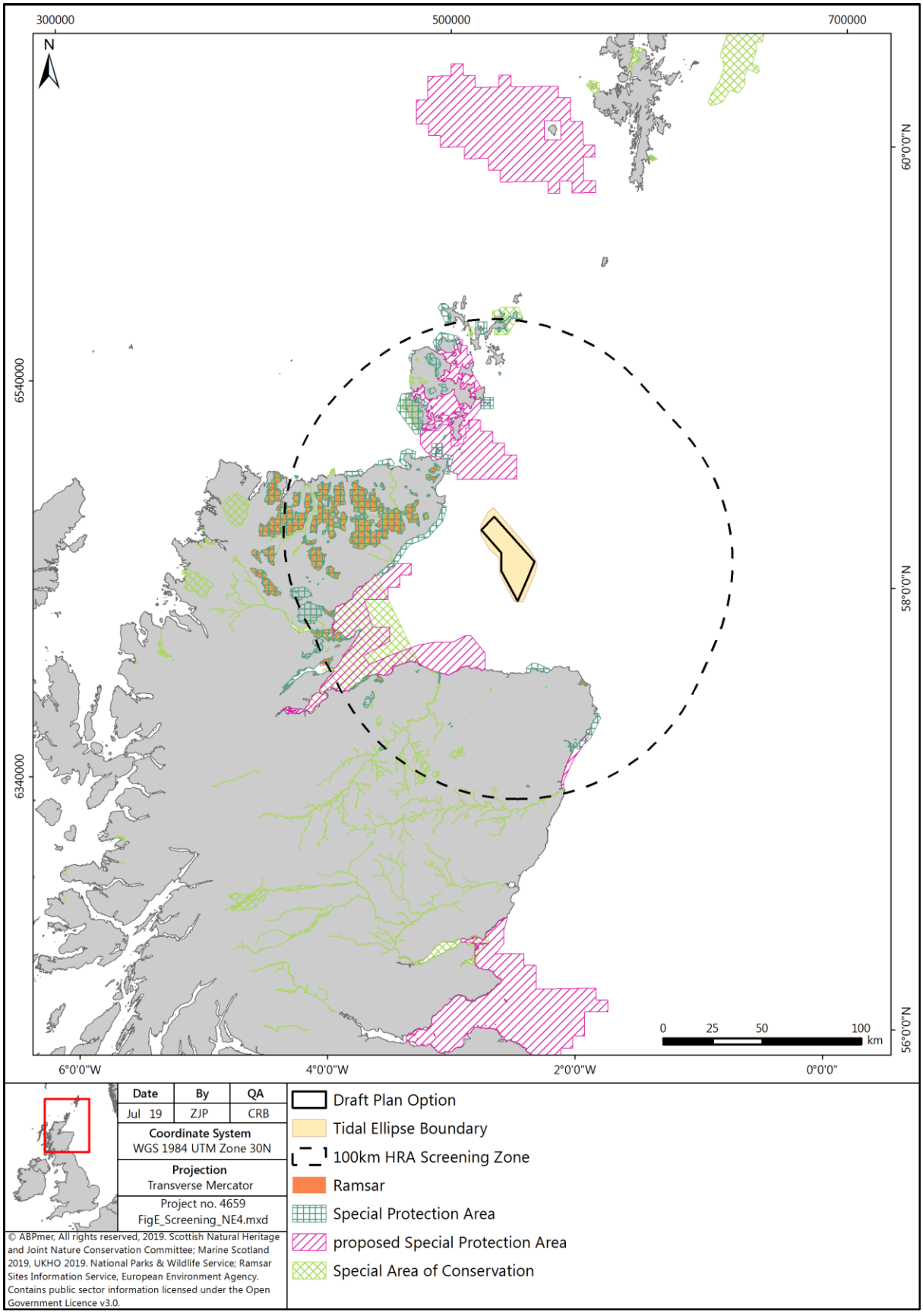


Figure E10. NE4: European/Ramsar sites screened in for potential LSE

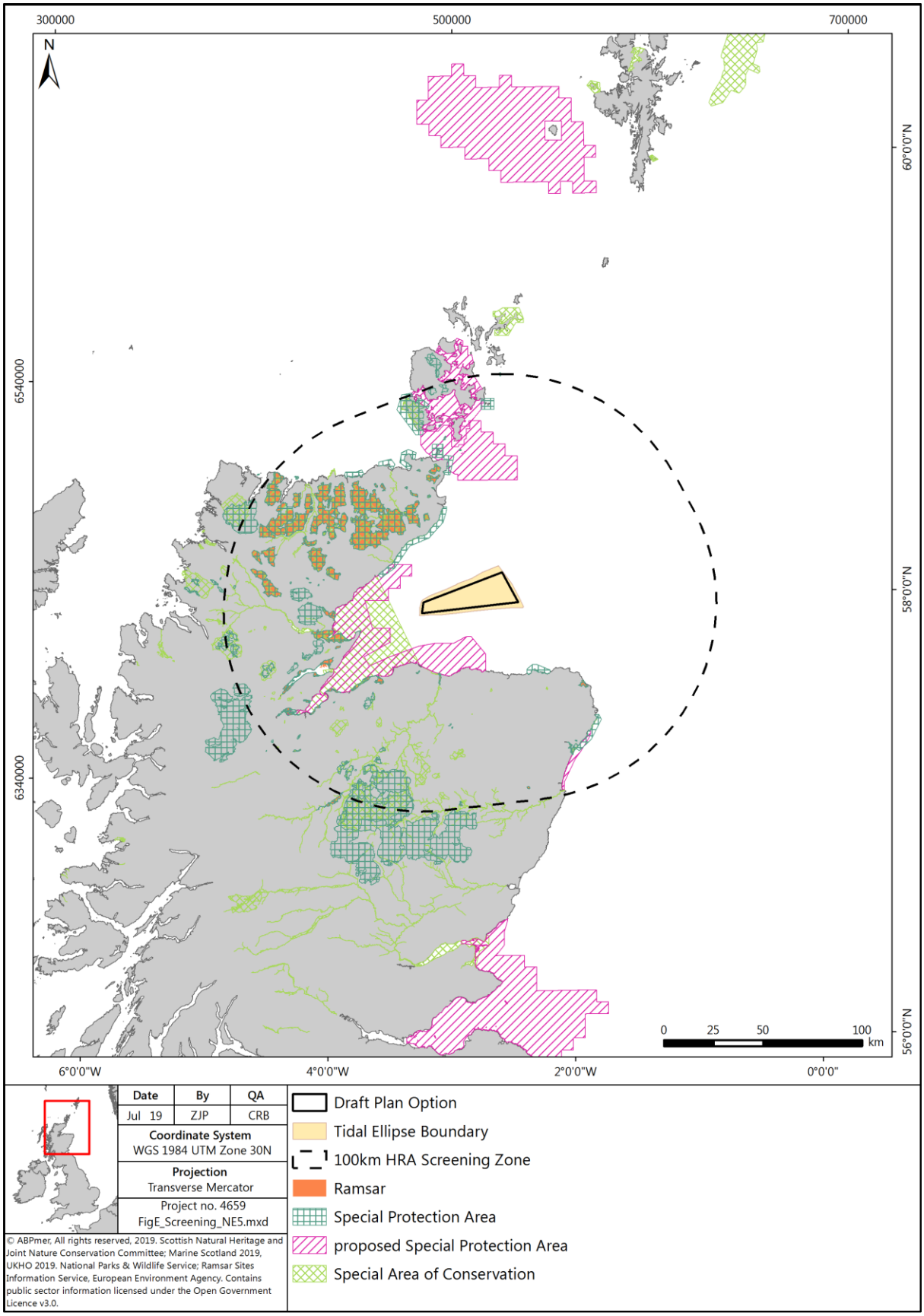


Figure E11. NE5: European/Ramsar sites screened in for potential LSE

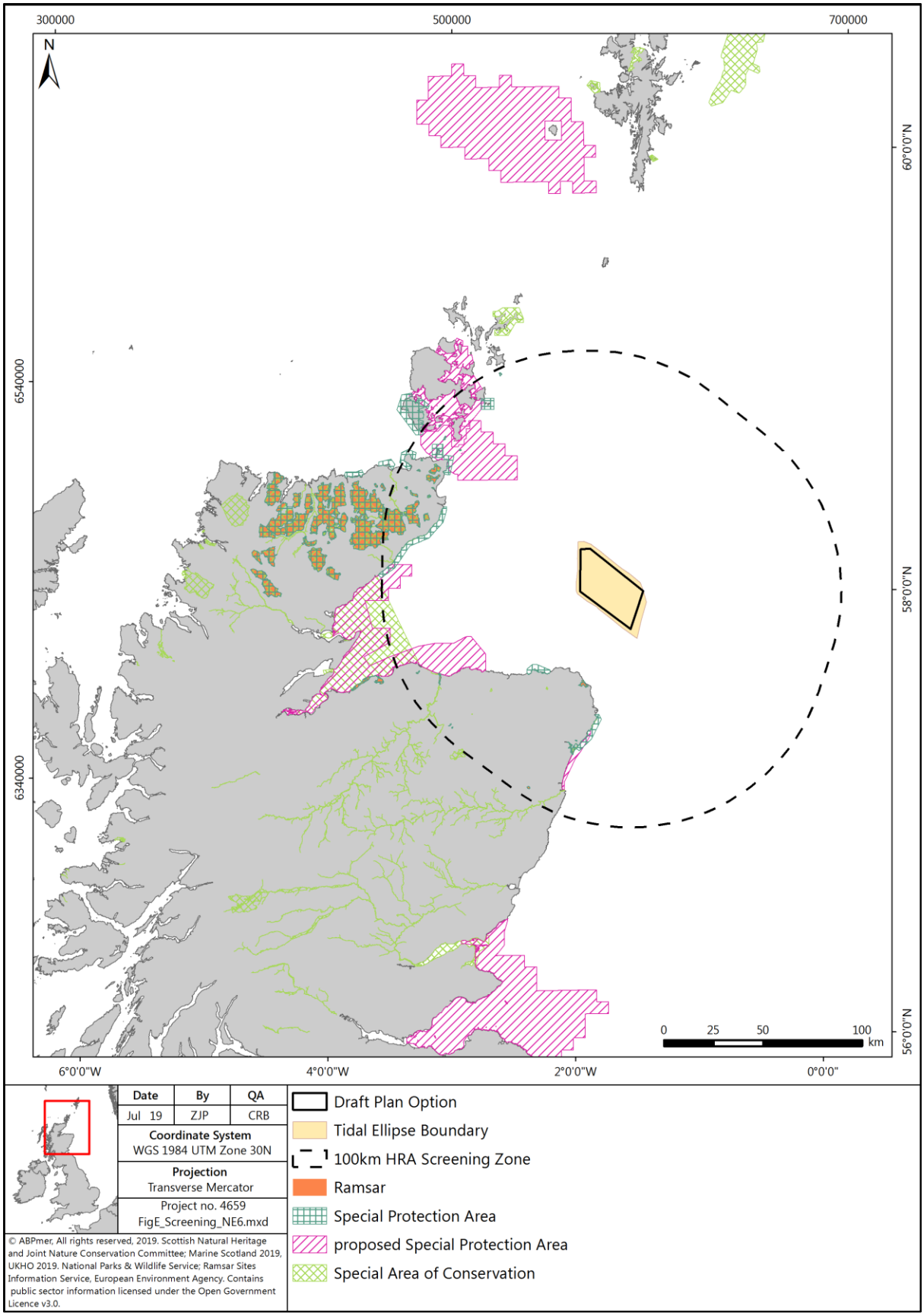


Figure E12. NE6: European/Ramsar sites screened in for potential LSE

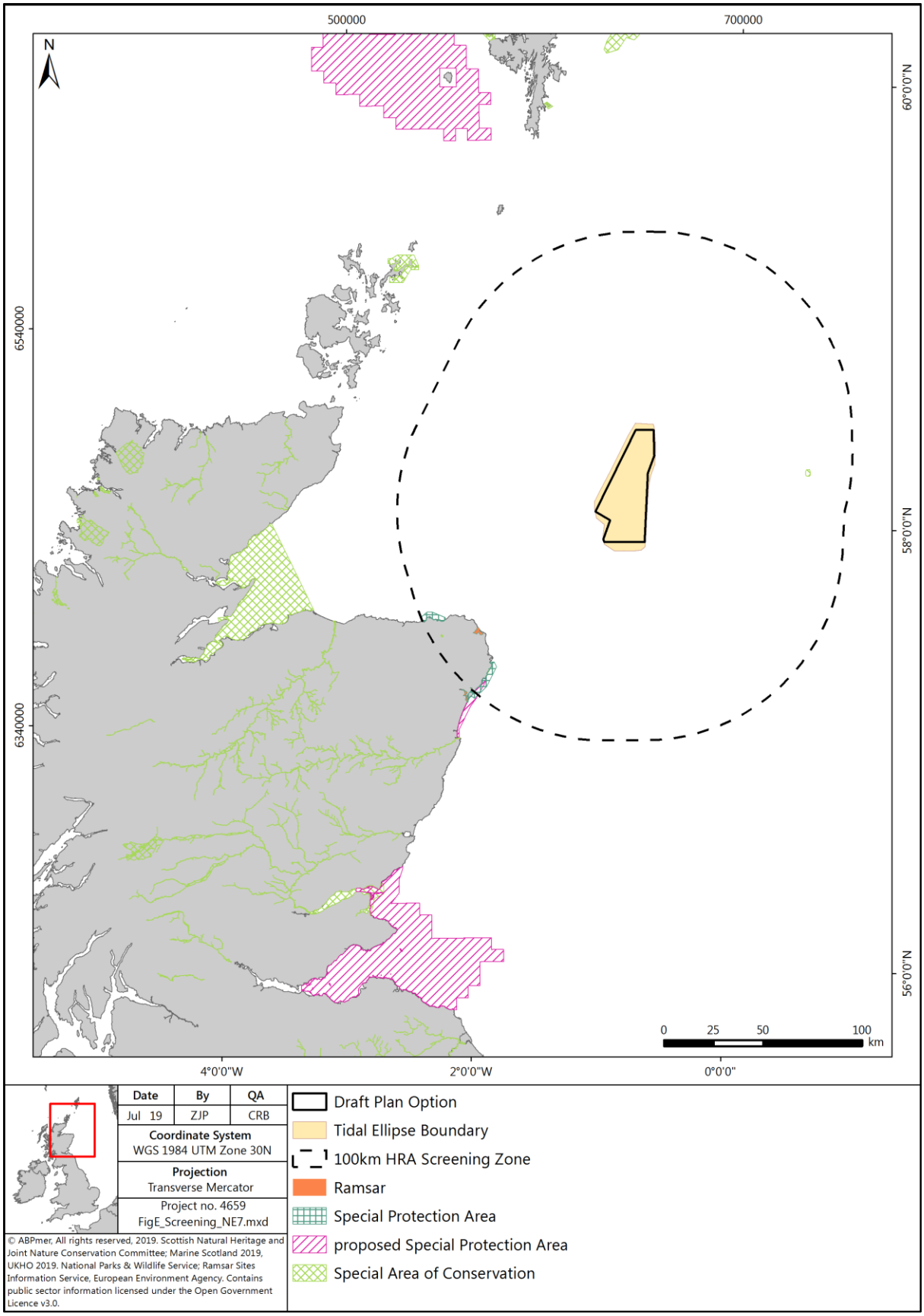


Figure E13. NE7: European/Ramsar sites screened in for potential LSE

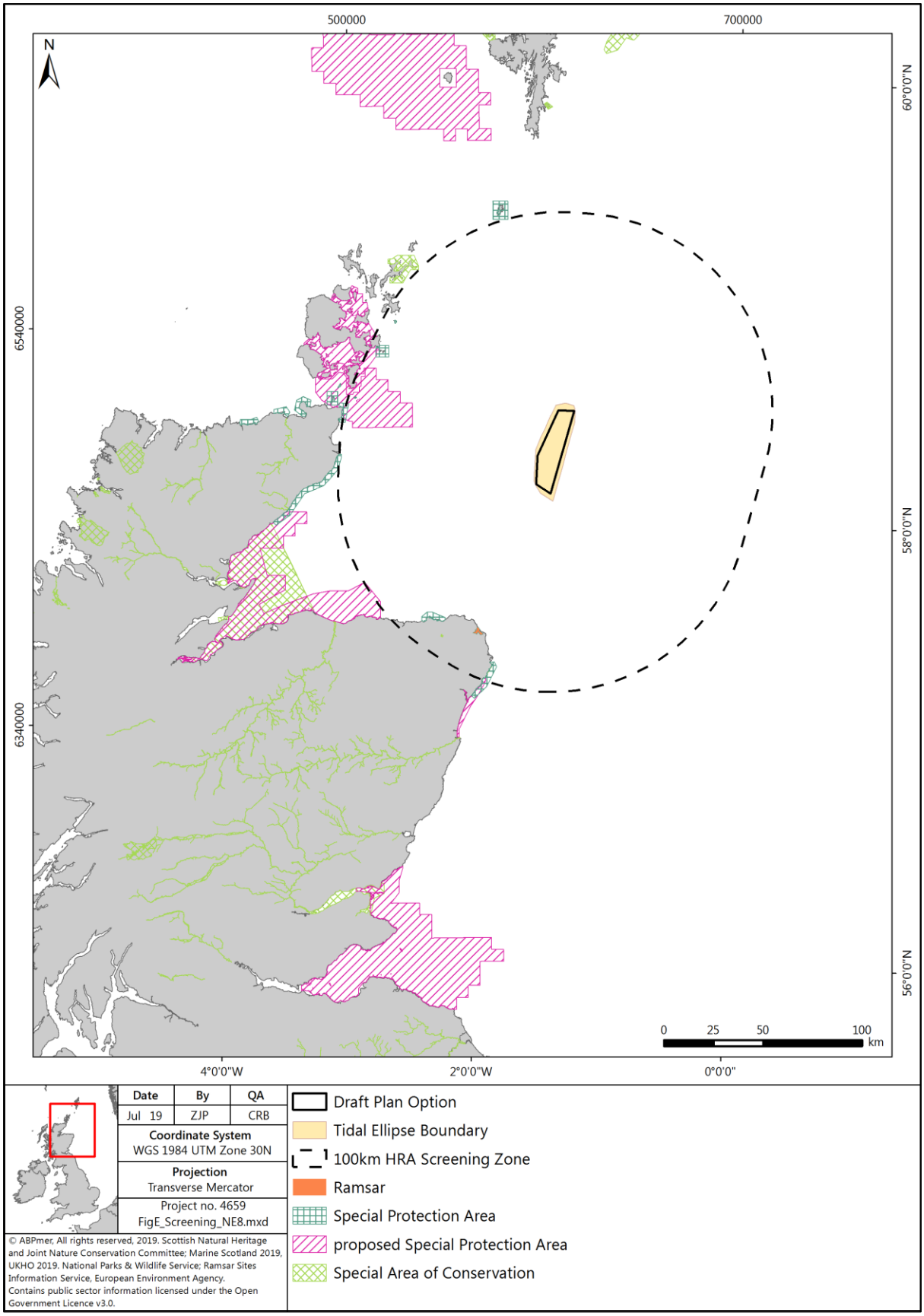


Figure E14. NE8: European/Ramsar sites screened in for potential LSE

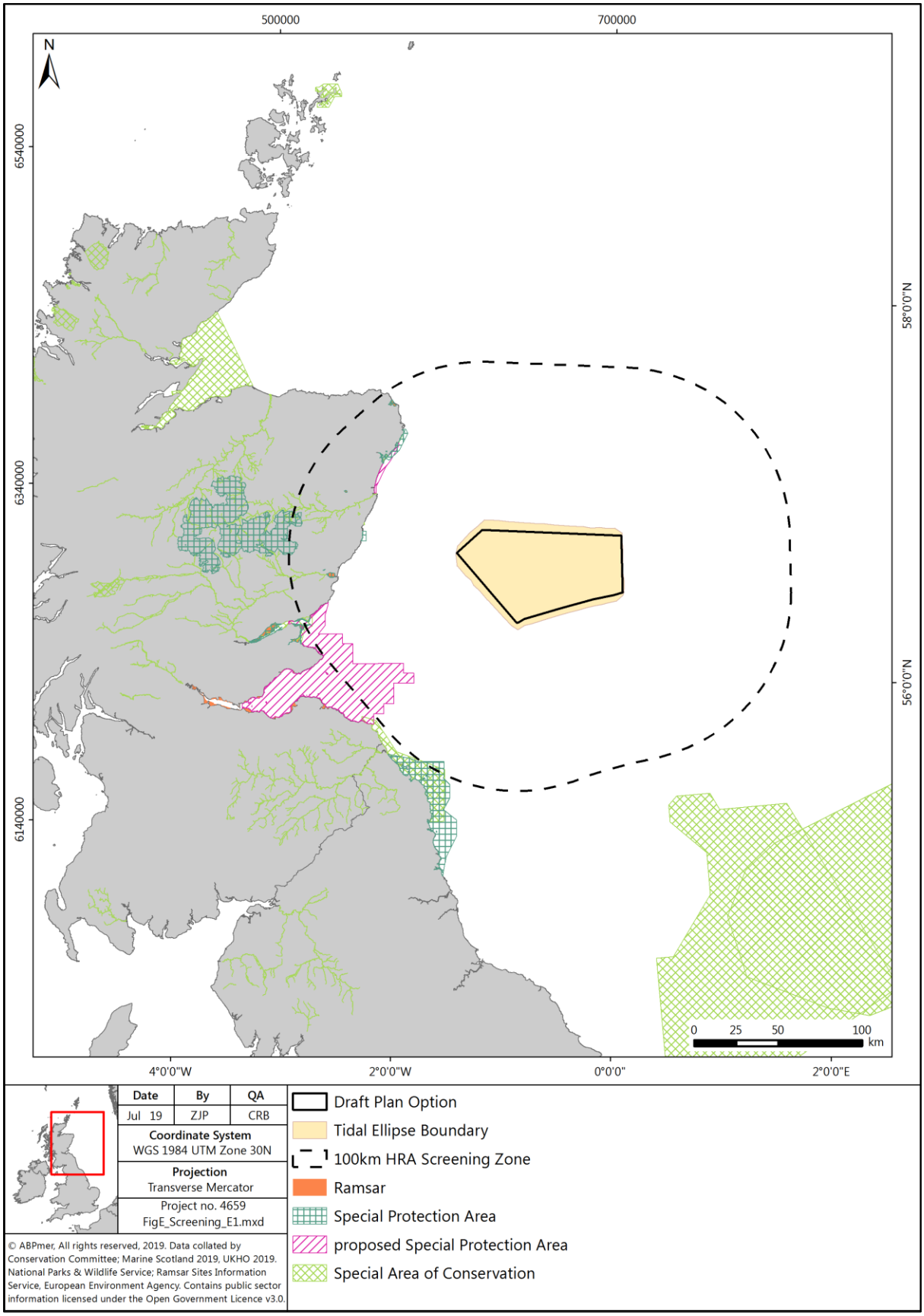


Figure E15. E1: European/Ramsar sites screened in for potential LSE

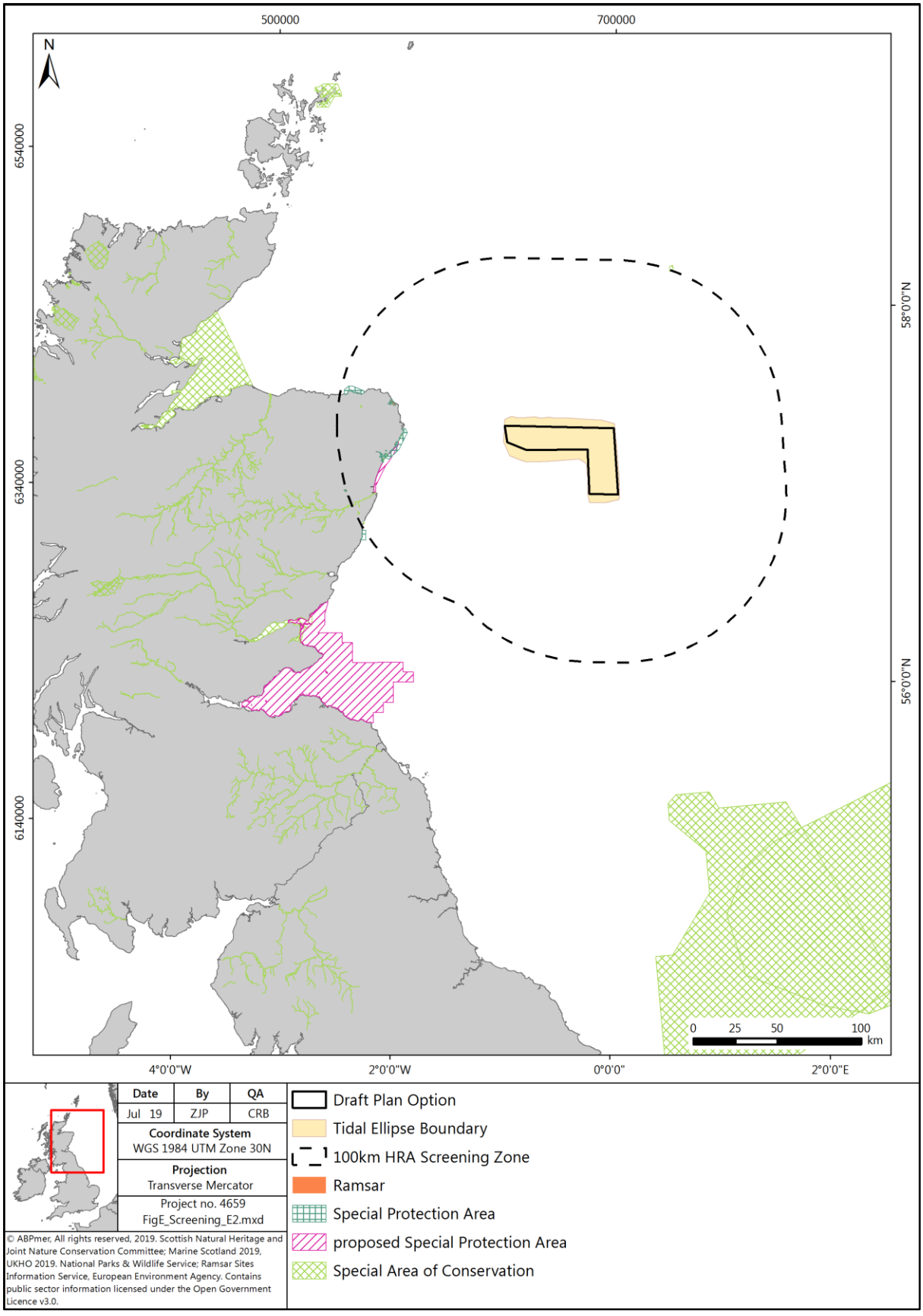


Figure E16. E2: European/Ramsar sites screened in for potential LSE

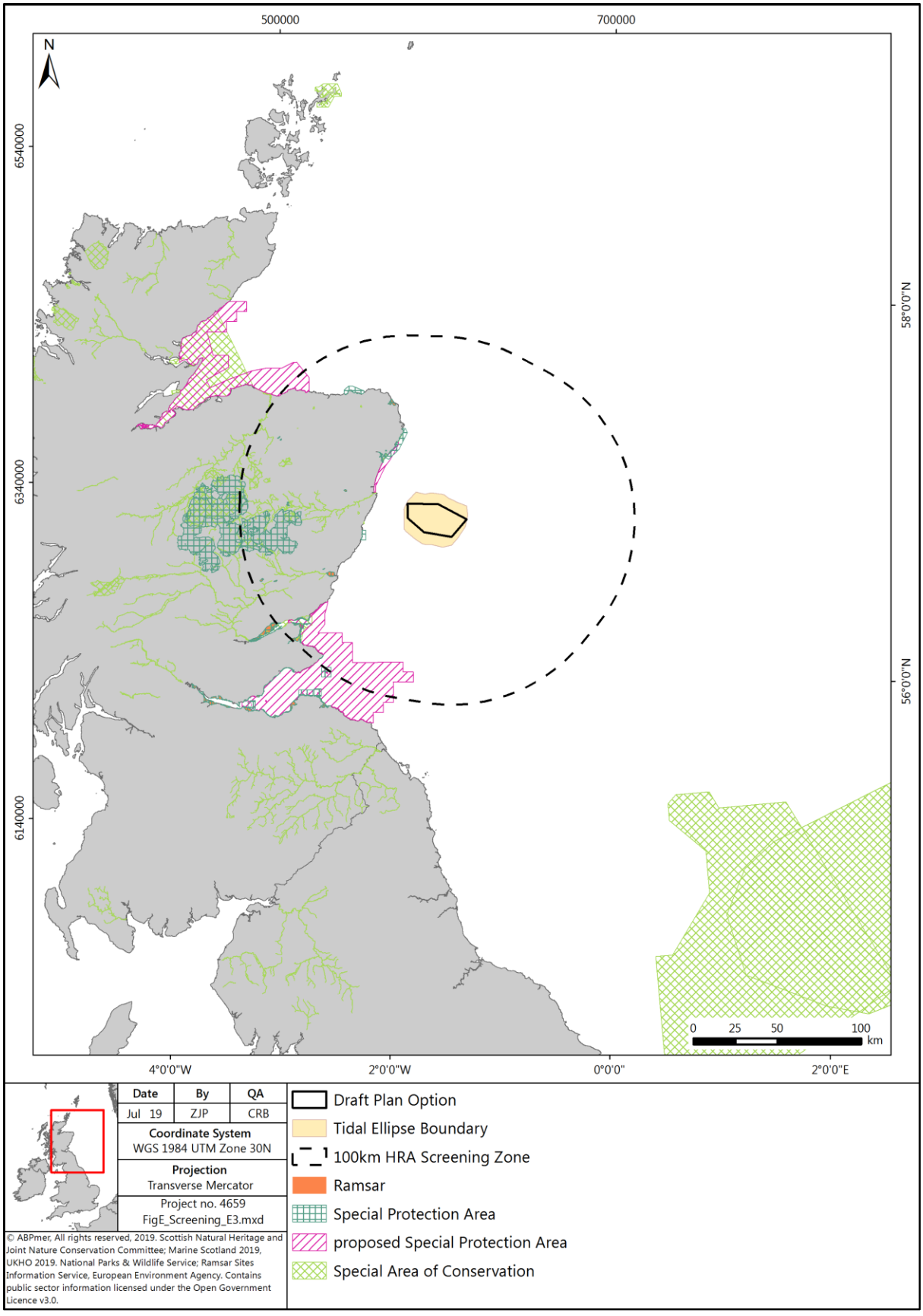


Figure E17. E3: European/Ramsar sites screened in for potential LSE

Appendix F.>100 km Screening Maps

Figure F1. Puffin European/Ramsar sites screened in for potential LSE
Figure F2. Northern gannet European/Ramsar sites screened in for potential LSE
Figure F3. Manx shearwater European/Ramsar sites screened in for potential LSE
Figure F4. Lesser black-backed gull European/Ramsar sites screened in for potential LSE
Figure F5. Northern fulmar European/Ramsar sites screened in for potential LSE
Figure F6. Harbour porpoise European/Ramsar sites screened in for potential LSE
Figure F7. Bottlenose dolphin European/Ramsar sites screened in for potential LSE
Figure F8 Migratory fish and fresh water pearl mussel European/Ramsar sites screened in for potential LSE
Figure F9. Otter European/Ramsar sites screened in for potential LSE

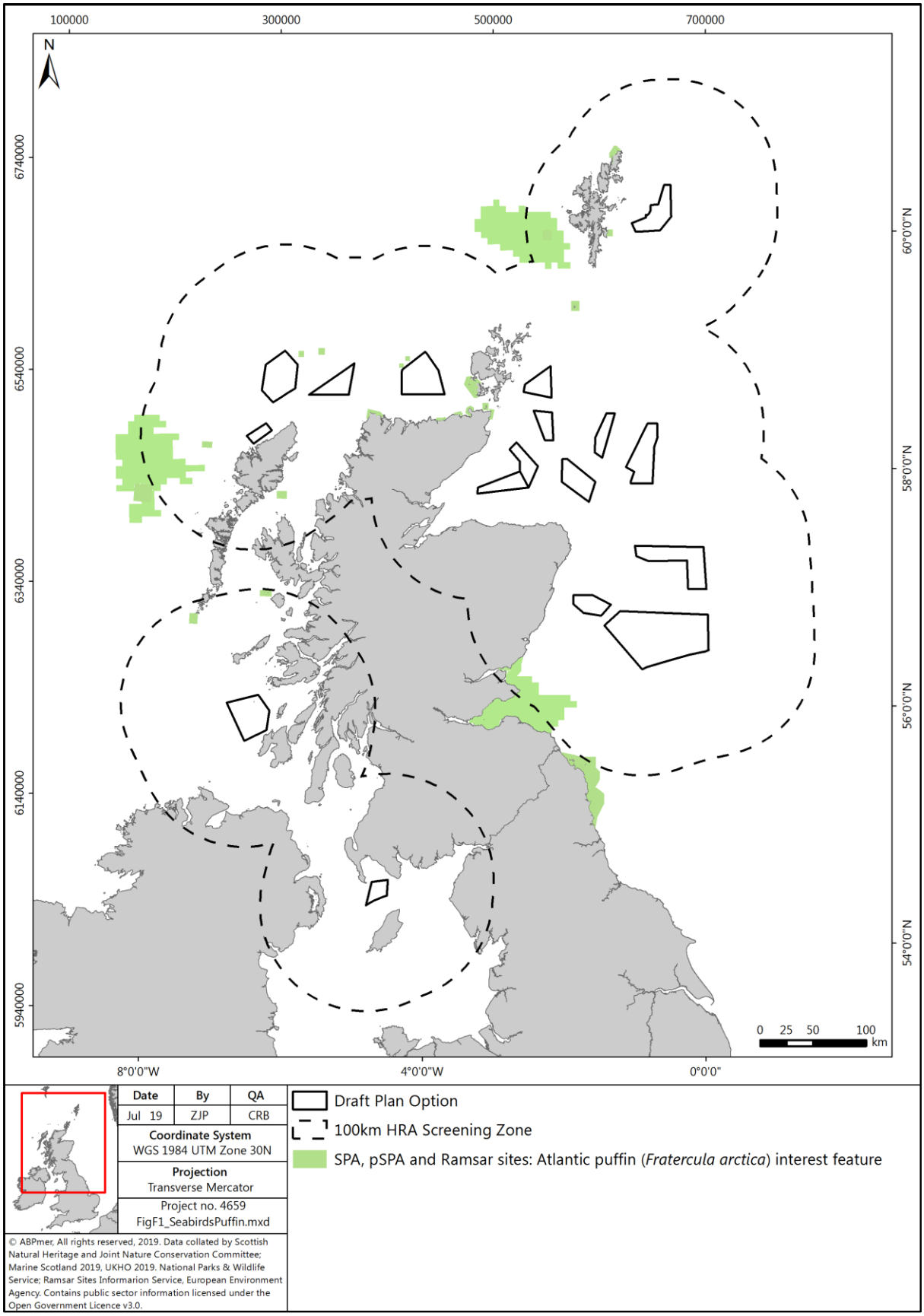


Figure F1. Puffin European/Ramsar sites screened in for potential LSE

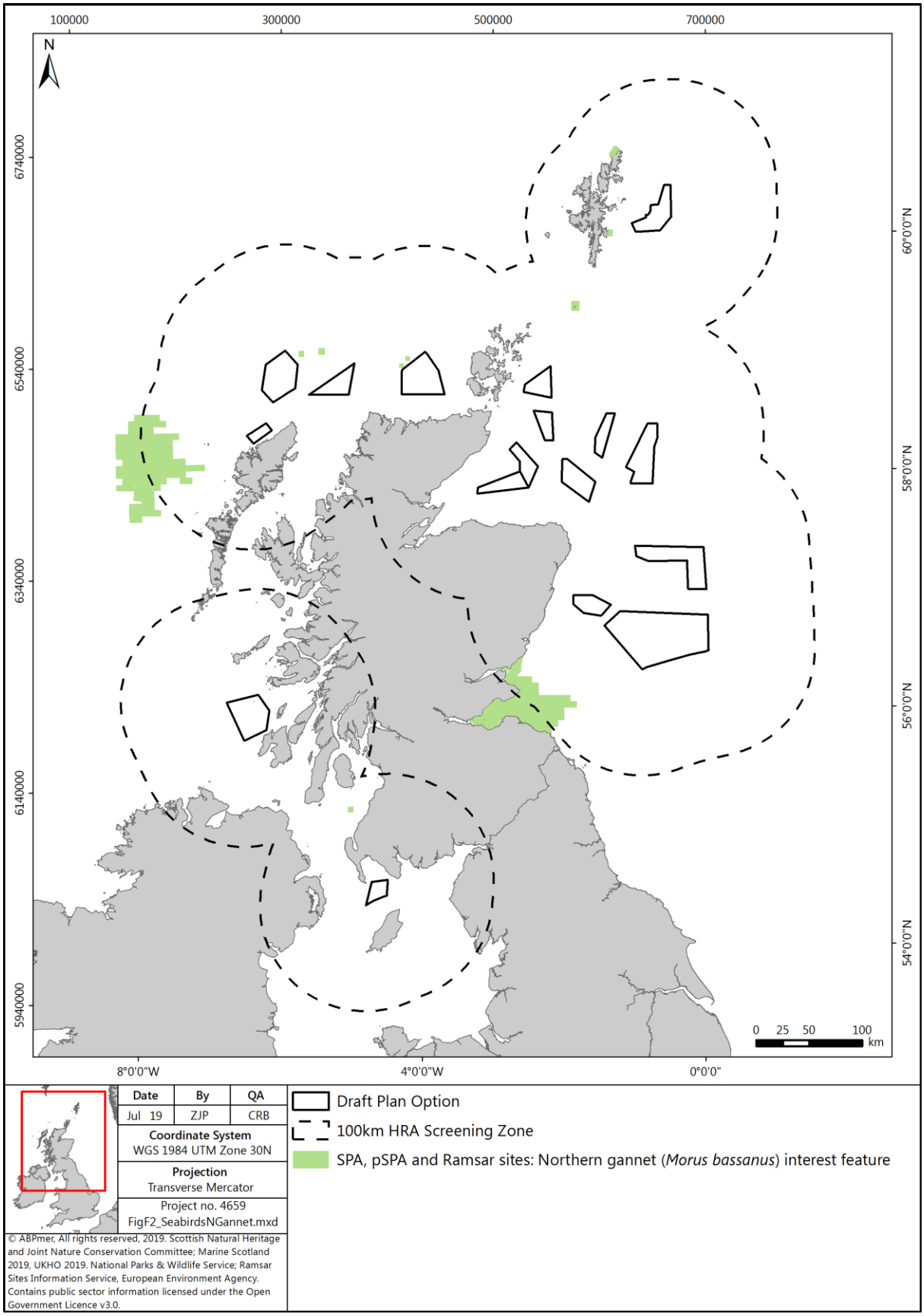


Figure F2. Northern Gannet European/Ramsar sites screened in for potential LSE

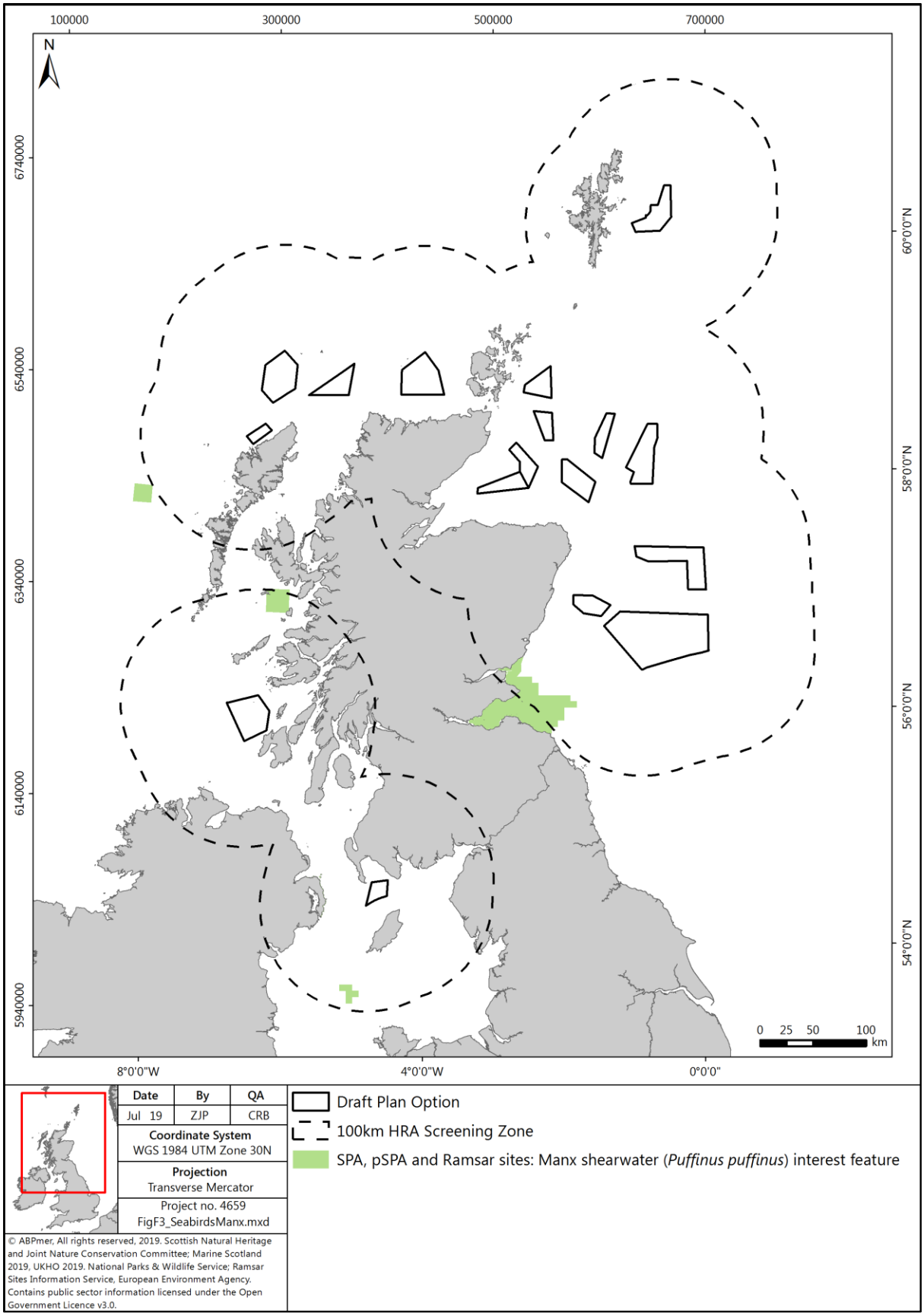


Figure F3. Manx Shearwater European/Ramsar sites screened in for potential LSE

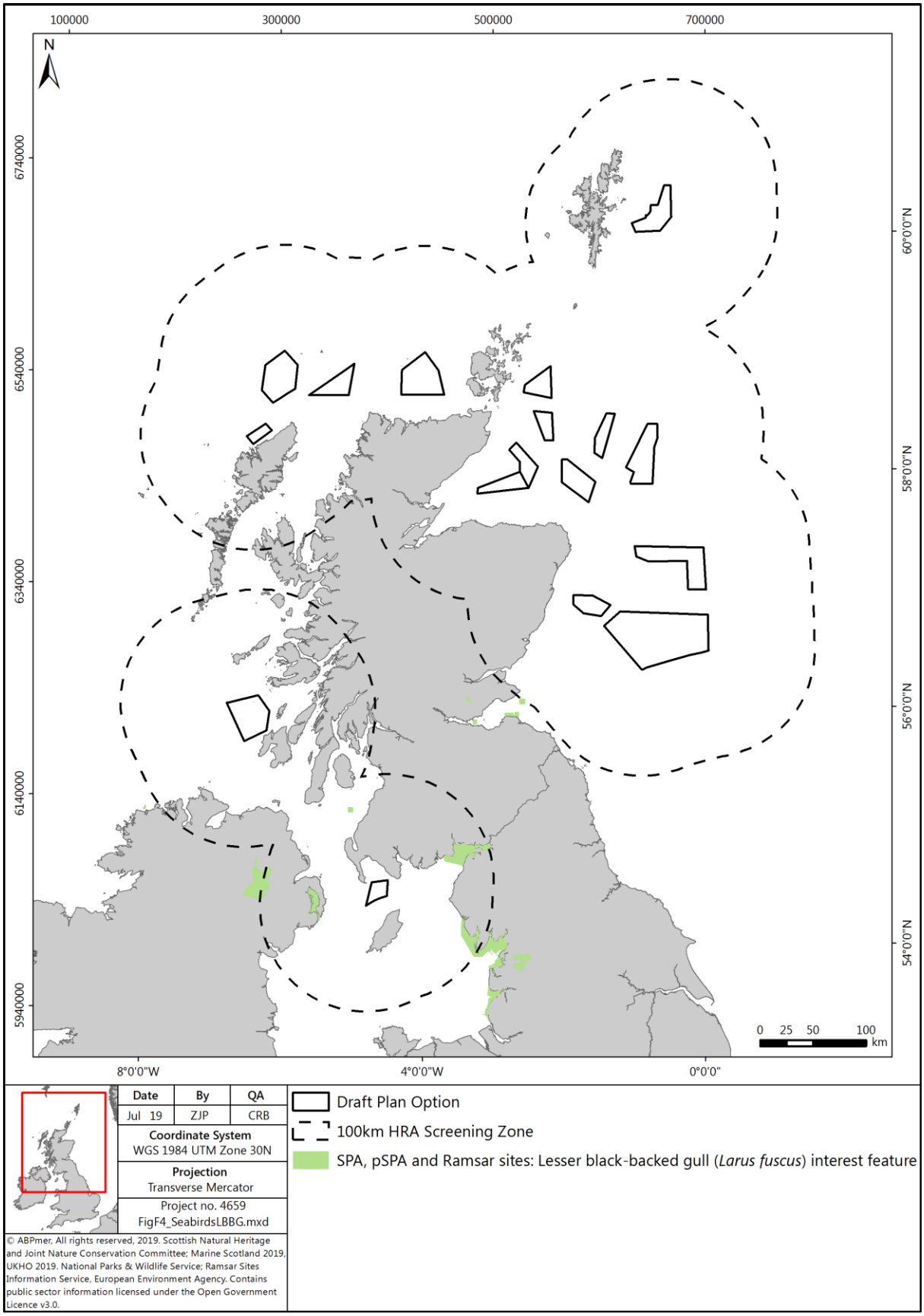


Figure F4. Lesser Black-backed Gull European/Ramsar sites screened in for potential LSE

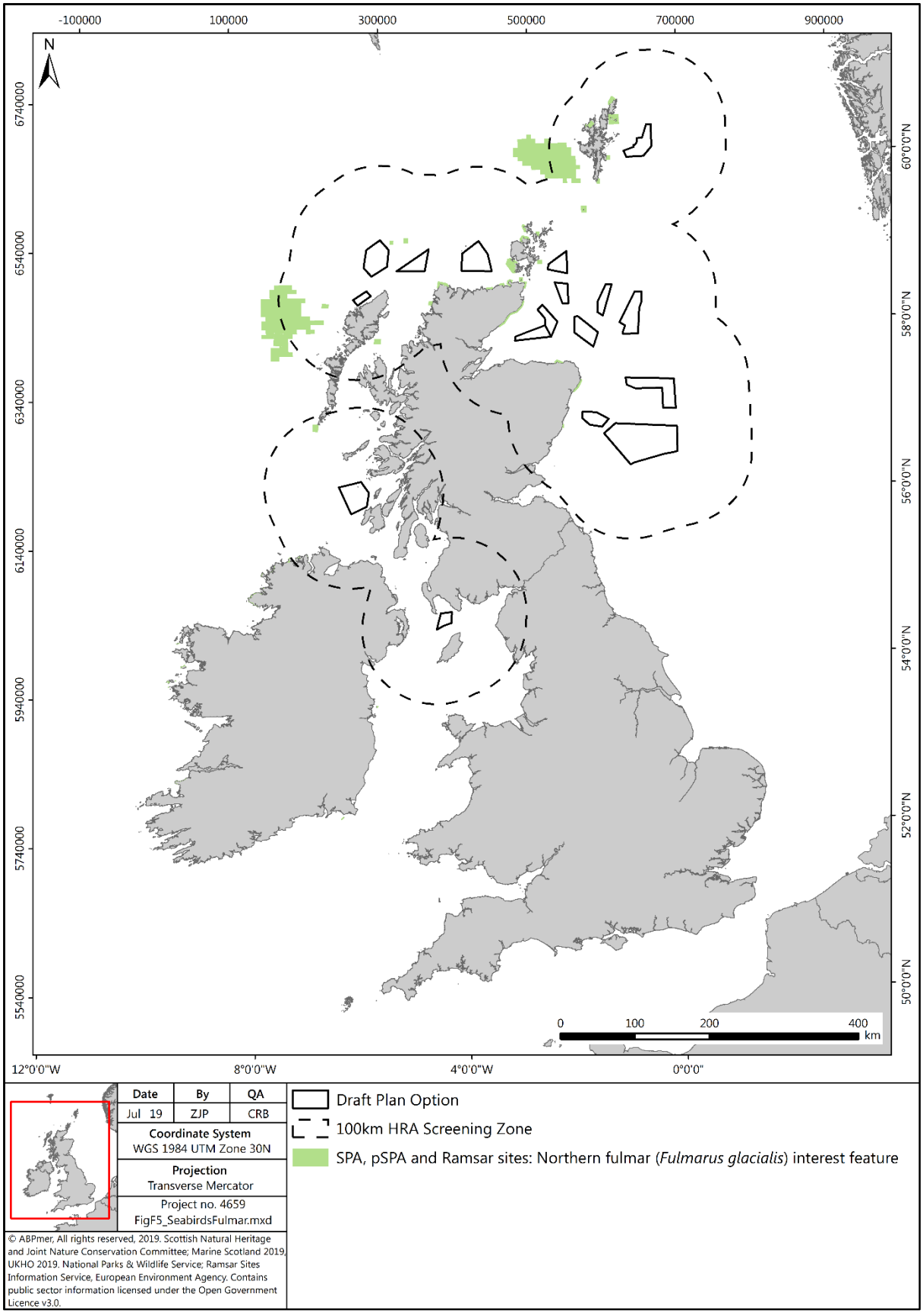


Figure F5. Northern Fulmar European/Ramsar sites screened in for potential LSE

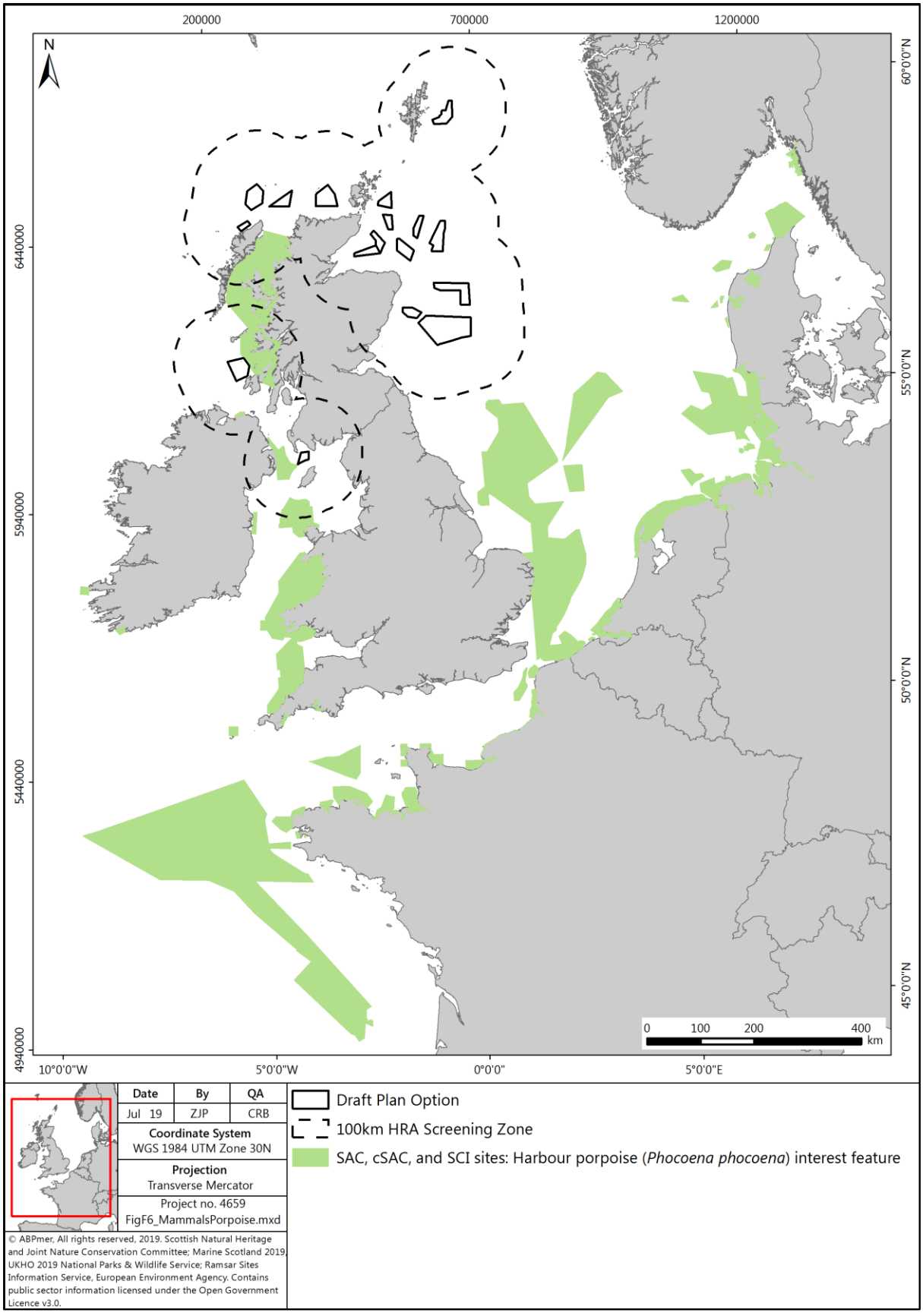


Figure F6. Harbour porpoise European/Ramsar sites screened in for potential LSE

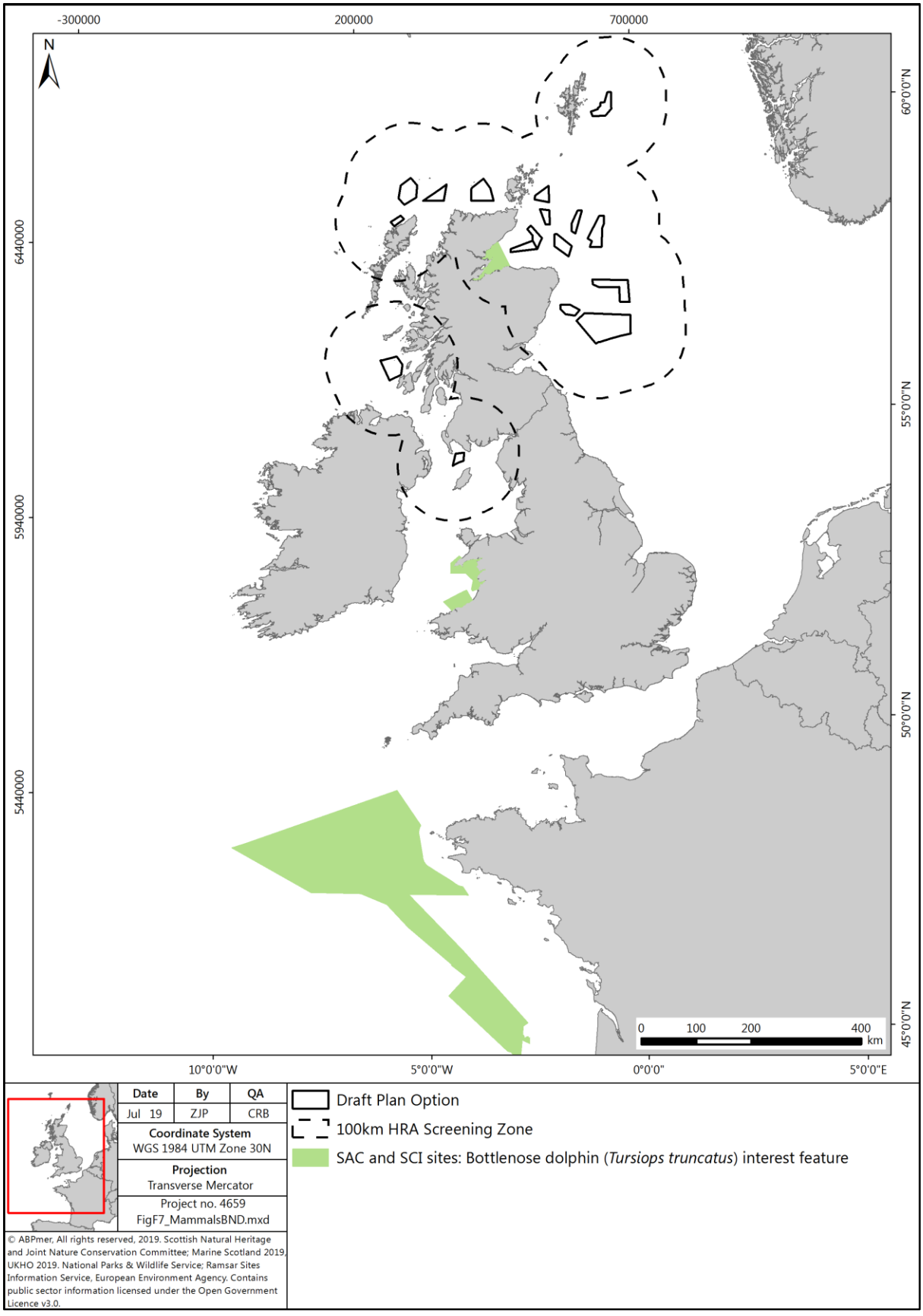


Figure F7. Bottlenose dolphin European/Ramsar sites screened in for potential LSE

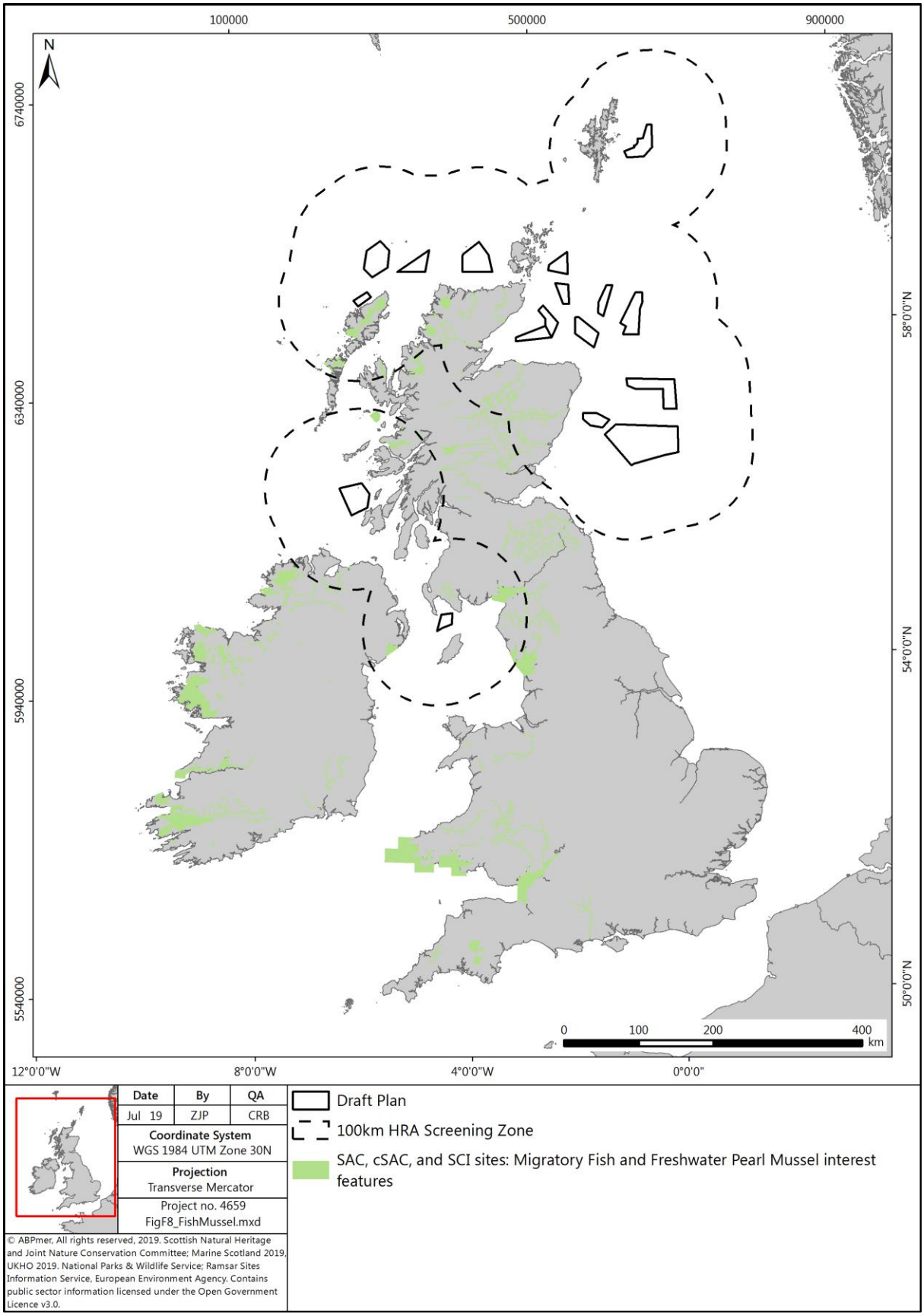


Figure F8 Migratory fish and fresh water pearl mussel European/Ramsar sites screened in for potential LSE

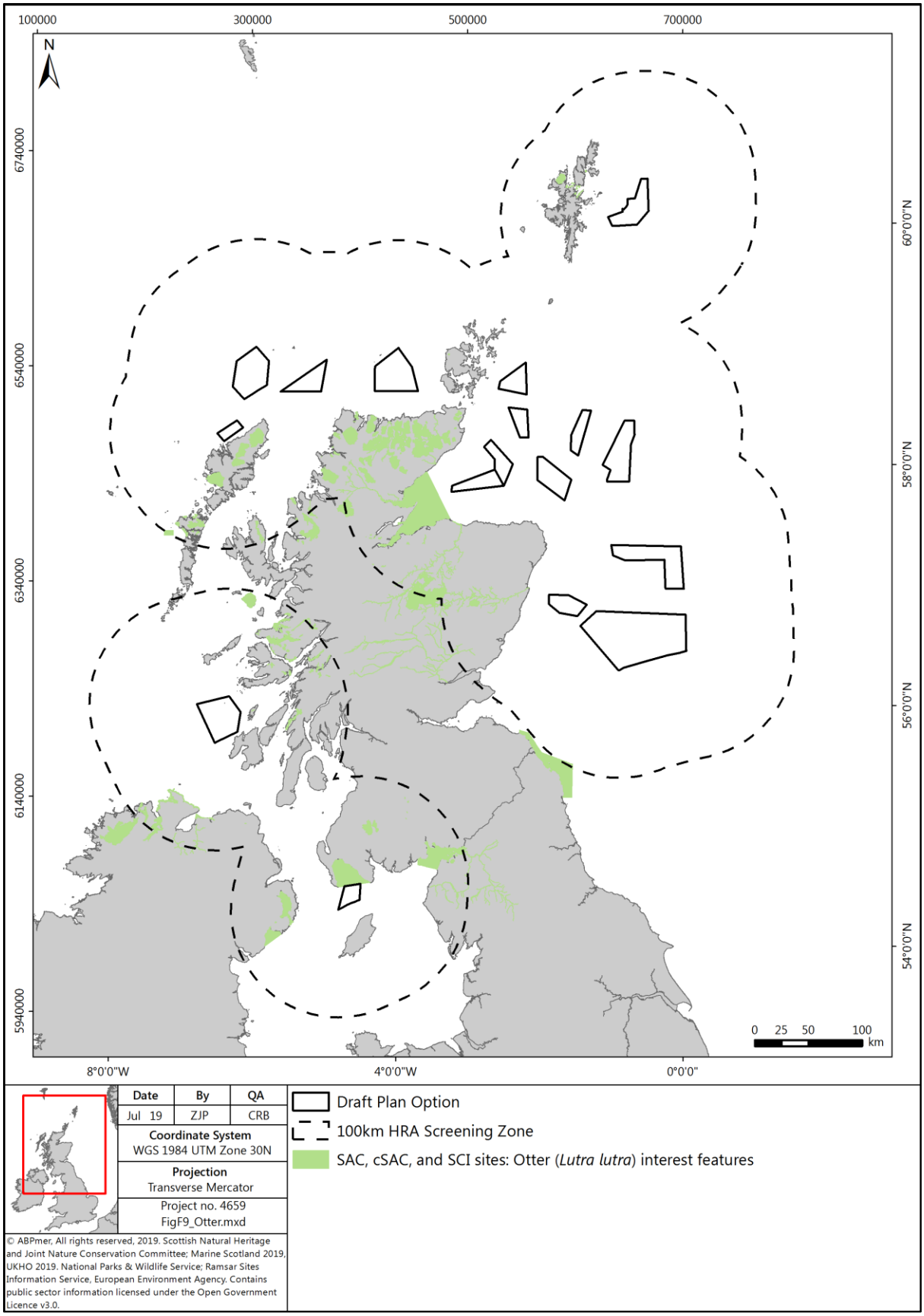


Figure F9. Otter European/Ramsar sites screened in for potential LSE

Appendix G. Seabirds Literature Review

G.1 Seabird Foraging Baseline Review for the Marine Sectoral Plan HRAs

This appendix reviews what is currently known about the foraging behaviour, feeding locations and distribution for coastal and offshore bird colonies (mainly breeding populations). It has been prepared to inform the HRA for the Sectoral Wind Plans for Offshore Renewable Energy (ORE) within Scottish waters. For the Sectoral WindPlan HRA, it is important to understand what current data exists to describe seabird distributions to inform the review of baseline conditions within Scottish waters and then evaluate the Plan's impacts. In particular, it is recognised, that a lot of work has been done in recent years to describe the distribution and behaviours of seabirds offshore in order to inform assessments of the impacts arising from coastal and offshore developments as well as to underpin marine spatial planning initiatives. The review presented in this appendix identifies this recent work to produce a stand-alone statement about the current 'state of knowledge' on sea bird distributions.

The focus of this review has been on birds foraging behaviour and 'at sea' distributions because it is during foraging excursions that birds are at risk of impacts from proposed marine renewables energy development (typically wave devices pose less of a threat to seabirds than tidal devices, and both present less of a hazard than offshore wind farms). This review has also considered seasonal migratory flyways and species-specific vulnerability to wind energy generation.

G.2 Key Data Sources

The recent work reviewed in this appendix includes the Future of the Atlantic Marine Environment (FAME) project which is a large-scale GPS bird-tagging exercise that is being lead by the RSPB. This project considers the foraging behaviour, direction and distances of seabirds from breeding colonies. FAME is designed to inform the designation of Marine Protected Areas (MPAs) and develop best practice management recommendations for these areas. This is a pan-European Union (EU) partner scheme involving the UK (as lead), Ireland, France, Spain and Portugal. In addition, STAR (Seabird and Tracking Research) which is a twin project to FAME, has also collected further tracking data from sites in the UK and Ireland. Data from these projects have been used to develop predictive species distribution models and high-density usage maps for a variety of species (Wakefield et al., 2017; Cleasby et al., 2018).

In addition to the FAME work, a review of the foraging ranges of 25 species of UK seabirds has recently been prepared jointly by BTO, RSPB and Birdlife International (Thaxter, 2012) with the aim of being used for scoping candidate MPAs has been

included in this report. This recent paper provides a robust and most up to date assessment of data which is useful to this HRA and helps towards a comprehensive view of seabird populations and behaviour in the area.

BirdLife International also created a online seabird foraging range database (http://seabird.wikispaces.com) which has also been reviewed in this appendix. This database was compiled by BirdLife and included seabird ecology and foraging ranges to be used to help identify important marine bird areas to help inform MPA designations and marine spatial planning.

In addition, a survey of the Pentland Firth and Orkney Waters area (PFOW) has been completed by APEM (2012) for Marine Scotland and The Crown Estate (TCE) and the report of this work has been obtained and reviewed. This report aims to gain a better understanding of the distribution and utilisation of sea space by birds in the Pentland Firth and Orkney Waters (PFOW) area. APEM (2012) undertook seven aerial surveys of the area between November 2010 and August 2011 . It has been included here because the PFOW area is an important location for marine energy resources as well as being a known important area for seabirds throughout the year. Also as part of the PFSA HRA (ABPmer, 2010) the BTO reviewed the degree to which seabird species are potentially exposed to effects within the PFOW area and identified which European/Ramsar sites outside the area may be affected. We have carried some of this information through into this HRA.

In addition to reviewing these data sources, throughout this appendix we have also drawn upon a Joint Nature Conservation Committee (JNCC) report looking at the distribution of seabirds in the study area (Pollock et al, 2000). This report considers data from surveys conducted in waters north and west of Scotland from 1979 to 1999. The results of this report give us a clearer understanding of where individual sea bird species are during different times of the year and provides good visual interpretations of the distribution of these species.

In addition to the above, European Seabirds at Sea (ESAS) information has been included (www.seamap.env.duke.edu last accessed 13/02/12). This is a collaborative dataset with inputs from the JNCC, and other north western European organisations. The dataset was established in 1991 with the aim of collecting data on the distribution of seabirds in north-west European offshore areas.

These data sources provide information at a wide range of spatial scales from a national scale (e.g. the OBIS Seamap) to a more regional scale (e.g. the recent APEM surveys of PFOW) and then to a local level (e.g. the individual bird tagging routes provided by the FAME project). Each also employs different methods and analysis and they cover different areas. This needs to be borne in mind when making any between-survey comparisons. However, collectively these data give a

very comprehensive description of the broad distributions and behaviours of the key bird species.

Information on the ecology of seabirds based on recent tagging studies for a range of species including Gannets (Langston et al., 3013; Soanes et al., 2013; Wakefield et al., 2013), Great Skua (Wade et al., 2014), Kittiwakes (Trevail et al., 2019) and Fulmars (Quinn, 2014) were also reviewed. In addition, research on the distribution and ecology of species during the non-breeding season has also be presented (such as Bogdanova et al., (2017); Glew et al., (2018) and Furness (2015)).

G.3 Seabird Foraging Behaviour

The distances over which waterbirds forage offshore has been reviewed to inform particularly the screening review for the Sectoral WindPlan HRA. For this review, information was drawn upon from a range of studies including those listed above and the other studies of seabird foraging distances that were undertaken by BTO (Roos et al 2009) as part of the PFSA HRA work (ABPmer, 2010), and reports reviewed therein including; Furness and Tasker (2000), Hamer et al., (2000, 2001, 2007), Suryan et al. (2000), Thaxter et al. (2010) and Wanless et al. (1990, 1991, 1998). The online BirdLife International (2018) seabird foraging database was also reviewed along with a number of other papers including; BirdLife International (2000), Fenny & Walls (2009), Ratcliffe et al. (2000) and Thaxter, 2012 and the maximum foraging ranges for each species were identified. Thaxter et al. (2012) was also reviewed to identify the mean maximum foraging ranges for each species. The reference section in each of the retrieved papers was also scanned to make sure that no relevant studies were missed. Where possible the methodology used in each study was identified, as different approaches may have intrinsic problems. The results are presented as a summary table showing mean maximum foraging ranges for each species along with text summaries for each of the species that forage over the greatest distances offshore (Table G1).

This summary review is designed to provide guidance of the sites and species that need to be considered during the screening and assessment work for this Plan-level HRA as well as for future project-level HRAs. Focus is on seabirds foraging offshore as opposed to species (especially waders) that forage in intertidal areas. In summary, the factors that might affect offshore seabird foraging range distances include:

- Spatial variation in food abundance (including anthropogenic factors such as fishing vessels);
- The risk of predation/kleptoparasitism by other bird species;
- The importance of nest attending to incubate eggs and protect nest from predators; and

- Weather and climatological factors (British Trust for Ornithology (Roos et al., 2009).

The distances that are typically covered by seabirds foraging offshore vary greatly between species and research and understanding of their foraging behaviour has increased in recent years. As part of this research, increasingly novel techniques and technologies are being developed to track birds and to investigate foraging behaviour. Over relatively short distances and timescales transects, ship-based surveys and radio-telemetry have been used (Pollock et al, 2000; Perrow et al., 2006; Wilson et al., 2009). To track birds over considerably greater distances and over larger time scales GPS data loggers are deployed, however they necessitate recovery of the data logger to extract information, or close approach for remote data download (Guilford et al., 2008; and the FAME work). The greatest opportunity to follow birds over potentially large distances and over extended time periods comes from satellite tracking, but at present this is only useful for birds of large body size such as northern gannet (Hamer et al., 2000; 2001; 2007). Radar is one of the more powerful tools available to describe the movement of birds in three-dimensional space and its use has been long-established and well described (Desholm et al., 2004). Relationships between foraging trip duration and, respectively, maximum distance from the colony and total trip distance have also been estimated for many bird species to determine foraging behaviour (Hamer et al., 2007). From the available range of literature sources and different methods, Table G1 presents the maximum and mean maximum (i.e. the maximum range reported from the studies reviewed in Thaxter et al., 2012 averaged across studies), foraging distances of seabirds (from breeding colonies).

A review as part of previous HRA screening work (ABPmer, 2010) highlighted seabirds that typically forage within 100km of breeding site and those which travel beyond 100km. Thaxter et al (2012) and the FAME project (Table G1) have been used to update foraging distance information taking account of advice from SNH and the PSG. Taking this updated information and following advice from SNH, an overall list of species with mean maximum foraging distances greater than 100km has been produced for screening the Sectorla Wind Plan HRA . These species are as follows (mean maximum foraging distances are highlighted in brackets):

- Atlantic Puffin (105 km);
- Manx Shearwater (330 km);
- Northern Gannet (229 km);
- Northern Fulmar (400 km); and
- Lesser Black-backed gull (141 km)

Although foraging distances are relatively well understood, less information is available to indicate foraging directions. However, the recent FAME studies are

providing a lot of new and useful data on this issue. The results from this and other previous analyses are reviewed below.

Table G1. Maximum and mean maximum foraging distances of seabirds (from breeding colonies) from a number of literature sources

Species Common Name	Maximum Foraging Range (km)								Mean Maximum Foraging Range (km)
	BirdLife International (2010)	BLI Mean Max	BTO Review (Roos *et al*., 2009 in ABPmer 2010)	Furness & Tasker (2000)	Ratcliffe et *al.* (2000)	Fenny & Walls (2009)	FAME/STAR	Thaxter *et al* (BTO/BLI/ RSPB) (2012)	Thaxter *et al* (2012)
Arctic Skua	100	40	Unknown	<10	≤5			75	63
Arctic Tern	20.6	12	25	<5	≤15	20-30		30	24
Atlantic Puffin	200	62	137	<50	≤40	40		200	105
Black Guillemot	55	12			≤5				
Black-headed Gull					≤15			40	26
Black-legged Kittiwake	200	66	83	<50	≤40	40	300	120	60
Common Eider	100	38						80	80
Common Guillemot	200	61	123	<50	≤40	40	340	135	84
Common Gull					≤15			50	50
Common Scoter	2	8	Unknown	-					

Species Common Name	Maximum Foraging Range (km)								Mean Maximum Foraging Range (km)
	BirdLife International (2010)	BLI Mean Max	BTO Review (Roos *et al*., 2009 in ABPmer 2010)	Furness & Tasker (2000)	Ratcliffe et *al.* (2000)	Fenny & Walls (2009)	FAME/STAR	Thaxter *et al* (BTO/BLI/ RSPB) (2012)	Thaxter *et al* (2012)
Common Tern	37	34			≤15	20-30		30	24
European Shag	20	16	17	<10	≤15	15		17	15
European Storm Petrel			Unknown	<50	>100			>65	
Gt. Black-backed Gull			Unknown	<10	≤40	40			
Great Cormorant	50	32	35	<5	≤15	15		35	25
Great Skua	100	42	31 (est.)	<10	≤40			219	86
Herring Gull			54	<10	≤40	40		92	61
Leach's Storm Petrel			Unknown	<50	>100			<120	92
Lesser Black-backed Gull					≤40	40		181	141
Little Gull	50								
Little Tern	11	7			≤5	20-30		11	6

Species Common Name	Maximum Foraging Range (km)								Mean Maximum Foraging Range (km)
	BirdLife International (2010)	BLI Mean Max	BTO Review (Roos *et al*., 2009 in ABPmer 2010)	Furness & Tasker (2000)	Ratcliffe et *al.* (2000)	Fenny & Walls (2009)	FAME/STAR	Thaxter *et al* (BTO/BLI/ RSPB) (2012)	Thaxter *et al* (2012)
Manx Shearwater	400	196	330	>50	>100			>330	330
Northern Fulmar	664	311	245	>50	>100	>100		580	400
Northern Gannet	640	308	540	>50	>100	>100		590	229
Razorbill	51	31	150	<20	≤40	40	312	95	49
Red-throated diver	50	12	13	<5				9	9
Roseate Tern	30	18			≤15	20-30		30	17
Sandwich tern	70	42			≤15	20-30		54	49
Velvet Scoter	20								
Highlighted species are those with mean maximum foraging ranges of ≥ 100km which meant that those European/Ramsar sites which support these species but lie outside the 100km pre-screening buffer zone needed to be considered at the screening stage.									

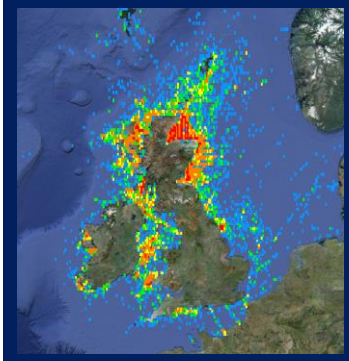
G.3.1 Species review

Those species listed-above which forage over long distances have been included in more detail in the following review. These species are reviewed particularly because they could forage within the short and long term option areas even though the European/Ramsar sites for which they are a qualifying interest features lie at some distance away. In particular, because they are likely to forage over distances of greater than 100km, the sites for which they are designated features could lie outside the 100km boundary area that was used to inform the screening of the AA. In addition, the Leach's storm petrel, great skua, black-legged kittiwake, razorbill, European storm petrel and common guillemot have maximum foraging distances >100km and these have also been reviewed. These reviews of foraging distances for individual species draw predominantly upon the information contained within the online BirdLife International (2018) seabird foraging database.

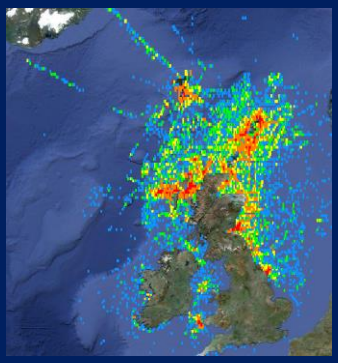
As a first stage analysis, for each species the relevant seabird distribution from OBIS Seamap is presented in Image G1 which presents data from the OBIS Seamap website. The data is presented in terms of density (birds/km2). This is achieved by summing the number of birds recorded in the transect, both on the water and flying, in each of the 1/36 ICES rectangles. This value is then divided by the area surveyed within that rectangle. In order to account for the variations in detection of birds on the water at different distances from the ship, the numbers of birds (excluding those flying) were multiplied by a factor according to species and width of the strip transect. The data in Image G1 represents the density for each species from 1978 to 2002. The information here demonstrates the value of Scottish waters and the SREZ as a whole to seabirds. This information and other data are reviewed for each key species below.

Some of the species listed above were tagged as part of the FAME project. Tagging work was carried out between April and August both in 2010 and in 2011 at various locations around the SREZ. GPS loggers (I-gotU GT-120, Mobile Action Technology) were attached to breeding birds using a temporary attachment method that would allow the tag to fall off the birds in the event that they were not re-caught. The tags recorded the bird's location once every 100 seconds to an accuracy of approximately 15 m which provided high resolution location data. Data collated from the tags were only accessible by re-catching the bird to remove the tag between one and five days after attachment. Images G2-G4 show foraging patterns over a two-year period of Common Guillemot, Kittiwake, Razorbill, European Shag and Fulmar at various locations around the SREZ. It is clear from the images that at some locations, for example Colonsay there are foraging hotspots for the majority of the species tagged. Further research into foraging activity of these birds in relation to physical processes (e.g. tidal flows) and other biological surveys (e.g. seabird prey

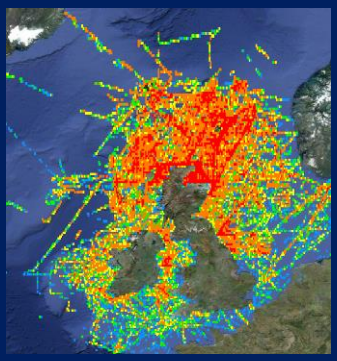
location) is being undertaken by RSPB (Owen, 2012) but there are no publicly available results to date.



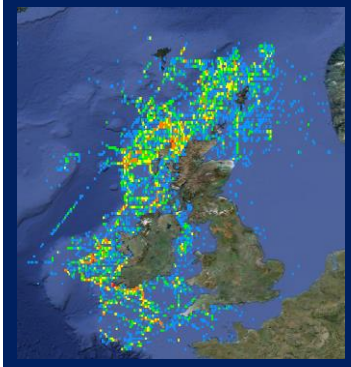
Razorbill



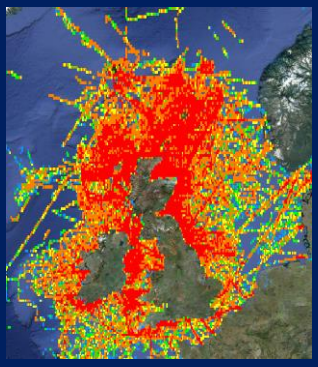
Atlantic Puffin



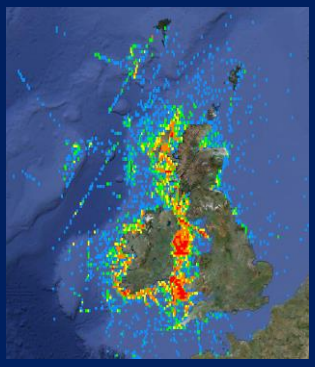
Northern Fulmar



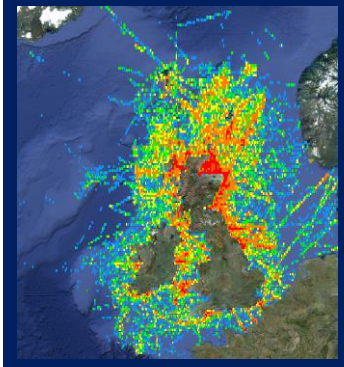
European Storm Petrel



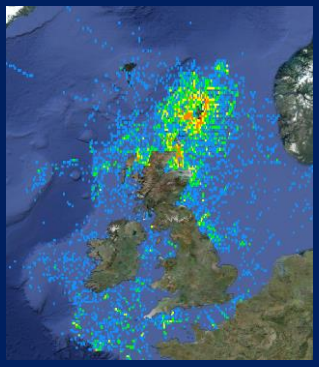
Leach's Storm Petrel



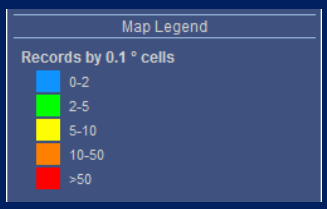
Manx Shearwater



Black-legged Kittiwake



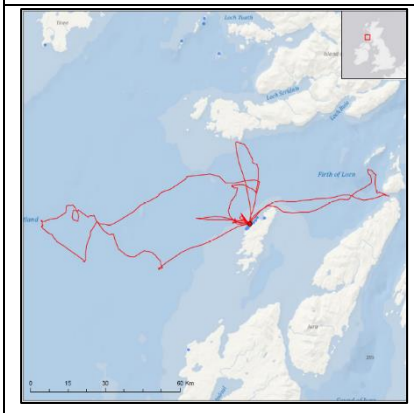
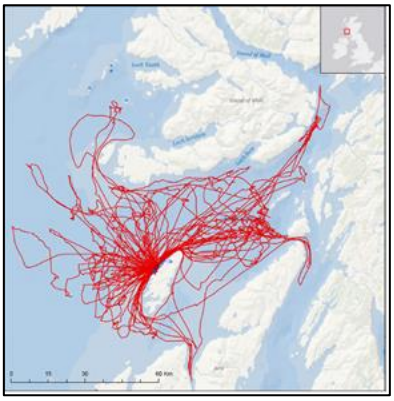
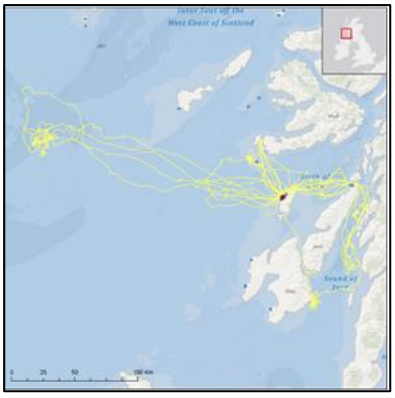
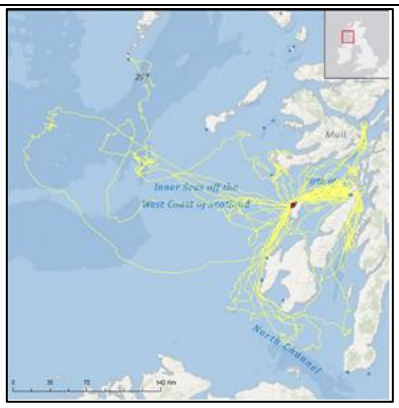
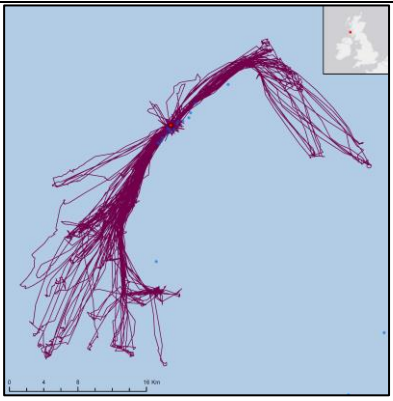
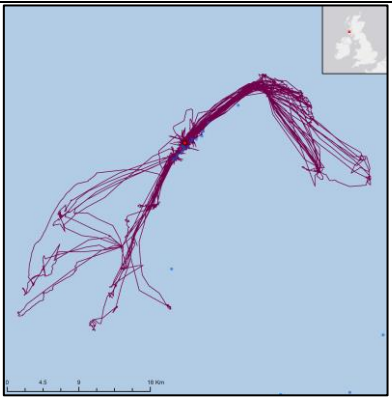
Great Skua



.www.seamap.env.duke.edu

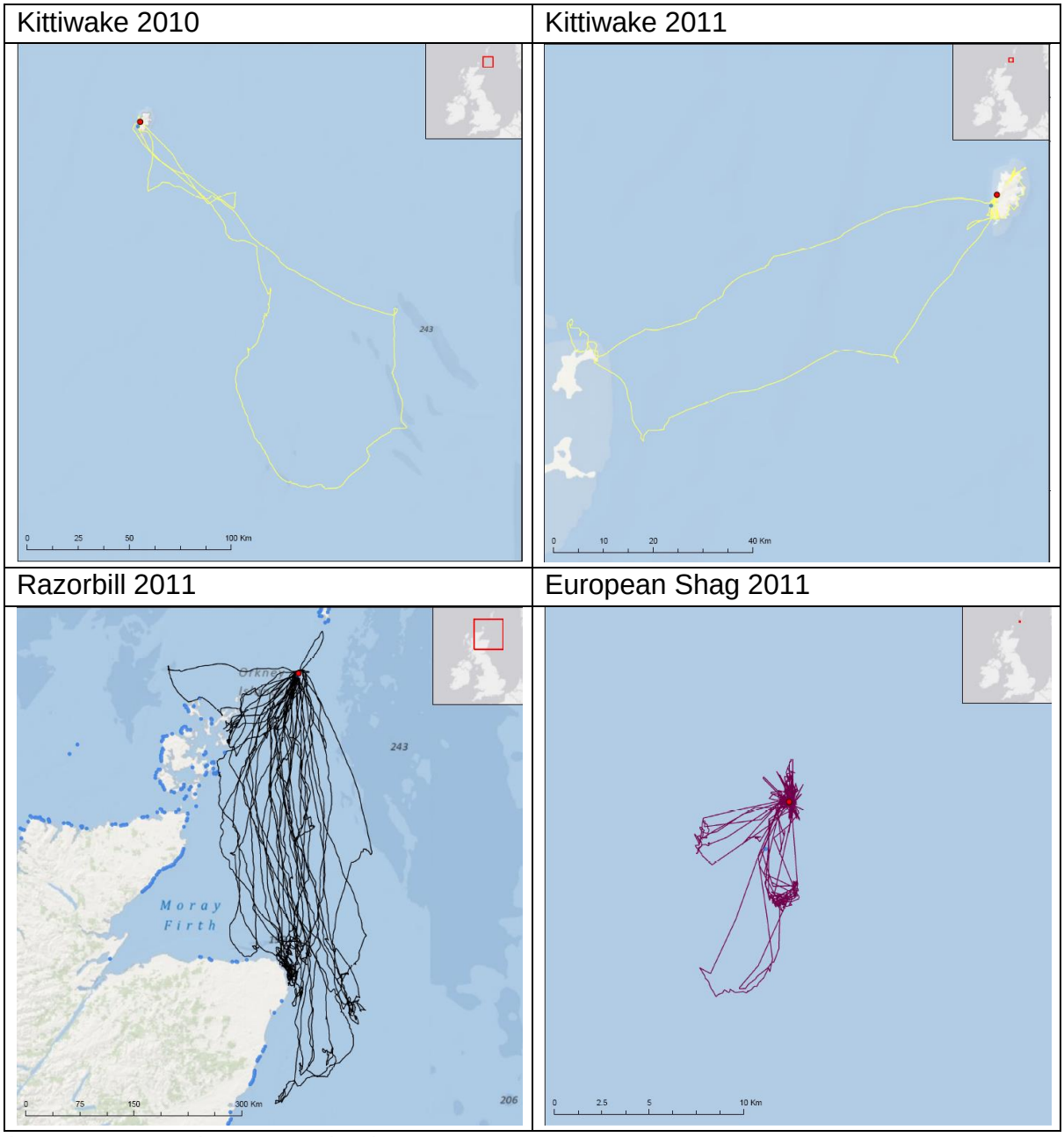
last accessed 13/02/12

Image G1. Data From OBIS-Seamap (Seabird Distribution and Abundance Data for Each Month From 1978 to 2002)

Common Guillemot - 2010	Common Guillemot - 2011
	
Kittiwake - 2010	Kittiwake - 2011
	
Razorbill 2010	Razorbill 2011
European Shag 2010	European Shag 2011
	

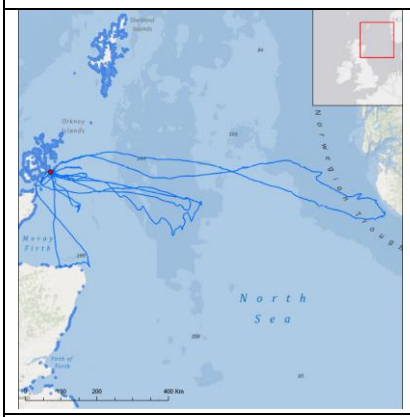
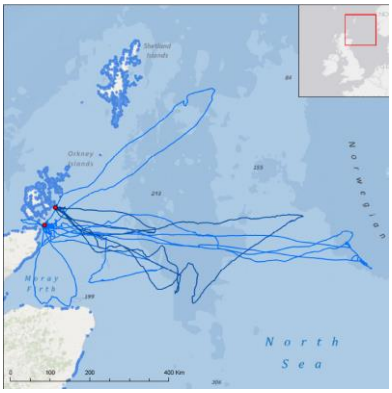
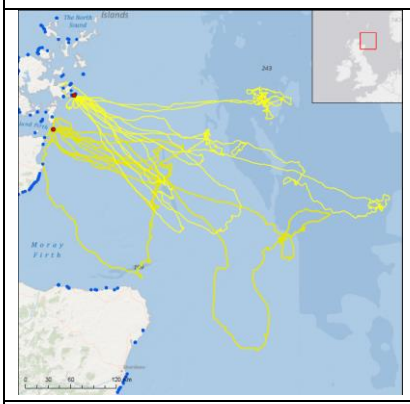
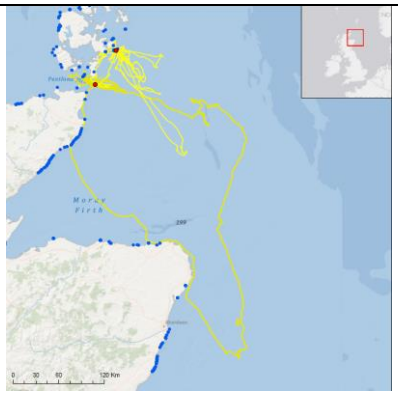
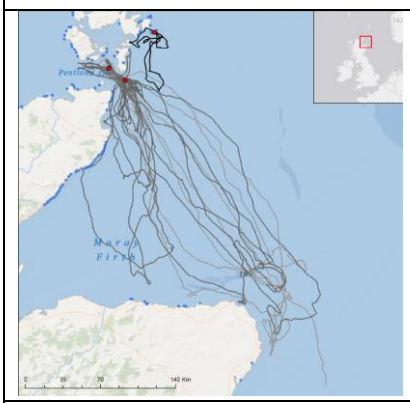
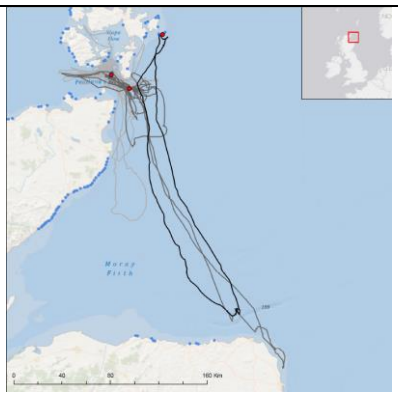
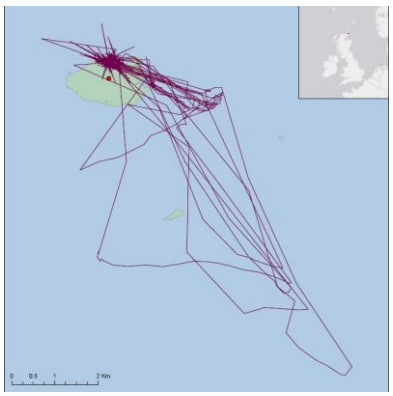
(Source: RSPB/FAME project)

Image G2. Foraging tracks of seabirds from Colonsay



(Source: RSPB/FAME project)

Image G3. Foraging tracks of seabirds from Fair Isle

Fulmar 2010	Fulmar 2011
	
Kittiwake 2010	Kittiwake 2011
	
Razorbill 2010	Razorbill 2011
	
European Shag 2010	European Shag 2011
	

(Source: RSPB/FAME project)

Image G4. Foraging tracks of seabirds from Orkney

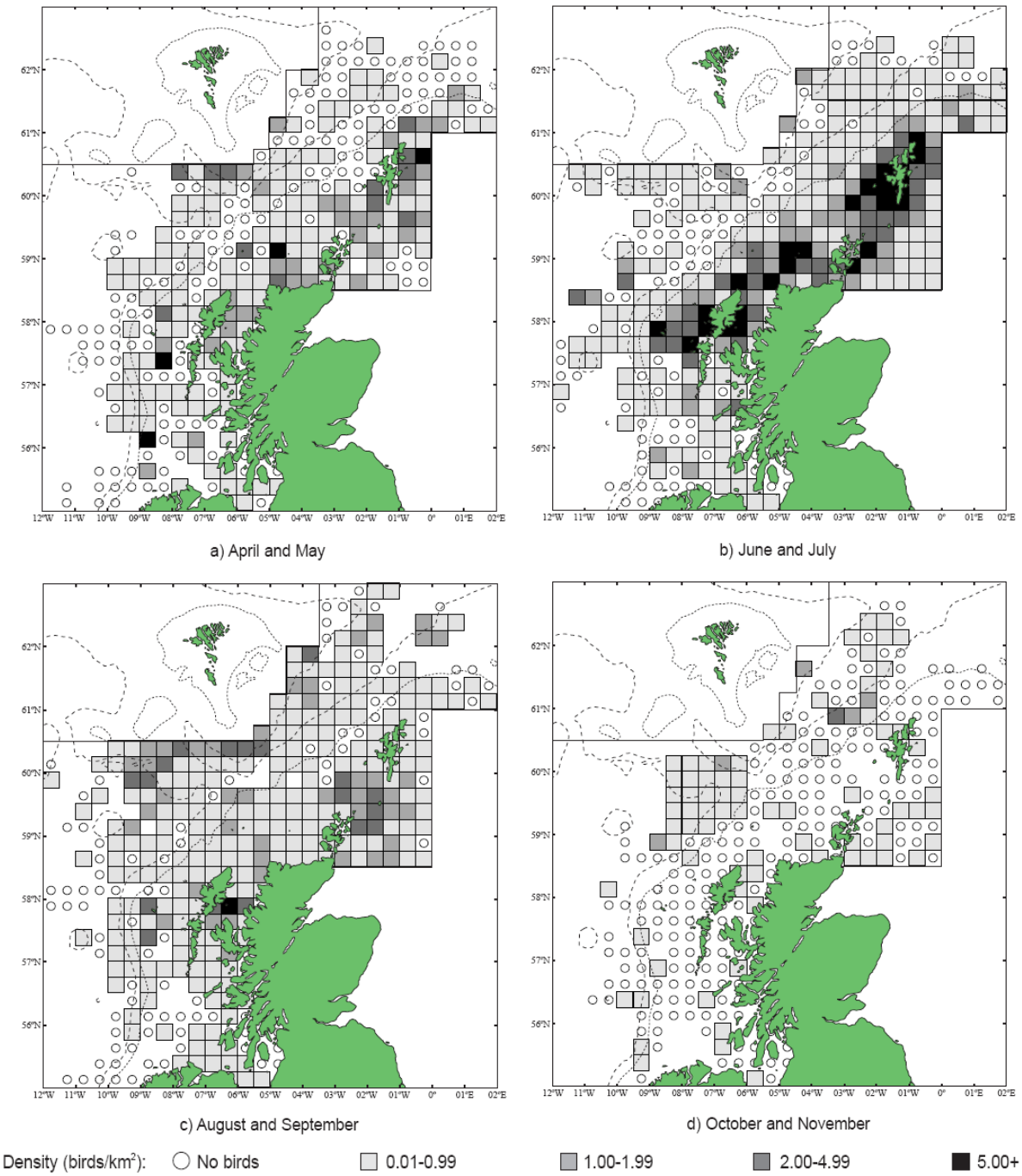
G.3.2 Atlantic Puffin Fratercula arctica

Atlantic Puffins (hereafter Puffin) from north west Britain disperse widely and have been observed in Newfoundland, the Canary Islands and the Mediterranean. Puffins are pelagic and more work is required to gain a better understanding of where they spend their time away from the colony.

One study in 1987 used direct tracking to study the foraging range of Puffins breeding on Isle of May, Scotland, using a VHF radio transmitter. Of the trips made 64% were within 2km, 7% between 2-10km and 29% more than 10km (Wanless et al., 1990). Transect surveys around the Isle of May also found that Puffins were most common close to the colony but on some occasions birds occurred at a sandbank, the Wee Bankie, 40km away.

After a crash of herring stocks near to the colony, Puffins at Røst Island, Norway were observed to travel at least 137km to fishing grounds (Anker-Nilssen and Lorentsen, 1990). Another study (Pearson, 1968) also estimated that Puffins breeding on the Farne Islands could forage a maximum distance of 137km from the colony. Based on average trip durations at UK colonies (various sources) and flight speeds of 82km/h one study suggested a potential range of over 200km from Great Island, Newfoundland, Canada (Bradstreet & Brown, 1985), which has now been supported by Birdlife International and Thaxter et al, (2012). Therefore, for the purposes of the Sectoral Marine Plan HRA, this mean maximum quoted foraging range has been assumed for Puffin (see Table G1).

Puffins arrive during April and May for the breeding season, with a large percentage foraging over shelf waters (Image G5a). From June to July, highest densities of Puffins occurred with concentrations around the main breeding sites (Image G5b) of Shetland, Orkney, North Rona, the Shiants and St. Kilda (Pollock et al, 2000 and APEM 2012) with Orkney having particular importance to breeding auks, with an estimate by Mitchell et al (2004) of 250,000 individuals in the area. Image G5b demonstrates that low to moderate densities are observed beyond the shelf edge and over deep water as far west as the Rockall Trough and north to the Norwegian Sea. It is suspected that these are most likely non-breeding individuals as it is thought that breeders will generally forage nearer the colony. From August onwards the species are most widespread in deep waters (Image G5c), possibly due to leaving the colonies as the chicks have now fledged (Stone et al, 1995). October onwards birds leave the area and migrate south for the winter (Image D6d). The Pollock et al., (2000) data does not cover the east coast area but the OBIS mapping (Image G1) fills this gap to some degree and, in particular, shows how this area is also of high value for this species including especially the Forth Islands SPA site and the waters around it.



(Source: Pollock *et al*., 2000)

Images G5.a-d Puffin Distribution

G.3.3 Black-legged Kittiwake *Rissa tridactyla*

The foraging range of Kittiwakes has been widely studied using a range of techniques. Radio tracked Kittiwakes were found to forage a maximum of 62km in Prince William Sound, Alaska (Ostrand et al., 1998), and over 40km at Sumburgh Head, Scotland (Hamer et al., 1993). Kittiwakes have also been calculated to forage 55km from a colony at Farne Island based on mean trip duration of 158 min during chick-rearing, and a flight speed of 48km/h (Pearson, 1968). A study at Prince Leopold Island, Canada used aerial surveys of Kittiwake densities. They found that during chick-rearing Kittiwakes were most abundant within 48km of the colony, although some large concentrations were found up to twice that distance away (Nettleship & Gaston, 1978). High concentrations of Kittiwakes have also been observed 20-30km from the nearest colonies at Caithness, Scotland (Mudge & Crooke, 1986) and at 30km from a colony on the Isle of May (Wanless et al., 1998). Both Daunt et al., (2002) and Humphreys et al., (2006) recorded that the maximum foraging range for Kittiwakes on the Isle of May was 83km.

Foraging distances have been shown to be dependent on prey availability. Suryan et al., (2000) found that increased foraging distances at two separate colonies at Prince William Sound, Alaska were associated with low prey abundance. In years where herring dominated diets mean distance to the farthest feeding location was 40km, whereas when Kittiwakes consumed other species foraging distance increased to 60km, with the maximum recorded foraging range being 120km (Suryan et al., 2000). GPS tagging of 464 Kittiwakes as part of the FAME/STAR projects recorded a maximum foraging range of 300km (Wakefield et al., 2017).

According to Thaxter et al. (2012) their mean maximum foraging distance is 60km and this value will be used for the purpose of screening the Sectoral Wind Plan HRA (see Table G1).

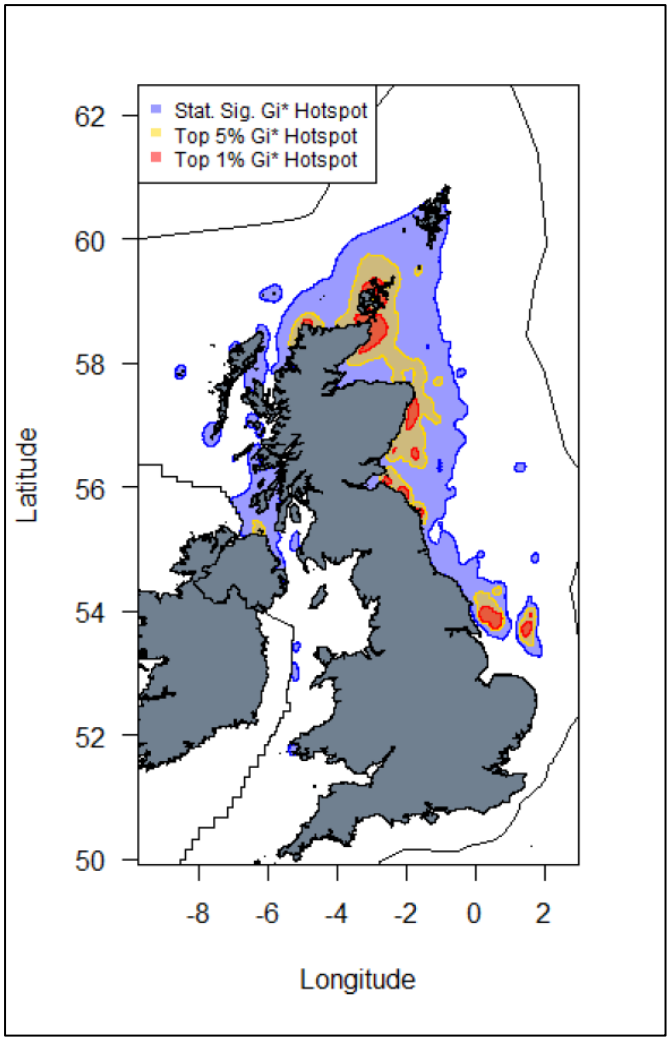
The distribution of Kittiwakes has been considered for the JNCC by Pollock et al 2000 and APEM 2012. From January to April highest densities were over the continental slope along the Rockall Trough (Pollock et al 2000) (Image G6a). Kittiwakes are scavengers and this area is associated with fishing vessels and so the high abundance in this area is most likely due to this. May to July Kittiwake distribution is much more coastal and close to colonies (Image G6b) as this is the breeding season. August and September the distribution is patchy, Image G6c. October to December Kittiwakes are in inshore waters west of Scotland, lowest numbers were recorded offshore at this time (Image G6d) (Pollock et al, 2000). Of the small gulls identified in the APEM (2012) report Kittiwakes were the most abundant species resulting in 72% of all small gulls recorded. Kittiwakes also had the most consistent pattern of abundance which is likely to be a consequence of their nomadic behaviour across the north Atlantic in the winter (Wernham et al, 2002).

The Pollock et al., (2000) data does not cover the east coast area but the OBIS mapping (Image G1) fills this gap to some degree and, in particular, shows how this area and the coastal waters are also of high value for this species including those from a range of SPA sites along this coastline (e.g. Troup, Pennan and Lion's Head SPA; Buchan Head and Collieston Coast SPA).

Important areas of high seabird density at sea, based on hotspot mapping techniques derived from large-scale seabird tracking as part of the FAME and STAR projects
emphasized the importance of areas along the entire east coast of Scotland and off the coast of Yorkshire (in proximity to where some of the largest Kittiwake colonies are located) for Kittiwake. In addition, hotspot areas were identified around the coast of Shetland, the Hebrides, Northern Ireland and North-East England (Image G7) (Cleasby et al., 2018; Wakefield et al., 2017).

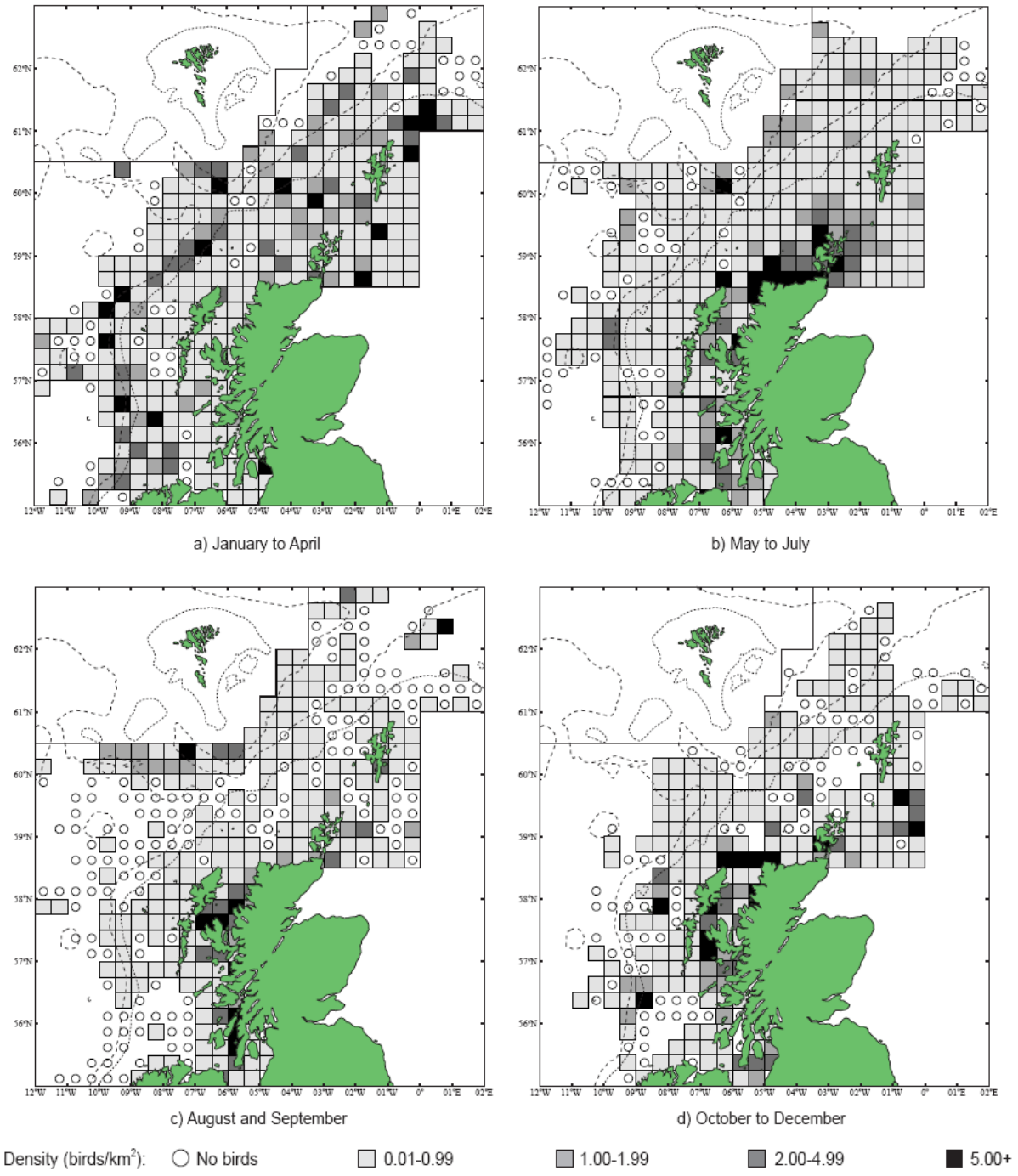
Kittiwake foraging behaviour has been shown to be influenced by temporal cycles. For example, Trevail et al., (2019) found that Kittiwakes adjusted their foraging habitat selection according to the tidal cycle. Kittiwakes not only showed a preference for foraging nearer breeding colonies but that habitat selection changed over the 12.4-h tidal cycle, most likely because of changes in resource availability.

Spatial and temporal variations in migration has been linked to breeding success in Kittiwakes. Bogdanova et al. (2017) found that both successful and unsuccessful breeders wintered primarily in the north-west Atlantic. However, at some colonies, breeding success affected the timing of migration, whereby unsuccessful breeders departed the colony earlier, arrived at the post-breeding and main wintering areas sooner, and departed later the following spring.



(Source: Cleasby *et al*., 2018)

Images G6 Map displaying hotspots identified at the UK-level for Kittiwake.



(Source: Pollock *et al*., 2000)

Images G7.a-d Kittiwake Distribution

G.3.4 Common Guillemot *Uria aalge*

The foraging behaviour of auks, including foraging range, has been studied in depth for many years throughout the UK and North America using a variety of different methods. Numerous studies have taken place in Scotland, in particular at the Isle of May (Tasker et al., 1987, Thaxter et al., 2009; 2010, Wanless et al., 1990; 1998). The most recent of these surveys by Thaxter et al. 2009 and 2010, used bird-borne compass loggers to study foraging ranges. Thaxter et al., (2009) found that of 19 Common Guillemots breeding on the Isle of May (28 trips from 11 males plus 29 trips from 8 females), the maximum range for males was 14.4 ± 6.6km and 7.9 ± 5.3km for females. During a similar study Thaxter et al., (2010) observed 61 Guillemots travel an average distance of 34.5km/trip (±29.8), with the maximum observed distance from the colony being 14.1km (±12.2).

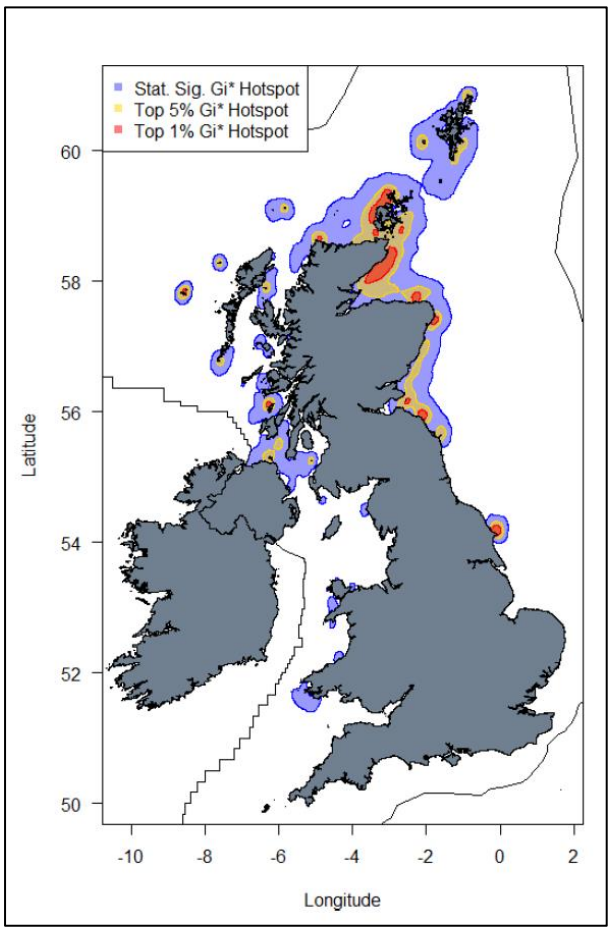
A study from North America (Cairns et al., 1987), used data loggers in combination with recorded flight speed, to estimate that the longest foraging range for Guillemots was 123km during incubation and 80km during chick rearing. However, median foraging ranges were much smaller.

GPS tagging of 178 Guillemots as part of the FAME/STAR projects recorded a maximum foraging range of 340km (Wakefield et al., 2017). The FAME project has had some recent findings using high resolution tagging with GPS tags which are able to record a bird's location with a high frequency (as described above). Using this method it has found that the maximum known foraging distance for Guillemots is currently 340km. According to Thaxter et al. (2012) their mean maximum foraging distance is 84km and this distance has been used for the purpose of screening the Sectoral Wind Plan HRA (see Table G1).

The JNCC have considered the distribution of guillemots in Scottish waters (Pollock et al, 2000), see Image G8. Near-shore concentrations were very high May to July with the highest densities of Guillemots found around Shetland, Orkney, along the northern coast of Caithness and Sutherland (Image G8a). It is thought that the reason for this is because this is during the breeding season and so birds are expected to stay relatively close to the nest with most breeding birds feed within 55 km of their colony (Leaper et al, 1988). August to September Guillemots undergo a complete body moult and so are unable to fly. During this time they gather inshore (Image 89b). There are fewer numbers present than during the breeding season, due to some Guillemots moving to the Irish Sea (Harrison et al, 1989; Pollock et al, 1997; Pollock et al, 2000), into the North Sea and Faroe Bank (Tasker et al, 1986). October to November the moulting flocks have moved offshore (Image G8c). December through to April Guillemots are more widely dispersed with the highest concentrations over the continental shelf (Image G8d). Although birds do visit

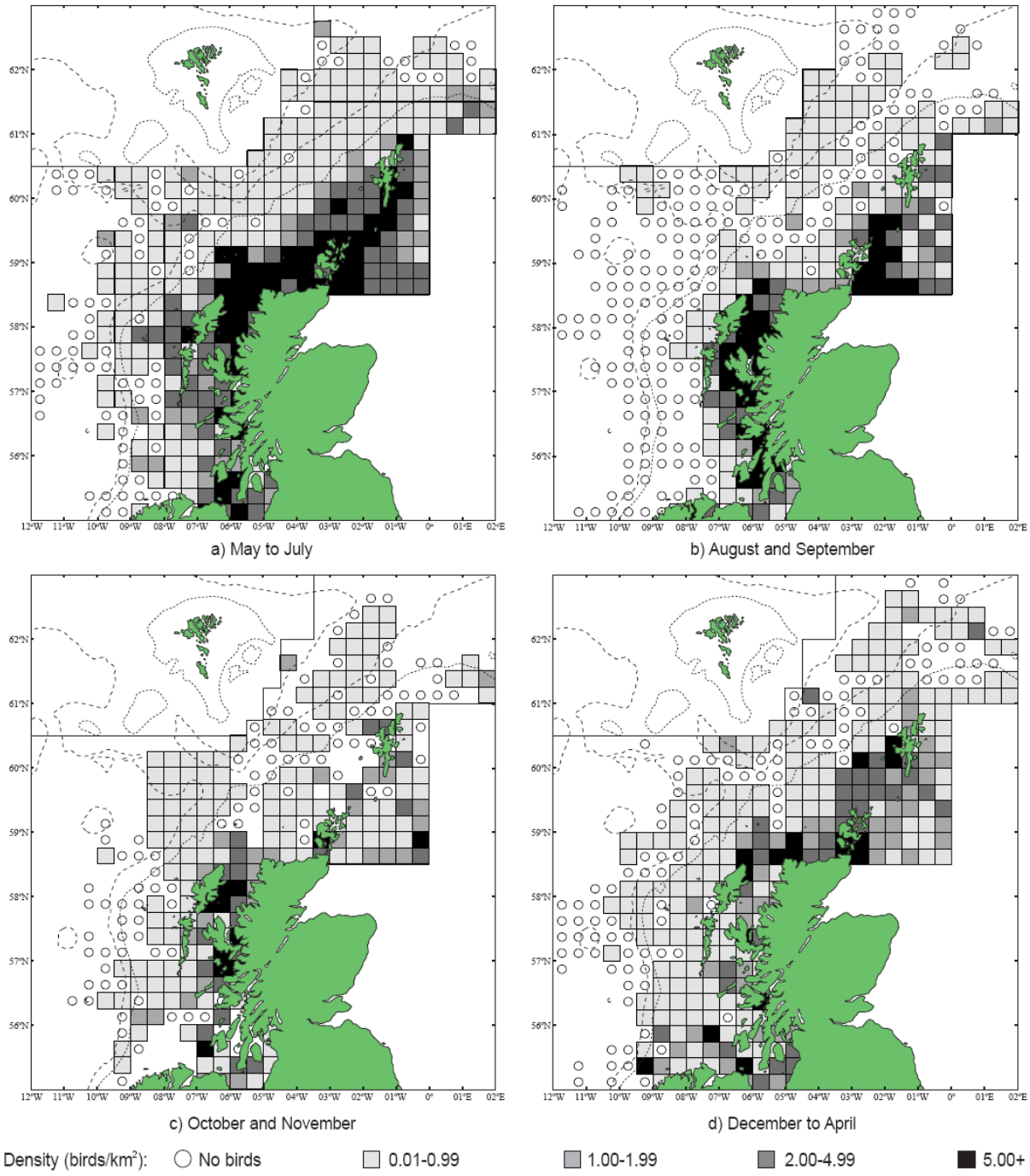
colonies during autumn and winter months, highest densities were during April (Pollock et al, 2000).

Important areas of high seabird density at sea, based on hotspot mapping techniques derived from large-scale seabird tracking as part of the FAME and STAR projects
emphasized the importance of emphasized the importance of areas along the entire east coast of Scotland with other hotspots also evident around some of the larger UK colonies, e.g. Flamborough Head, Yorkshire or Rathlin Island, Northern Ireland. In addition, Guillemot hotspots in the Irish Sea were identified, including areas off the Pembrokeshire coast and Anglesey (Image G9) (Cleasby et al., 2018; Wakefield et al., 2017).



(Source: Cleasby *et al*., 2018)

Images G8 Map displaying hotspots identified at the UK-level for Guillemot



(Source: Pollock *et al*., 2000)

Images G9.a-d Common Guillemot Distribution

G.3.5 Common Scoter Melanitta nigra

A number of studies into the foraging range of Common Scoter have taken place off the Welsh coast. At Llanfairfechan concentrations of birds were found between 1-4km offshore and at Red Wharf Bay the majority of birds were more than 3km offshore (Kaiser, 2004). In Conwy Bay birds were also recorded 3-4km offshore (Kaiser et al., 2006). However, studies over Lithuania and Estonia, using radar observations, recorded massive summer movements of Scoter with birds travelling 20-30km from the shore over the Baltic Sea (Kumari, 1979; Zalakevicius & Jacoby, 1992).

Based on an estimate by BirdLife International (2010), the maximum foraging range of Common Scoter has been given in Table G1 as 8km and this value has been used for the purposes of the Sectoral Wind Plan HRA. Therefore, this species is not included within the screening report as a long-distance foraging species that then requires the additional consideration of sites outside the 100km buffer area. It is worth noting however that a value of 200km is incorrectly quoted on the BirdLife International website and was used for screening the OWE HRA (ABPmer 2011). Care will be needed to avoid using this erroneous value in future project-level assessments and Plan reviews.

G.3.6 European Storm Petrel *Hydrobates pelagicus*

There is a lack of detailed information on the foraging ranges of the European Storm Petrel. A study by Thaxter et al., (2012) found that the maximum foraging distance of European Storm Petrels is >65km. Image G1 shows that there is a high abundance of European Storm Petrels off the North-west coast of Scotland, especially around Orkney and Shetland.

G.3.7 Great Skua Catharacta Skua

As with the Arctic Skua, there is little detailed information on the foraging ranges of Great Skua. A number of studies (Votier et al., 2004; 2006, Wood, 1989) have found that Great Skuas feeding on seabird prey tend to have small foraging ranges confined to the coastline of their breeding colonies, and seldom move more than 2km from their nest site (Votier et al., 2004). In contrast Great Skuas feeding on fish will often travel long distances to find them at sea. As such Thaxter et al (2012) has spilt this species into colony based foraging and offshore foraging activities. The study by Votier et al., (2004) used radio-transmitters to track Great Skuas at Hermaness. Those feeding on discards often flew several tens of km to fishing fleets off Muckle Flugga. Smith & Jones (2006) indirectly estimated a foraging range of

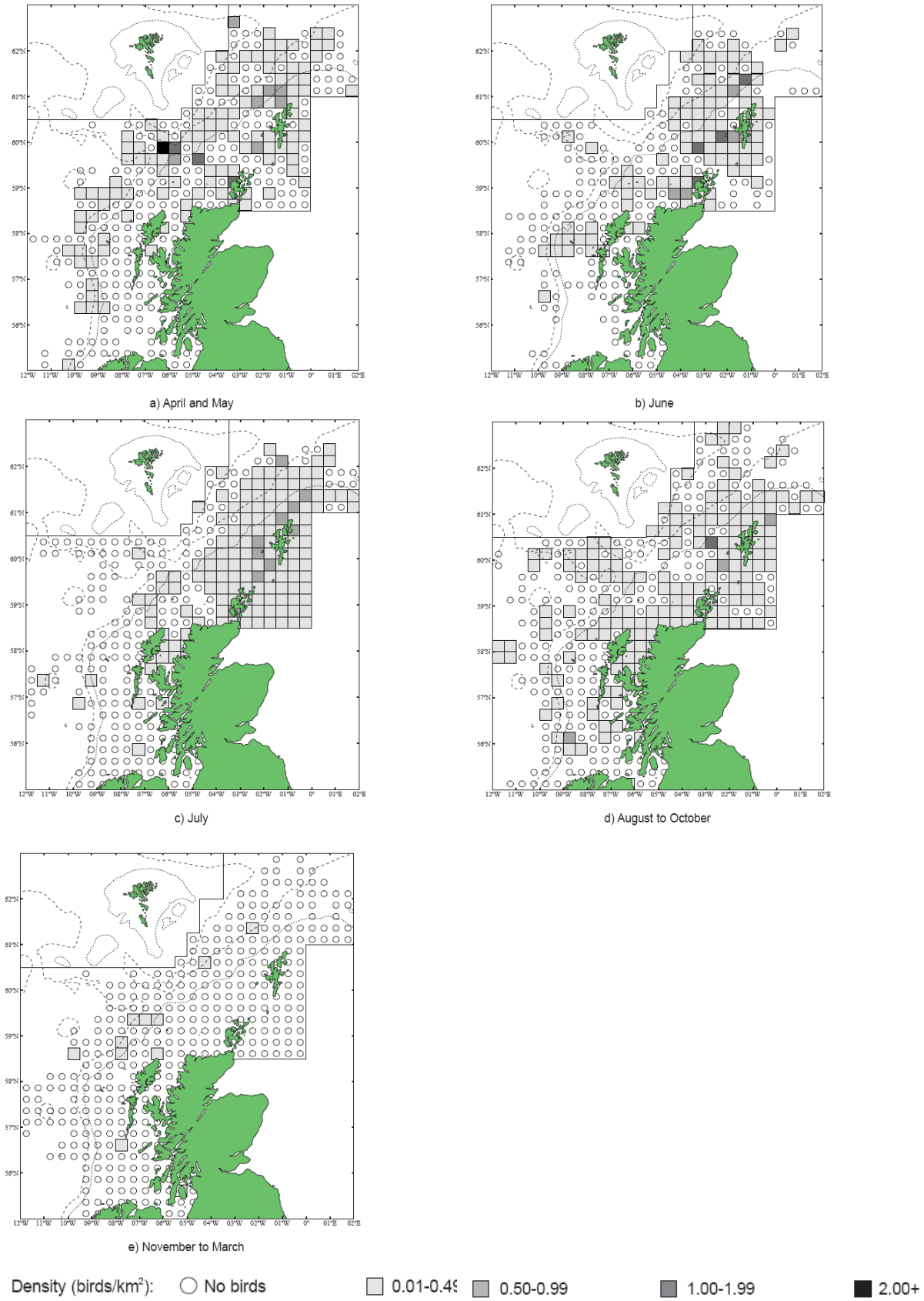
31km for Great Skua following the recovery of a bird ring from a Razorbill chick in a Skua pellet.

During the early-mid 1970s the estimated maximum foraging range of breeding Great Skua on Foula was 14km, based on the mean length of foraging trips of around 35 minutes (Furness, 1978). However, probably due to a reflection of changes in diet, foraging trip durations have become far longer in more recent years. Throughout the 1994 and 1995 breeding seasons, feeding trips were taking in excess of one hour, with a median length during chick-rearing of more than 3.5 hrs, and some breeding adults could easily have been ranging much further afield, perhaps 50-100km or more (BirdLife International, 2010). Increased foraging distances in more recent years compared with historic data was also identified by Wade et al. (2014).

As recorded by Thaxter et al¸ 2011 and 2012, the maximum distance for Great Skuas feeding on discards (offshore) is 219km. This distance has been rounded up to 220km for the purpose of screening this Sectoral Wind Plan HRA, (see Table G1).

The JNCC have considered the distribution of Great Skuas in Scottish waters (Pollock et al, 2000). From April to May Great Skuas are widespread but in fairly low densities (Image G10a), with larger numbers around the colonies in Orkney and Shetland and in offshore waters Great Skuas are found along the shelf break. There is a high concentration of birds in the south-west area of the Faroe-Shetland Channel, where the birds are associated with fishing vessels (Pollock et al, 2000). The distribution of Great Skuas in June is still widespread inshore and around Orkney and Shetland (Image G10b) but the number offshore has reduced as mature birds will have started nesting at this stage (Pollock et al, 2000). Along the continental shelf around the Northern Isles low numbers of Great Skuas are recorded across a wide area (Image G10c), with moderate numbers recorded around the colonies as breeding birds forage in close proximity to the colonies. The offshore distribution of birds were again in low numbers and in waters closest to the Northern Isles possibly due to immature birds which visit club sites (sites made up of non-breeders) within colonies before departing in August (Tasker et al, 1985b and Pollock et al, 2000). Associations with fishing vessels are widespread north of Scotland although again the densities recorded are low. Fishing vessels and their discards form an important part of breeding Skuas diet (Pollock et al, 2000).

While the Pollock et al., (2000) data does not cover east coast but the OBIS mapping (Image G1) shows that while the PFOW area is of highest value (as indicated above by Pollock and JNCC studies), the east coast also supports areas of Great Skua foraging. This includes particularly the mouth of the Moray Firth. However, there are no European/Ramsar sites for this is an interest feature species outwith the PFOW area and Outer Hebrides (Handa and St Kilda SPAs).



(Source: Pollock *et al*., 2000)

Image G10.a-e Great Skua Distribution

G.3.8 Leach's Storm Petrel *Oceanodroma leucorhoa*

There is a lack of detailed information on the foraging ranges of the Leach's Storm Petrel. A study by Thaxter et al., (2012) found that the maximum foraging distance of Leach's Storm Petrels is <120km and their mean maximum foraging distance is 92km.

G.3.9 Lesser Black-backed Gull *Larus fuscus*

Lesser Black-backed Gulls (LBBG) fly readily and strongly, at low and medium altitudes, and less frequently in upper airspace. Furness et al., (2013) recorded that an estimated 30% of LBBGs fly at blade height and they, amongst other large gull species, have a high collision risk with offshore wind turbines. ORJIP (2018) findings were higher again, showing that 67% fly at blade height and found that they also display variable flight patterns and foraging behaviour.

LBBGs have a wide breeding range which covers the area from Iceland, all the way east to the Taimyr peninsula and south to Portugal. They have colonies of breeding populations on the west coast of England and Wales and in Central Scotland, specifically Alde Ore Estuary and the Firth of Forth.

LBBGs are a highly migratory species outside of their breeding season, travellimg along the west coast of Europe and Africa, sometimes as far as Nigeria.

A study by Thaxter et al., (2012) found that the maximum densities of LBBGs were recorded foraging 181km from colonies. The mean maximum foraging distance was recorded as 141km and has been used for screening the Sectoral Wind Plan HRA.

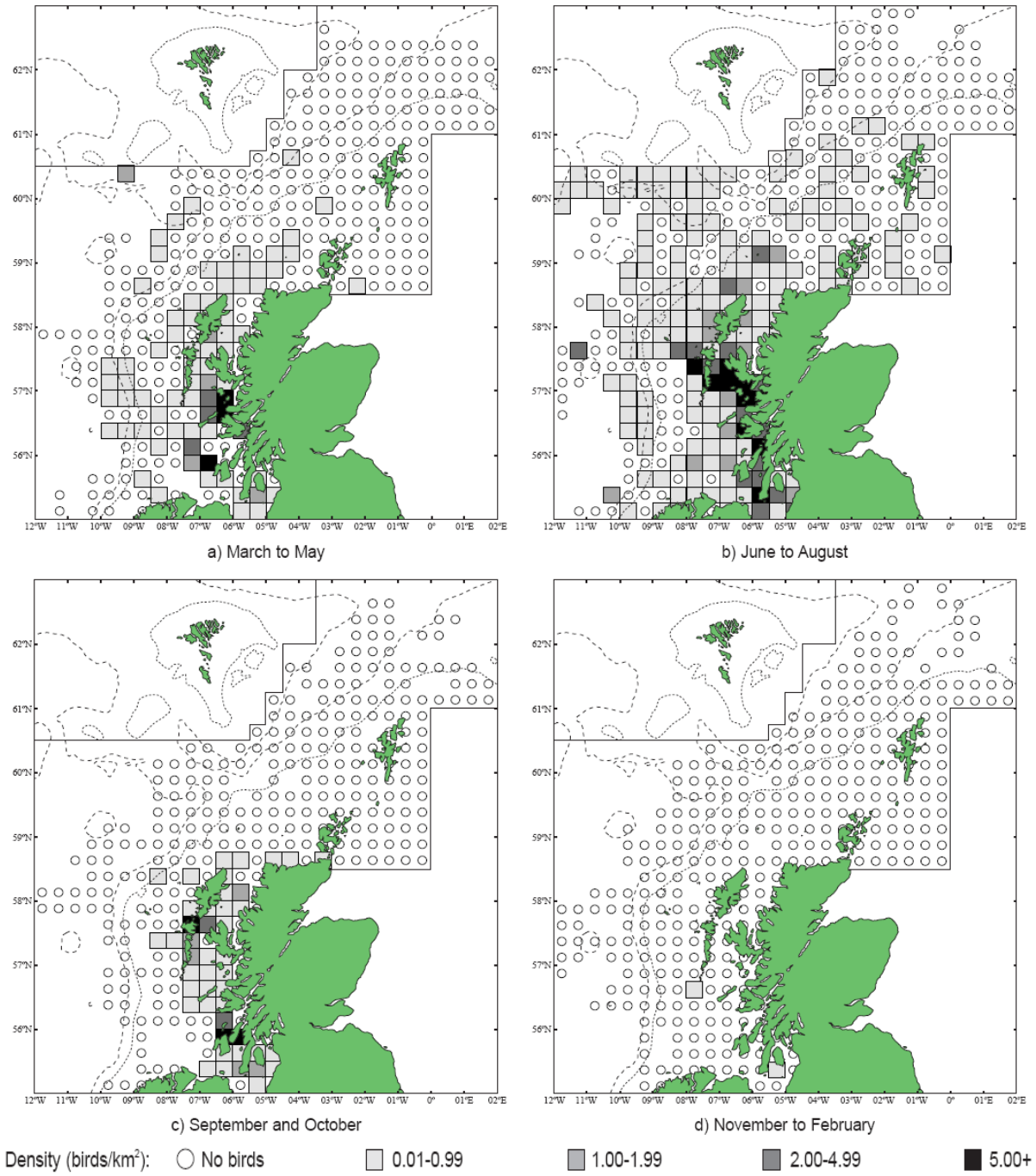
Thaxter et al., (2015) made an interesting study of foraging behaviour of LBBGs from Alde-Ore, England using GPS-telemetry. These birds were tracked and only small spatio-temporal overlaps with the offshore wind developments were observed. Similar findings were also observed by Champhyusen (2011).

G.3.10 Manx Shearwater Puffinus puffinus

Guilford et al., (2008) made an interesting study of foraging behaviour of Manx Shearwaters from Skomer Island, Wales using GPS tags attached to individuals. These birds were tracked flying north to the Mull of Galloway to feed, travelling a straight-line distance of more than 330km each way. Another study by Brooke (1990) estimated that Manx Shearwater could travel as far as 360km from the colony during chick rearing, based on an absence of two days, a flight speed of 45km/hr and 8hr flying in each direction (although the values chosen for the time spent flying were arbitrary). A conservative estimate of 400km, as set out in Table G1, has been given as maximum foraging range for Manx Shearwater, based on the assessment by BirdLife International (2010). This value has been used for screening the Sectoral Wind Plan HRA.

The JNCC have considered the distribution of Manx Shearwaters in Scottish waters (Pollock et al, 2000). They use this area to breed during the summer and start to return to the study area in March. Relatively low numbers were recorded during this time with the highest number recorded near Rum (Image G11a) which holds one of the largest Manx Shearwater colonies in the world with an estimated population of 61,000 pairs (Furness 1997) as in the Natura 2000 standard data form. Between June and August Manx Shearwaters are very widespread, as far west as Lousy Bank, but, with highest numbers recorded close to the colonies along the west coast (Image G11b). Birds were also recorded north-eastwards along the Faroe-Shetland Channel and east towards Shetland and Orkney (Pollock et al, 2000). It is supposed that sightings in these areas are due to the immature non-breeding birds (Brooke, 1990). From September and October, the numbers reduced dramatically (Image G11c) as birds migrate southwards. The birds that are still in the area were found to be restricted to inshore waters along the west coast, this population is made up of adults that have finished breeding and left the colonies and chicks that fledge in mid-September (Brooke, 1990). During the winter months, November to February, Manx Shearwaters are rarely recorded in the region (Image G11d) as most have migrated by this time, spending their winter off the east coast of South America (Brooke, 1990).

The Pollock et al., (2000) data does not cover the east coast area but the OBIS mapping (Image G1) fills this gap to some degree. It shows how this area and the coastal waters are also of relatively low value for this species and there are no designated SPAs along the east coast for which Manx Shearwater is a qualifying species.



(Source: Pollock *et al*., 2000)

Images G11.a-d Manx Shearwater Distribution

G.3.11 Northern Fulmar Fulmarus glacialis

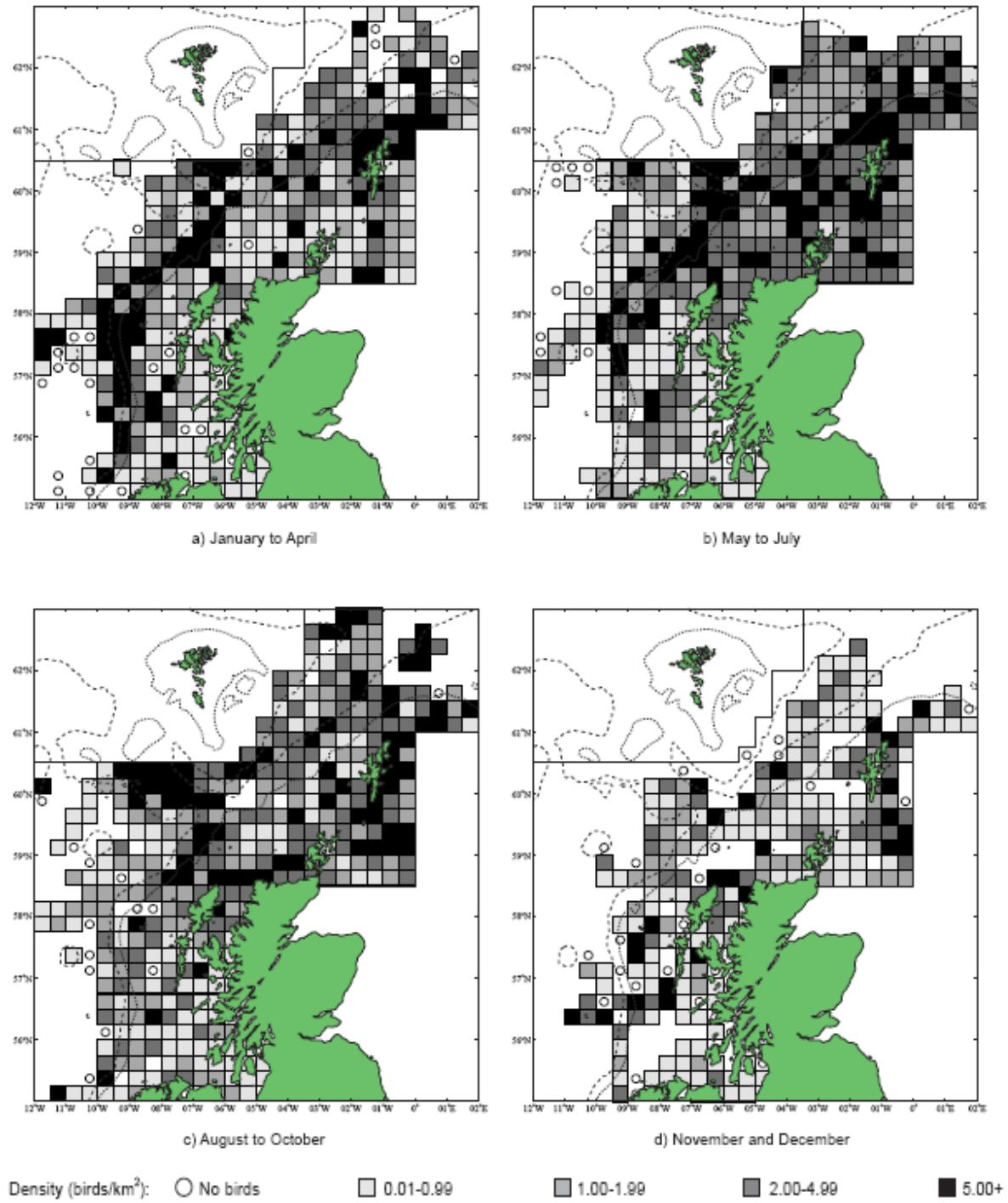
Most of the information on Northern Fulmar (hereafter Fulmar) foraging ranges is based on trip durations, which, given the many assumptions involved in calculating ranges from such data, should be viewed as maxima. Foraging trip durations for Fulmars are variable among sites and years.

Hamer et al., (1997) studied populations of Fulmars on St Kilda, Outer Hebrides and Foula (Shetland). They estimated that the maximum foraging trip distances would be 245km for birds on St Kilda and 122km for Fulmars on Foula (Hamer et al., 1997). A study in Scotland also trapped one live breeding adult 460km from its nest site (Dunnet & Ollason, 1982) and in north east Greenland satellite tracked radio-tagged adults foraged 40-200km during incubation and chick-rearing, with failed breeders travelling more than 300km (Falk & Møller, 1995). Other authorities have given potential maxima of foraging radii of between 140km and 750km, assuming linear flight and negligible time spent on the water. While these will be overestimates of the radii travelled (as Fulmars deviate from straight line flight and spend time on the water feeding and resting, and may make overnight visits to feed chicks, which are often not recorded), they demonstrate that Fulmars have time to travel very long distances during foraging trips and could easily exceed a 100km radius from the colony (BirdLife International, 2010). As set out in Table G1, a maximum foraging range of 664km has been given for Fulmar based on BirdLife International (2010) data. A rounded up value of 670km value has been used for screening the Sectoral Wind Plan HRA.

The JNCC have considered the distribution of Fulmars in Scottish waters (Pollock et al, 2000). Prior to the breeding season (January to April) Fulmar distribution is concentrated along the continental slope (Image G12a), which was recorded as most obvious in April when the birds are known to leave the colonies in a ‘pre-laying exodus’ (Macdonald et al, 1977, Pollock et al 2000 and APEM 2012) and have a nomadic offshore distribution during the non-breeding season (APEM 2012). Many Fulmars along the continental shelf are associated with fishing vessels as they scavenge on discards (Pollock et al, 2000). The Fulmar breeding season is May to July where higher densities occur over the continental shelf (Image G12b). Beyond the continental shelf, Fulmar were recorded over the deep waters of the Norwegian Sea and the continental break north and west of Scotland (Pollock et al, 2000), this evidence that Fulmars will forage at large distances from the colony even during the breeding season. August to October (Image G12c) Fulmar distribution was largely in shallower waters, apart from the high numbers over the Wyville-Thomson Ridge and the shelf break to the north-west of Western Isles. In the shallow waters (<200m) there are areas of high density north of Scotland and around Shetland, suggesting this may be recently fledged birds (Pollock et al, 2000), although this may also be a reflection of fishing vessels in the area. Numbers are lowest during November and

December (Image G12d). Ringing recoveries have suggested that much of the breeding population stay within a few hundred kilometres of the breeding colonies in winter, whilst the young travel over large distances during this time (Dunnet et al, 1979 and Pollock et al, 2000). During this time very few birds were recorded associated with fishing vessels.

The Pollock *et al*., (2000) data does not cover the east coast area but the OBIS mapping (Image G1) fills this gap and in particular shows how this species is widely recorded across the coastal and offshore waters of much of the SREZ. There are also several designated SPAs along the east coast for which Fulmar is a qualifying species.



(Source: Pollock *et al*., 2000)

Images G12.a-d Northern Fulmer Distribution

G.3.12 Northern Gannet *Morus bassanus*

Gannets breeding on Bass Rock, Scotland have been studied in detail using GPS transmitters (Hamer et al., 2000; 2001; 2006; 2007 and 2009). Hamer et al. (2001) recorded a maximum foraging range of 540km from Gannets at Bass Rock, Wanless et al. (1998) recorded feeding at sites 33km (Wee Bankie) and 20km (Fife Ness) away whilst another study (field work undertaken in July and August 2003) by Hamer et al., (2009) found the mean foraging range per trip by Gannets was 155km, with a maximum of 276km recorded.

Hamer et al. (2007) further investigated the foraging behaviour of gannets in the North Sea and found that they tended to forage repeatedly over a narrow range of bearings, despite marked annual variations in foraging ranges and trip durations (Image G13).

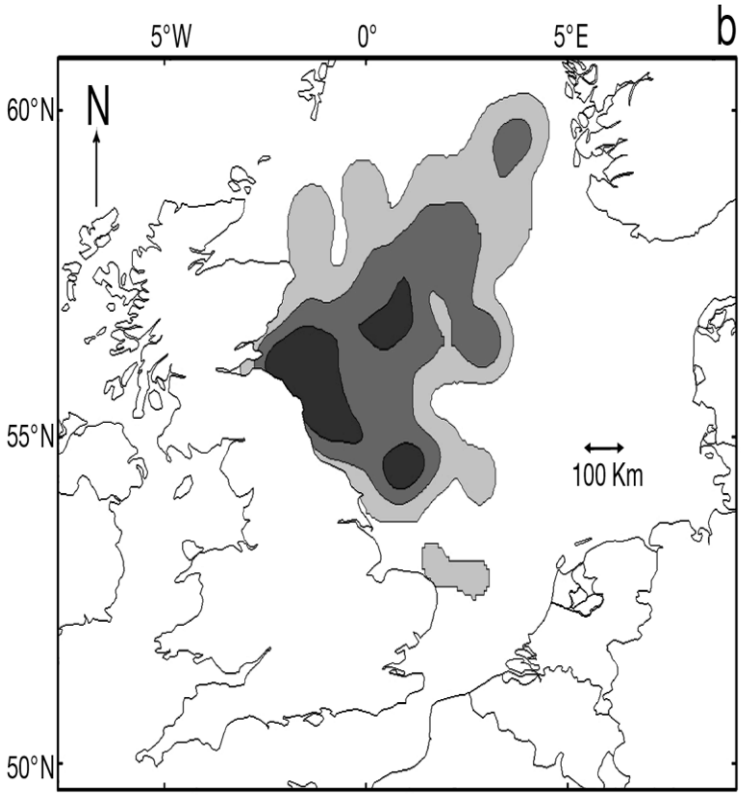


Image G13. Representation of One of the Maps Produced in Hamer *et al*. (2007) Indicating the Foraging Locations of Northern Gannet From Bass Rock in 2002

Hamer et al. (2001) also recorded gannets foraging repeatedly over a narrow range of bearings from their breeding location at Bass Rock. This study also observed gannets switching to a separate range of bearings in a markedly different direction from the breeding colony, providing strong evidence that on subsequent foraging trips individuals remembered the directions to feeding sites (Hamer et al., 2007).

However, conversely, birds at a much smaller site in the Celtic Sea (Great Saltee) did not show this pattern (Hamer et al., 2001). Hamer et al. (2007) concluded that these differences in the consistency of foraging locations were related mainly to difference in the spatial and temporal predictability of prey resources in the North Sea and Celtic Sea.

Northern Gannets at Great Saltee, Ireland were recorded travelling a maximum of 240km (Hamer et al., 2001) and 293km (Hamer et al., 2006) to foraging grounds. At Rouzic, France a breeding colony of Gannets were found to have a mean foraging range of 100km, with a maximum of 176km (Grémillet et al., 2006). Large feeding flocks of Gannets were also recorded, using ship-based transects around St Kilda, within only a few km of Boreray whilst several smaller groups were seen 40km away (at the Whale Rock Bank) (Leaper et al., 1988). A study by Tasker et al., (1985a) also observed a maximum foraging range of Gannets to be 150km from Noss, UK, however the majority were seen within 37km. Nelson (1978) estimated a range of 320 to 480km for breeding Gannets from a colony, based on observed trip durations and assuming continuous flight at 65 to 80km/h.

Tagging of fourteen adult Northern Gannets from Bempton Cliffs found that most foraging trips from Bempton occurred within 50 - 100 km of the colony (Langston et al., 2013). Similar foraging distances were recorded by Soanes et al., (2013).The study tracked 15 Northern Gannets breeding on Les Etacs, Channel Islands, to determine their use of both local and international waters and examine the consistency between an individual's foraging trips. The study found that the birds had a mean foraging trip of approximately 18 hours and had a mean foraging range of 106 km.

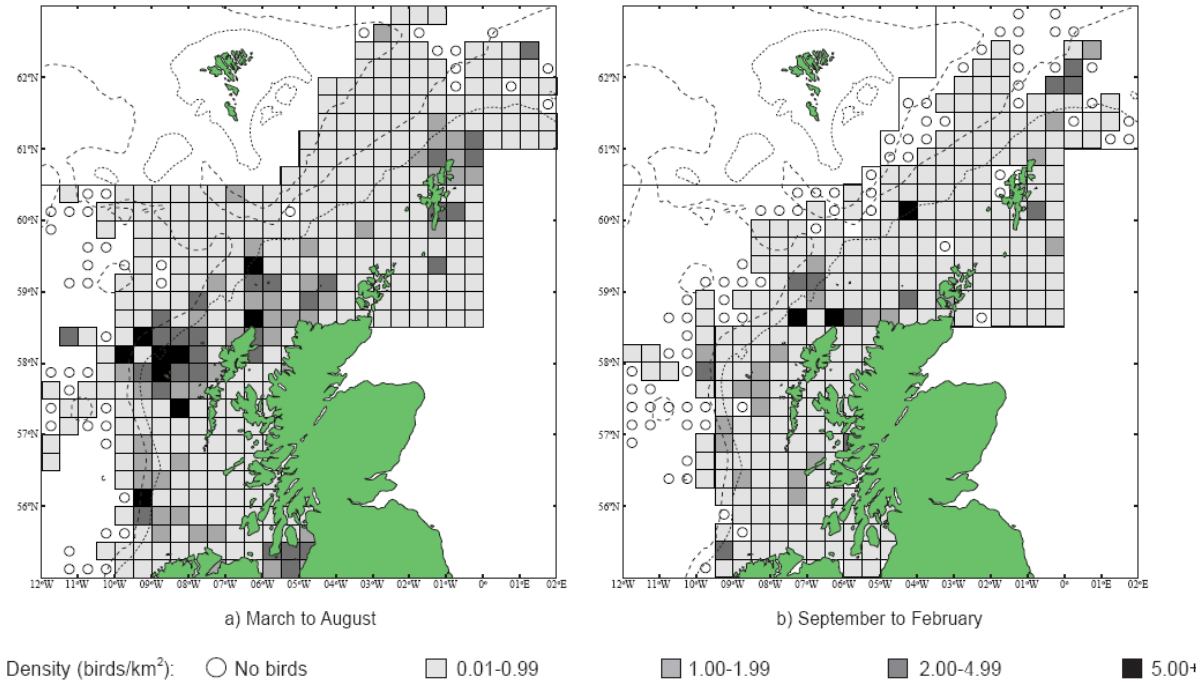
A study by Lewis et al., 2001 suggests that foraging range increases significantly for Northern Gannets with increasing colony size, probably as a result of intra-specific competition causing birds to forage further away from the colony during years with higher numbers of breeding Gannets (Lewis et al., 2001 & Thaxter et al, 2012). Northern Gannets from different colonies have also been shown to forage in largely mutually exclusive areas and that these colony-specific home ranges are determined by density dependent competition (Wakefield et al., 2013).

Based on an estimate by BirdLife International (2010) the maximum foraging range of Northern Gannet has been given in Table G1 as 640km. This value has been used for the Sectoral Wind Plan HRA.

The distribution of Gannets has been considered for the JNCC by Pollock et al 2000 and APEM (2012). Adults return to the region in March with immature birds arriving later in May (Pollock, 2000). Between March and August Gannets use a lot of the study area regardless of the water depth, with the highest concentrations of gannets

found near the breeding colonies at Shetland, North Rona and especially St. Kilda (Image G14a).

It is likely that these are breeding birds and so will not be foraging at great distances from the colonies (Pollock *et al*, 2000) which is in contrast to the conclusion of APEM (2012) in the PFOW area who suggest that the individuals in this apparent population could be from a number of Gannetries as this species has a large foraging range. The distribution of Gannets during this time is often associated with fishing vessels as they scavenge the discards. During September and October Gannets leave the study area and so there are fewer numbers found during the winter months (Image G14b). Any birds that do remain the in the area stay around the colonies and along the continental shelf.

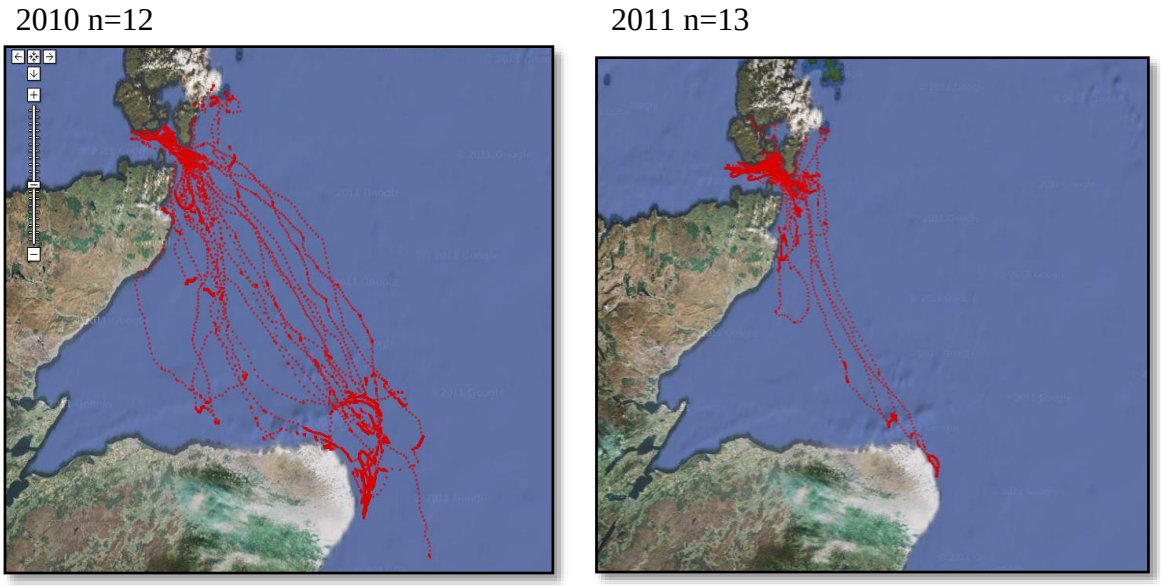


(Source: Pollock *et al*., 2000)

Images G14.a-b Gannet Distribution

G.3.13 Razorbill *Alca torda*

A study by Webb et al., (1985) at Flamborough Head found that maximum densities of Razorbill were recorded foraging at 26-28km from colonies, although large numbers were also seen from the coast within 1km from the colony. A more recent study by Thaxter et al., (2010) supports this conclusion. Using bird-borne data loggers to record foraging trips made by 14 Razorbills from the Isle of May breeding colony, they found that of the 76 foraging trips made just under half were within 10km of the coast, with the remainder of trips to areas 30-40km offshore, with the longest foraging trip being approximately 60km. Gaston and Jones (1998, cited in Thaxter et al., 2010) however, have reported Razorbills carrying prey more than 150km from the nearest breeding colony. This distance has now been superseded by the FAME project data and it is now considered that the maximum foraging range of Razorbill, as set out in Table G1 is 312km. FAME used GPS tracking data from Orkney during 2010 and 2011 and are displayed in Image G15. A rounded-up value of 320Km has been used as the maximum foraging distance for screening the Sectoral Wind Plan HRA.

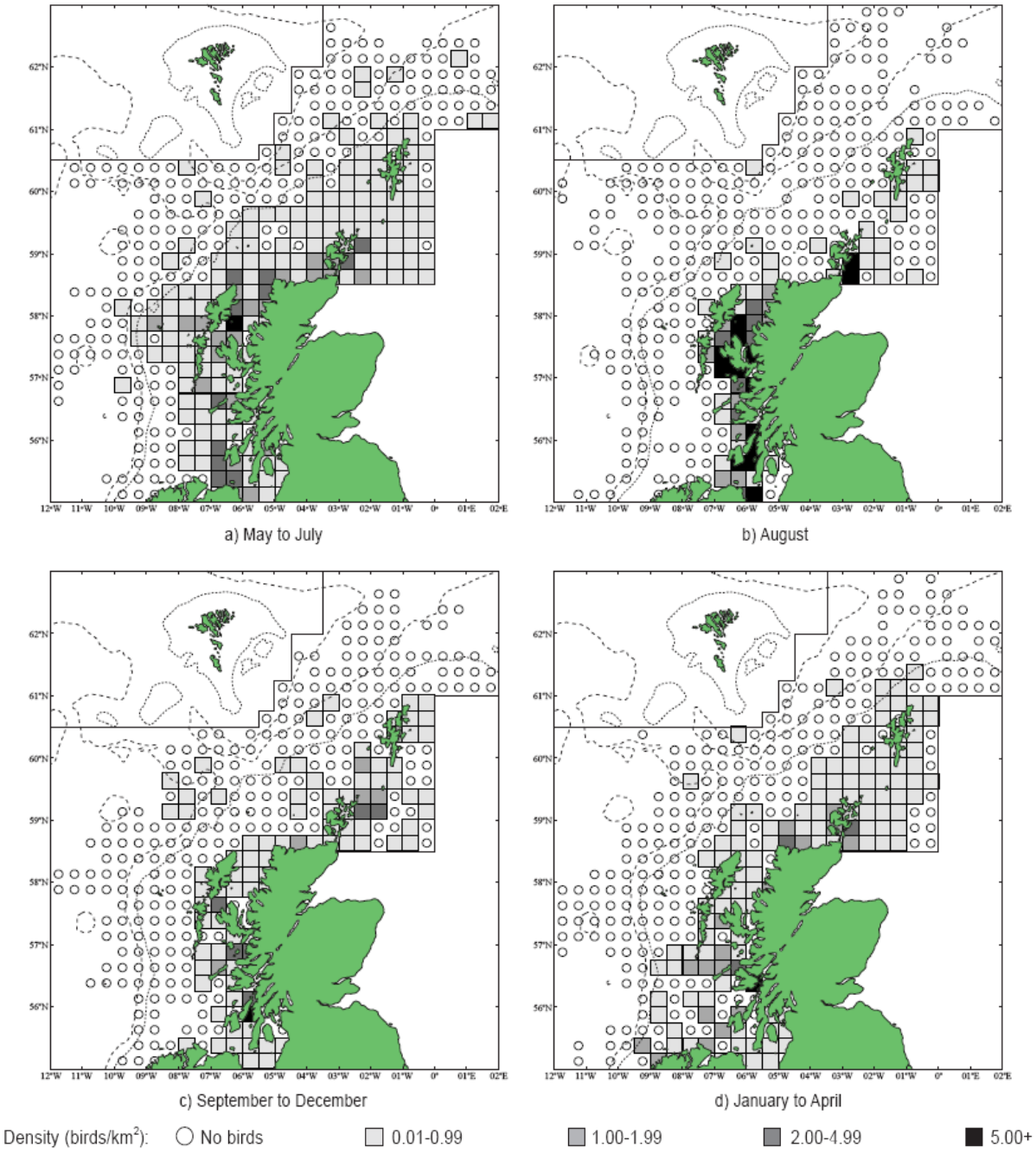


(Source: FAME project.)

Image G15. Razorbills Tracked From Orkney During the Breeding Season in 2010 and 2011

The distribution of Razorbills has been considered for the JNCC by Pollock et al 2000 and Scottish Government (APEM, 2012). During the breeding season (May-July) highest densities of Razorbills are found inshore off the west coast of Scotland (Image G14a). During August there is a high proportion of Razorbills inshore on the

west coast of Scotland (Image G16b). In the PFOW area, Orkney in particular is considered to be of great importance to breeding auks with an estimate by Mitchell et al (2004) of 250,000 individuals in the area.



(Source: Pollock *et al*., 2000)

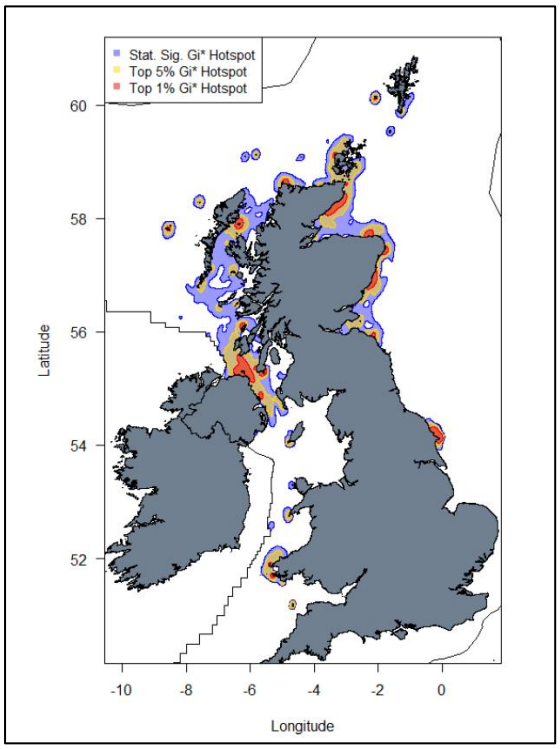
Images G16a-d Razorbill Distribution

The Minch is an important area for moulting Razorbills with an estimated two thirds of the west coast population congregating in the area during this time (Pollock et al, 2000). From September to December razorbills start to spread out in the study area once again and forage offshore (Image G16c). During the winter early spring, the

distribution is fairly evenly spread along the continental shelf with birds tending to stay close to shore (Image G16d).

The Pollock et al., (2000) data does not cover the east coast area but the OBIS mapping (Image G1) shows how this area is also of high value for this species. There are also several SPAs (including Forth Islands SPA) along this coastline for which Razorbill is a qualifying interest feature species.

Important areas of high seabird density at sea, based on hotspot mapping techniques derived from large-scale seabird tracking as part of the FAME and STAR projects emphasized the importance of areas along the east coast of Scotland and the Orkney Islands as well as hotspots in the Hebrides and around Foula and Shetland. Outside of Scotland, hotspots were identified along the Northern Irish coast, around the Yorkshire coast in England and around the Pembrokeshire coast in Wales (Image G17) (Cleasby et al., 2018; Wakefield et al., 2017).



(Source: Cleasby *et al*., 2018)

Image G17 Map displaying hotspots identified at the UK-level for Razorbill

G.3.14 Velvet Scoter *Melanitta fusca*

The Velvet scoter is seen in small numbers around Britain, mainly off the east coast. It is known to have difficulty in becoming airborne and commonly flies low, especially over water.

A recent draft plan (AEWA, 2018) highlights specific management measures for designated sites to ensure the protection of the Velvet Scoter in the UK.

G.4 Migration Behaviour and Flyways

Seabird species undertake large scale seasonal migrations outside of the breeding season (Furness, 2015). Within the same local populations or breeding colony, different non-breeding strategies can be employed. For example, Quinn (2014) found that individual differences in winter distribution existed within a single North Sea Fulmar colony, with a higher proportion of females than males utilizing the West Atlantic region, compared to local North Sea waters. Older individuals were more likely to remain within North Sea waters than travel further from the colony. The distribution of auk species outside of the breeding season during moulting was investigated by Glew et al (2018). The study aimed to quantify species-specific foraging locations and individual trophic variability during feather regrowth in three sympatric auk populations breeding on the Isle of May, Scotland (Common Guillemot, Razorbill and Atlantic puffin). Foraging areas during moult differed between species and feather types. Guillemots likely underwent moult within the southern North Sea, Razorbills along the east coast of England and into the southern North Sea and Puffins off the east coast of Scotland. Estimates of individual trophic position varied considerably within feather types (up to one trophic level difference between individuals), among feather types grown during different time periods and across the three species, with Guillemots consistently foraging at higher trophic positions than Razorbills and Puffins.

The UK lies on some of the major migratory flyways of the east Atlantic, with large numbers of coastal waterbirds attracted each year by the relatively mild winter climate and extensive estuarine and wetland habitats. Every year, large numbers of birds traverse the North Sea and Irish Sea during the spring and autumn migrations on their way between breeding and wintering grounds. There appear to be no fixed corridors preferred by migratory birds and instead migration usually takes the form of broad-front. There can be high intensity migration (i.e. a few days with extremely high numbers) and flight heights can vary depending on the species and weather conditions (DECC, 2009). Heights can range from just above the water surface to several thousand metres and as migration is costly in terms of energy expenditure, birds will generally try and fly at altitudes where effort is least (Köller et al. 2006).

The height a given species flies at can influence the risk of collision with wind turbines (Furness et al, 2012). Recent studies have investigated the use of LiDAR to determine concentrations of seabirds flying at heights which may place them at risk of collision from wind turbines (Cook et al., 2018).

The issue of potential impacts to migratory birds is key for the Sectoral Wind Plan HRA and it is understood that there is a limited amount of robust data on this aspect. This is recognised within the SEA for the Draft OWE Plan (Marine Scotland, 2010) which records that there is a lack of accurate data showing migratory routes and this has also been confirmed via correspondence with the RSPB and SNH as part of

consultations . It is noted however, that the Wildfowl and Wetlands Trust (WWT) are researching migration routes of several bird species in relation to proposed UK wind farm sites. The WWT work included mapping routes of Greenland Barnacle Geese, Greenland White-fronted Geese and Whooper Swans (Griffin et al., 2010) from or along the west coast of Scotland to Iceland and Svalbard Barnacle Geese routes from South-West Scotland to Norway and Svalbard (WWT, 2010). Geese and swans were the focus for this research as they tend to fly at less than 100m above sea level and could be at risk of collision with wind turbines. This study was commissioned by COWRIE and involved a tracking study of Whooper Swans to analyse flight heights and migration routes between their breeding grounds in Iceland and the UK in relation to offshore wind farms. The project entailed fitting satellite transmitters to forty known Whooper Swans in winter 2008/2009 at various wintering locations in mainland Britain. These included WWT sites at Caerlaverock (SW Scotland), Welney (SE England) Martin Mere (NW England). Of the 40 individuals tagged, 35 were tracked to Iceland during spring migration 2009. These included 5 birds from Caerlaverock, 13 from Welney and 17 from Martin Mere. In addition, 10 transmitters were fitted in August 2009 in Iceland to provide information during autumn migration of the swan's southbound tracks.

As part of this summary review, key scientific literature relating to migratory pathways has been further reviewed to provide additional information on the routes that are taken. In particular, the above study by Griffin et al. (2010) into migration routes and flight heights of Whooper Swans has been reviewed here. In addition, the review by Cramp (2000) and the literature that has been compiled as part of this review was summarised to identify the locations of migrant, resident and winter distributions for a range of bird qualifying features. This review is presented in tabular for at the end of this appendix and includes maps of bird distributions that are provided within the Cramp (2000) review. Recently there have been reviews of flight heights, avoidance rates and seabird vulnerability and sensitivity to offshore wind farms (Cook et al, 2012, Marine Scotland, 2012, Furness et al, 2012). A summary of these is also provided below.

G.4.1 Flight Heights

Flight height appears to be a key factor influencing the collision mortality risk of seabirds colliding with wind turbines. Griffin et al. (2010) concluded that on average, the flight heights for swans were lower for birds migrating over water along the British coast (9m) compared to when crossing from Britain to Iceland (32m), thus flights occurred below or within the rotor swept area and so potentially at risk of collision. Two records however may provide evidence of avoidance of offshore windfarms. At 8.9km north of Barrow (operational) and 3.8km north of Robin Rigg (near operational) swans were recorded flying at altitudes of 172 metres and 160

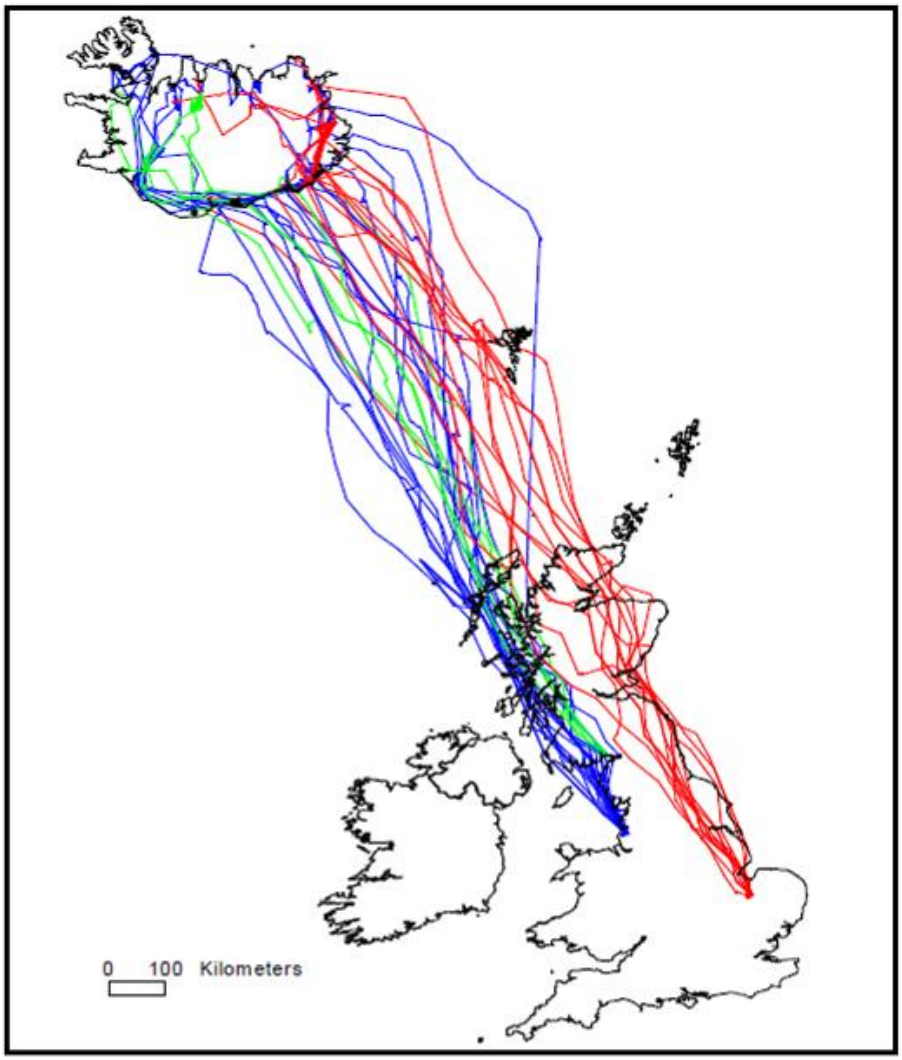
metres respectively, where one hour previously their flight heights had been recorded at approximately 50 metres above land (Griffin et al., 2010).

A study into seabird vulnerability reviewed collision index calculations and identified populations of gulls, white tailed eagles, northern gannets and skuas as being of particularly high concern in Scottish waters (Furness et al, 2013). This index is influenced by the flight height of species. In contrast, when considering the displacement index calculations, different species were identified as most vulnerable, namely divers and common scoters. Collision is more likely to occur if seabirds fail to avoid the wind farms (displacement), whereas displacement from foraging habitats is more likely to occur if seabirds can avoid wind farms, i.e. displacement is a function of avoidance behaviour. There are two kinds of avoidance observed by birds; 'macro-avoidance' when birds alter their flight path to completely avoid the whole wind farm; and 'micro-avoidance' when the bird will fly into the windfarm but acts to avoid the individual turbines. If species specific rates of macro- and micro-avoidance behaviour were known, a clearer understanding of species specific vulnerability would be understood. In addition, if more robust data were gathered regarding bird flight height, the most 'at risk' populations could be a focus in the monitoring and mitigation of these developments.

Cook et al., (2018) used LiDAR and digital aerial imaging to collect estimates of the altitude of birds in flight. The study successfully collected flight height information on 2,201 birds of which 806 were believed to be black-legged kittiwakes and 377 were identified as northern gannets. This data was used to derive continuous flight height distributions for these species. The study found that the proportion of birds recorded at collision risk height (20-120 m) was 0.081 and 0.043 for Gannet and Kittiwake respectively based on all surveys undertaken.

G.4.2 Migration Routes

Griffin et al. (2010) found that swans migrating from southeast England (Welney) generally migrated north along the east coast of Britain whereas those from northwest England and southwest Scotland (Martin Mere and Caerlaverock) followed the western coastline (see Image G18).



(Griffin *et al*., 2010)

Image G18 Migration routes of 35 Whooper Swans tracked from the UK to Iceland from WWT Wetland Centres at Welney (red lines), Martin Mere (blue lines) and Caerlaverock (green lines)

The swans' satellite tracks were inspected in relation to the distribution of the potential and actual footprint areas of individual windfarms in six key overlapping areas: the East Irish Sea, the Solway Firth, the North Channel/Inner Hebrides, the Greater Wash/North Sea, the Firth of Forth and the Moray Firth. A total of 48 Round 1 (R1), Round 2 (R2), Round 3 (R3) and Scottish Territorial Water (STW) offshore sites were considered in the analysis.

Of the 19 Whooper Swans tagged at Martin Mere seven flight lines (37%) across the East Irish Sea passed across or immediately adjacent to existing or proposed R1 and R2 windfarm sites with an additional eight tracks (42%) passing within 5km of these sites. Whilst up to ten flight lines (50%) crossing the Solway Firth passed across or immediately adjacent to the existing or proposed R1 or STW windfarm sites with another two (10%) passing within 5 km of these sites. Of these birds

crossing the North Channel/Inner Hebrides area no birds were likely to have flown across or adjacent to (within 5km) of STW sites. Of the 15 swans tagged at Welney only one bird stopped and flew across a proposed STW site (Neart na Gaoithe) and one bird flew within 4km of the site proposed at Westermost Rough (R2).

Of the eight birds producing reasonably detailed tracks during the return autumn migration from Iceland, five birds passed across or immediately adjacent to planned offshore windfarm sites with six birds passing within 10km of the planned sites.

Griffin et al. (2010) concluded that swans migrating along the east coast of Britain tended not to pass within or near the footprints of existing or proposed offshore windfarms, preferring to stick close to the coast or overland. However, swans migrating along the west coast more frequently flew into or close to the footprints of several offshore windfarms, preferring to fly over coastal waters. Although this tracking study is not representative of the migration pathways taken by Whooper Swans every year, it is a useful study to add to understanding and risk evaluation to birds arising from windfarms.

Information and knowledge on specific migration routes is also expanding rapidly with recent technological advances and through the application of useful tools (e.g. Burger & Shaffer, 2008). However, it is recognised that identifying distinct flyway routes is difficult both because of the nature and limitations of available information on this subject and because these movements are likely to occur across broad fronts rather than along clearly definable routes. Although little information is known about actual routes taken between breeding and non-breeding areas, a relatively large amount of information is known about the origins and destinations for many bird species, through data from the UK ringing scheme (Langston, 2010 - Wernham et al., 2002, BTO Migration Mapping Tool http://blx1.bto.org/ai-eu/). The destinations outside of the UK where tagged birds migrate to and from Scotland has been reproduced in Table G2. This table is derived from information within the BTO Migration Atlas Project report (Wernham et al., 2002) and is presented within the SEA Environmental Report (Marine Scotland, 2010). As recognised within the SEA document, this information does not specifically describe the migration routes but presents a useful collection of ringing recovery information ‘for birds that fly to and from Scotland (not necessarily from other parts of the UK)’.

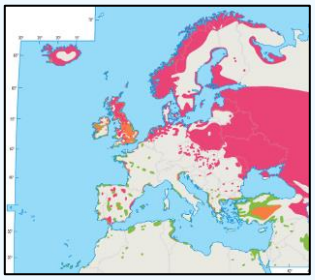
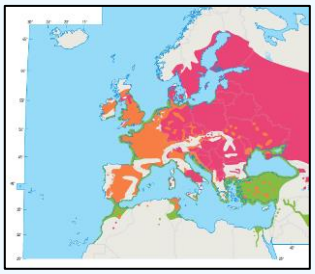
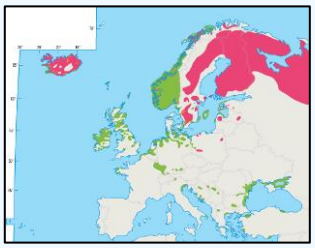
Table G2. Principal recovery locations for likely focal bird species

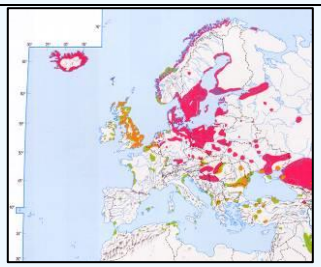
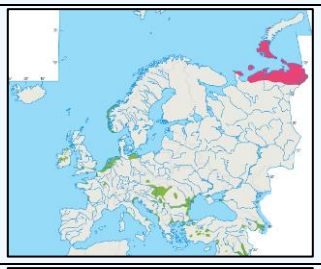
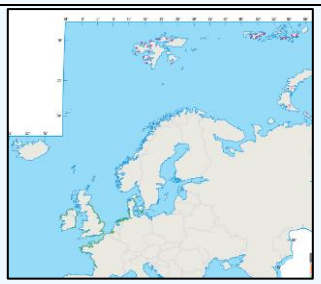
Species	Principal Recovery Locations of Ringed Birds Outside of Mainland UK
Arctic Skua	Concentrated around Orkney and Shetland Isles
Arctic Tern	Concentrated around Orkney and Shetland Isles, Scandinavia, W Africa
Atlantic Puffin	Canary Islands, Mediterranean
Barnacle Goose (Nearctic)	Iceland, Greenland, Svalbard
Black-legged Kittiwake	USA, Greenland, Faroes, Continental Europe
Brent Goose (light bellied, E. Canada)	Svalbard
Common Tern	Continental Europe, Ireland, W Africa
Common Guillemot	Continental Europe, Scandinavia, Ireland, Orkney and Shetland Isles, Iceland
Common Scoter	Moray Firth, Firth of Forth, Northern Europe, North Africa.
Corncrake	Unrecorded in Bird Atlas
European Storm Petrel	Ireland, Iceland, Faroe Islands, Scandinavia, Portugal, S Africa
European Shag	Ireland, Faroe Islands, Continental Europe, Scandinavia
Great Northern Diver	Unrecorded in Bird Atlas
Greenland White Fronted Goose	Iceland, Greenland, Orkney
Herring Gull	Ireland, Orkney, Shetland Isles
Lesser Black-backed Gull	Northern Ireland, Firth of Forth, Alde Ore Estuary, Africa
Manx Shearwater	Ireland, Continental Europe
Migrating waterbirds	Various destinations
Northern Gannet	Ireland, Iceland, Continental Europe, Orkney, Shetland Isles, northern Scandinavia, NW Africa
Pink-footed Goose	Iceland, Greenland
Razorbill	Continental Europe, Scandinavia, Ireland, Orkney and Shetland Isles
Velvet Scoter	Firth of Forth, Tay and Eden Estuary, Moray and Naim coast, Northern Europe, West and Central America
Whooper Swan	Ireland, Western Isles, Orkney

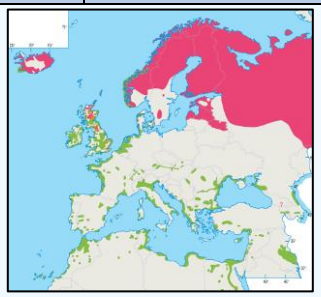
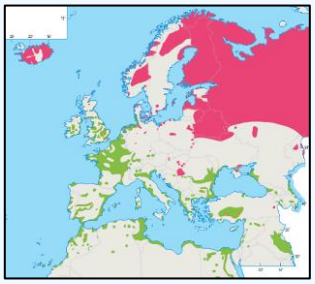
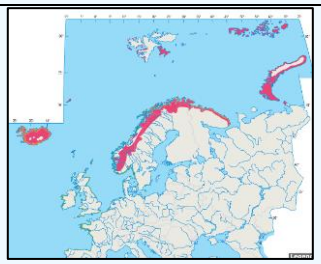
(Marine Scotland, 2010)

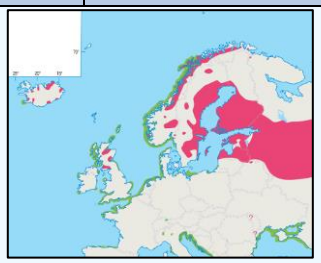
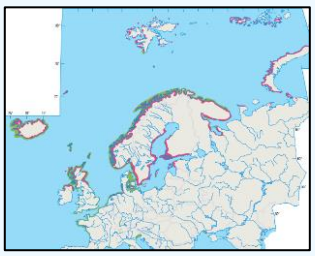
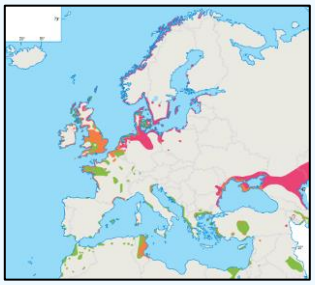
Further details and maps describing the origins and destinations for many bird species are also presented in Table G3 which provides general information on migrant, resident and winter distributions around the UK and the rest of Europe for many bird species (Cramp *et al.,* 2000). The birds listed in this table have been included as they have been identified as qualifying features within SPA sites within 100 km of the DPOs.

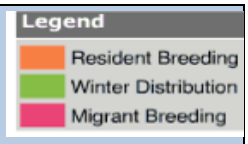
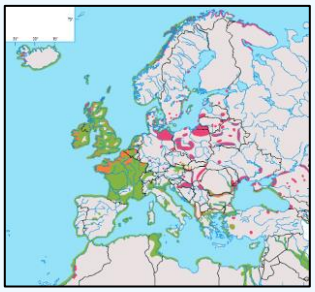
Table G3. Migrant, resident and winter distributions, as well as general flight heights, for a number of bird species

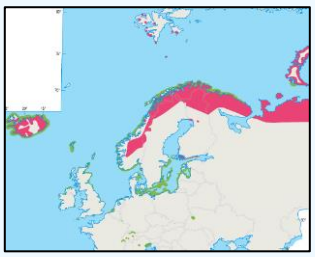
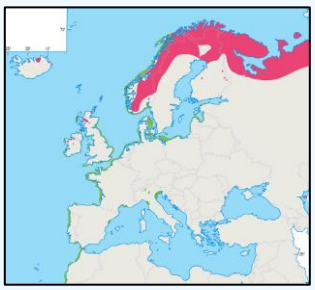
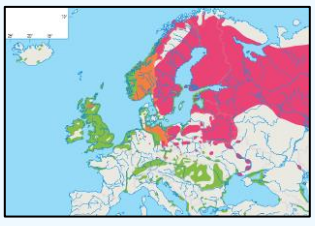
Species	Summary Information	Map
Common Redshank	Migrate between Iceland and Britain (Orkney to Hampshire) (Ogilvie 1963; Hale 1973; Folkstad 1975; Minton 1975; Boere 1976; Holden & Cleeves, 2002). Some birds from Scotland and northern England winter in Ireland, but southward movement within Britain more usual, and others continue south to continental coasts (Netherlands to Portugal, especially western France). Flies freely in lower airspace.	
Great Crested Grebe	As few ringed, little known of migration routes, though apparently broad-front overland as well as coastal. Some autumn and winter immigration into British waters from Denmark and Netherlands. Often active aerially on moonlight nights, visiting neighbouring waters in search of mate or territory. Uses airspace somewhat sparingly, although strong flier once airborne, not often at much height.	
Whooper Swan	Migrate between Iceland and Britain (Pennycuick *et al.,* 1996; Holden & Cleeves, 2002). Once thought to fly at high altitudes between Iceland and the UK; more recent evidence shows that the birds also migrate at just above sea level, and land on the sea in adverse weather or poor visibility (Pennycuick *et al.,* 1996).	
Barnacle Goose	East Greenland population migrates via Iceland to winter in west Scotland and Ireland (Salomonsen 1967; Holden & Cleeves, 2002). The Svalbard population moves down the west coast of Norway and across the North Sea, crossing overland in north England and South	

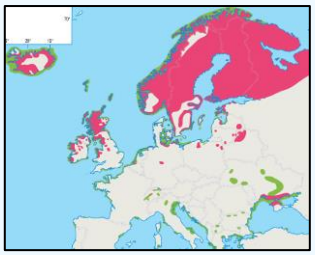
Species	Summary Information	Map
	Scotland to winter in Solway Firth (Holden & Cleeves, 2002).	
Greylag Goose	Migrates between Iceland and Scotland and Ireland (Mitchell 1996; Hearn 2000; Swann and Brockway 2002; Swann 2000; Mitchell and Sigfússon 1999; Cranswick *et al.,* 1997; Holden & Cleeves, 2002)	
Greenland White-fronted Goose	Geese collared in Scotland, Iceland, and Greenland as part of continuing international marking programme.	
Pink-footed Goose	Migrates between Iceland and Britain (Fisher 1951, Thom 1983, Newton *et al.,* 1990, Dix 1991, 1992; Fox *et al.,* 1992; Holden & Cleeves, 2002)	
Light-bellied Brent Goose	Migrates between Spitsbergen and Franz Josef Island to Britain and Denmark (Løvenskiold 1964) Although strong flier, takes wing with some reluctance, and flies no higher than essential.	
Bar-tailed Godwit	Winters North Sea and Atlantic coasts of Europe. Major passages in spring and autumn are through Baltic and North Seas and thence along western seaboard. Exceptional flight capability used at relatively low height except on migration.	

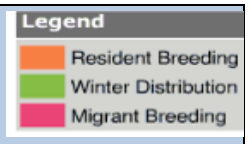
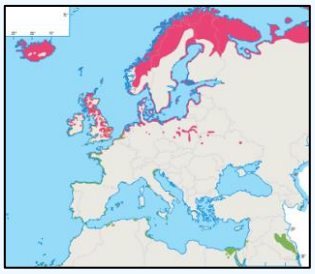
Species	Summary Information	Map
Eurasian Wigeon	Migrates between Iceland and Britain Fenno-Scandia and USSR east populations migrate to winter quarters in west and south-west Europe, especially Britain and Ireland. Usually fly at no great height.	
Northern Pintail	Migrates between Iceland to Britain and Ireland (Bruun 1971; Holden & Cleeves, 2002). Breeding populations of north Russia east to north-west Siberia (Omsk), Fenno-Scandia, and Baltic migrate south-west to winter Netherlands and British Isles. Use of airspace even freer than for other Anas and often at considerable heights.	
Red Knot	Migration occurs from Canada and Greenland to western Europe, including Britain and southern north sea (Andreasson and Råd 1977; Netterstrøm 1970; Holden & Cleeves, 2002) Winter range of Spitsbergen birds unknown.	
Purple Sandpiper	Migrates between Iceland and Norway to Britain (Atkinson *et al.,* 1981; Holden & Cleeves, 2002) Not known to fly regularly in upper airspace.	
Ruddy Turnstone	Migration occurs between Northern Europe, Greenland and Canada to Britain and Ireland (Holden & Cleeves, 2002; Morrison 1975; Clapham 1979; Wilson 1981; Branson *et al.,* 1978) Also a strong flier, most often within lowest airspace.	

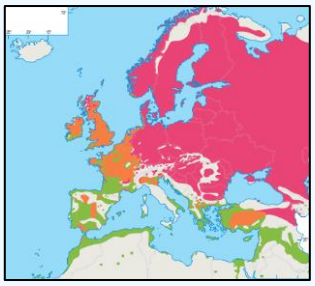
Species	Summary Information	Map
Slavonian Grebe	Breeding populations in Iceland, Norway and Scotland winter around Scotland and Atlantic coast of Ireland. Flies readily, visiting neighbouring waters but observations of high flight lacking	
Red-throated Diver	Migration routes not well known. Migration occurs between Spitsbergen, Lapland and USSR to Atlantic and North Sea coasts around Britain and Ireland. 2 chicks from Scotland (Shetland) also found French coast (Finistère, Vendée). Migrants from Europe and Iceland winter around British and Irish coasts (Holden & Cleeves, 2002) Entirely aquatic and aerial, normally on land only for nesting. Inadequacy of food on small breeding pools requires frequent flighting to better fishing lakes or sea, involving dual aquatic habitat and much use of airspace up to at least 1000 m. Mobility aided by ability to rise readily from small water surfaces, and exceptionally from land.	
Common Eider	Partially migratory. Small movement within British and Irish breeders, rarely over 200km (Milne 1965a). Recoveries of Dutch birds in Fife. British and Irish birds do not generally move far from their breeding grounds (Holden & Cleeves, 2002). Although flying freely, normally keeps to lowest few metres of airspace, mostly over water.	
Common Shelduck	Breeders and immatures leave nesting grounds in Britain, Ireland, Belgium, Netherlands, Denmark, Scandinavia, north Germany, north Poland, and Baltic States, for annual moult in German Waddenzee area (Goethe 1961a). Birds from Germany and farther east arrive in Britain in winter (Holden & Cleeves, 2002). Flies strongly, rising on passage to 1000 m or more above ground.	

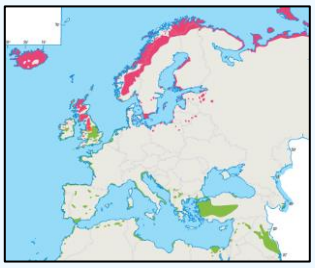
Species	Summary Information	Map	
Great Cormorant	British and Irish populations non-migratory but show extensive dispersal with small proportion crossing English Channel; mainly coastwise, but also inland usually within 60 km of coast (Mills 1965). Recoveries in France and Iberia (mainly Brittany to north Portugal) continuance of southward dispersal in Britain and Ireland, and originate mainly from Irish Sea and Galloway. North Sea effective barrier to eastward movement from Britain, recoveries Norway to north France being quite exceptional. Circles or soars up to considerable heights and flies overland, often for long distances, occasionally or regularly.		
Mallard	Many Icelandic birds winter Britain and Ireland. Those from north-west Russia, Fenno-Scandia, Baltic states, north Poland, north Germany, and Denmark winter from Denmark to north France and in Britain, with slight onward passage as far as north Spain. Many birds that breed in Iceland and northern Europe spend the winter in Britain and Ireland (Holden & Cleeves, 2002). Can rise steeply up and away even in awkwardly confined spaces; much given to circling around, usually at heights below c. 500 m.		
Greater Scaup	In Iceland, ringing of young showed migration chiefly to Ireland, Britain, and Netherlands (Boyd 1959), with smaller numbers reaching north France, Denmark, and north Germany. Important winter concentrations in Firth of Forth (Scotland). Take-off somewhat laboured, and use of airspace relatively infrequent.		

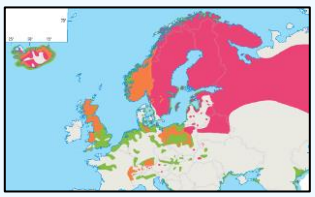
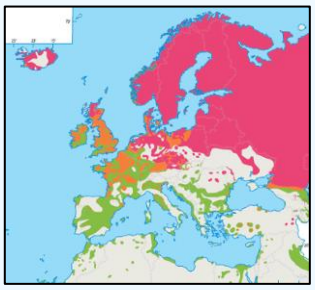
Species	Summary Information	Map
Long-tailed Duck	No evidence of Icelandic birds reaching continental Europe; yet ones ringed west Greenland moved south-east to Iceland and Denmark, and to Atlantic seaboard of North America, while others wintered in Greenland seas. Origins of British winterers unknown. Makes maximum use of airspace, readily flying between coast and inland sites at up to 200-1200 m over land, although usually low over water.	
Black (Common) Scoter	Icelandic breeders winter around Ireland, Britain, and Atlantic coasts France, Spain, and Portugal Movement by small British and Irish population largely unknown, but breeding lakes deserted. Breeders from Arctic USSR, Sweden and Finland migrate WSW to winter on both sides of North Sea (west coasts of Britain). Uses airspace often in long formations, and normally at low altitude, but flies fairly high overland; generally flies only when need pressing.	
Velet Scoter	Small numbers winter around Britain (mainly east coast) Has difficulty in becoming airborne and commonly flies low, especially over water.	
Common Goldeneye	Breeding populations of Fenno-Scandia, north Germany, Poland, Baltic States and north-west Russia mostly winter Baltic States, Denmark, Netherlands, Britain and Ireland. Airspace over water and land freely used at wide range of altitudes.	

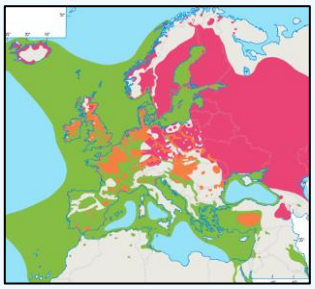
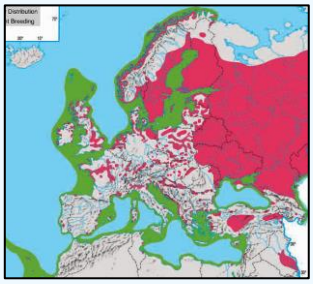
Species	Summary Information	Map
Red-breasted Merganser	Breeding population of Iceland partially migratory; some resident, others migrate to Britain and Ireland. Movements of British breeders not fully known, but at least disperse from inland breeding waters. Migrants from Finland, Poland and north-west USSR winter in Britain. Spends much time in aerial excursions, usually at fairly low altitude.	
Eurasian Curlew	Large resident population in Ireland, with local movements to coast, though many also winter inland; movements unconfirmed in absence of ringing. Some British birds winter near breeding site, though most move south-west. Thus birds from Scotland and northern England move to British west coast and Ireland; those from southern England to south-west England, some to France and Iberia (Bainbridge and Minton 1978). Scandinavian population moves south-west: Norwegian birds to northern Britain, Ireland, and western France; main wintering area for Swedish birds is Britain and Ireland, though also some on Continental coasts from Denmark to western France (Nørrevang 1959). Some USSR, German and Dutch populations also reach Britain and Ireland (Holden & Cleeves, 2002). Except on migration flies mainly in lower airspace.	
Eurasian Oystercatcher	Birds reared Iceland, Faeroes, and northern Britain moult and winter mainly around Irish Sea and on other western coasts of Britain and Ireland; few reach North Sea coast (Dare 1970; Dare and Mercer 1974b; Anderson and Minton 1978). Some British birds, especially in southern England, remain near breeding areas, but the general trend for these to move south to moult and winter takes some to France and Iberia and	

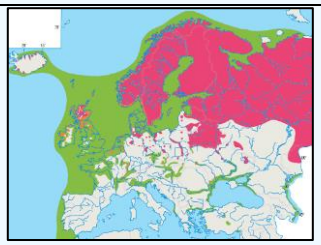
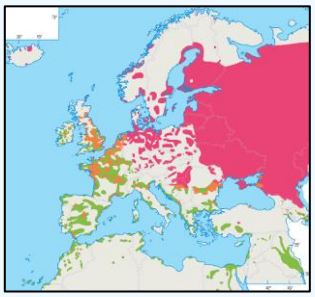
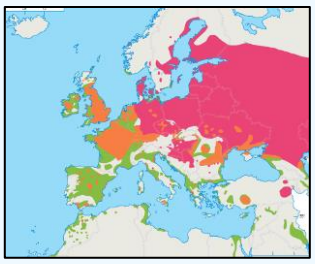
Species	Summary Information	Map	
	exceptionally to Morocco (Buxton 1957; Andrew 1959; Dare 1970; Pienkowski 1972). Migration also noted frequently across southern Scotland, between Firth of Forth and Solway Firth (e.g. Andrew 1959), and west of south from north-east England (Evans 1966); by no means certain, however, that Continental immigrants predominate in such movements. 3 recoveries of birds moving between eastern England (all autumn dates) and USSR (Murmansk, Arkhangel'sk), but clearly these atypical. Considerable movement may occur within a linked estuarine complex, such as Wash-Humber system (England), though apparently little movement between sites within Firth of Forth (Scotland) (e.g. Minton 1975; M W Pienkowski). Although a strong flier, shows marked reluctance to venture out of sight of land, and usually travels within lower airspace.		
Ringed Plover	Largely migratory but some British birds resident. North-western populations of Canada and Greenland, majority pass through Britain and Ireland European populations - Birds from coasts of Scandinavia and Baltic and from East and West Germany south-westwards move widely to wintering areas extending from Britain and Ireland to West Africa.		
European Golden Plover	Partially migratory in Britain and Ireland; wholly migratory elsewhere. 23 recoveries of birds ringed Britain as chicks, 21 recovered within Britain, so only minority emigrate. British internal recoveries showed mean movement of 115 km (0-500).		

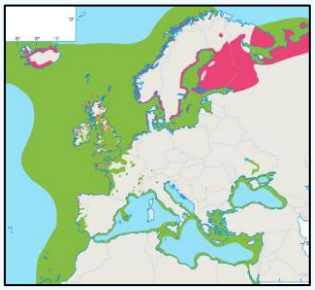
Species	Summary Information	Map
	Icelandic population (115 ringing recoveries) wholly migratory, with western route to and through Ireland, western Britain, western France, and Iberia. Norway to Western Siberian birds, many found in Britain between November to April Use of airspace (especially above the lowest) normally confined to migration, advertising flights over territory, etc. Wading also infrequent.	
Grey Plover	Those occurring in west Palearctic come from breeding population of northern USSR. In Britain, arrives July onward through autumn and winter (Mason 1969, Mason 1972; Branson and Minton 1976). Wariness leads to frequent use of outstanding powers of flight, mostly in low airspace but migrating flocks fly high in massed formations (Bent 1929).	
Northern Lapwing	Britain and Ireland constitute northernmost regular wintering areas. In contrast to continental birds, British breeders mainly make short summer dispersals (within 100 km), though some indication of adult movement west to south-west into Ireland. Birds from Hungary, Czechoslovakia, Switzerland, and southern West Germany move to Britain. British Isles especially important as winter quarters for Scandinavian birds; south-westerly movements by those from south and east Baltic countries largely bypass Britain. In flight, lower airspace usually preferred except on movements, when altitudes of 250-400 m are	

Species	Summary Information	Map
	common and up to 2000 m or more recorded (Meinertzhagen 1920).	
Dunlin	Holarctic breeding distribution, wintering on most ice-free coasts of northern hemisphere Iceland to Britain and western France (Rosenberg *et al.,* 1970; Meltofte 1975; Pienkowski and Dick 1975; Green 1978; Hardy and Minton 1980). Baltic region to Britain (Minton 1966, Minton 1975; Pienkowski and Dick 1975). Flies much in lowest airspace, infrequently higher.	
Sandwich Tern	Some birds from Britain and Ireland disperse to Netherlands, and vice versa (Møller 1981a). Recoveries of British and Irish birds extend from France to Angola, with 30% of recoveries in Sénégal (Langham 1971; A P Møller). In some circumstances, as in display, rises into upper airspace, and normally flies somewhat higher over water than most seabirds.	
Sanderling	With Holarctic breeding range, winter distribution very large: both sides of Americas and Africa, western and southern Europe, and across southern Asia to Micronesia and Australia (rare in New Zealand). Although readily taking wing, tends to stay in lowest airspace and not to indulge much in unnecessary flights.	
Black-tailed Godwit	Icelandic population winter in large numbers in Ireland and Britain and in western France (Williamson and Ruttledge 1957; Vernon 1963; Fournier and D'Elbée 1974; Prater 1975a). Although primarily a ground and wading species (up to belly-depth), flies readily at all seasons, rising freely above lower airspace.	

Species	Summary Information	Map
Goosander	Migratory and partially migratory. No evidence yet that any Icelandic breeders emigrate. Similarly, British breeders almost entirely resident, moving short distances (mainly within 150 km) from breeding waters to lakes and sheltered estuaries	
Eurasian Teal	All but a few Icelandic breeders migrate to Britain (chiefly Scotland) and Ireland. Most or all breeders from north Russia, Baltic states, Fenno-Scandia, north Poland, north Germany, and Denmark fly south-west in autumn to North Sea wintering grounds, chiefly Netherlands and Britain. Winter distribution between Netherlands, England, Wales, and Ireland greatly dependent on weather. Breeders of Britain largely resident, moving only in severe weather. Makes full use of flight, mainly at medium and low heights, for reconnoitring secure places and for daily movements between feeding and resting areas.	
Gadwall	Icelandic breeders winter Ireland and Britain. Breeders from Scotland move to Ireland (chiefly) and England. Those breeding north Germany, Poland, south Sweden, and west-central Russia winter North Sea, chiefly Netherlands and Britain, with some as far as Mediterranean. Mobile on ground as well as swimming and flying. Takes off less often in steep ascent from confined spaces than A. platyrhynchos or Teal A. crecca, but equally prone to make circling reconnaissance flights at low or medium heights, and frequent local movements between resting, foraging, and breeding haunts.	

Species	Summary Information	Map
Common Greenshank	Scottish population - passage occurs through Britain and Ireland Those to and from Fenno-Scandia and Denmark show movement through Poland, West Germany, eastern Britain, Low Countries, France, Italy, Iberia, and Morocco. Flight normally in lower airspace except during display and migration when upper airspace up to some hundreds of metres used.	
Black-headed Gull	European winter range extends from southern Iceland, Faeroes, southern Norway, western Baltic, Balkans, and southern Russia southwards; common winter visitor in Iberia and around Mediterranean. Icelandic population recovered in Scotland and Ireland Fenno-Scandian and Baltic Populations - many migrate to western seaboard countries (North Sea and British Isles to north-west Africa) Norwegian birds winter mainly around North Sea, with those from western Norway especially in Britain.	
Common Tern	Migratory Behaviour - Radar-tracked terns (both Arctic and Common) crossing south Sweden in late July took off in small flocks during evening, ascended at rates of c. 1.2 m/s to heights of 1000-3000 m flying 12-15 m/s (40-55 km/h) in level flight, suggesting that terns start migratory flights in evening and fly at high altitudes at night (Alerstam 1985). In north Germany, >50% of visible terns migrate <20m or >80% <100 m, and only c. 10% higher than 250 m, single birds >500m (3985 migrating terns observed). North and east European populations migrate westwards to Great Britain (Norman 2002).	

Species	Summary Information	Map
	Main wintering areas of British and Irish birds are Ghana and Senegal.	
Common Gull (Mew)	Many of the Common Gulls that winter in Britain are birds that nested in Scandinavia (Holden & Cleeves, 2002).	
Northern Shoveler	Mostly migratory. Breeders of Iceland all migrate, probably to Ireland or Britain. Most British breeders move southwards to south France, south Spain, north and central Italy, a few to north Africa. Breeders from south Fenno-Scandia and USSR east migrate west and south-west to western seaboard, chiefly Netherlands, Britain, and Ireland. Circles like other Anas and usually flies below 100 m; shares generic capacity for quick and ready movement between sites.	
Bewick's (Tundra) Swan	Wintering sites in Denmark, northwest Germany (few), Netherlands, Britain, and Ireland Bewick's swan leave Siberia and migrate to Britain, the Netherlands or Germany (Holden & Cleeves, 2002).	
Common Pochard	Mainly migratory, but some resident or partially migratory. Many of the birds that winter in Britain migrate here from northern and eastern Europe and central Russia (Holden & Cleeves, 2002). Freely uses excellent powers of flight, and will rise on occasion to considerable altitudes.	
Tufted Duck	Predominantly migratory though largely resident in a few areas. Some Icelandic breeders winter on coast and other ice-free waters there, but most move to Ireland (chiefly) and Britain. Breeders of northern Britain mainly move south-west to Ireland, though Scottish juveniles recovered exceptionally north to Norway and	

Species	Summary Information	Map	Legend
	south to Portugal; those of south Britain believed largely resident. Vigorous flier making full use of surrounding airspace over fairly wide radius and to considerable heights.		
Lesser Black-back Gull	Total winter range now extends from Britain, Mediterranean, Black and Caspian Seas (uncommon), Turkmeniya, and Persian Gulf to Arabian Sea and West and East Africa (sparingly further south). Main wintering region for British birds comprises Portugal, south-west Spain, and north-west Africa. Flies readily and strongly, at low and medium altitudes, and less frequently in upper airspace.		
Taiga Bean Goose	In west Europe, winters in Britain (few), Denmark, south Sweden, East and West Germany, Netherlands, Belgium, France and Spain. Birds from Scandinavia migrate to Britain (Holden & Cleeves, 2002). As forest breeder, can rise steeply from confined spaces, but frequency and patterns of aerial activity otherwise resemble other geese.		

(Source: Cramp *et al.,* 2000 and references therein)

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Appendix H. Mammals Literature Review

H.1 Marine Mammal and Otter Baseline Characterisation

H.1.1 Scope of Review

This appendix presents a general review of the marine mammal populations found in Scottish waters. It is designed to provide a screening context for the HRA of the Plan Options in Scottish Waters and includes information on the background ecology, population, distribution, abundance and foraging behaviour of the following marine mammal species:

- Grey seal (Halichoerus grypus);
- Common seal (*Phoca vitulina*);
- Bottlenose dolphin (*Tursiops truncatus*); and
- Harbour porpoise (*Phocoena phocoena*).

The European otter (*Lutra lutra*) has also been included in the scope of this review as it is recorded living on and near the coast around Scotland and travelling/foraging within the marine environment.

It should be emphasised that this is a broad-scale characterisation only. It seeks to draw upon available information to understand the value of the area in general terms. It does not specifically focus on the interest features of the European/Ramsar sites but provides a context for the assessment in recognition of the importance of mammals in this area.

H.1.2 Major Information Sources

Due to the scale of the proposed development and work being proposed in Scottish waters and the subsequent need for a coherent and comprehensive ecological management system for these waters, there is currently a significant level of research effort to improve the evidence base on the abundance and distribution of marine mammals in Scottish waters.

Detailed reviews of marine mammal distributions and ecology in UK waters have been carried out by the Sea Mammal Research Unit (SMRU), University of St. Andrews, as a contribution to the UK Department of Energy and Climate Change (DECC) Offshore Energy Strategic Environmental Assessment (SEA) (DECC, 2009; DECC, 2016) and previous oil and gas SEAs (Hammond et al. 2004 and Hammond et al. 2005).

Information on the status of seals around the UK coast is also reported annually by the SMRU-advised Special Committee on Seals (SCOS) (SCOS, 2017; SCOS, 2018). Studies on the movements of seals fitted with satellite tags have been undertaken by;; Cunningham et al. 2009; Cronin et al., 2013; McConnell et al. 1999; Tollitand Thompson et al. 1996 to investigate their distributions in UK waters. Research on seal site use, population structure, fidelity and philopatry (i.e. behaviour of remaining in, or returning to, an individual's birthplace) was reviewed by SCOS (2011) with specific research undertaken by Allen et al. (1996), Goodman (1998), Pomeroy et al. (2000), Pomeroy et al. (1994); Härkönen and Harding (2001); Cordes et al, (2011) and SMRU (2011). At sea movement data and terrestrial colony count data for seals has been used to produce high resolution broad-scale maps of distribution by the SMRU (Jones et al., 2015; Russel et al., 2017)

The 'Small Cetacean Abundance in the European Atlantic and North Sea' programmes (SCANS, SCANS-II and SCANS-III) undertook widespread ship based and aerial surveys of cetaceans in the North Sea and adjacent waters in the summers of 1994, 2005 and 2016 (SCANS, 1995; SCANS-II, 2008; SCANS-III, 2017). The programme provides the most comprehensive wide-scale survey data on cetacean abundance, distribution and density available in northwest European waters. Comprehensive information on cetacean distribution in northwest European waters is also presented in Reid et al. (2003). This report provides a compilation of cetacean sighting records from a variety of systematic surveys and opportunistic sightings amounting to over 2,500 days of observation carried out since 1973. Survey data for cetaceans recorded along the shelf edge (and offshore waters beyond this) of the UK, Ireland, France and Spain is provided by the Cetacean Offshore Distribution and Abundance (CODA) survey (CODA, 2009).

Understanding of cetacean population structure was reviewed in the ASCOBANS/HELCOM small cetacean population structure workshop (Evans and Teilmann, 2009) and more recently by the Inter-Agency Marine Mammal Working Group (IAMMWG, 2015).

The WDCS (Whale and Dolphin Conservation Society) additionally undertook a review identifying critical habitat for cetaceans to help highlight potential Marine Protected Areas (MPA's) for cetacean species (Clark et al. 2010).

The results of a number of research studies to determine the distribution, abundance and population structure of bottlenose dolphins around the Scottish coast is presented in Thompson et al. (2011). The collaborative project commissioned by Scottish Natural Heritage (SNH) was carried out by the University of St Andrews' Sea Mammal Research Unit (SMRU), the Scottish Association for Marine Science (SAMS), the Hebridean Whale and Dolphin Trust (HWDT) and the University of Aberdeen's Lighthouse Field Station (AULFS), with additional support from a wide

range of different individuals and bodies. The results of this collaborative research have also been presented in Cheney et al (2013) and provide the first comprehensive assessment of abundance of bottlenose dolphins in the inshore waters of Scotland. More recently, Nykänen (2019) investigated the fine-scale population structure and connectivity of bottlenose dolphins in European waters (including UK populations).

Studies and surveys at a more local scale on the bottlenose dolphins have been undertaken by a range of organisations including the University of Aberdeen/SMRU (Hastie et al. 2003, Bailey 2006, SMRU, 2007), Talisman Energy (UK) Limited (2006), WDCS, 2009) and the Hebridean Whale and Dolphin Trust (Mandleberg, 2006). The potential for long distance movements of the bottlenose dolphins around UK waters has been investigated by a collaboration of organisations including Cetacean Research and Rescue Unit (CRRU), AULFS, HWDT and Irish Whale and Dolphin Group (IWDG), which has resulted in the first evidence for long-term re-sightings between the Moray Firth, Inner Hebrides and across international borders to the Republic of Ireland (Robinson et al, 2012).

Heinänen and Skov, (2015) used spatial modelling and the results of detailed analyses of 18 years of survey data in the Joint Cetacean Protocol (JCP) undertaken to inform the identification of discrete and persistent areas of relatively high harbour porpoise desnity in the UK marine area within the UK Exclusive Economic Zone (EEZ).

Satellite tagging of harbour porpoises showing evidence of animals moving from northern Denmark to the western part of the North Sea and Shetland has been undertaken by the National Environmental Research Institute (NERI), Denmark (Teilmann et al. 2008; Sveegaard et al. 2011). Surveys on harbour porpoise abundance and distribution at a regional scale and have been undertaken by a range of authors including Bailey and Thompson (2009), Goodwin and Speedie (2008), Robinson et al. (2007) and Marubini et al. (2009).

Detailed research on otter ecology in coastal and marine environments has been undertaken around Shetland by members of the Institute of Terrestrial Ecology and University of Groningen (Kruuk et al. 1991; Kruuk and Moorhouse, 1991; Kruuk et al.. 1993; Kruuk, 1995; Kruuk et al. 1998 and Nolet et al. 1993). In addition, reviews of otter ecology have been produced as part of the Life in UK Rivers project, a project which aimed to develop methods for conserving the wildlife and habitats of rivers within the Natura 2000 network of protected European sites (Chanin, 2003) and by Mason and Macdonald (2008).

A number of other surveys and studies on marine mammals and otters have also been included where appropriate.

H.2 Pinnipeds

H.2.1 Grey Seal Halichoerus grypus

13.1.1 Ecology

The grey seal is the larger of the two seal species found in British waters, with males reaching a length of 2.45m and weigh over 300kg. In Scotland, grey seals predominantly inhabit remote islands and coastlines, giving birth to their pups from September to early November. About 38% of the world population of grey seals is found in Britain and over 88% of British grey seals breed in Scotland (Tables H1 and H2), the majority in the Hebrides and in Orkney. There are also breeding colonies in Shetland, on the north and east coasts of mainland Britain and in SW England and Wales (SCOS, 2018). The Monach Islands off the Outer Hebrides holds the largest single breeding colony in the UK, (contributing over 20% of annual UK pup production) with Faray and Holm of Faray (uninhabited islands in the northern part of Orkney) supporting the second-largest breeding colony in the UK, contributing around 9% of annual UK pup production.

Grey seals are generalist feeders, foraging mainly on the sea bed at depths of up to 100m although they are probably capable of feeding at all the depths found across the UK continental shelf. They take a wide variety of prey including sandeels, gadoids (cod, whiting, haddock, ling), and flatfish (plaice, sole, flounder, dab). Amongst these, sandeels are typically the predominant prey species. Diet varies seasonally and from region to region (SCOS, 2018). Tracking of individual seals has shown that they can feed up to several hundred kilometres offshore, with foraging trips lasting between 1-30 days although most foraging probably occurs within 100km of a haulout site (SCOS, 2018). Research into the diving behaviour of grey seals around the Orkney coast found that they appear to use the whole water column with a mean dive duration of 3.82 minutes recorded (SMRU, 2011).

13.1.2 Population structure, philopatry and site fidelity

A range of studies suggest that site fidelity and philopatry is common in grey seals. Allen et al. (1995) examined the genetic variability and differentiation of grey seals in two widely spaced British breeding colonies. Samples were collected from adults and pups on the island of North Rona, off the north-west coast of Scotland, and on the Isle of May, situated at the mouth of the Firth of Forth on the east coast. Highly significant differences in allele frequencies between these two sites indicated considerable genetic differentiation. The authors suggested that although grey seals are known to range over very large areas outside the breeding season, site fidelity of

adults and philopatry of pups for these breeding colonies must be sufficiently common to have effects, through genetic drift, at the sub-population level.

Within Europe there are two apparently reproductively isolated populations, one that breeds in the Baltic, usually pupping on sea ice in the spring, and one that breeds outside the Baltic, usually pupping on land in Autumn and early winter. These populations appear to have been reproductively isolated at least since the Last Glacial Maximum (between 26,500 and 19,000-20,000 years ago).

Little movement of breeding animals between sites in the Inner Hebrides, Outer Hebrides, Orkney and North Sea has been indicated by a spatially-explicit model that has been used to estimate the British grey seal population from geographically structured pup production estimates (SCOS, 2011). This finding is further supported by recent results from other grey seal population models that indicate an absence of large scale redistribution of breeding females between regions (Graves et al. 2009) again implying a high degree of philopatry (SCOS, 2011). The lack of large scale redistribution is also supported by Pomeroy et al. (2000). The study showed that grey seals born and marked by tagging and cohort brands at colonies on North Rona, Outer Hebrides since 1960 and at the Isle of May, Firth of Forth since 1981 have shown philopatry (particularly for females) and that females born at N. Rona pupped closer to their natal sites than would be expected by chance providing evidence of fine scale natal site fidelity. Pomeroy et al (1994) also found evidence of philopatry with 93% of marked females in 1985 returning to N. Rona to breed in at least one season up to 1989 with 27% present in all five years.

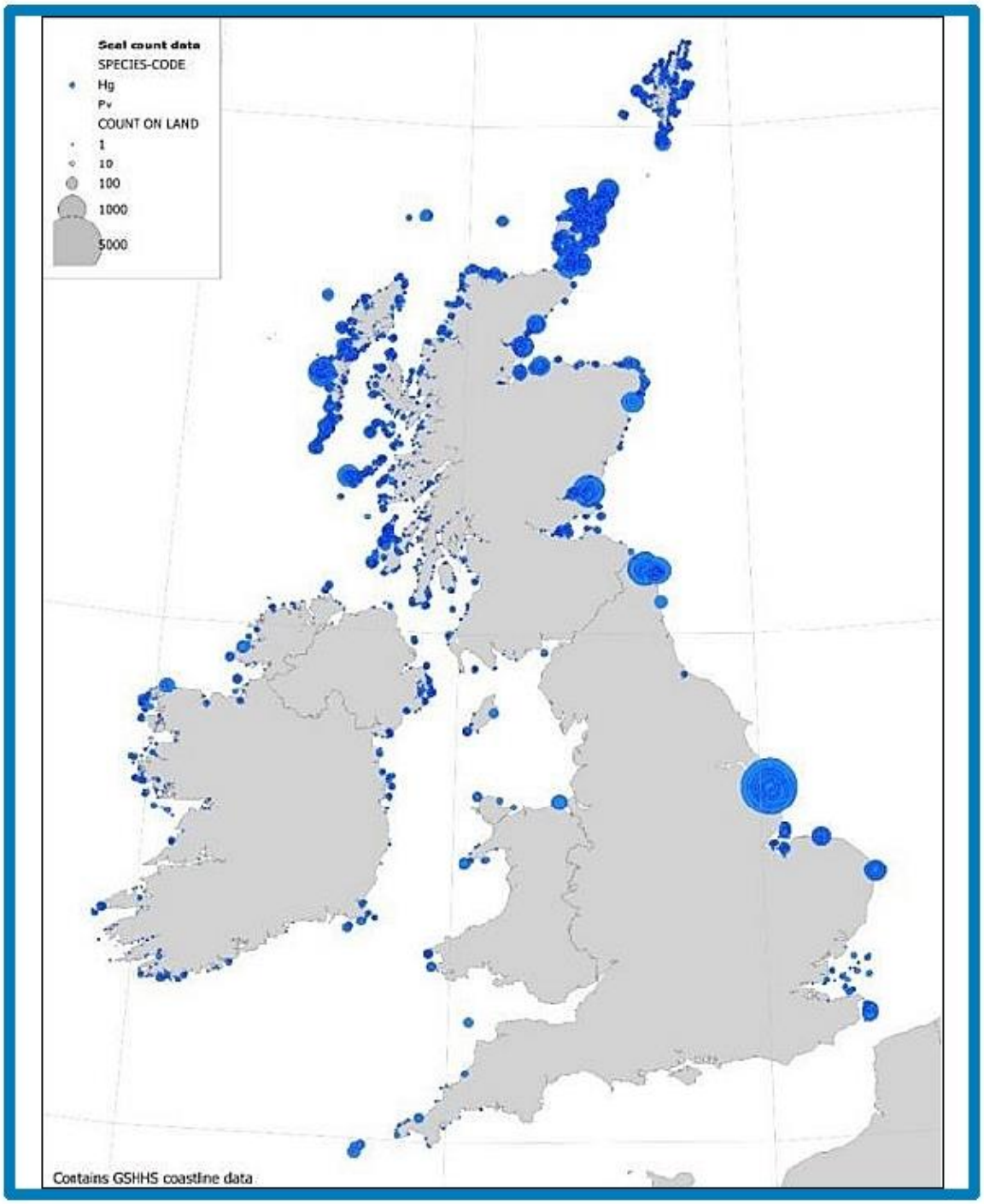
13.1.3 Population trends

Pup production estimates are typically used to compare the relative sizes of grey seal populations (SCOS, 2017). The total number of pups born in 2014 at all annually surveyed UK colonies was estimated to be 65,000. Regional estimates were 4,541 in the Inner Hebrides, 15,732 in the Outer Hebrides, 23,849 in Orkney, and 6,426 in the Firth of Forth. A further 4,193 pups were estimated to have been born at other scattered colonies. Overall, there has been a continual increase in pup production since regular surveys began in the 1960s. Between 1992 – 2009 there were indications that population growth was levelling off, for example the number of pups born in the Hebrides and Orkney have remained approximately constant since 1992 (SCOS, 2010). However, the most recent surveys in 2014 and 2016 shows an increase in pup production. Grey seal pup production in 2016 can be seen in Table H1 and the major breeding colonies are highlighted in Image H1.

Table H1. Grey seal pup production estimates for the main colonies surveyed in 2014

Region	Location	2016 Pup Production	Pup production in 2014	Average Annual Change in Pup Production From 2014-2016
Scotland	Inner Hebrides	4,541	4,054	+5.8%
	Outer Hebrides	15,732	14,316	+4.8%
	Orkney	23,849	23,758	+0.2%
	Firth of Forth	6,426	5,860	+4.7%
	All other Scottish colonies incl Shetland & mainland	4,193	3,875	+4.0%
	Total	54,741	51,863	+2.7%
England and Wales	Donna Nook +East Anglia	5,919	5,029	+8.5%
	Farne Islands	2,238	1,600	+18.3%
	SW England (last surveyed 1994)*	350	250	-
	Wales *	1,650	1650	-
	Total	10,157	8,527	+9.1%
Northern Ireland*		100	100	-
Total (UK)		64,998	60,490	+3.7%
*Estimated production for colonies that are rarely monitored				

(Source: SCOS, 2017)

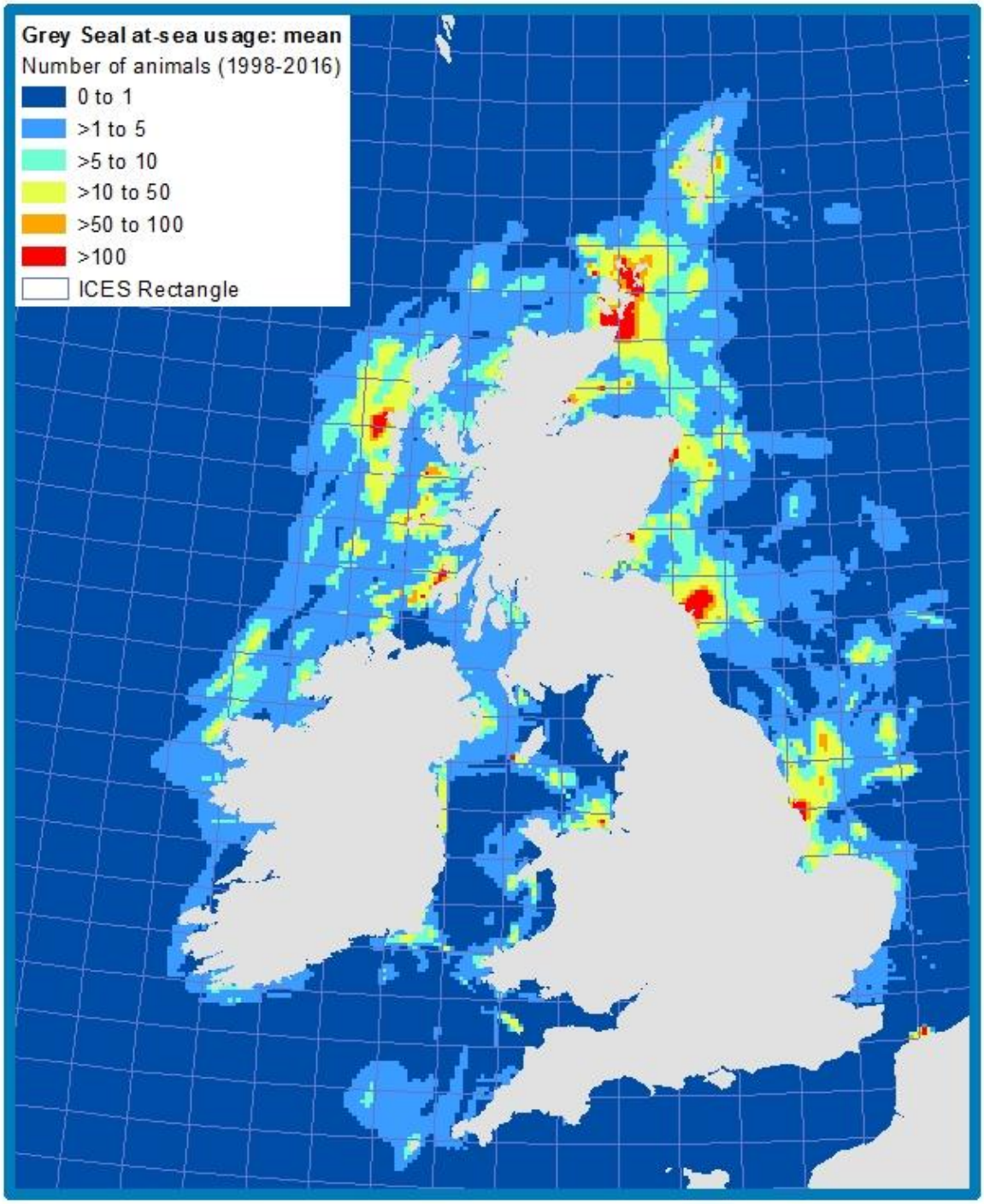


(Source: Russel et al., 2017)

Image H1. Grey Seal Breeding Colonies in the UK

13.1.4 Grey seal movement at sea

Grey seals can undertake wide ranging seasonal movements over several thousand kilometres (McConnell et al. 1999; Jones et al., 2015; Russel et al., 2017). However, while grey seals may range widely between haul out sites, tracking has shown that most foraging probably occurs within 100 km of a haul-out site (SCOS, 2018). For example, Cronin et al. (2013) found that the mean distance travelled by tagged seals during foraging trips was 50 km from haul out sites in south west Ireland. McConnell et al. (1999) found that most tagged grey seals stayed relatively close to haul out sites in the North Sea (mean distance of 39.8 km travelled on a foraging trip) with an average of 43% of the grey seals' time spent within 10 km of a haul out site. This is reflected in seal usage maps which shows the highest densities of seal movements to occur around the seal colonies with the largest populations (such as Orkney, North Rona, the Monach Isles, the Farne Islands, and Donna Nook) (Image H2).



(Source: Russel *et al.* 2017)

Image H2. Mean grey seal at-sea usage

H.2.2 Common Seal Phoca vitulina

13.1.5 Ecology

The common seal (also known as harbour seal) is the smaller of the two native UK seals measuring up to approximately 1.85m in length and typically weigh 80-100kg. Britain is home to approximately 30% of the population of the European sub-species of common seal (having declined from approximately 40% in 2002). Scotland holds approximately 79% of the UK common seal population (SCOS, 2018).

The population along the east coast of England (mainly in The Wash) was reduced by 52% following the 1988 phocine distemper virus (PDV) epidemic. A second epidemic in 2002 resulted in a decline of 22% in The Wash, but had limited impact elsewhere in Britain. Counts in the Wash and eastern England did not demonstrate any immediate recovery from the 2002 epidemic and continued to decline until 2006. The counts increased rapidly from 2006 to 2012 but have remained relatively constant since. In contrast, the adjacent European colonies in the Wadden Sea experienced continuous rapid growth after the epidemic, but again, the counts over the last 5 years suggest that the rate of increase has slowed dramatically. Major declines have now been documented in several harbour seal populations around Scotland, with declines since 2001 of 76% in Orkney, 30% in Shetland between 2000 and 2009, and 92% between 2002 and 2013 in the Firth of Tay. However the pattern of declines is not universal. The Moray Firth count apparently declined by 50% before 2005, remained reasonably stable for 4 years, then increased by 40% in 2010 and has fluctuated since, showing no significant trend since 2000. The 8 Outer Hebrides apparently declined by 35% between 1996 and 2008 but the 2011 count was >50% higher than the 2008 count. The recorded declines are not thought to have been linked to the 2002 PDV epidemic that seems to have had little effect on harbour seals in Scotland (SCOS, 2018).

Common seals are widespread around the west coast of Scotland and throughout the Hebrides and Northern Isles (SCOS, 2011). On the east coast, their distribution is more restricted with concentrations in the major estuaries of the Thames, The Wash, Firth of Tay and the Moray Firth. In Scotland, common seals are typically found in a wide variety of coastal habitats and come ashore in sheltered waters, including on sandbanks, in estuaries and along rocky areas (particularly on the west and north coasts). Adult common seals can remain very faithful to particular haul-out areas, moving around the same group of favoured locations on a seasonal basis and over a number of years (SNH, 2006). Tollit et al. (1998) found that the diet of common seals in north eastern Scotland primarily consisted of sandeel with octopus, gadoids and clupeids also consumed.

Research into the diving behaviour of common seals around the Orkney coast found that they appear to utilise the entire water column with dives lasting a mean duration of 4.14 minutes (SMRU, 2011).

13.1.6 Population structure, philopatry and site fidelity

Genetic analysis on common seals in European waters has found evidence of significant genetic differentiation between different areas. Goodman (1998) identified six distinct population units: Ireland-Scotland, English east coast, Wadden Sea, western Scandinavia (Norway-Kattegat-Skagerrak-west Baltic), east Baltic and Iceland. Within the Ireland-Scotland population there is probably occasional movement of animals between regions, but there is no evidence from satellite telemetry of any long-range movements (for example, between the east and west coasts of Scotland) comparable to those observed in grey seals. Similarly, studies of the movements of branded seals in the Kattegat/Skagerrak indicate that there is only limited movement within the western Scandinavia population. However, satellite telemetry has revealed some interchange between the Wadden Sea and the English east coast populations outside the breeding season (SCOS, 2010). This evidence and the fact that the phocine distemper virus spread rapidly throughout European common seal populations indicates that movement of individuals between locations does occur, but reproduction does not occur in the regions they visit (SCOS, 2010).

In the Moray Firth, repeat sightings of adult branded seals have shown that at least some individuals remain faithful to a single haul out site, or small group of sites both during the breeding season and in successive years (H Corpe and PM Thompson unpublished data, cited by Corpe, 1996). However, recent evidence from Cordes et al (2011) have shown that when looking at long term trends (decadal), breeding females may be changing their pupping sites in the Moray Firth to new sites. It has been suggested that this is due to changes in site characteristics, rather than changes in foraging behaviour. On the west coast of Sweden, Härkönen and Harding (2001) observed that all of the branded adult females returned to within 7 km of their natal site. Males, in contrast, showed an increased rate of dispersal from their natal site from the age of two, yet appeared to remain within approximately 50 km of their natal site.

13.1.7 Population trends

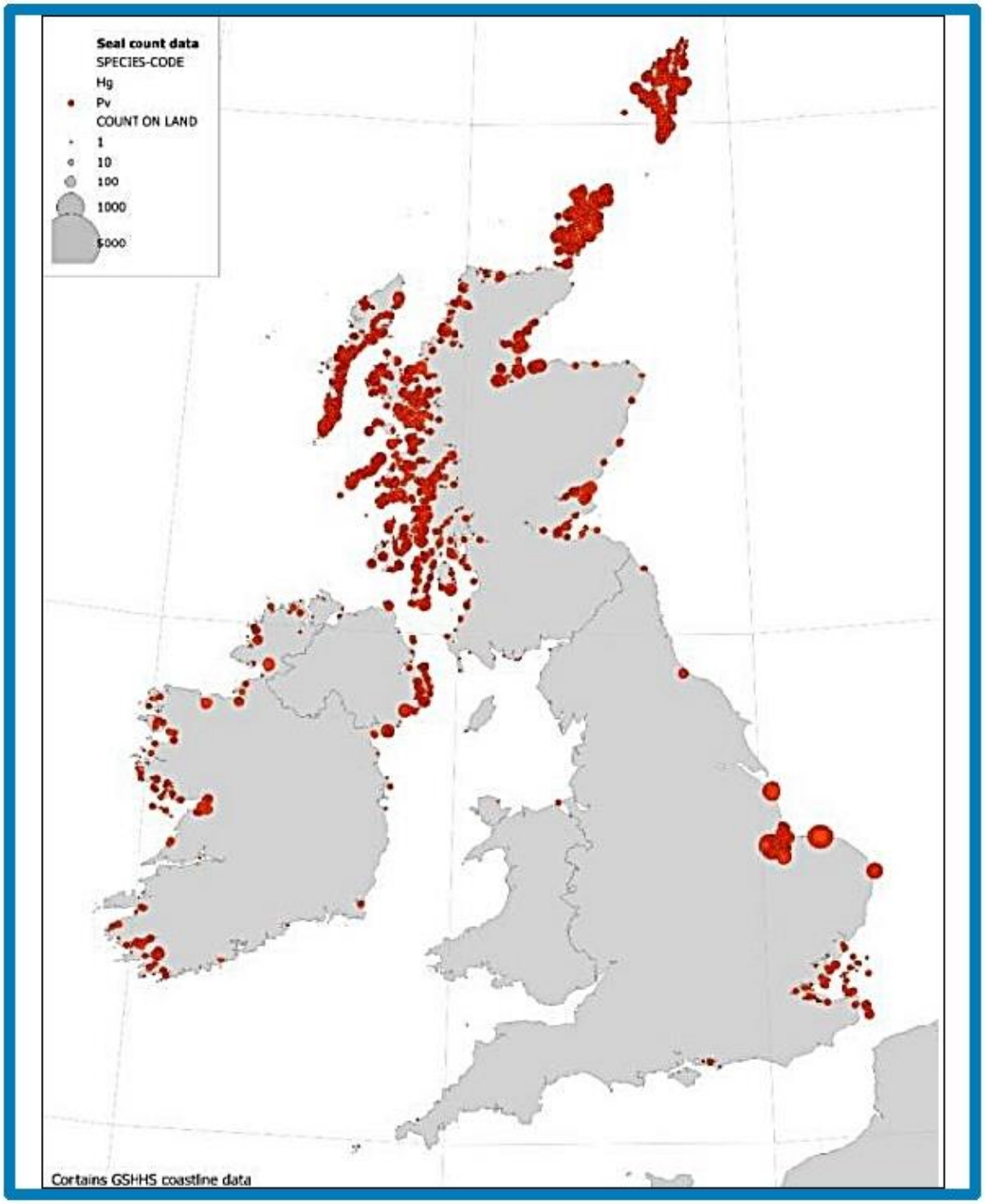
Overall, the common seal population has increased from 25,600 (rounded to the nearest 100) in the 2007-09 period to 31,400 animals during the 2013-2016 period, but remain slightly below the 1996-97 level of 32,800 (SCOS, 2017). However, as reported in SCOS 2008 to 2016, patterns of changes in abundance have not been universal; although declines have been observed in several regions around Scotland

some populations appear to be either stable or increasing. The common seal population is currently showing a decline in many populations along its range in the UK in comparison to population counts in the mid-1990s. The Orkney common seal population counts in 2016 were >30% lower than the same areas in 2013 (SCOS, 2017). The Orkney Harbour seal population has continued to decline since the late 1990's and has been falling at an average rate >11% p.a. since 2001 (SCOS, 2011).

Counts in the Outer Hebrides in 2008 were 35% lower than the peak count in 1996. Counts in the Strathclyde region in 2009 were 15% higher than 2007 and like the counts in the mid-1990s. Surveys of the east coast populations in 2010 showed contrasting trends. The Firth of Tay SAC population has declined at an average rate of 20% p.a. since 2002 with the 2016 count 90% lower than the peak counts between 2000 and 2002 (SCOS, 2017). There is an increase in the population at the Moray Firth. The total counts in 2016 were 26% higher than the previous two years, although still significantly lower than the 1996-97 counts (SCOS, 2017). The combined count for the English east coast population (Donna Nook to Scroby Sands) in 2010 was 5% higher than the 2009 count which was 21% higher than the 2008 count, meaning that population is nearing pre-epidemic levels in 2002. The west coast of Highland Region appears to be stable, while the north coast of Highland Region has declined by 35% since the 2005 survey and is approximately 60% lower than in 1997. Interestingly, the nearest European population in the Wadden Sea has shown a rapid growth in populations which increased 12% between 2008-2009 and has grown at 13% p.a. since the 2002 PDV epidemic (SCOS, 2011). The distribution of harbour seals 2016 in Great Britain and Ireland, by 10km squares can be seen in Image H3. A summary of counts of harbour seals from 2011-2016 can be seen in Table H2.

Table H2. Counts of harbour seals by region (2011-2016)

Region	Location	Count Estimate 2011-2016
Scotland	Southwest Scotland	1,200
	West Scotland	15,184
	Western Isles	2,739
	North Coast and Orkney	1,349
	Shetland	3,369
	Moray Firth	940
	East Scotland	368
England	Northeast England	86
	Southeast England	5,061
	South England	23
	Southwest England	0
	Wales	5
	Northwest England	10
Total Britain		30,334

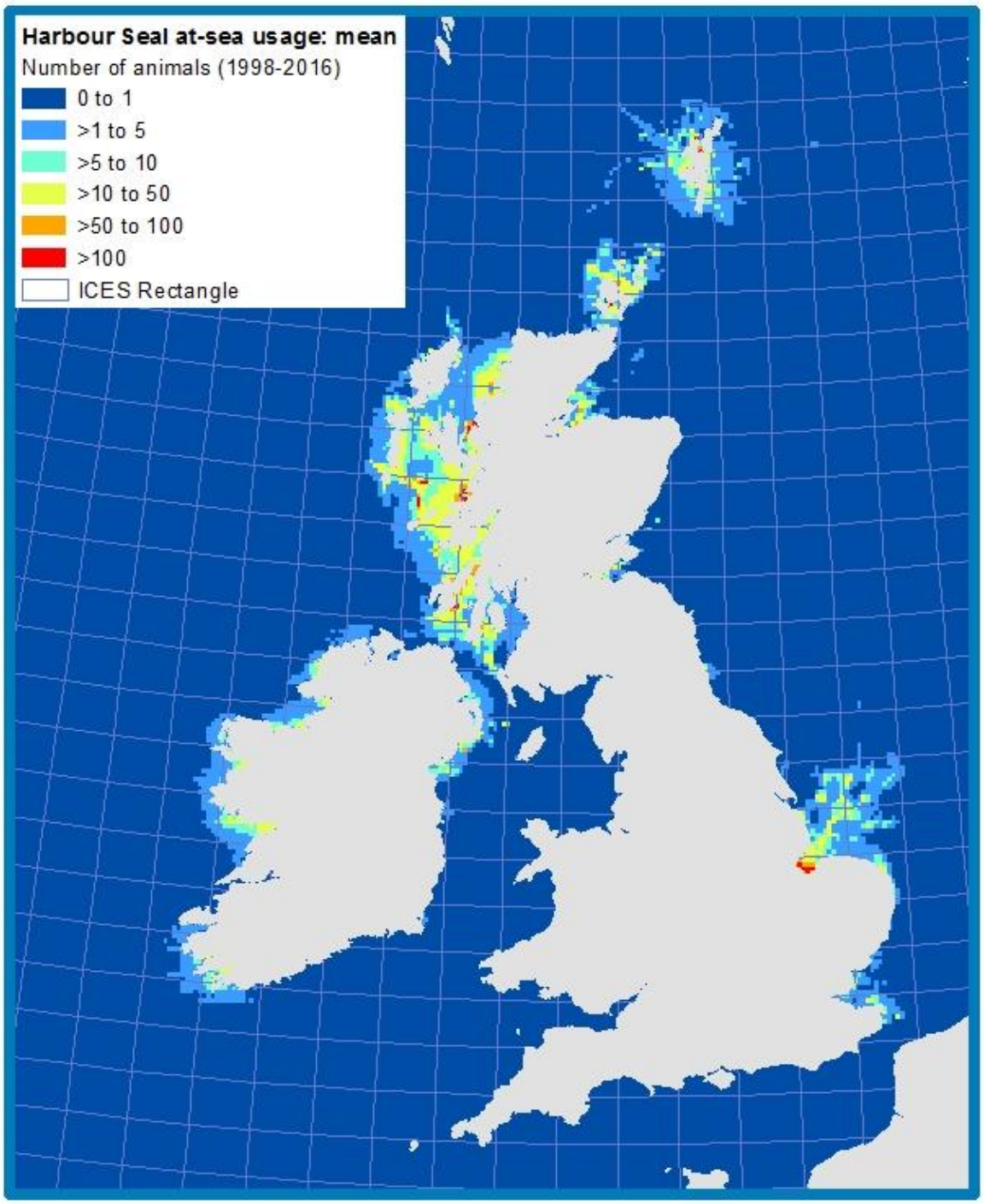


(Source: Russel et al., 2017)

Image H3. Haul-out count data for harbour seals between 1996 and 2015

13.1.8 Common seal movement at sea

Harbour seals are not believed to travel as far as grey seals, usually staying closer to haul out sites, typically within 40-60 km (for example Thompson et al., 1996; Cunningham et al., 2009; Tollit et al., 1998; SCOS, 2011). This is reflected in at-sea usage maps which show the highest densities of seal movements in close proximity to haul-out sites with foraging areas off much of the east and west coast of Scotland, with hotspots of activity north of St Andrews, in the Moray Firth, northeast of Orkney, the east of Shetland and the Hebrides (Image H4) (Russel et al., 2017). However, seals tagged in The Wash have been observed making longer trips of between 75 and 120 km offshore during foraging trips averaging ten days in duration (SCOS, 2004). All seals tagged in The Wash were highly consistent in their individual foraging habits, repeatedly travelling to the same areas. No seasonality in behaviour was apparent, though diet varies seasonally based on the availability of prey (Hall et al., 1998). All but one of the seals tagged remained faithful to the haul-out site at which they were recorded (SCOS, 2004).



(Source: Russel et al., 2017)

Image H4. Mean harbour seal at-sea usage

H.3 Cetaceans

H.3.1 Bottlenose Dolphin *Tursiops truncatus*

13.1.9 Ecology

The bottlenose dolphin has a worldwide distribution in tropical and temperate seas of both hemispheres in both shelf and coastal waters. In coastal waters, bottlenose dolphins favour river estuaries, headlands and sandbanks, mainly where there is uneven bottom relief and/or strong tidal currents (DECC, 2009; DECC, 2016). Bottlenose dolphins are a social dolphin, commonly forming groups of 2-25 individuals with larger schools occurring in offshore areas (Reid et al. 2003). Bottlenose dolphins in Scotland have been found to feed primarily on gadoids such as cod, saithe and whiting as well as Atlantic salmon and cephalopods (Santos et al. 2001).

13.1.10 Population structure

Bottlenose dolphins in the North Atlantic appear to consist in two forms, coastal and offshore. The better known coastal form is locally common in the Irish Sea (particularly Cardigan Bay) and off north east Scotland (particularly the inner Moray Firth), and in smaller numbers in the Hebrides (west Scotland), and off south west England. Little is known about the offshore form of bottlenose dolphins, including the relationship between the offshore and coastal forms (Clark et al. 2010). More detailed studies in the North West Atlantic suggest that inshore and offshore (pelagic) populations are ecologically and genetically discrete (Hoelzel et al. 1998).

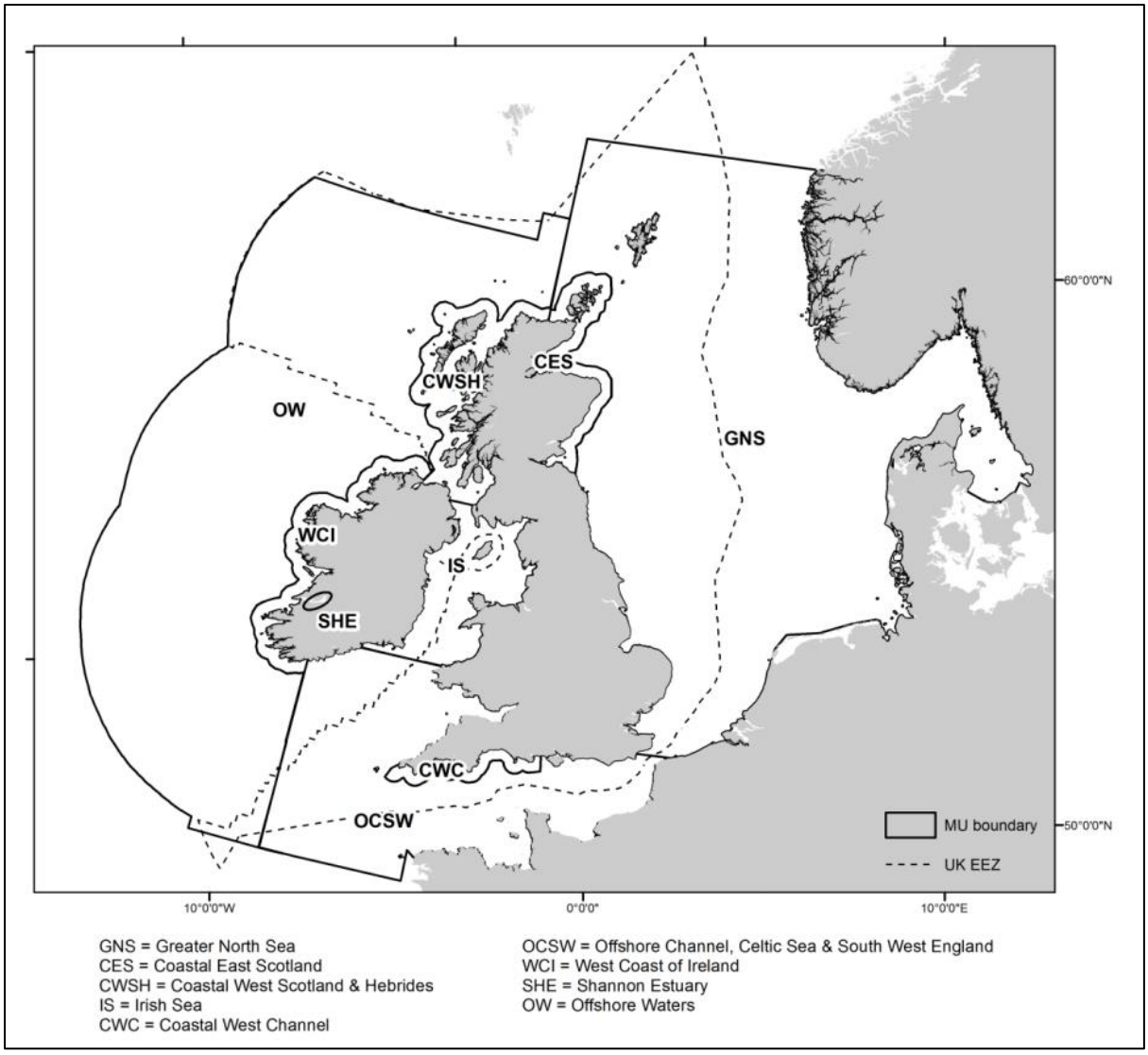
Nykänen et al (2019 also found a high level of genetic differentiation between coastal and pelagic populations. The study also found that genetic structure was defined at an unprecedented fine-scale level for coastal dolphins, leading to identification of five distinct coastal populations inhabiting the following areas: Shannon estuary, west coast of Ireland, English Channel, coastal Galicia, east coast of Scotland and Wales/west Scotland. Demographic connectivity was very low among most populations with <10% migration rate, suggesting no demographic coupling among them. The study concluded that each local population should therefore be monitored separately.

Based on the current understanding of near-shore bottlenose dolphin population and community structure the IAMMWG (2015) identified six MUs in British waters:

- Coastal West Scotland and the Hebrides (CWSH, to 12nm);
- Coastal East Scotland (CES, to 12nm);

- North Sea (NS, represented by ICES Area IV, excluding coastal east Scotland) It should be noted that very few bottlenose dolphin are seen in this area and, although there is no conclusive evidence, those seen are thought to belong to the Coastal Scottish group;
- The Channel and South West England (CSW) (ICES Divisions VIId to h);
- Irish Sea (IS) (ICES Division VIIa); and
- Oceanic waters (OW) (ICES Divisions VIa-b, VIIb, c, k and j, excluding coastal west Scotland).

The location of these areas can be seen in Image H5.



(Source: IAMMWG, 2015)

Image H5. Bottlenose dolphin Management Units (MU)

13.1.11 Abundance and distribution of different populations

Photo-identification studies indicate that around 200-300 individual dolphins occur regularly in Scottish coastal waters. The majority of sightings of bottlenose dolphins around the Scottish coastline are concentrated on the east and west coasts with numbers on the east coast being approximately five times higher (Thompson et al. 2011). A population of 195 dolphins (95% highest posterior density interval-HPDI: 162-253) has been estimated for the east coast and 45 (95% HPDI: 33-66) dolphins for the west coast (Cheney et al. 2013). Estimates an order of magnitude higher have been estimated for offshore bottlenose dolphins from wide-scale surveys such as SCANS-II, SCANS-III and CODA.

As discussed in Section 13.1.2, four distinct populations are currently considered to occur around Scotland, these are the North Sea, Outer Hebrides, Inner Hebrides and an offshore form.

The three parapatric communities of bottlenose dolphins in Scottish coastal waters, which vary considerably in population size have marked contrasts in their ranging patterns. On the west coast there are two small and socially segregated communities of dolphins, one of which includes approximately 15 individuals that have only been recorded in the waters around the Sound of Barra whereas the other is double in size and ranges more widely throughout the Inner Hebrides and mainland coasts. Due to the lack of movement between the two west coast communities, it has been recommended by Cheney et al (2013) that these communities should be considered as separate units for management purposes, pending further study. On the east coast there is a population of nearly 200 interacting dolphins between the Moray Firth and Fife with individual differences in ranging behaviour and site fidelity. Information on the abundance and distributions of these populations is shown in Table H3. A recent report by Robinson et al. (2012) provides evidence for the first time of bottlenose dolphins being re-sighted between the Moray Firth, Inner Hebrides and the Republic of Ireland, suggesting that a small number of individuals do have long range dispersal routes of up to 1,277km. This research provides evidence that communities are discrete from one another and should be managed as separate units, but that these wide ranging individuals may provide an important function in gene pool flow meaning North Atlantic bottlenose dolphin populations are not completely isolated.

Analyses of photo-identification data and genetic studies indicate that coastal bottlenose dolphins can make long-distance movements between the east and west coast of Scotland (Cheney et al. 2013), although this appears extremely rare with relatively few reports of bottlenose dolphins on the north coast of mainland Scotland or around Orkney and Shetland suggesting that the north coast and Northern Isles are not significant bottlenose dolphin habitat (Thompson et al. 2011).

Research has also indicated a level of population genetic structure among the resident populations of dolphins from East Scotland and West Scotland, and those in adjacent waters in Wales and Ireland. However, there appears to be insufficient genetic divergence to suggest that these are demographically isolated populations. At the same time, the analyses indicated that animals from these four areas do not form a single randomly mating population (Thompson et al. 2011). It has however been identified that inshore and offshore populations are ecologically and genetically discrete (Hoelzel et al, 1998 and Thompson et al, 2011).

Table H3. Abundance and distribution of Scottish bottlenose dolphin populations

Area	Population	Background Information
East	North Sea (Eastern Scotland from Caithness to the borders with England)	The population of bottlenose dolphins on the north east coast of Scotland is estimated at around 193 animals (Thompson *et al*. 2011), with all animals considered highly mobile (Cheney *et al*, 2013). The core range of the north east Scottish population is the Moray Firth which has 2 communities; community 1, animals that are regularly seen outside the inner Moray Firth (38% of individuals seen 2006-2007); and community 2, animals which are rarely seen outside in inner Moray Firth (20% of individuals seen 2006-2007). The remaining individuals comprise calves and juveniles which are yet to be assigned to a community. Bottlenose dolphin is listed in Annex II of the Habitats Directive, and the importance of this population, and the inner Moray Firth, is reflected in the designation of part of this area as a Special Area of Conservation (SAC). In the 1980s, the population's known range was focused in the inner Moray Firth but since the early 1990s, the population's range has expanded and they now inhabit the coastal waters of eastern Scotland from north of the Moray Firth to the Firth of Forth. Surveys along the southern coast of the Moray Firth from 2001-2005 encountered bottlenose dolphins along the majority of the coastline, primarily in waters <25m depth (Robinson *et al.* 2007). Observations are also occasionally made in northern England (Thompson *et al*. 2011; Evans and Teilmann, 2009). Occasional visual and acoustic surveys in offshore waters of the Moray Firth have encountered very few bottlenose dolphins (Hastie *et al.* 2003, Bailey 2006, Talisman Energy (UK) Limited, 2006, SCANS-II 2008). The Whale and Dolphin Conservation Society conducted surveys of the outer Moray Firth in 2008 and recorded no bottlenose dolphin sightings, with the main cetaceans recorded consisting of harbour porpoise and minke whale (WDCS, 2009).
West	Outer Hebrides (Island of Barra)	In total a maximum of 15 dolphins were identified from surveys in and around the Sound of Barra in 2007. The dolphins appeared to have a very small range and

Area	Population	Background Information
		they were encountered during every visit to the area (Thompson *et al*. 2011).
	Inner Hebrides / mainland	In the Inner Hebrides a maximum of 25 dolphins were identified in 2007. In contrast to the dolphins using the Sound of Barra this community ranged widely with identifications from Kintyre to the north coast of the Isle of Skye and Gairloch (Thompson *et al*. 2011). Systematic data from HWDT shows greater relative densities in certain parts of the Inner Hebrides. During the monthly surveys carried out by HWDT in the summer months between 2003-2005, the southern coast of Islay (at the entrance to Loch Indaal), Mull, Tiree and Skye were found to be of particular relevance for bottlenose dolphin sightings (Mandleberg, 2006).
Offshore	Offshore	High densities of bottlenose dolphins have been recorded in the deep waters of the North Atlantic, often in association with long-finned pilot whales and Atlantic white-sided dolphins such as in the vicinity of Rockall Bank and over the Wyville Thompson Ridge and Ymir Ridge (Reid *et al* .2003). In European offshore waters, the CODA survey (in waters deeper than 200m) estimated bottlenose dolphin abundance in the summer of 2007 as 19,295 with an abundance of 5,700 in waters north of 53ºN, including offshore Scottish waters (CODA 2009).

H.3.2 Harbour Porpoise *Phocoena phocoena*

13.1.12 Ecology

Harbour porpoise distribution is restricted to temperate and sub-arctic (primarily 5 14ºC) seas of the Northern Hemisphere. The harbour porpoise is the most commonly recorded cetacean in UK waters, primarily occurring on the continental shelf (Hammond et al, 2005; and DECC 2016). In coastal waters, they are often encountered close to islands and headlands with strong tidal currents (Pierpoint, 2008; Marubini et al, 2009 and DECC, 2016). Harbour porpoise often show large seasonal variations in their distribution (Read & Westgate, 1997 and Sveegard et al, 2011). These seasonal changes may be linked to migrations/changes in the distribution of prey (Sveegaard et al, 2011).

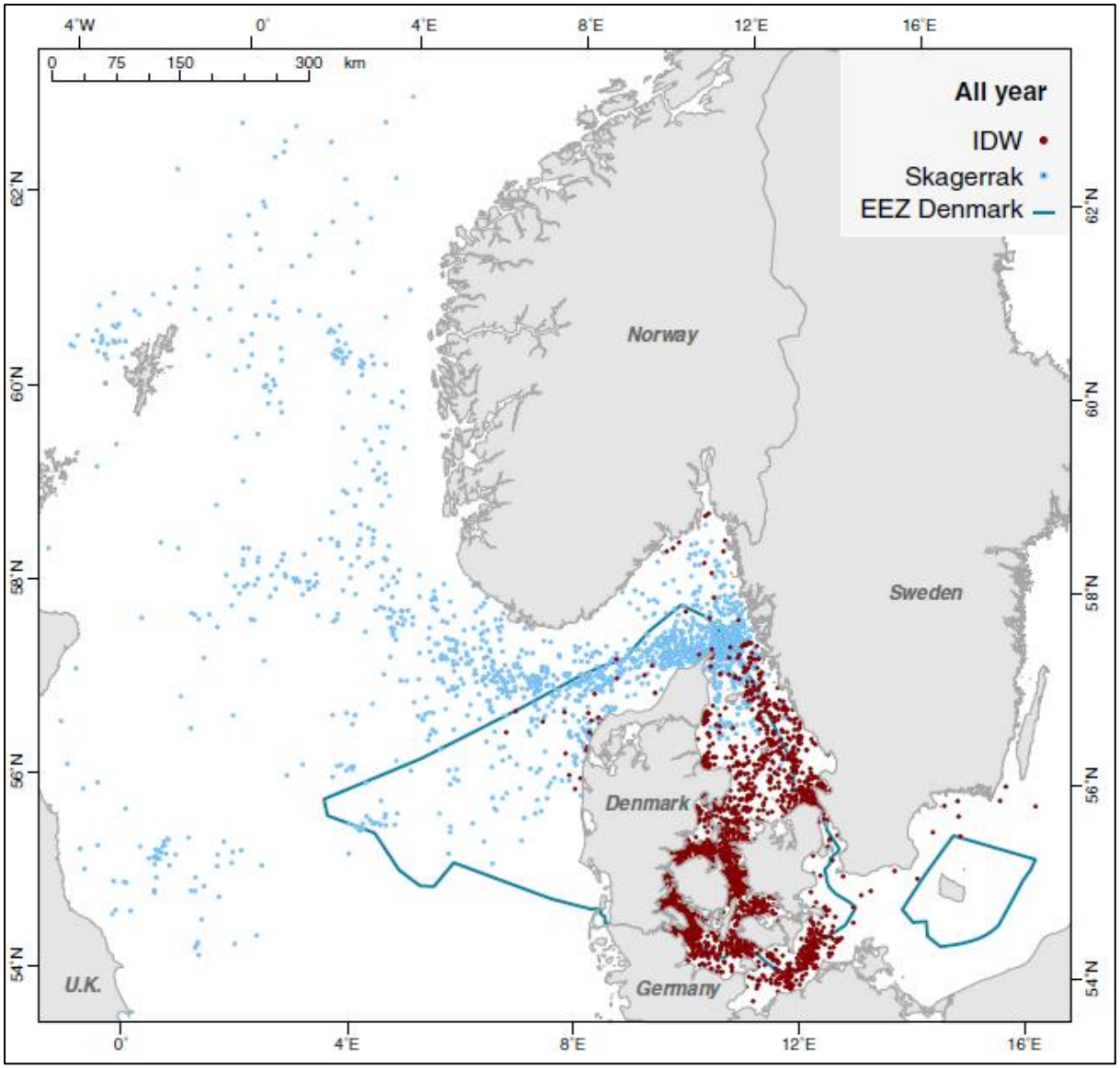
Harbour porpoises around the coasts of Scotland forage on a range of species including sandeels (Ammodytidae), gadoids such as whiting (Merlangius merlangus) and clupeids (herring and sprats) (Santos et al. 2004; MacLeod et al. 2007).

13.1.13 Population structure

In the last three decades, photo-ID has become a standard tool in cetacean monitoring, being used for the estimation of various population parameters such as abundance, home range size and use, movements and for the better understanding of social structure. It relies upon natural markings (such as nicks in the dorsal fin or tail flukes, pigmentation patterns or chevrons). However for harbour porpoise it would be unrealistic to use photo-ID for distinguishing populations (Evans and Teilmann, 2009). Instead satellite tagging and genetic studies have been used to investigate population structure.

Johnston et al. (2005) investigated the fine-scale distribution of harbour porpoises, using satellite telemetry and found that harbour porpoises can range over large areas (up to 11,289 km2) but generally concentrated their movements in small focal regions often proximate to islands, headlands, or restricted channels.

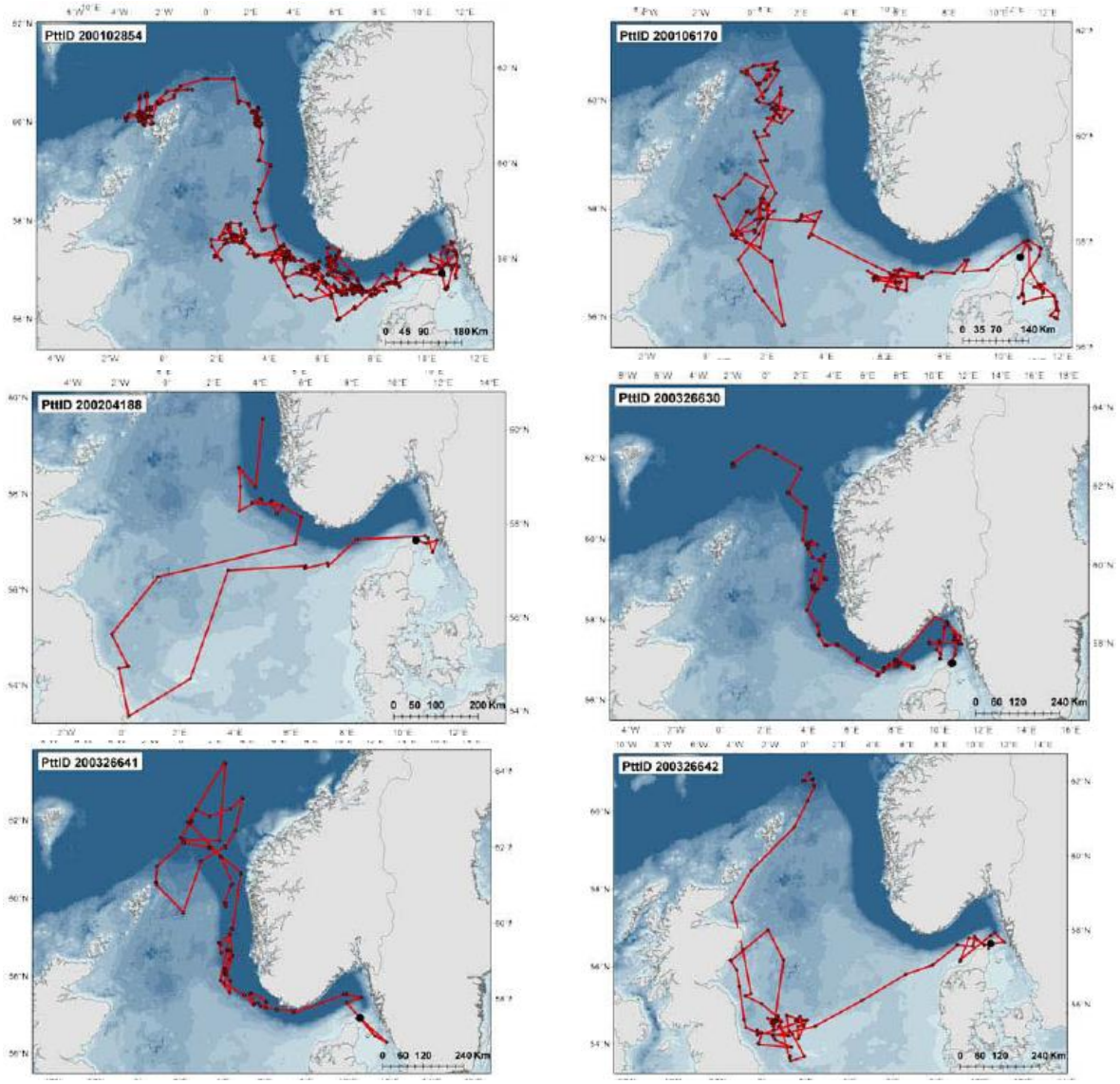
Satellite-tracking data has shown evidence of several animals moving from northern Denmark to the western part of the North Sea and Shetland. The study tagged 63 harbour porpoises with satellite transmitters in Danish waters from 1997 to 2007 (Teilmann et al. 2008; Sveegaard et al. 2011). Twenty-four harbour porpoises were tagged on the northern tip of Jylland (Skagen) at the border between Skagerrak and Kattegat and 39 harbour porpoises were tagged in the Inner Danish Waters (see Image H6). The majority of the tagged harbour porpoises remained within several hundred kilometres of the area where they were first tagged. Six animals (approximately 10% of the total number tagged) however undertook long distance travel into western parts of the North Sea. These animals were recorded approximately 800-1000km away from the point they were first tagged, travelling to various locations offshore from the East Coast of the UK and the Shetland Isles (Image H7).



Locations from porpoises tagged in the IDW are red and locations from porpoises tagged in Skagen are blue

(Source: Teilmann *et al.* 2008)

Image H6. Locations (1 Per Day) of the 63 Porpoises Tracked Between 1997 and 2007



(Source: Teilmann *et al.* 2008)

Image H7. Tracks Made by the Six Tagged Harbour Porpoise Recorded Moving into the Western Part of the North Sea

The identification of different stocks or subpopulations for harbour porpoise was undertaken by ASCOBANS Population Structure Workshop based on genetic studies and the combining of information from other approaches (e.g. telemetry). The Workshop identified 14 distinct stocks for the North Atlantic. The stocks relevant to UK waters are the North Eastern North Sea & Skagerrak (NENS), South Western North Sea & Eastern Channel (SWNS), Celtic Sea (plus South West Ireland, Irish Sea & Western Channel) (CES) and North West Ireland & West Scotland (NWIS) (Evans and Teilmann, 2009). More recently the IAMMWG identified three MUs appropriate for harbour porpoise in UK waters (IAMMWG, 2015):

- North Sea (NS) (comprising ICES area IV, VIId and Division IIIa [Skagerrak and northern Kattegat]). Noting that the northern and western boundary with Division VIa is arbitrary and that there will be an interchange of animals here with the West Scotland MU;
- West Scotland (WS) (comprising ICES area VIa and b). Noting that the boundary with the North Sea MU is arbitrary and that there will be an interchange of animals here and also with the Irish Sea and Celtic Sea MUs; and
- Celtic and Irish Seas (CIS) (comprising ICES area VI and VII, except VIId).

13.1.14 Abundance and distribution

The harbour porpoise in the most abundant cetacean in UK waters (Clark et al. 2010; DECC, 2016). The estimated abundance of harbour porpoise in different areas of the UK from the SCANS-II survey is presented in Table H4. While sighted throughout the year, peak numbers are generally recorded in summer months from June to October.

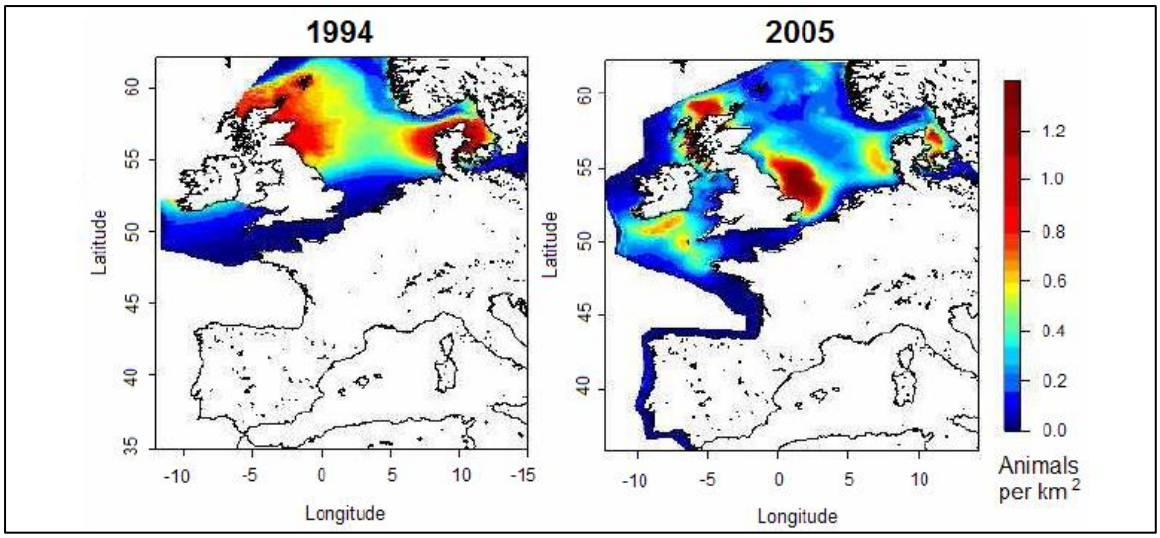
Table H4. Estimated abundance and density of harbour porpoise in UK waters

Area	Abundance	Density
Northern Isles and Moray Firth	10,254	0.274
Northern North Sea	23,766	0.177
Central North Sea (north)	47,131	0.294
Central North Sea (south)	88,143	0.562
Southern North Sea and Channel	40,972	0.331
Celtic Shelf	80,163	0.408
Irish Sea	15,230	0.335
Minches and western Scotland	12,076	0.394
Shelf waters west of Scotland and Ireland	10,002	0.067
Total (strata overlapping UK waters)	328,142	0.317

(Source: SCANS-II)

Density surface modelling of harbour porpoise from the SCANS project in 1994 suggested high densities of animals north of Scotland and in the western central and northern North Sea. The highest density of porpoises in UK waters in the SCANS survey was recorded off the Northern Isles and the Inner Moray Firth at 0.783km animals/km2 and an abundance of 24,355 animals. Repeat surveys for SCANS-II in 2005 showed considerable differences in distribution (DECC, 2009). While areas of high density remained north of Scotland, density around Orkney and Shetland

appeared considerably lower than in 1994 (see Image H8). In addition a more southerly distribution in the North Sea was observed in 2005 with elevated densities in the southern North Sea and only moderately low densities for the northern North Sea and Moray Firth. The reason for the change is unknown but changes in prey abundance and distribution have been suggested. The Minches and western Scotland (Hebrides) were not surveyed in the original 1994 SCANS survey but high densities were recorded in SCANS-II. Various studies that have investigated harbour porpoise distribution at a more local level are summarised in Table H5.



(Source: DECC, 2009)

Image H8. Modelled Density of Harbour Porpoise in 1994 SCANS and 2005 SCANS Surveys

More recently collected data from the SCANS-III survey carried out in 2016 (SCANS-III, 2017) showed that the shift seen in harbour porpoise distribution in the North Sea from the northwest in 1994 to the south in 2005 was maintained in 2016, with highest densities found in the southwestern North Sea, and north and east of Denmark.

The series of abundance estimates for harbour porpoise shows no change and a stable trend in abundance over the 22 years covered by the SCANS surveys (SCANS-III, 2017).

Table H5. Regional studies into harbour porpoise abundance and distribution

Area	Summary	Data Source
Hebrides	Sightings collected by the Sea Watch Foundation during vessel surveys in West Scotland were critically analysed and used to construct a predictive habitat model for harbour porpoises in the Greater Minch.	Marubini *et al*. 2009

Area	Summary	Data Source
	Four 'Hotspot' areas with high relative abundance were identified in (1) the region between Ardnamurchan, Coll and the Small Isles, (2) southeast of Barra, (3) northeast of Skye to Gairloch, and (4) west of Pairc Peninsula (Isle of Lewis) to Shiant Islands.	
Moray Firth	An examination of the animals using the southern coastal waters of the outer Moray Firth was carried out between May and October 2001 to 2005 inclusive. The most commonly sighted cetaceans were harbour porpoises (comprising 60% of all encounters).	Robinson *et al.* 2007
West Coast	During May-August, 2002-2004 a boat-based visual survey, employing effort-related line transect methodology was conducted for specified areas of the west coast of the UK. Harbour porpoise density showed a significant decrease in the South West, with an increase for West Scotland over the study period, whilst the highest numbers for both Northern Ireland and the Firth of Clyde were recorded in 2003. The porpoise population around the Firth of Clyde in July was estimated at 1645 (823LCI-3289UCI) individuals and off the West Scotland during August and September 3105 (2032LCI-4745UCI) individuals.	Goodwin and Speedie, 2008.
Moray Firth	Used broad-scale surveys in the Moray Firth SAC to model habitat preferences of different marine mammals. The predictions from the model indicated highest relative densities occurring within the centre of the area from the outer SAC boundary towards the Inverness Firth and also off Helmsdale.	Bailey and Thompson, 2009.

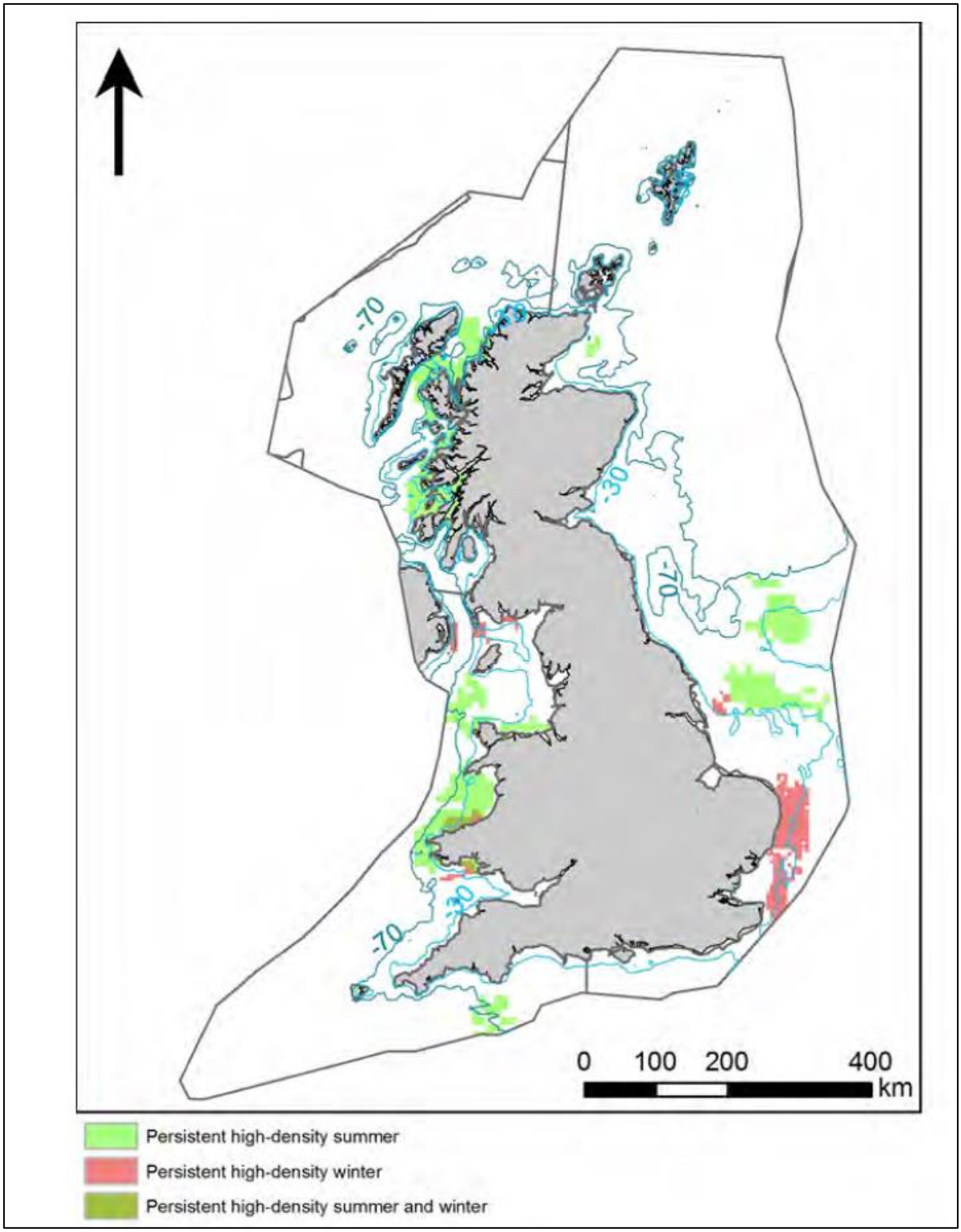
Heinänen and Skov, (2015)used spatial modelling and the results of detailed analyses of 18 years of survey data in the Joint Cetacean Protocol (JCP) undertaken to inform the identification of discrete and persistent areas of relatively high harbour porpoise density the UK marine area within the UK Exclusive Economic Zone (EEZ). The following persistent high-density areas were identified (Image H9):

- Three coastal areas off west Wales (Pembrokeshire and Cardigan Bay), and north-west Wales (Anglesey, Lleyn Peninsula), and part of the Bristol Channel (Camarthen Bay)
- Smaller areas north of Isle of Man (winter) and on the Northern Irish coast near Strangford Lough

- Western Channel off Start Point, Cornwall (summer)
- North-western edge of Dogger Bank (summer)
- Inner Silver Pit
- Offshore area east of Norfolk and east of outer Thames estuary (winter)
- Smith Bank, Outer Moray Firth (summer)
- Coastal areas off north-west Scotland, including the Minches and eastern parts of the Sea of Hebrides.

In addition, the following areas were also identified as persistent high-density areas, but due to less than three years of survey effort they were not included in the above list:

- Parts of high density zone between western edge of Dogger Bank and Norfolk coast, including both the Inner and Outer Silver Pit areas
- Offshore area north of Shetland
- Edge of the Norwegian Trench
- Shelf edge off south-west Cornwall.



(Source: Heinänen and Skov, 2015)

Image H9. Map showing selected persistent high-density areas of harbour porpoise with survey effort from three or more years, as derived from the statistical manipulations used in the present report.

H.4 European Otter *Lutra lutra*

H.4.1 Ecology

The Eurasian or European otter (Lutra lutra) is native to the UK. It belongs to the Mustelid family that includes weasels, stoats, badgers, polecats, pine martins and mink. The otter has a broad geographical distribution that extends west-to-east from Ireland to Japan and north-to-south between the Arctic Circle and Southeast Asia (Chanin, 2003).

In Scotland otters are widely distributed with strongholds in the Highlands, Hebrides and Shetland (Strachan, 2007). Populations of otters in England and Wales are confined mainly to fresh water but coastal habitats in Scotland are also readily exploited. Coastal holts are typically found within 100 m of the shore but can be further inland (Chanin, 2003; Kruuk, 1995). The diet of otters in coastal areas of Scotland is dominated by fish such as eelpout (Zoarces viviparous) and rocklings (Ciliata mustela), sea-scorpions (Taurulus bubalis), butterfish (Pholis gunnellus) as well as consuming some crabs (Kruuk et al. 1991; Chanin, 2003).

Otters have large ranges with average linear territories along rivers of 40-50km recorded for dog (male) otters and about half this distance for females (Strachan, 2007; Kruuk et al. 1993; Birkeland, 2003; Chanin, 2003; Mason and Macdonald, 2008). The range of otters utilising coastal areas in less well understood. In Shetland resident females have been recorded living in ranges of 5-14 km along the coast, males had larger ranges of up to 19 km. Transient dog otters have been recorded moving 40km along the coast (Kruuk, 1995).

H.4.2 Use of Marine Environment by Otters

Otters make use of shallow, sheltered, inshore marine areas. Feeding is usually within 100m of the shore (Kruuk et al. 1998). Kruuk and Moorhouse (1991) found that on 500 otter dives, 84% occurred within 50m of the coast. Otters also typically dive to less than the 10m depth contour with deeper water generally avoided (Scottish Executive, 2007). A detailed study in Shetland during 1983 to 1985 found that although otters were recorded diving as deep as 14m, the vast majority of dives occurred at shallower depths (54% of 3558 dives were in water less than 2m deep and 98% were in less than 8m) (Nolet et al. 1993; Kruuk (1995). Evidence from accidental captures of otters in lobster pots has shown that they are capable of diving to depths of 15m (Twelves 1983).

The preference for foraging in shallow water is thought to be related to energetic costs (with deep dives more demanding and allowing less time for foraging along the bottom (Nolet et al. 1993). This energetic need for shallow water could possible explain the low densities observed along steep coasts (Kruuk et al. 1998).

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Appendix I. Fish Literature Review

I.1 Migratory Fish Baseline Characteristics

I.1.1 Scope of Review

This appendix presents a review of the ecology of migratory fish populations found in Scottish waters and is designed to provide a context for the HRA of the DPOs in Scottish waters. The review focuses specifically on the migratory behaviour and distribution at sea of the following species as qualifying interest species identified during the HRA for the Sectoral Wind Plan:

- Atlantic salmon *Salmo salar*;
- Sea lamprey Petromyzon marinus L;
- River lamprey Lampetra fluviatilis;
- Allis shad *Alosa alosa*; and
- Twaite shad *Alosa fallax*.

This is a broad-scale characterisation only which seeks to draw upon available information to understand the value of the area in general terms. It does not specifically focus on the interest features of the European/Ramsar sites but provides a context for that assessment in recognition of the importance of migratory fish in this area.

I.1.2 Major Information Sources

This appendix presents a review of the ecology of migratory fish populations found in Scottish waters and is designed to provide a context for the HRA of the DPOs in Scottish waters. The review focuses specifically on the migratory behaviour and distribution at sea of the following species as qualifying interest species identified during the HRA for the Sectoral Wind Plan:

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I.2 Atlantic Salmon *Salmo salar*

I.2.1 Ecology

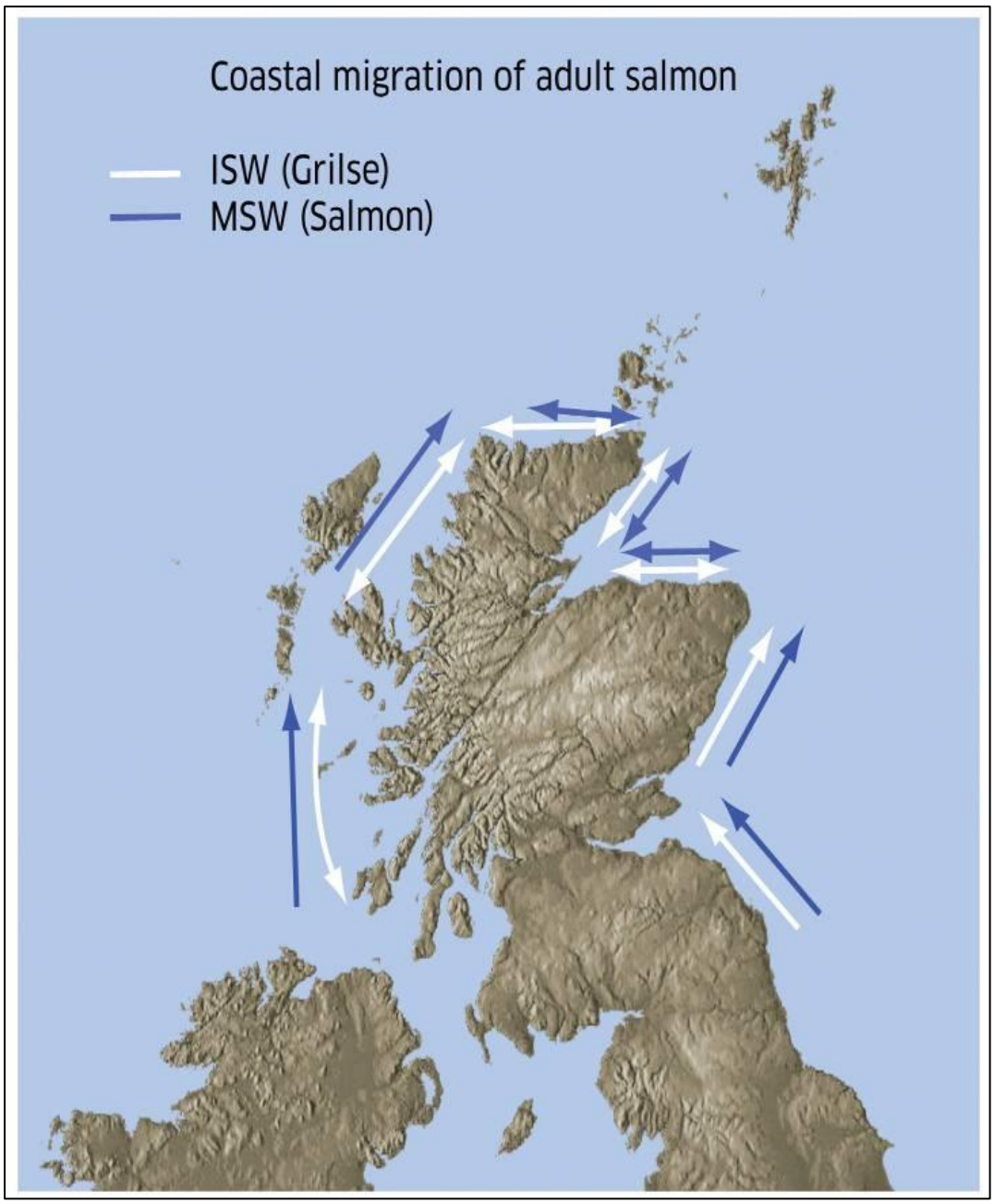
The Atlantic salmon is anadromous, its life cycle involving both a freshwater and seawater phase. Salmon utilize rivers for reproductive and nursery phases and the marine environment for adult development and rapid growth (Hendry and Cragg-Hine, 2003). In late autumn and early winter adult salmon spawn in clean gravel in the river or stream of their origin. Eggs are deposited in spawning reeds, depressions in the gravel bed excavated by the female salmon (Birkeland, 2003).

Juvenile salmon usually remain in fresh water for between two and four years, before migrating to sea. Migration takes place between April and June, when the parr begin to turn silver and become smolts. During the smoltification process salmon undergo a number of behavioural, morphological and physiological changes, which prepare them for a life in the sea. Upon reaching the sea, salmon grow rapidly, feeding on a variety of small fish including capelin, herring, sand eels and sprats. After one winter at sea a salmon is called a grilse or 1 sea-winter (1SW), and fish that have spent more than one winter at sea are called a multi-sea-winter (MSW) salmon. The length of time salmon spend in the sea before returning to their river of origin to spawn varies from one winter to five winters (Birkeland, 2003; Hendry & Cragg-Hine, 2003; Malcom *et al*. 2010).

The UK Atlantic salmon population comprises a significant proportion of the total European stock. Scottish rivers are a European stronghold for the species (JNCC, 2007).

I.2.2 Distribution and Migration Routes at Sea

Adult and sub-adult salmon have been observed using the marine environment at locations extending from Labrador in the west to Faroe and the Norwegian Sea in the east. No tagged Scottish Atlantic salmon have been observed on the Norwegian coast. Holm *et al.* (2000) investigated the spatial and temporal distribution of post-smolts of Atlantic salmon in the Norwegian Sea and adjacent areas. The highest incidences of post-smolts were in the slope current west of the British Isles, where the highest catch per unit of effort (cpue) value was recorded between northern Scotland and the Faroes in June 1997 (Image I1). The post-smolts appear to follow the main surface currents northwards into the Norwegian Sea where they spread in a fan-like distribution over an area covering most of the international waters between the exclusive economic zone (EEZ) of Norway, the Faroes and Iceland up to about latitude 73-75 N. Hansen and Jacobsen (2003) investigated the origin and migration of wild and escaped farmed Atlantic salmon in oceanic areas north of the Faroe Islands. The tagging experiment found relatively large numbers of returns were observed in Scotland.



(Source: Malcom *et al.* 2010)

Image I1. Dominant Directions of Travel for Atlantic Salmon (1SW and MSW) in Scottish Coastal Waters Based on Tagging Studies

Greenland and Faroe seas are considered to be particularly important as a feeding area for Scottish salmon based on data from the fisheries in these areas. However, the exact spatial distribution is currently unknown as most data has only come from Greenland and Faroese fisheries, representing only two sampling points for the much larger area of the ocean in which salmon are potentially represented. The concept that salmon tend towards broader, less clearly defined marine habitat use making use of oceans currents has been suggested by some research but data is

currently not considered sufficiently detailed to infer specific migration corridors (Malcolm *et al.* 2010).

Patterns of migration indicated by tagging studies around the Scottish coast suggest that Atlantic salmon make landfalls at many different parts of the coast and then redistribute themselves (Dunkley, 1985). Malcom *et al.* (2010) concluded that 1SW and MSW sea-age classes may return towards the Scottish coasts across a broad front with the marine origins of the fish are likely to be highly biased towards a range of locations to the north and west of the British Isles. Malcom *et al.* (2010) also suggested a conceptual model on how Scottish salmon reaching the coast subsequently migrate towards their natal river based on a review of available evidence. The model proposed that salmon and grilse return both to the north and west coasts of Scotland, and may even reach the north east coast directly having passed Orkney and Shetland. In general, this wide geographic distribution of potential arrival locations gives variable and apparent random directions of migration. However, several broad trends in migration patterns are evident:

- Given that MSW salmon rivers dominate the north and east coasts, the dominant direction of movement for MSW fish caught on the west will be north and east. However, for grilse, the pattern of movement would depend on where they reach the shoreline and where their native river was located.
- For east coast rivers south of Aberdeenshire fish generally moving in a northward direction from the Northumberland coast

I.3 Sea Lamprey Petromyzon marinus

I.3.1 Ecology

The sea lamprey is the largest of the British lampreys. This anadromous species occurs over much of the Atlantic coastal area of western and northern Europe, from northern Norway to the western Mediterranean, and eastern North America (Maitland, 2003). Metamorphosis to the adult form takes place between July and September and the process usually takes a few weeks. The time of the main migration downstream seems to vary from river to river and relatively little is known about them after they reach the sea, where they have been found in both shallow coastal and deep offshore waters. The spawning migration in Europe usually takes place in April and May when the adults start to migrate back into fresh water (Maitland, 2003; Harvey & Cox, 2003).

I.3.2 Distribution and Migratory Routes at Sea

Sea lampreys adult (growth) phase is short and lasts around 2 years. In this time, the species is parasitic feeding on a variety of marine and anadromous fishes,

including shad, herring, pollack, salmon, mullets, cod, haddock, greenland sharks and basking sharks (OSPAR, 2008; Gallant *et al.* 2006).

The rarity of capture in coastal and estuarine waters suggests that marine lampreys are solitary hunters and widely dispersed at sea. Sea lamprey has been caught at considerable depth (up to 4099m) suggesting that they can feed in deeper offshore waters (Haedrich, 1977). However, owing to the parasitic nature of the adult phase their distribution is largely dictated by their host. Homing behaviour is not apparent in this species. However, they are selective in their choice of spawning streams and are thought to favour sites where ammocoete larvae are present due to olfactory cues (OSPAR, 2008).

I.4 River Lamprey Lampetra fluviatilis

I.4.1 Ecology

The river lamprey (*Lampetra fluviatilis*) is intermediate in size between the large sea lamprey and the small brook lamprey. The average adult length is around 30cm with a corresponding weight of about 60 g, but specimens over 40cm can be found, and the unusual race in Loch Lomond is often less than 20 cm. River Lamprey are anadromous migratory species, which grows to maturity in estuaries around Britain and then moves into fresh water to spawn in clean rivers and streams (Maitland, 2003).

I.4.2 Distribution and Migratory Routes at Sea

Unlike sea lamprey the growth phase of river lamprey is primarily restricted to estuaries. In the estuary the river lamprey feeds on a variety of fish, but particularly herring *Clupea harengus*, sprat *Sprattus sprattus* and flounder *Platichthys flesus*. After one to two years in estuaries, river lamprey stop feeding in the autumn and move upstream into medium to large rivers, usually migrating into fresh water from October to December (Maitland, 2003).

I.5 Shad Species

I.5.1 Ecology

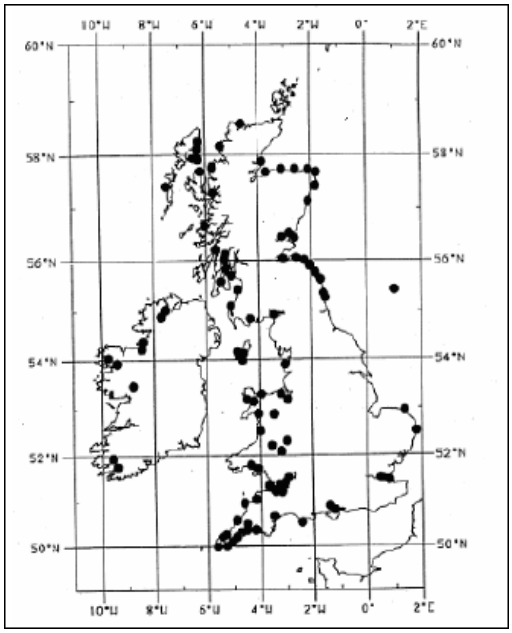
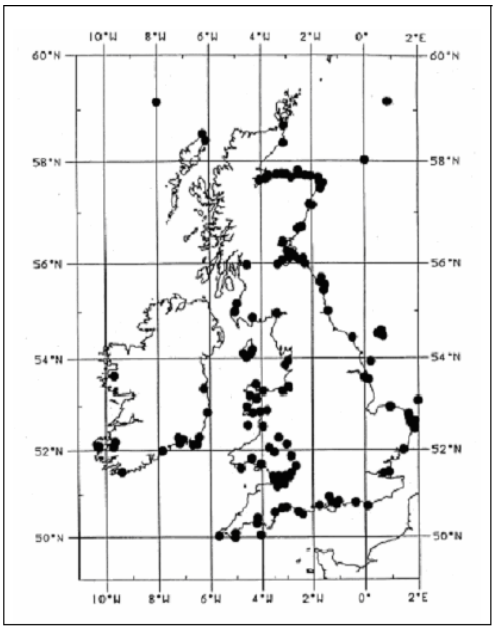
The allis and twaite shad *Alosa alosa* and *Alosa fallax* respectively are both members of the herring family *Clupeidae*. The species are anadromous, and have a pelagic-sea life mainly inshore along the coast migrating to the higher, middle watercourse of rivers to spawn (Maitland and Hatton-Ellis, 2003). Mature fish that have spent most of their lives in the sea stop feeding and move into the estuaries of

large rivers, migrating into fresh water during late spring (April to June). Males migrate upstream first, followed by females one or two weeks later. At maturity both species stop feeding and gather in the estuaries of suitable rivers in early summer (April and May), moving upstream to spawn from mid-May to mid-July. Allis shad are almost exclusively planktivorous, whereas twaite shad also feed on small fish such as sprats, and this is likely to be reflected in their habitat selection.

No subspecies of allis shad are recognised, but there is some evidence that they return to the natal river, suggesting that there may be some genetic integrity within populations. Several subspecies of twaite shad have been recognised by various authors but only one of these, *Alosa fallax fallax*, occurs in Britain (Maitland and Hatton-Ellis, 2003).

I.5.2 Distribution and Migratory Routes at Sea

The requirements of shads at sea are very poorly understood, but they appear to be mainly coastal and pelagic in habit, but have both been occasionally recorded over 100 km offshore (Image I2). Allis shad have been reported from depths of 10-150 m, and twaite shad from depths of 10-110 m, with a preference for water 10-20 m deep. A suitable estuarine habitat is likely to be very important for shad, both for passage of adults and as a nursery ground for juveniles (Maitland and Hatton-Ellis, 2003; OSPAR, 2009).

Allis shad	Twaite shad
	

Source: JNCC, 2007)

Image I2. Presence/Absence Data for Allis and Twaite Shad

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Appendix J. Mitigation Measures

Tables J1 and J2 provided in an Excel Datasheet. Avialable at https://www.gov.scot/publications/draft-sectoral-marine-plan-offshore-wind-energy-habitat-regulations-appraisal/

Table J1. Initial plan-level mitigation measure as derived from various sources

Table J2. Impact matrix for offshore renewable projects showing the activities, changes, standard sensitivities categories and affected features and mitigation measures for each environmental impact pathway

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