JNCC Report
No: 568

Seabird Displacement Impacts from Offshore Wind Farms: report of the MROG Workshop, 6-7th May 2015

JNCC

August 2015

0963 8091

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This report should be cited as:

JNCC. 2015. Seabird Displacement Impacts from Offshore Wind Farms: report of the MROG Workshop, 6-7th May 2015. *JNCC Report No 568.* JNCC Peterborough.

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Executive Summary

The Joint Nature Conservation Committee (JNCC), on behalf of the Marine Renewables Ornithology Group (MROG), convened a two day expert workshop on assessing displacement impacts to seabirds from Offshore Wind Farms (OWFs) on 6-7 May 2015 at SNH offices, Perth. The purpose of the workshop was to review new and existing evidence of seabird displacement from OWFs. The workshop considered current assessment approaches, both in the UK and abroad, with the aim of developing a more co-ordinated UK assessment approach. The ultimate aim was to identify an agreed best practice Displacement Assessment Framework (DAF) or at least the key components that might feed into such an approach.

The workshop, involving 35 participants from eight European countries, comprised a series of short presentations (providing background evidence/methods to inform later discussions), group discussion work and plenary sessions. Participants were tasked with answering a number of questions relating to the evidence underpinning, processes required, and methods feeding into a future DAF.

Participants concluded there was likely a need for both short and long-term solutions to the DAF. The short-term to meet immediate needs of projects currently going through (or shortly entering) the consenting process, the longer-term to allow time to address substantial evidence gaps on the true impact of displacement, as well as develop more robust methods to feed into the DAF. Ultimately, these two initially parallel approaches would likely merge into a single, best-practice approach. It was also felt important to consider 'combined impacts' (i.e. displacement, barrier and collisions), Cumulative Impacts Assessment (CIA) and transboundary impacts in any future framework. For any future DAF to be effective, participants noted the need for common analytical approaches, better/more empirical evidence and clearer guidance. There appeared to be consensus on the benefits of continuing to use some form of 'Matrix Approach'[1], at least in the short-term, but that further work was required to appropriately integrate species-specific variation in displacement levels/impacts, seasonal life history stage (e.g. breeding adult, juvenile, non-breeder), and particularly demographic rates (survival and productivity) into the Matrix Approach. Also that it might be helpful to add aspects of 'habitat quality' (or 'habitat importance') to the Matrix Approach, but that this might have to be a medium-term aim.

The group felt there was potential for integrating some elements of the 'Displacement as Habitat Loss Approach' into a future DAF, but that this was likely to be part of a medium or long-term approach. As assessment methods continue to improve over time, individual/agent-based models were thought likely to develop and be more routinely used in any future DAF. For the development of a short-term DAF, it was broadly felt there should be 3 key stages: (1) screening (using expert elicitation to inform/chose parameters), (2) a refined Matrix Approach, and (3) analyses of the population consequences. Finally, there was a recommendation that displacement/abundance data from individual projects must be comparable, with a clear record of methods used, decisions made and outcomes from each assessment, readily available[2].

[1] See Concept Note (CN) 7 for further details on the existing 'Matrix Approach'.

[2] While assessments are available on the PINS website, it does not cover all UK projects nor does it always cover all datasets, methods and analytical approaches presented during latter stages of the assessment process.

1. Introduction

1.1 About this report

This is a report of a technical workshop that was held at SNH Battleby, Perth on 6 and 7 May 2015. It is primarily intended as a record for participants, which includes the conveners of the workshop (JNCC/MROG), The Crown Estate (TCE), Statutory Nature Conservation Bodies (SNCBs), Royal Society for the Protection of Birds (RSPB), consultants, industry representatives and academics. However, the report has been compiled in such a way as to make it useful for a wider audience. The report was compiled by R K Partnership, with input and advice from JNCC and feedback from participants.
The report has been compiled from the following sources:

- Background 'Concept Notes'[3] prepared in advance of workshop;
- Preparatory work for the workshop by R K Partnership Ltd;
- Abstracts submitted by those who gave presentations at the workshop;
- Notes taken during each table/group discussion session;
- Notes taken during each workshop plenary session.

The report follows, as far as possible, a consistent structure for each workshop session. Namely, the session title, a description of how the session was run, a summary of materials provided to participants to inform discussions, the questions participants were asked to answer, notes from these discussions, and finally any conclusions or suggestions that arose from the session.

The report represents a record of:

- Sub-group discussions with summaries of key points made by attendees. However, this does not necessarily mean a consensus was always formed. Where there was consensus in a sub-group this has been highlighted.
- The group's plenary discussions with a summary of common points from sub group work. These points are closer to "agreed" by the whole group but this was not explicitly drawn out during the meeting as this was not a requirement and there was not enough time to explore if the whole group was in "consensus". The final plenary at the end of the workshop was more explicitly seeking to find where there was agreement/ consensus and this has been captured.

1.2 Context of the workshop

The numbers of offshore wind farm (OWF) development sites are increasing in UK waters, as the UK government seeks to make progress towards its renewable energy targets. A key concern from this expansion is the potential impact on wildlife, including collision risk, barrier effects and displacement of seabirds that spend a large portion of their life cycle in the offshore environment. Some species of seabirds are known to be displaced from historic foraging areas by wind farms. However, at present there is a paucity of information monitoring information of seabirds at sea to inform assessments and there are difficulties in both detecting a change in abundance (due to the high degree of variability in baseline data associated with snapshot surveys) and in quantifying the consequences of displacement and/or barrier effects on mortality and/or productivity. Due to these uncertainties, a variety of impact assessment approaches are currently being used by industry, regulators and statutory advisors, making consistency across projects and regions increasingly difficult. Consistency of approach is vital when considering and/or estimating cumulative impacts across multiple projects, regions and sectors.

[3] 'Concept Notes' (hereafter CN) were produced by JNCC, NE, SNH and external contractors in order to facilitate useful discussion and progress difficult sub-topics within the workshop. They were not necessarily for wider dissemination and publication after the workshop (although a number have since been made publicly available through JNCC and NE websites).

In the absence of good quality data on the extent and effects on seabird populations resulting from displacement from OWF sites a consistent approach to the treatment of displacement effects within the impact assessment process is urgently required.

1.3 Aims of the workshop

The purpose of the workshop was for experts to review new and existing evidence for displacement effects on seabirds from OWF projects and consider the consenting requirements of regulatory, agencies and industry. It considered current assessment approaches, both within the UK and abroad with the aim of developing a more co-ordinated UK assessment approach. The ultimate aim was to (if possible) identify and agreed best practice Displacement Assessment Framework (DAF) – or at least the key components which might feed into such an approach.

1.4 Objectives of the workshop

The objectives for the workshop were agreed before hand by MROG and JNCC and then endorsed at the workshop. They were:

- Agree the key components (or approaches) of a seabird Displacement Assessment Framework (DAF);
- Agree the next steps/how the DAF will be developed beyond the workshop;
- Identify areas for further research that would help develop the DAF, either in the short or longer-term.

1.5 Funding for the workshop

The workshop itself was funded by The Crown Estate (TCE). As managers of the UK's seabed out to the 12 nautical mile limit with rights to renewable energy out to the continental shelf, TCE plays a major role in the development of the offshore renewable energy industry through leasing areas of seabed for developments sighting.

JNCC provided funding and project management for a contract with APEM to produce Concept Note CN1. JNCC also drafted and produced two other Concept Notes (CN2 and CN4) internally. NE provided funding and project management for CN5, while SNH drafted and produced CN 7 internally. Industry representatives drafted and produced CN6, while CN3 was put on hold due to lack of available funding to develop further in time for the workshop.

The Concept Notes were:

CN1: Developing a Habitat Loss Method for Assessing Displacement Impacts
CN2: Sensitivity Scores as a Proxy
CN4: Evidence for Displacement; an Aide-Memoire
CN5: Integrating Collision Displacement and Barrier Effects
CN6: Developer Perspective on Seabird Displacement
CN7: Displacement Matrix Approach

All venue and catering costs were provided by SNH.

1.6 Convening the workshop

JNCC, with support from SNH, took a lead role in organising and convening the workshop on behalf of MROG. The MROG Displacement sub-group formed a Displacement Workshop Technical Working Group (TWG) to provide input and steer leading up to the workshop. The TWG met at regular intervals to progress the Concept Notes (the background papers for the workshop), to arrange logistics for the workshop, to arrange a facilitator, and to contribute to the finalisation of a workshop report (i.e. this document).

The MROG Displacement sub-group has representation from a wide range of stakeholders, including; Marine Scotland Science (MSS), Natural England (NE), Natural Resources Wales (NRW), Scottish Natural Heritage (SNH) and the Royal Society for the Protection of Birds (RSPB).

1.7 Workshop design and facilitation

JNCC, on behalf of MROG, engaged R K Partnership Ltd to work with them on the design, preparation and running of the workshop. Rob Angell acted as lead consultant and designed a detailed workshop programme as well as facilitated the running of the workshop over the two days. R K Partnership also compiled this report on behalf of JNCC.

1.8 Workshop key elements

Stage 1: Day 1 of the workshop covered the following topics, in small groups and/or in plenary:

- Offshore Wind Farm Industry perspective (CN6) (plenary).
- Evidence for displacement – an aide memoire (CN4) (groups + plenary).
- Using the Furness & Wade Sensitivity scores as a proxy (CN2)/The Displacement Matrix Approach (CN7) (groups + plenary).
- Centre for Ecology & Hydrology (CEH) Displacement Model/Integrating collision, barrier and displacement effects (CN5) (groups + plenary).

Stage 2: Day 2 of the workshop covered the following topics, in small groups and/or in plenary:

- Developing a Habitat Loss Method for assessing displacement (CN1) (groups + plenary).
- Other considerations for a future DAF (groups + plenary).

Stage 3: The group then worked to bring ideas together by developing an outline DAF (groups in carousel + plenary).

Stage 4: Finally there was a discussion of next steps (plenary).

1.9 Presentations to inform discussions

To inform the group and plenary discussions input was given in the form of short presentations by expert attendees, relating to each of the above topics. The titles of these presentations and the names of presenters are given in the body text. Abstracts for each presentation, and all authors, can be found in Appendix V. After each presentation there was an opportunity for clarification and comments, and these are detailed where applicable.

2. Offshore Wind Farm Industry Perspective

Marcus Cross from Scottish Power Renewables, on behalf of the OWF industry, gave a five minute presentation on their perspective of the relevance of this work.

[See Appendix V – Section 2 abstract]

The group then gave their thoughts and reactions to this in a plenary session.

2.1 Plenary discussion key points

The group found it useful to hear the number of projects currently in, or likely to be in, the consenting process in the short to medium term. Fewer than 10 offshore wind farm proposals are anticipated to be come through the UK licensing process in the next few years. Because of this, the group felt there perhaps needed to be a focus on short-term solutions in the next six months (i.e. developing a pragmatic interim approach to assess displacement impacts for those windfarms likely to be in or going through the consenting process shortly). However, the group also felt there was still a balance required between what is currently available in guidance, what short-term improvements can be made to that guidance, and what may be helpful in the medium to longer-term. It also needs to be recognised that any guidance may also be of assistance to other industries (e.g. wet renewables).

While there is a lack of evidence of gross impacts over the last 10 years from operating OWFs (no mass mortality has been observed nor has there been a collapse in any seabird colonies directly and solely attributable to OWFs), this is not effectively monitored for at present nor is it sufficiently targeted to discern population level effects. Moreover, there is a substantial time-lag before we would anticipate picking up any population level effects (~30 years, as seabirds are long-lived). Therefore, it could take longer than the current operational period (i.e. a generation time) to observe such effects. Another aspect to consider is seasonality – the focus of seabird impact assessments, and of research, has been on the summer breeding season and we know very little about birds' winter movements or adult survival over winter.

There needs to be greater clarity in the use of terminology to ensure that everyone understands what is being described/required (e.g. need to differentiate between an "effect" and a "consequence" or "impact").

We also need to be clear that small impacts can mount up, and the workshop was welcomed as an opportunity to discuss population impacts of displacement at an individual and cumulative project scale against a relevant biogeographic population. The group felt that consideration of cumulative impacts in the DAF was vital.

Industry agreed with the need for short and long-term approaches, but wanted a greater degree of certainty with regard to short-term guidance. The political context is one of the most important drivers for wind farm development and the numbers of wind farms that may be developed in any particular country. It is important to realise that this can change quickly. The perspective needs to be wider than the UK, as seabirds do not recognise political boundaries. There is a need to work towards an approach that has relevance across Europe. This workshop is an important opportunity to tap into the experience of European colleagues.

2.2 Conclusions/Suggestions

At this stage it would appear there was consensus on the need for:

i. Short and long-term perspectives on guidance requirements;
ii. Consideration of species and seasonal aspects, within UK waters;
iii. Consideration of the European dimension in the development of methods for considering population consequences of displacement, which may be useful to all in the short and long-term.

3. Evidence of Displacement Effects

There were four short presentations to inform thinking on this topic:

1. Evidence for displacement: an aide-memoire - Orea Anderson, JNCC.
2. Latest displacement results from Dutch studies - Mardik Leopold, IMARES.
3. Seabird displacement at an offshore wind farm in the Belgian part of the North Sea – Nicolas Vanermen, INBO.
4. Changes in distribution and abundance of Red-throated Diver (RTD) in Greater Wash - Andy Webb, HiDef.

[See Appendix V, Section 3 abstracts A-D]

Participants had an opportunity to ask questions of clarification (Appendix V, Section 3) The group then split into sub-groups to suggest key elements they thought should form part of a DAF. After this the groups shared key discussion points and suggestions in a plenary session.

3.1 Summary of group and plenary discussions

A group consensus developed around the need for a 'common currency' and standardised analytical approaches, including; an agreed approach to detecting and measuring displacement, the use of modelling to identify population consequences, (where necessary), and gradient analysis to determine buffer zones (i.e. to determine the effect of increasing effect with distance).

The group also felt there was a need for more empirical data, including better spatial and temporal coverage, and a better understanding of population-level impacts of OWFs (i.e. impacts on demographic rates, notably survival and productivity).

There was broad agreement on the need for clearer guidance on species/group percentage ranges within the matrix (i.e. for displacement effects and impacts on survival/productivity) and seasonality (i.e. which seasons to consider for different species).

Other factors needing further consideration were:

1. Behavioural responses.
2. Identification of clear species of interest at a particular site.
3. Screening key species through a modified matrix approach.

There remained a question as to whether an individual project approach to assessment should be used, or a Cumulative Impact Assessment (CIA) approach (e.g. to take into account the international movement of some species).

There were concerns from industry around who would actually be responsible for doing any CIA of displacement impacts because of known difficulties around developing methodological approaches and the short timescales involved in the examination process.

3.2 Questions participants were asked to address

- Based on what we've just covered, what elements might be most suitable to take forward as common themes in a DAF (e.g. buffers, seasonality, species-grouping behaviour)?
- Choose top 3 if your list is long (for feedback).

3.3 Group discussion key points

Group 1

A common currency and analytical approach: A standardisation of displacement assessment would also enable a relative comparison of effect between Offshore Wind Farms (OWFs).

A review of evidence is needed: Need to have a better understanding of empirical evidence. It will be useful to identify what the specific drivers of displacement behaviour are from the empirical evidence (e.g. turbine density, layout, distance from shore, activity of craft/personnel). Advice is needed on how to handle non-standard evidence.

Clear guidance: There needs to be clear guidance on how to use the Displacement Assessment Framework (DAF), including a consistent approach to analysis using best available evidence.

A risk-based approach: Any guidance/framework should include a risk-based approach. For example, with the Matrix Approach presenting the whole range, there needs to be a risk-based approach to refining the range to a more realistic scenario. This was seen to be important for examiners (under the PINS process) to ensure they understand how to interpret the results being put forward.

Reference populations: Identify what reference populations the impacts are assessed against (i.e. flyway, regional, Special Protected Area (SPA), *etc*).

Seasonality: There is a need to identify if the effect is different at different times of the year (i.e. are we confident it is likely to be adult survival impacted in the winter and productivity in the summer?). There also needs to be agreement on the temporal approach to the assessment; will it be applied seasonally or month-by-month, as with Collision Risk Modelling (CRM)? There were different views on whether monthly impacts should be added together (as this might assume it is always different birds being affected). This was not resolved. Finally, it is necessary to consider whether the non-breeding season needs sub-dividing into autumn migration, winter, spring migration, post-breeding etc.

Habitats Regulations Assessment (HRA) versus Environmental Impact Assessment (EIA): Will we need to consider different approaches depending on when an SPA is designated (i.e. for breeding versus non-breeding) and would there be any differences between HRA and EIA approach?

Mortality and productivity: What should we be focusing on? To date we have focused on mortality but impacts on productivity could be equally important.

Buffers: Consideration should be given as to whether a sliding scale of displacement with distance from windfarm, rather than a distinct buffer with assumed uniform displacement, is more appropriate.

Habitat quality: The importance of the quality of habitat lost relative to the habitat individuals may be displaced to, is not currently captured in the guidance (although has been attempted by some developers) but it would seem logical to do so.

Combining mortality/productivity changes: Advice is needed on how to combine any predictions (e.g. do you add together breeding + non-breeding mortality?).

Turnover: Survey data is just a snapshot in time. How do we handle turnover when the total number of birds exposed to a risk could be much greater, but their individual exposure much smaller? Equally, seasonality, in relation to turnover, may require different treatment. In other words, individuals during the breeding season are more likely to be subject to high individual exposure to displacement effects (high number of bird hours/individual) compared to birds on migration (low number of bird hours/individual).These particular points need further consideration.

Habituation rate: Capture any species-specific variation on this. This links back to review of evidence.

Top 3-4 Key Points:

i. Clearer guidance.
ii. A common currency and analytical approach.
iii. Seasonality.
iv. Productivity.

Group 2

Survey design: The DAF should include recommendations on survey design and analyses, with Before After Gradient Impact (BAGI) preferred over Before After Control Impact (BACI) designs, and buffer sizes should not be explicitly set – or set out to a distance of 10km so that any effects were guaranteed to be covered by the overall buffer distance around the project site. Other suggestions included a strip only design (to avoid the problem of a 10km all around 'buffer' making any area unwieldy to survey) and making sure that buffers should vary by species.

Barrier impacts: The framework should also not ignore barrier impacts, but the group acknowledged there was an issue with trying to distinguish between barrier and displacement effects and impacts. In certain species a degree of barrier effect has been measured (e.g. Divers and Scoter at Horns Rev) but not many. These studies suggest how the issue could be addressed.

Species: To include in any DAF. Only certain species are likely to be much affected and studies should concentrate on these. Uncertainty around which data should be recorded, and what protocols should be applied when data collected Not all data is available at the moment (some is privately held) but it should be made clear that all data collected during the assessment process should be publically available and in a form suitable for analysis.

Post-Construction Monitoring (PCM): 10 years PCM was suggested as a minimum period necessary (statistically) to detect changes, but it is unlikely that developers would agree to such a level. Better pre-construction design would ensure optimal benefits from any post construction monitoring, with longer pre-construction monitoring suggested to improve knowledge of background populations. Equally, spacing out survey years post-construction (e.g. Year 1, Year 3, Year 5, etc. rather than every year) might give greater confidence that any differences being observed were not due to natural annual variation. Baselines need to be established and surveys need to be adequate to address the key input parameters.

Seasonality: The DAF should take account of seasonality, but there is a very poor understanding of different impacts at the moment. All separate periods when birds have different vulnerability (e.g. moulting periods for sea duck) should be accounted for separately. At these times birds are very sensitive to changes in condition of the site. It is a learned behaviour (finding the location) and takes a long time for populations to shift sites.

International impacts: There is an international aspect to displacement (birds move through many areas, and may encounter many wind farms) and logger data is the way to get information on this. This would help assess what impact multiple wind farms are having on a single SPA population. To address international impacts would require better co-operation between EU member states to share data, for example. In that case it would be clear that impacts need to be apportioned more widely (to larger populations).

Top 3-4 Key Points:

i. **Better survey design:** Both spatially and temporally. BAGI survey design is preferable to BACI design. BAGI can be used to define a buffer area. Buffer size is species specific.
ii. **Data availability:** There is a need for empirical data to understand the potential impacts. Data is required when assessing demographic rates such as mortality and productivity.
iii. **Need to consider broad range of species and cumulative impacts:** International consideration is important as some species cover large cross boundary areas.

Group 3

A top-down approach: i.e. 1) species; 2) context and 3) consequences. Noting that in order to undertake the assessment you need a get to a number, such as mortality or number displaced, ideally with confidence limits. However, we struggle to get to the consequence stage. The group suggested that a key element was to identify and define the link between displacement and survival. We can measure displacement, but it is very difficult to measure the consequences of displacement at the individual and population level.

There is a need to clearly define the building blocks for population changes, summarised by the following pathway:

> *Effect -> Behavioural change -> Physiological changes -> Demographic changes -> Population change -> Individual -> Population*

Interim Population Consequences of Disturbance (PCoD): An interim framework for modelling disturbance from noise (e.g. piling) on marine mammal populations has been developed by St Andrews on behalf of UK regulators and SNCBs. It is an interim approach to modelling population effects, which highlighted key knowledge gaps and used expert elicitation to fill gaps until empirical data become available. It was suggested that a similar approach could be applied to bird species at risk of displacement. But there are many more bird species so it may be more complicated to develop than it was for marine mammals.

Linking habitat loss and mortality in waders: The link between displacement and survival in waders has been estimated, which is easier to do because they are more visible (i.e. in an estuary situation), but it can also be undertaken for benthic feeders such as the Common Scoter. All that would be required is a survey of food availability, depth of water and then to model energetic consequences with different OWF scenarios. But there is greater difficulty mapping prey availability for most other seabird species.

Matrix Approach: A key issue here is the need to hone in on an estimate of the displacement and survival link. It may have merit as a screening approach, adapting the matrix to include sensitivity scores, density and the relative importance of the site compared with other available habitat (e.g. the approach adopted by Forewind in the examinations for the Dogger Bank Creyke Beck and Dogger Bank Teesside A&B projects). However, it was felt that the initial screening step should be a discussion between SNCB and developers due the need to consider site specific issues.

Turnover: An issue that is not currently accounted for but requires further consideration (i.e. what proportion of time are birds spending within the footprint and their foraging site fidelity).

Seasonality: Any DAF would need some kind of breakdown between breeding and non-breeding season impacts.

Top 3-4 Key Points:

i. **Screening Stage 1:** A stage required before the Matrix Approach is used, which uses expert judgement on site-specific issues to remove species.
ii. **Screening Stage 2:** There is merit to using the Matrix as a further screening stage. This stage should incorporate some element of habitat suitability, possibly in place of mortality within the matrix. Another suggestion was using some metric to represent the proportion of total habitat within the wind farm (e.g. using the radius around breeding area).
iii. **Modelling Stage 3:** For species flagged as 'of concern' from the Matrix stage, then look to undertake some modelling analysis (e.g. energetics, PCoD *etc*).

Group 4

The Displacement Assessment Framework (DAF)

A Displacement Assessment Framework (DAF) is required. Any framework should help in all aspects of project consideration i.e. at Strategic Environmental Assessment (SEA) level of new development rounds (a potential possibility in the future) or for wider marine spatial plans, as well as EIA / HRA at an individual project level. Any framework that is developed should be evidence based (potentially including expert elicitation as evidence).

Data and methods: There was concern that there was little evidence on displacement and questions around how such evidence should be collected. It was suggested that there was a need for a workshop for statisticians regarding data methods, but unlikely that agreement would be reached as each statistician probably favours their own methods.

There was discussion around whether existing data sets from operating wind farms could be re-examined to a common standard, rather than as currently where there was uncertainty around existing studies and how conclusions had been reached.

A note on technology: tracking data can suffer from sample size issues (i.e. too few birds, at too few locations). Also it is often difficult to determine commuting flights and therefore how to define foraging areas.

The following should be considered for inclusion in a DAF:

- A list of species likely to be at risk from displacement.
- A screening phase (to focus in on the species at risk and observed during site characterisation studies).
- A clearer process/pathway – similar to CRM, so that outcomes are the focus rather than 'nit-picking' on choice of parameters.
- The ability to assess at individual project level as well as cumulatively.
- A requirement to answer questions raised in the HRA process.

A sample framework using a matrix approach (i.e. 0-100% at regular intervals) with the identification of a general threshold below which no further work was required, would be helpful as there is a need to narrow down the confidence limits and gather evidence to help inform the process. Another view would be to continue with the matrix and focus in on the numbers for the rows and columns.

Buffers: More discussion on buffers – their application/size and how they should be identified was discussed at length, as well as the use of the gradient approach in the selection of buffers.

Seasonality and species: Definition of seasons is not always clear/or is inconsistent.

- Treatment of birds found on an OWF site during the breeding season, where projects are beyond current mean/maximum foraging distances.
- There may be considerable variability in breeding success between years; looking at only 2 or 3 years post-construction data as the norm may not be sufficient to truly understand the impacts of displacement.
- Consideration of how successful breeding seasons are or are not, particularly in the Southern North Sea.
- The first clear action should be to develop a long list and short list of species at risk from displacement effects.

Developer perspective: Assessment beyond the individual wind farm i.e. cumulative level. The developer perspective in the group was that collision risk modelling is suitable at individual site level and then easy to combine, but displacement might be better carried out a wider scale due to the lack of existing assessment from historic projects (i.e. those before Round 3) for key displacement species for current projects (i.e. auks and gannet).

- The developer perspective highlighted issues around trying to constrain turbine spacing or size, and implications for commerciality and the ability to retain flexibility for procurement and not to be driven to a specific turbine type thus reducing competitive tendering.
- If short-term and long-term approaches are developed, then a flowchart alerting developers to which method to be used should be provided.

Terminology & definitions: e.g. do displacement effects consider: birds on the water and/or flying birds. There is a question around how to define travelling birds – this is not seen to be displacement. Any methods/guidance developed should have a glossary of terms.
There was further discussion about terms such as functionality/status (i.e. why the birds were present and whether displacement effects were additive with CRM).

Top 3:

1. A Data and Methods approach to detecting evidence of displacement (i.e. detecting displacement and common ways of doing it).
2. Buffers (Gradient Approach).
3. Seasonality and how to address this for different species.

Group 5

What is a DAF? What is actually meant by a 'displacement assessment framework' – is it a decision-making tool, a process, a flow-chart, or a means to establish common ground between the different parties involved in wind farm licensing?

Three main steps in the process of assessing displacement impacts at an OWF site:

i. **Understanding and defining displacement** – the extent/level of bird reactions to wind turbines, spatial scale, temporal aspects.
ii. **Understanding the effect on the individual bird** – what does being displaced mean in terms of energetic costs and resulting effects on individual fitness?
iii. **Understanding the population consequences**.

Any DAF would need to address cumulative impacts, differentiating between the two approaches it is possible to adopt in this regard: either strategic or project-based ('building block'). The group also agreed that it is important to understand the mechanism by which

displacement occurs and effort should be focussed on studying seabird behaviour and reactions to / interactions with wind turbines.

Complexity: There is a need for more complex representation of bird behaviour in our assessments (and models). This is not a constant - it will vary between species and each individual bird can react differently to wind turbines depending on status (particularly whether they are breeding or non-breeding), time of year, what they are using the area for (loafing, foraging, habitat preferences) and other factors. One group member commented that how 'willing' a bird is to be displaced depends on how hungry it is.

It is important to understand species' habitat requirements, but this is only easy for inshore species with fixed habitat preferences (such as divers, ducks and waders). Seabirds are not as straightforward as they are usually reliant on pelagic prey. It might be possible to come up with proxies that address functionality (such as fronts, tidal states etc.) rather than habitat *per se*.

Data and methods*:* There is an argument that any study / survey area should be considered as a whole, not artificially divided into impact and control areas. Rather than using pre-determined buffer zones, these should be calculated from actual data through the data analysis stage at the individual assessment level.

It could be useful to investigate the available studies in more detail: What do we know about the way these studies have been carried out? What aspects have or have not been looked at (included or excluded) in each study? How has the data analysis been done?

Realism: It is very important to be realistic about what was achievable in the time available. The current NE/JNCC guidance is serviceable and the focus should be on its improvement.

3.4 Conclusions/Suggestions

There was general agreement that, for an effective assessment framework, the following need to be developed:

i. Common analytical approaches;
ii. More empirical evidence;
iii. Clearer guidance;
iv. And to build on the current approach.

4. Using the Furness & Wade Sensitivity Scores as a Proxy/The Displacement Matrix Approach

There were three short presentations to inform thinking on this topic:

1. Use of Furness & Wade (2012) Sensitivity Scores as a proxy for displacement levels – Vicki Saint, JNCC.
2. Key revisions to assessments of displacement presented in the Furness & Wade (2012) offshore wind vulnerability indices – Helen Wade, MacArthur Green.
3. Summary of the Displacement Matrix Approach – Glen Tyler, SNH.

Participants then had an opportunity to ask questions of clarification to any of the presenters. Following this the group worked in five sub groups; three tackling one set of questions and the other two groups tackling a second set of questions. Following this the groups shared their key points in a plenary session.

[See Appendix V, Section 4 abstracts A-C]

4.1 Summary of group and plenary discussions

The group felt the Matrix Approach is a useful, simple and transparent tool for screening, particularly when focussing on species of concern. It can indicate where mortality rates are too high and highlight the possible range of risk/uncertainty. However, there are issues with the Matrix Approach as it stands, in relation to the way that population estimates are calculated and the over-simplification of displacement effects.

Ways forward suggested by participants include refining the matrix to take account of density dependence (although there are significant gaps in empirical data and understanding in this area) and productivity.

Generally it was felt that a more structured review of the evidence from UK and European wind farms is required, including post-consent monitoring data (e.g. where there are different turbine densities).

4.2 Questions participants were asked to address

Groups 1, 2, 3 were asked to answer:

i. What are the merits/issues of the Matrix Approach?
ii. Should it be a part/component of the DAF? If so – how?
iii. How should these updated sensitivity scores be used with the matrix?

Groups 4, 5 were asked to answer:

iv. Is there sufficient evidence to support use of particular displacement and mortality rates?
v. What is the evidence for spatial extent of displacement for different species?

4.3 Group discussions - key points

Groups answering these questions:

i. What are the merits/issues of the Matrix Approach?
ii. Should it be a part/component of the DAF? If so – how?
iii. How should these updated sensitivity scores be used with the matrix?

Group 1

i. Merits/issues of the Matrix Approach?

- The matrix sets the envelope within which 'reality' (i.e. the total extent of displacement effect occurring) must lie and it is simple and transparent.
- However, this approach could displace more than 100% of birds due to the issue of 'turnover' (i.e. a matrix approach based on a one-off count, which does not really account for the issue of turnover). This could be a problem for particular species. Then again, if turnover happening frequently, this is an indication that the area is not that heavily relied upon as a feeding resource (i.e. if more migrants passing through). Need to consider if bird hours could be used instead of raw numbers.
- There is not always a seasonal dimension at present.
- Productivity is not currently captured.

ii. Should it be part of the DAF?

Yes with some modifications, namely:

- The DAF would need to reflect the uncertainty of the matrix;
- Potentially multiple matrices will be needed, that are combined in some manner at the end (i.e. mortality and productivity tables, seasonal tables, etc.);
- There is a need to present clearer guidance on what ranges are believed to be closer to reality.

iii. How should the updated sensitivity scores be used in the matrix?

- The scores should be used but the group felt that the relationship between displacement and species sensitivity to disturbance from OWF is unlikely to be linear. If there is evidence it may be possible to come up with a more realistic relationship and thereby use of proxy. There needs to be further consideration of how existing empirical data is used – a review of the evidence needed (i.e. understanding the differences between population change and percentage displaced).

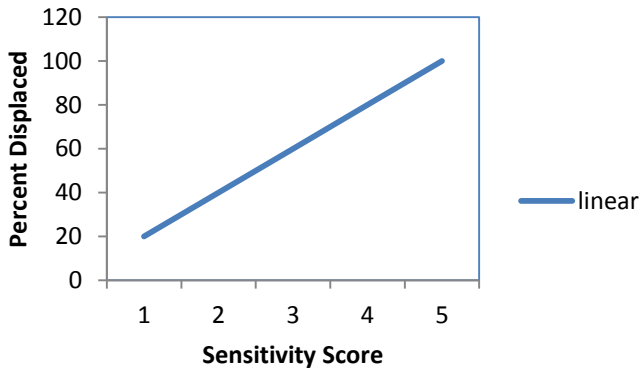

Figure 1. Graphical representation of a possible interpretation of Furness & Wade (2012) sensitivity scores into a predictive relationship with percentage displaced birds from a project site, for those species with a lack of empirical data on likely percentage displacement rates.

Group 2

i. Merits/issues of the Matrix Approach?

There was merit in the Displacement Matrix Approach (DMA). It provides a simple approach, conceptually easy to understand. It is a good way of screening out species that are not of particular concern, although in some cases data can be poor so caution is needed.

Although the focus of the matrix so far has been adult mortality, the more relevant cost is impacts to productivity, which is a more likely impact. Any assessment of this impact could be used in a population model. While the Matrix Approach is useful, and there is definite need for some tool like it, it would be much more useful if specific values of displacement and impacts could be obtained.

There is a question as to whether the flexibility scores can really be used as an indicator of mortality/productivity impacts, as this is not straightforward and needed careful consideration. Also using scores risked double counting, in that scores are used to screen species at risk and then again, within the matrix, to fix the percentages.

ii. Should it be part of the DAF?

Yes it should be part of the DAF, but there are concerns, from 'it's better than nothing', to 'but we need to be confident in the data (if any) behind it'. Generally, it was felt that the score values might vary considerably between colonies/sites in specific cases. So really need information for every colony and site under consideration.

To get an idea of the impact level, it was suggested that colony size might be useful as an indication of typical foraging range. This relationship has at least been shown for gannet if not for other species.

iii. How should the updated sensitivity scores be used in the matrix?

The updated scores were considered useful, but it was suggested that their value might vary with individual colonies and site-specific factors, so ideally there should be information from each colony.

Group 3

i. Merits/issues of the Matrix Approach?

Merits:

- it is simple and easy to explain;
- It captures everything;
- It is possible to capture uncertainty depending on the range used, as you can present a range of outcomes;
- You can consider the context of how far away the predicted impact is from a given threshold. On this basis you could adapt the matrix to 'traffic light' areas where the impact is potentially too big, where it may be an issue or is likely to be ok.

Issues:

- It is oversimplified;
- You can only assess mortality or breeding success, but the impacts are much more complex than that and it does not capture the actual consequences (e.g. it does not capture con-specific issues such as competition with others, nor account for different life stages or carrying capacity).

ii. Should it be part of the DAF?

In the end the group concluded that it should form part of the DAF. There was merit to the approach but it required separate tables for adult mortality, chick productivity and other life stages (e.g. immatures/non-breeders). Otherwise a single table is very difficult to use expert judgement.

iii. How should the updated sensitivity scores be used in the matrix?

Data is available but requires review in a way that will generate values.

Groups answering these questions:

i. Is there sufficient evidence to support use of particular displacement and mortality rates?
ii. What is the evidence for spatial extent of displacement for different species?

Group 4

i. Is there sufficient evidence to support use of particular displacement and mortality rates?

This question was split to allow consideration of displacement effects and mortality effects.

- In 3-4 years the assessment may have moved from scores to empirical evidence. There was a lot of discussion around spatial variability. The group felt the only way forward was to have context dependent variation (i.e. by sites and species).
- There is a need to look at what current site characterisation surveys and post consent monitoring studies are expected to deliver in terms of empirical evidence for displacement effects.
- The group felt there was little point in updating the scores in Furness & Wade (2012).
- There was consideration of whether or not to further develop 'Habitat Quality' scores (1-5).

- The group felt there was a lack of data from the wind farm sector, but that there might be data available elsewhere (e.g. Sarah Wanless's Gannet Ring Recovery Data).
- If habitat quality was seen as important within the matrix and attempts were to be made to link it to productivity effects (i.e. from prey resource changes), then sources of data were required. There is a huge amount of literature available regarding shore birds – could they be used as a proxy for seabirds?
- There is limited evidence around what rates to use for displacement, but it has not been pulled together in a consistent form. Equally, it is likely to be highly variable between species and sites and there are only a limited number of studies that report displacement as a percentage (i.e. in the format necessary for translation into the existing Matrix Approach). For mortality impacts, there was no evidence for seabirds, but there was for shore birds.
- Expert elicitation may help to identify appropriate rates for displacement and mortality. Question for experts: *"What is the evidence for spatial extent of displacement for different species (i.e. buffers)?"*
- While the lack of statistical evidence was discussed, there were thoughts about permeability in wind farm design (i.e. spacing which allowed more bird movements to reduce displacement effects).

Group 4 Suggestions:

- There might be merit in considering wind farm permeability in the Irish Sea, where multiple sites have been developed with various turbine spacing.
- There might be utility in gathering expert elicitation on the issue of different distances/gradient effects to consider buffer distances. However, there was caution about the total extent of survey requirements from industry (i.e. they may end up having to survey the entire southern North Sea depending on sizes of buffers chosen).

Group 5

i. Is there sufficient evidence to support use of particular displacement and mortality rates?

Limitations of the available data: We only have indicative displacement rates for a limited number of species (such as scoters, divers and terns) mainly inshore where most wind farms have been located to date (UK Rounds 1 & 2 and most European sites). Few wind farms have yet been built within the foraging ranges of breeding seabird colonies and so almost nothing is known about the reactions of breeding seabirds to wind turbines (whether this might be the same as, or different to, the way they react in the non-breeding season).

ii. What is the evidence for spatial extent of displacement for different species?

Displacement rates: The current state of knowledge about wind farm displacement rates for each species is summarised as follows, noting whether there is low, medium or high confidence in the quality/representativeness of the data:

Common scoter: inshore species with a medium/high confidence in the data.
Red throated diver: inshore species with a high confidence in the data.
Grebes: densities are low across UK waters such that it will never be possible to measure a displacement effect for this species.
Fulmar: densities are low across UK waters such that it will never be possible to measure a displacement effect for this species.
Gannet: medium confidence in the available data but it's for the non-breeding season only.

Great cormorant: high confidence in data.
Kittiwake: low/medium confidence in the data and non-breeding season only.
Gull sp: low confidence in the data – it's difficult to determine displacement rates due to compounding issues (such as the exclusion of fishing boats from wind farm sites).
Tern sp: high confidence in the data.
Guillemot: low/medium confidence in the data and non-breeding season only.
Razorbill: low/medium confidence in the data and non-breeding season only.

Impact rates (mortality/productivity): Direct mortality not considered to be the key, or only, consequence of seabird displacement. Greater attention should be paid to impacts on productivity (for breeding seabirds). The effect of seabird displacement from an OWF can be considered most simply as a depletion in the food supply available to the birds. In this regard, it can be helpful to consider other examples of food losses (such as fish stock collapse) in order to understand how the population is affected over time.

An extreme example would be the collapse of the Wee Bankie fish stock in the mid 1980s, where the consequences were studied for the breeding kittiwake colonies around the Forth. The mortality rates increased by 6-7% (on average) and productivity declined to 0%. Also, Shetland, where the seabird colonies have become "geriatric". The adult birds do not die from poor resources but they are unable to breed successfully, leading to an ageing population with no young birds coming through as the next cohort.

Spatial extent of displacement: Any evidence on the spatial extent of displacement is limited to inshore species and/or the non-breeding season. Most studies are European and little has been done for UK Rounds 1 & 2 wind farms.

The spatial extent of displacement will not be constant and could depend on the size and design of each wind farm, including the size of individual turbines and the amount of spacing between them. The rate of displacement across distance is unknown. It may not uniformly decrease and there may be a displacement 'cliff' or cut-off point.

4.4 Conclusions/Suggestions

i. The consensus among the groups indicated that:
ii. The matrix approach has merit but that it has significant issues, and requires refinement;
iii. There is a need for a more structured review of the evidence (UK and European).

5. CEH Displacement Model + Integrating Collision, Barrier and Displacement Effects

There were two short presentations to inform thinking on this topic:

1. Potential for wider application of the CEH Displacement Model approach used in the Firth and Tay – Francis Daunt, CEH
2. Integrating collision, displacement and barrier effects – Liz Humphreys, BTO

[See Appendix V, Section 5 abstracts A and B]

Participants then had an opportunity to ask questions of clarification to any of the presenters. Following this the group worked in five sub groups; three tackling one set of questions and the other two groups tackling a second set of questions. Following this the groups shared their key points in a plenary session.

5.1 Summary of group and plenary discussions

The consensus was that the CEH approach could be used more widely, but only where there is sufficient quantity of data available (or that could be collected), so possibly only for certain species and in certain locations. It is possible that models could be simplified over time. Further analysis of existing data is also needed to understand the relationship between, for example, survival and body mass.

It was felt that it could potentially fit into the DAF as it provides a framework for considering the issues, and a risk-based approach to decision-making. However, this approach requires specialist input.

5.2 Questions participants were asked to address

Groups 1, 2, 3 were asked:

i. How could the CEH approach be applied more widely?

ii. How might it fit in the future DAF?

Groups 4 and 5 were asked:

iii. How can interacting impacts be dealt with in DAF?

5.3 Group discussions – key points

Groups answering these questions:

i. How could the CEH approach be applied more widely?
ii. How might it fit in the future DAF?

Group 1

The CEH approach is a good one, but there is a risk applying it elsewhere as it is a data hungry approach. It was used on colonies with some of the best availability/quality of seabird data and even then there were input parameters that came from other locations.

It may be that for some developments only a single or a few species may be possible to model. There is a need to identify the rate limiting factors (i.e. is adult survival key and what quality/quantity of data do you have for your sites).

It may be more appropriate for some types of species than others (i.e. benthic feeding seaducks where we know more about the habitat that they are limited to).

It may be worth considering the models used outside of the marine renewables industry (i.e. for oil spills).

It may be possible to use a CEH-type approach in the DAF, but this would need a pre-requisite check list to ensure it is appropriate to proceed. It was felt that if it did appear in the DAF it is likely to be towards the bottom of any flowchart (i.e. only once you have met the criteria can you proceed, and probably only included as part of a longer-term DAF).

It could be a technique used for scenario testing.

How this model could either be improved or would merit further clarity:

- The ability of this model to incorporate density-dependence in the future.
- The model has similarities with wader models that are used more widely, however in those models the understanding of prey availability exceeds what we currently know about seabirds.
- It would be beneficial to validate the model before improving it.

In the longer term, if it was seen as a solution in some/all scenarios, then an “off-the-shelf” format may be necessary to ensure that the model is not misused.

Group 2

The CEH model is data hungry and would be difficult to use in other locations.

It would be useful if CEH could say what parameters/data is required for the model.
Even so it is difficult to see it being widely applicable

There may be difficulties with longer ranging birds. Suggested sites: Bempton Cliffs, Netherland LBB Gulls - where tracking data was gathered from other projects.

The same result from the agent based model on divers in Denmark might be true – it was difficult to build a model and took a lot of time and data.

There needs to be a careful assessment of the amount of data required to build the models for all the species we might be interested in. One useful source might be the recent JNCC funded review into Demographic data performed by the BTO.

This could be used in non-breeding season if data is available. The BDMPS report was indicated as a source of information to compare background populations outside the breeding season for any assessments.

However the model is potentially expensive to run and needs specialist input.

Group 3

The CEH model could incorporate assessments for displacement, barrier and collision avoidance. This just requires some adjustments in terms of the 'decisions' the birds make within the model. This links into an integrated assessment with collision which was touched on in some of the plenary discussions.

There is the possibility of a different matrix for barrier effects and displacement effects. There is no need to consider barrier for non-breeding birds as they are not centrally-placed foragers.

CEH has modelled both single project scenarios and a cumulative scenario – so it has the flexibility to do both.

A model produced for oystercatchers on the Exe estuary 10 years ago could be revised and simplified over time, removing aspects that were not required.

It is the same where some parameters affect the baseline but there is no difference between the baseline and impact scenarios. The functional response for the wader model was the amount of food and how fast they eat. In the CEH model this was the maximum intake rate calculation but there were issues in that they could not estimate the shape of this, and that it would take a lot of time to do this.

The replication of a more detailed model is unlikely as there are limitations in how you would parameterise it. There are some key data gaps: in particular, both conspecific competition and the functional response are very difficult to estimate for seabirds.

There was a query around the application where you have good GPS tracking data (as CEH used this to inform the heterogeneous prey availability in their model). It was concluded that it requires a judgement about what values within the model could be applied to other areas.

The key limitation to the CEH model is estimating the mass-survival link. An analysis of this could be undertaken using IoM data, which could help better inform this parameter. Measuring foraging rates for different species could help refine aspects of the model.

It is much easier to produce a model for benthic feeding seaducks, as more is known about their prey distribution. With other seabirds it becomes more difficult to model, hence why CEH modelled scenarios with homogeneous and heterogeneous prey distributions - using high, medium and low prey availability. This approach was caveated in the CEH report, in that reality was likely to lie somewhere between the first two categories.

There could be some lessons that could be drawn from the CEH model results, such as barrier being more of an effect at closer distance and displacement at a great distance.

There was a suggestion that all birds flying could be subject to barrier effects and all birds on the water subject to displacement, but the group concluded that it was not this simple due to the different foraging techniques applied by different species.

In summary:

i. The approach could be applied in similarly data rich areas initially. (For data poor areas, the method may be difficult or impossible to apply).
ii. Through time you can refine and simplify the models, and
iii. Key aspects of additional data required further study, such as the body mass and survival link.

Groups answering this question:

iii. How can interacting impacts be dealt with in DAF?

Group 4

There was a suggestion that species at risk from both collision and displacement could be identified and a list provided. This however raised questions about what aspects of Avoidance Rates in CRM considered macro-, meso- and micro-avoidance and whether this already took into consideration displacement effects, otherwise assessment calculations could be over counting precaution.

Species where displacement and collision effects should be considered: Kittiwake, Gannet, Terns, Gulls.

If a list was developed, this could enable an initial screening exercise, to identify species on which further assessment work might be required.

More guidance is required on how to interpret and use Collision Risk Modelling (CRM) outputs and displacement outputs and whether outputs across both impact pathways could be identified. There was concern that currently the displacement rate p/a did not reflect impacts over the OWF lifespan. A more qualitative approach could be considered.

There is an issue of turnover and how it should be calculated. In effect does the OWF footprint become a sterile area, eradicating this piece of habitat or is it still likely to be used by birds? Experience is indicating that OWF areas are on a continuum of change, with evidence that harbour seals and porpoises as well as cormorants taking advantage of the new habitat a wind farm creates.

Can the assessment process combine impacts? There has to be a decision on how to deal with impacts, particularly displacement first.

The principle of adding impact effects was discussed – it cannot be biologically justified, there needs to be an agreed approach.

There were concerns that if an approach relied on too simple a method or was too over precautionary then what happened to projects near the tipping point?

Key outputs suggested by the group were:

- A list of species at risk from both displacement and collision.
- Consideration of the avoidance of double counting of impacts.
- Consideration of site-specific barrier effects (e.g. avoiding using strategic planning, the siting of OWFs in areas likely to have a barrier effect e.g. mouth of English Channel).

In the short term, identify experts who can identify strategic areas where barrier effects would be of key concern.

Any framework model outputs would be useful for Population Viability Analysis (PVA) not necessarily Potential Biological Removal (PBR). There is a need for more evidence surrounding habituation at species level; this was more likely to be a long term ambition.

The developers emphasised that there were requirements for short term and longer term consideration of how any guidance should be developed and a need also to think about the short and long term evidence gathering that could help such as bird tagging.

Group 5

The group determined that the interacting impacts in question are collision mortality and displacement. The interaction between these impacts needs to be fully understood, in terms of the combined consequences for seabird populations likely to be affected. Therefore these impacts are considered together and worked together into the same population model. There will be a range of questions around population modelling (although these were not discussed in any detail): which type of model is chosen, how the impacts are incorporated and at what point in the model they are incorporated.

The over-arching question remains: what is the scope of any displacement assessment framework (DAF)? In this context, the group queried whether the population modelling was included as part of a DAF, or rather, was a subsequent step in the wider impact assessment (EIA/HRA) process using the outputs from the DAF.

There was a question around how to treat the outputs from collision risk modelling and displacement assessment - Is there any risk of "double-counting" impacts? Does the macro-avoidance rate applied in collision risk modelling effectively equate to a rate of displacement?

5.4 Conclusions/Suggestions

Combining Effects:

- Step 1: Select which species likely to be subject to both collision and displacement;
- Step 2: Consider what population being used (i.e. birds in flight/on water/both);
- Step 3: A few suggestions:
    - Is it possible to treat 'birds in flight' as subject to 'barrier' and 'birds on water' subject to 'displacement' BUT also need to consider species ecology (i.e. surface feeders versus plunge divers)?
    - Re-visit evidence to determine what fed into Avoidance Rate. If macro-avoidance accounted for, can use 'birds on water' to assess displacement; if not, need to use 'both'.
    - Using Liz's Option 2 BUT CRM takes account of macro-avoidance?

Issues:

How should previously consented projects be handled (i.e. how to combine for CIA if different approaches are used)? This is more than just a re-analysis of existing data, where different DAF approaches have been used in the past. Some projects are missing displacement assessments at all; so there is a potential need to revisit site count data (if available) to conduct adequate CIA.

6. Developing a Habitat Loss Method

Roger Buisson, APEM, gave a short presentation to inform thinking; titled 'Developing a Habitat Loss Method for assessing displacement'.

[See Appendix V, Section 6 abstract]

Participants had an opportunity to ask questions of clarification and then worked in five sub-groups to consider if the approach should form part of a DAF. Following this the group shared their key points in a plenary session.

6.1 Summary of group and plenary discussions

There was consensus among participants that it is possible to use the presented 'Displacement as Habitat Loss' approach as part of a DAF. It was felt that it could not be used in the short-term, as there are still considerable data gaps and uncertainty, but some aspects of the approach could be worth pursuing in the longer-term, for example to help improve understanding of habitat quality in the Matrix Approach.

Questions remained around the constraint of one-off effect; the definition/quantification of habitat; the measurement of quantity/quality of habitat that birds are displaced from; and long term impact. However, it was acknowledged there are similar problems/uncertainties with the Matrix Approach.

6.2 Questions participants were asked to address

i. Should the habitat loss approach form part of/a component of the DAF? If so, how?

6.3 Group discussions - key points

Group A

Key issues/limitations:

OWF developers felt that the science behind the presented 'Displacement as Habitat Loss' approach has more justification than the current Matrix Approach. However, timescales to fill the knowledge/evidence gaps required were likely to be a considerable problem. Hence a full development of the method (in terms of evidence and methodology) was unlikely to be possible. The approach starts well, but runs into significant issues with uncertainty and does not seem to fit well with the purpose of EIA / HRA, which is to identify and assess the effect.

The ability to reconsider the effects and calculate a new equilibrium population is useful. However, it is not clear if or how habituation of birds to a wind farm is considered.

It was noted that throughout the workshop, habituation and displacement effects were continually mentioned as if they could be measured. However, all that could effectively be measured once a wind farm was built is change and these changes cannot always be attributed to the wind farm.

Ways forward:

Once a DAF is agreed; there might be two purposes:

i. To generate information to inform the application determination process;
ii. To identify any ongoing changes during the wind farm life span.

It remains unclear how the new equilibrium population is to be [would be] calculated/measured or even recognised. Whilst there are still some issues with the Matrix Approach, the use of the presented 'Displacement as Habitat Loss' method in the DAF, whether in the short or longer-term, was not considered feasible.

Some further consideration of expert elicitation for the Matrix Approach (similar to the PCOD work done for marine mammals) is the best way forward and this could also consider how, if possible, habitat quality scoring could be implemented within the Matrix Approach.

A simple approach would be to consider in the habitat scoring:

i. Habitat quality;
ii. Breeding/non breeding;
iii. Flexibility in habitat recognition.

These could then all be considered by experts in an elicitation process. This is more likely to inform any longer-term work than short-terms requirements for current projects in the system.

Remaining concerns/questions:
There were still some concerns regarding the cumulative aspects of what happens to projects at or near the tipping point, if significant amounts of precaution are included in the assessment.

Use of the 'Displacement as Habitat Loss' approach (i.e. the APEM approach), in the short-term, was not supported. However, further consideration of 'habitat quality' in the Matrix Approach would be useful. In the long-term there could be a role for academia to help inform some of the key missing data gaps. Perhaps even a PhD could start to fill in the blanks identified in this research contract.

Group B

The approach of the report was felt to be useful in identifying the uncertainty in the assessment process.

Key issues/limitations:
The difficulties in defining the habitat lost:

- How do you quantify the habitat lost?
  - Often at a very course scale but this is **potentially easier/more appropriate for benthic feeding species** than pelagic (i.e. seafloor mapping data can be used to inform assessment for benthic feeding species).
  - Used sand eel fishery data to inform habitat lost for auk species, however there can be limitations to this dataset as data is constrained by sand eel fishery data not wind farm extent, but is the best available evidence in that scenario.
  - For mobile species associated with mobile prey the year-to-year variation makes this particularly challenging.
  - Value judgements need to be made to define the area excluded from and the availability of alternative habitat in the surrounding area. More information will undoubtedly be known for the OWF area as opposed to the habitat and density of con-specifics etc. in the area that affected birds are displaced to.

- If you never reach equilibrium with this approach the one-off scenario is never reached.

- Some of the issues are shared with the Matrix Approach (i.e. it does not account for habituation), a matrix approach could by use of multiple matrices (i.e. year 1, year 5, year 10 *etc*). However, the uncertainty with quantifying the loss of habitat from OWFs and quantifying the alternative habitat available was felt specific to this approach.

Ways forward:
It may be an approach to aspire towards.

It might be possible to run a Monte-Carlo simulation engine and subject the different approaches ('Displacement as Habitat Loss'/'Matrix Approach') to a run/test of scenarios.

Remaining concerns/questions:
We need to get a better understanding of density-dependence in seabirds. We need to make sure that any short-term work does not prevent the necessary work being undertaken to have a better understanding of displacement.

Group C

The approach followed a logical sequence, but after stage 4 we know very little and the assumptions made at each stage build the level of uncertainty.

Key issues/limitations:

- Defining the quality of the habitat is very difficult;
- Displacement should be considered as sub-lethal impact rather than mortality event;
- The approach does not consider the effect of a recovering population and the life time of the project, i.e. it is a one off event;
- There is a need to build in more flexibility in to the approach, e.g. habituation, which will be species specific;
- It is also difficult to define population equilibrium, due to difficulties in defining the quality of the habitat.

Ways forward:
It is possible that the uncertainties of the approach could be used to inform research.

Group D

The 'Displacement as Habitat Loss' method is conceptually not that much of a change from dealing with year-on-year displacement. However, describing it as 'one-off' habitat loss is confusing - the loss is not instantaneous and will occur over an unknown time-scale. However, it is a permanent loss.

This method builds the population modelling into the displacement assessment; also it explicitly frames the question in density dependence terms. This could be helpful.

Key issues/limitations:
The lack of data on the way that density dependence operates in seabird populations. If we do not understand the baseline situation – whether or not seabird populations are at carrying capacity, or what the carrying capacity of a particular area might be – then it is just not possible to calculate, or model, the new population equilibrium for any impacted scenario (i.e. an operational wind farm development).

Ways forward:
The approach could have mileage as a strategic assessment tool – modelling the impact ("habitat loss") of all UK wind farms against the distribution of seabirds in UK waters. However a number of the UK representatives felt we just did not have a good enough knowledge base for doing this.

Group E

The Matrix Approach and CEH approach both provided annual mortality/productivity which can feed directly into a population model. The habitat loss approach reduces carrying capacity so it is unclear how you would integrate the two.

It is important to drill down to the key concept: how do you measure the quality of habitat remaining? This is much more easily achieved for benthic feeding species.

Key issues/limitations
The key issue is therefore assessing the quality of habitat.

There are issues with assuming that the change in habitat is a one-off – we know that over time birds could habituate; also the habitat within the wind farm could change i.e. acting as fish attracting devices (FADs) which could in turn attract birds into the wind farm. Also if more and more OWF are built there will be less and less alternative habitat available so birds may end up returning to some OWF.

Ways forward
The approach used in Germany is to consider habitat loss as a % of an area, having identified different qualities based on bird usage. Therefore you can ensure you do not lose a higher % of preferred habitats. For red-throated divers, when this exceeds 1% they stop licensing OWFs and this protects the main concentrations of birds.

It would be useful to define what % of area shouldn't be affected. For wading birds they have established that % of habitat loss results in % of population change. There might be the potential to study % habitat loss - or indeed prey availability as that is for the most part what we are referring to for most bird species – with changes in survival rates of seabirds. This would require long-term data sets.

Remaining concerns/questions

One of the key issues arising that we do not know what the relationship is between habitat loss and mortality (or other demographic metrics).

Would we approach a cumulative tipping point and where will that be? Some visual habituation may occur but some birds may be forced to go back to foraging within wind farms due to multiple wind farms being in any given foraging range

6.4 Conclusions/Suggestions

The group felt that a 'Displacement as Habitat Loss' approach could potentially be used as part of a DAF, although more likely in the longer-term than in the short-term, as there are too many uncertainties and data gaps.

Although the approach is used in Germany (habitat loss as a % of area) in wind farm licensing, it was generally felt that the evidence base is not currently strong enough to support the use of a similar approach in the UK.

However, there is potential to use the approach in research, modelling or an expert elicitation process.

7. Bringing it together: Developing a DAF

7.1 Other considerations for a future Displacement Assessment Framework (DAF)

There were three short presentations to inform thinking:

1. Determining fine scale pre- and post-construction bird distribution and abundance changes in and around two Danish offshore wind farms – Monique MacKenzie, CREEM.
2. Agent-based models to assess the cumulative impact of displacement from offshore wind farms on bird populations – Ib Krag Petersen, DMU.
3. Wader displacement/habitat loss assessment and parallels for seabirds – Richard Stillman, Bournemouth University.

[See Appendix V, Section 7 abstracts A-C]

7.2 Developing a DAF

Participants worked in three carousel sub-groups to try to develop a future DAF, with a separate focus on short and long-term considerations. Each having the chance to critique and add to each other's work. This was followed by a plenary session where participants were asked to identify what they thought were the common themes from each of the three attempts at a DAF.

7.3 Carousel groups and plenary discussions summary

Participants were asked to identify key components that should go into a DAF. As there was a desire for both short-term and longer-term approaches to the DAF, the groups were given a steer to focus on both elements individually during the discussion session.

There was agreement there should be roughly three key stages in any future **short-term DAF:**

i. Screening;
ii. Matrix;
iii. Population consequences (i.e. modelling population level impacts resulting from demographic rate changes predicted in Stage 2).

Short-term DAF

It was agreed to continue to use some form of the Matrix Approach in the short-term and that expert elicitation was needed to inform and decide the parameters to be used in any future DAF (both short and longer-term).

There was also consensus that the outputs from individual project assessments should be comparable and consistent. It was noted that the transparency of project assessments was very important and clear records should be kept of methods used, decisions made and outcomes of each assessment.

It was suggested that it would be helpful to introduce aspects of 'habitat quality' (or 'habitat importance') into the Matrix Approach. However, it was felt this was probably not achievable in the short-term and might be better considered as a medium-term aim.

There was agreement that there needed to be a further iteration, following the Matrix Approach, to determine the final 'short list' of species for which population modelling would be needed (i.e. the species to take forward to Stage 3 of assessment).

Longer-term DAF

It was suggested that the LSD approach (see Page 45) was worth further investigation, as a means of incorporating a measure of 'habitat quality' in a more refined way, but that this might have to fall into the longer-term approach.

There was consensus that key evidence gaps needed to be addressed in the longer-term and it was noted that as assessment methods improve over time, individual/agent based modelling will continue to develop and are likely to be used more commonly.

There was discussion around CIA; that a strategic overview is needed; but that it might be difficult to collate the figures for operational and consented wind farms.

Because of current data gaps and queries, it was suggested that a broader empirical approach be used, including using data from wider (not necessarily wind farm related) studies.

7.4 Carousel group discussions - key points

CAROUSEL GROUP 1 (Auditorium)

Group 1 Discussion
(These notes are a compilation of the group's initial discussion, comments by the second and third carousel groups and the review/overview of these comments by group 1)

The initial group discussed and agreed the following draft process for a Displacement Assessment Framework (DAF) applicable in the short-term (i.e. a 'sticking plaster approach' until a more comprehensive, longer-term approach could be developed), which could be applied at an individual project level.

Proposed short-term, individual project level DAF

7.4.1 Screening

Participants discussed, but did not reach a final view on, the point in the overall development process at which screening should be conducted for those seabird species potentially at risk from displacement. It seemed that screening would need to be informed by an understanding of the species found on-site. Therefore, it would have to take place after site surveys had commenced. It would be an iterative process, which could start as part of discussions over Year 1 survey reports, although some in the group thought this could be too early. It was noted that the regulatory process will formally set the timescale.

It is very important to improve documentation of the outcome of screening and for there to be a clear record of the reasons why particular species were screened in or out of later stages of displacement assessment.

Further guidance is needed: a list of standard questions to be asked during project-specific screening discussions. Expert advice could be sought to help develop this guidance, covering the following matters:

- **Seabird density and abundance on-site:** Advice on how these figures are calculated, including the treatment of buffer areas/gradients. (Aspects related to survey design were raised in passing: while there was consensus that this was very important, most people felt that the issues were sufficiently well covered in existing survey guidance).

- **Sensitivity to displacement:** Using the Furness & Wade scores and any further updates from empirical studies, including explicit acknowledgement of the confidence in the underpinning data.

- **Bird status:** Breeding/non-breeding. Potentially could include behaviour (if known) such as foraging/loafing.

- **Multiple impacts:** Is the species only sensitive to displacement or is it also at risk from collision?

- **Cumulative wind farm impacts:** The species might not be at significant risk at the particular wind farm site undergoing screening, but a wider range of wind farm developments could potentially impact on the same species (same colonies). It was noted that this overview/wider context might best be provided by the regulator and/or statutory nature conservation advisers. Some participants indicated that it would be helpful to collate the seabird density/abundance figures for built and consented wind farms in order to have a 'running total' on overall levels of displacement. This is needed

to inform Cumulative Impact Assessments (CIA) going forward (for those projects still in the consenting process).

- **SPA connectivity:** This was raised as something to consider, particularly during the breeding season. This determines whether assessment under the Habitats Regulations (i.e. HRA) is needed for a species as well as Environmental Impact Assessment (EIA). (Note that this is a wider aspect for screening discussions and does not just relate to displacement assessment).

There was consensus that these questions needed to be considered together (not sequentially) for those bird species recorded on-site. There was also consensus that there needs to be consistency in approach ('common currency') across projects, which the adoption of screening guidance (using standard questions) could help to achieve. It remains unclear how this screening might work in practice, including the appropriate level of detail for any discussions or reports. (Some participants emphasised 'a more quantitative approach', although there appeared no clear way to establish a common terminology: what different people meant when they used the terms 'qualitative', 'quantitative' or 'semi-quantitative').

7.4.2 Displacement Matrix

All participants agreed on the continued use of a matrix, or matrices, for the next stage in assessment (which some people viewed as 'screening: phase 2'). Some noted that discussions were not about changing the existing assessment process, but about informing the steps (using available data and expert judgement).

Participants generally agreed that multiple matrices (i.e. representing different seasons, mortality, productivity, life stage, *etc*) were probably needed and that these could help with more detailed interpretation of data, while some cautioned that the number of matrices would be limited by the available data.

Some participants recommended that expert advice was sought on the formulation and development of appropriate matrices and associated questions. They commented that the inputs required for any population model should be used to inform the scope for displacement matrices. Their feeling was that **three types of matrix** could be needed – **one for productivity in the breeding season, one for adult mortality in the breeding season, and one for adult mortality in the non-breeding season**. There was also a suggestion of a further matrix for sub-lethal non-breeding season effects, which would cover impacts on productivity in the following season(s), but this was not universally thought to be achievable, at least in the short-term. Some participants recommended that expert advice be sought on whether displacement in the breeding season could lead to adult mortality. A concern was raised that we would need to be careful that the use of multiple matrices did not lead to any 'double-counting' of impacts.

It was noted that the process, judgements used in, and outputs from, displacement assessment would need to be comparable with those from collision risk modelling (i.e. where relevant - for species that could experience multiple impacts - the population consequences of displacement and collision impacts might need to be considered together in a population model). The issues that have a particular bearing include the treatment of bird status (seasonality) and age class.

Participants discussed ways to incorporate a view on habitat quality/importance in the process (including whether or not to try and include this aspect more directly in any matrix). Some noted this as another key matter to take forward with experts and/or that the Statutory Nature Conservation Bodies (SNCBs) would need to take a view.

Participants agreed that the concluding step in a future DAF would be to review the matrix outputs and determine whether any species could receive a significant* level of displacement impact (including in combination with collision risk) for which the population consequences would need to be assessed.

This final step could tie in with the test for 'Likely Significant Effect (LSE)' under the Habitats Regulations Appraisal (HRA) and determine the 'short-list' of species for which further population modelling might become necessary. It was noted that the relevant parties (developers, consultants, regulators and SNCBs) should document and properly record the decisions made and outcomes from this stage of the assessment process.

7.4.3 Population modelling

Participants agreed that this was the final step in any assessment, although there was some disagreement as to whether this should be incorporated in a displacement 'framework' or whether it fell under the overall HRA / EIA impact assessment. Under HRA, population modelling can be used to inform Appropriate Assessment (AA) (i.e. to make a judgement on whether conservation objectives for seabird populations can be met in the long-term, such that there will not be any adverse impact on site integrity for the SPA(s) in question).

There was less discussion on the range of population models available and their efficacy. This in itself is part of a wider discussion that needs to continue between the developers, consultants, regulators and SNCBs.

However, some participants discussed this topic, noting there are two main types of population model available: (i) individual-based models and (ii) cohort/age-class models. The question of which of these is used in a project assessment usually comes down to data availability and/or confidence in the data.

Wider (long-term) aspects

As part of the group discussions participants also touched on a number of wider issues and steps that could be taken to improve the assessment of displacement impacts in the longer-term.

Some participants felt that **three parallel approaches** were needed, operating over the **short, medium and long-term**:

i. **Short-term:** The key short-term aim is to get consistency (or 'common currency') between those forthcoming projects currently in the licensing/consenting process. The SNCBs will need to update the existing NE/JNCC guidance having (informally) sought advice from a select number of experts.
ii. **Medium-term:** All the steps in the DAF, as well as all of the relevant input parameters, will need to be written down and expert advice obtained on each through a more formal elicitation process (such as that used for Interim PCoD - modelling the population consequences of disturbance - in respect of marine mammals). This will include views on the use of proxy species and the confidence in available data/information.
iii. **Long-term:** Long-term work includes the ongoing review of post-consent monitoring (PCM) data as it becomes available from operational wind farm sites. We need to address knowledge gaps through research and monitoring and this takes time: it will be years before any population consequences from seabird displacement are manifested at UK breeding colonies.

* The group did not define how to determine significance - this is always a complex area.

On the latter point (long-term work), some felt that further attention should be paid to the development and improvement of individual-based population models, to try and get them to reflect reality as closely as possible, in order to gain a better understanding of how seabird populations interact with their environment, including the underpinning mechanisms/population dynamics for this.

For the short and medium-term options, participants felt that it would be worthwhile to work through the process (within any updated guidance) by giving some example species or case-studies. This would help determine how well the displacement assessment (or guidance) might work in practice and whether any refinement is needed before any new displacement assessment guidance is rolled out more widely.

CAROUSEL GROUP 2 (Juniper room)

Group 2 initial discussion

Context for framework:

- There was an initial attempt to define 'short-term' – it was felt that it should include consistent application for current developments. It was noted that the longer-term framework may require alternative data and that this may not be a current priority.
- Survey design is not part of the DAF currently under discussion, and so was not discussed further.
- In terms of dealing with seasonality in the DAF, it was felt the methodology should not differ between seasons until appropriate apportioning methods are developed for HRA/EIA.
- It was agreed that the DAF needs to work both alone and cumulatively. This is an iterative process (i.e. the DAF should be worked through for an individual project, and then following this also applied cumulatively). There is a potential problem with the cumulative application of the DAF, if this process required the re-estimation of existing site abundance/displacement data or the automatic use of reported numbers at face value (i.e. where historic methods may have differed or contained inaccuracies, which then got perpetuated through the use of the DAF in a cumulative OWF context).

Proposed Displacement Assessment Framework

Stage 1 – Define Area

- Species and seasonal specific buffers are required;
- There was uncertainty over the need for a gradient buffer.

For both points above, there are differences between short and long-term DAF with the following:

- Short-term – through expert judgement (a quick and coarse request for input).
- Medium-term – through expert elicitation (a longer, process-driven approach for eliciting expert input).
- Long-term – review (and potentially further collection) of empirical evidence.

Stage 2 – Define bird numbers

- Currently the options are to use: birds-on–water/birds-in–flight/both. This should be determined through expert elicitation, as it may be more appropriate to consider species-specific advice given different foraging behaviour among species.
- The DAF needs to include ways to deal with issues with observer effect of boat and aerial surveys.
- Metric: currently abundance estimates for use with displacement matrix are calculated using seasonal mean maximum figures. It was agreed that expert input was required to establish if this was indeed the preferred metric.
- Should turnover be included? The group felt this again requires expert input on how it should be incorporated both in the short and long-term DAF.
- Barrier (flight)? The group acknowledged that a decision needs to be made on whether to include barrier effects and that birds-in-flight was likely to be the appropriate metric to do this.

Stage 3 - Screening

- A sensible threshold could be identified to remove species occurring in minimal numbers (*de-minimus*?) at development site/not at any risk of displacement.
    - Short-term – through expert judgement;
    - Medium-term – through expert elicitation;
    - Long-term – review (and potentially further collection) of empirical evidence.

Stage 4 – Matrix

- Percentage of birds displaced;
- Demographic rate – need to decide which rates (adult mortality, productivity etc.);
- Habitat flexibility – a potential new aspect to include in the matrix (there is no clear method as to how to include this – it requires further expert input).

The group felt again these parameters would need to be derived in the following way:

- Short-term – through expert judgement;
- Medium-term – through expert elicitation;
- Long-term – review (and potentially further collection) of empirical evidence.

Stage 5 – Threshold

Stage 6 – Population modelling

The first group did not have time to go into detail on these last two stages but identified that a threshold for acceptable impact would need to be identified and that the population consequences of the predicted impact could be explored through population modelling.

Comments from second carousel group

- The group discussed whether it would be useful to include 'habitat quality' in the screening stage.
- The group raised concerns that with the first screening stage there was potential to screen out species that may require further assessment/flagging due to long-term cumulative issues.
- Another key issue with the approach identified is that you cannot model vital rates in the matrix.
- The group identified that it would be necessary to refine the likely range in percentage adult mortality linked to particular displacement ranges, in order to achieve a better short-list/predicted range of impact.
- The group amended the Matrix (Stage 4) to incorporate habitat quality within the assessment, so that the number in each box of the matrix is driven by habitat availability in range of the development, enabling a site specific assessment. The group went on to discuss possible streams of work to achieve the DAF.

Short-term DAF options:

- Using an Interim PCoD-type approach to improve the quality of expert elicitation (e.g. where in the matrix particular values should be highlighted). It was suggested this could be completed in 6 months.
- Modelling consequences of displacement on non-breeding birds (outside mean maximum foraging range) as a potential research project (i.e. in general not a project-specific issue). It was suggested that by using bird densities you could produce a model to look at energetic consequences on currently non-breeding birds. However, it was acknowledged there is a lack of data (which may also differ by species) on how non-breeding birds may behave (i.e. whether they remain central-place foragers or are prospecting at multiple colonies, *etc*).
- There is a need for further research on how food supply affects survival rates.
- Gannet data – aged at sea – but there is an issue with how often they attend colonies.
- There is a need for further data on which population of birds at sea might be associating with colonies at any given time.

Long-term DAF options:

- Develop a strategic, cumulative impact assessment, perhaps following the coping strategy CRM database approach (i.e. collate density figures and apply 'common currency' in terms of DAF to these figures).

Comments by third carousel group

- It was suggested that screening should be Stage 1, and that Stages 1 and 2 should be considered as background information, not separate stages.
- They identified that the first group had introduced a threshold at two different stages and noted that Stage 5 was akin to the LSE test (Likely Significant Effect test as part of the Habitats Regulation Appraisal) and also needed CIA considerations.
- This group, like the second group, felt the screening out (Stage 3) could be incorrect. Again this was because there can be issues with CIA, where some species could be screened out at an individual stage but still potentially be impacted at a cumulative level.
- This group agreed with the inclusion of barrier effects.
- The group was keen to highlight the importance of all other aspects of the ornithological assessment framework needing to be joined up. There was some discussion over combining displacement and collision assessments. For example, if collision is considered for different age classes then displacement needs to match this process.
- There is a need for the DAF to consider multiple effects and more detail is required.
- The group identified the need for strategic direction so the same information is presented and in a similar format by different projects (i.e. monthly counts, age classes etc.), to prevent multiple results in multiple formats.
- They noted that very few studies have looked at barrier effects (e.g. Sandwich tern at Sherringham Shoal, red-throated diver at Horns Rev and common scoter at Liverpool Bay). It was felt barrier effects were more important for breeding birds than birds on migration. They highlighted the need to look at evidence for barrier effects in both migration flights and commuting flights.
- One question the group considered was whether it possible, in the long-term, to undertake the opposite of deploy and monitor, in order to highlight absolute no-go areas.
- They queried whether it was possible to undertake a strategic CIA out with the DAF.
- The short-term DAF has to consider keeping consistent with work that has already been undertaken.
- The consequences of displacement are much more complicated than the matrix outputs. The group identified that a long-term DAF should incorporate an individual-based modelling approach.
- The group also noted that where 'reality' is located within the matrix is largely driven by 'habitat quality' not the actual numbers of birds.

Review/overview by original group of other groups' comments

- Population modelling should be out with the DAF, as this is part of the wider bird impact assessment and would require combining the displacement assessment with any other predicted impacts (e.g. collision).
- This group considered that the strategic overview discussed by the other two groups is also out with the DAF, but that it was important to establish consistency within the DAF to enable 'common currency' for cumulative assessments.
- The group disagreed with the suggestion of including 'habitat quality' as the Y-axis metric, driving the individual impact numbers within the matrix. Instead they felt that the 'reality' within the matrix (i.e. the % columns highlighted) should be driven by 'habitat quality' and 'species-sensitivity' considerations. In other words that, habitat quality aspects be considered qualitatively/subjectively in the % mortality/productivity ranges selected in the existing table, rather than replacing mortality/productivity with a habitat quality metric *per se*.
- The group felt that modelling the consequences of displacement on non-breeding birds, out with mean maximum foraging range, should be moved to a long-term project.

- The group agreed that a short-term project should be commissioned to undertake expert elicitation/Interim PCoD approach to refine the parameters used within the DAF.

CAROUSEL GROUP 3 (Oak)

Group 3 initial discussion

In Belgium they undertook separate displacement and collision assessments and then did a simple combination (addition) of predicted mortality from both impacts and then ran single prediction of mortality through a PVA. This is the same as the current NE approach. However, the group noted a problem with the potential double-counting of mortality across these two impacts (collision and displacement).

A. Short-term DAF approaches:
Initial brief attempt produced these three headings:

i. Quantifying displacement;
ii. Quantifying the consequences for the bird;
iii. Quantifying the consequences for the population.

Phases of assessment, things to consider/agree:
There was a question as to whether there is potential to use the Furness and Wade assessment to screen in/out a species. This was thought not so straight forward, as there other factors that need consideration for screening:

- Is the species on the site?
- What numbers are present?
- Is it close to a colony?
- Is it an important foraging area?

What is a precautionary assessment?

Stage 1 – Are we concerned about the species?
Stage 2 – Run the species through the matrix;
Stage 3 – Run a population model for species of concern.

Sensitivity scores:
It was agreed by some that it is useful to continue to use the sensitivity scores as a proxy.

Matrix Approach:
There was a suggestion that multiple matrices would potentially be required to account for mortality, productivity, seasonality, *etc*.

There was a discussion about the appropriateness of the current Matrix Approach, where there is an assumption that the same number of birds are going to be displaced and affected each year (e.g. 70% continually displaced and of these 5% die each year). The discussion seemed to reach a consensus that it was precautionary to continue to assume that a constant proportion is affected. Mortality should be proportionate to the reference population.

Leopold-Stillman-Daunt (LSD) Approach:
This approach was postulated as a mechanism to build in some element of 'habitat quality' or 'habitat importance' into the DAF. The focus was on considering the importance of the habitat of the OWF(s) relative to all other alternative available habitat. The formula was worked through using relative density of OWF compared to relative density of all alternative available habitat, to give an indication of how important/high quality the OWF habitat is. It was noted that quantifying the area of alternative habitat was extremely difficult for seabirds. In the breeding season this could be defined using mean maximum foraging range (as per Thaxter *et al* 2012) but in the non-breeding season this parameter would be much harder to define.

Summary/Decision Tree – first iteration:

1. **Screening:** ID species of Concern, are they there, are they in important numbers?
   YES: proceed to 2
   NO: Stop
2. **Construct matrices:** ID magnitude of concern. Compile multiple matrices to reflect seasons etc. Identify if there is a magnitude of concern. Feed in LSD approach at this as point. If:
   YES**:** proceed to 3
   NO: Stop
3. **Run population models:** The group did not resolve at this stage whether you would feed in other impacts at this point first.

Other items discussed in the group when trying to identify boundaries of discussion:

- Should integrating impacts be considered with other effects i.e. collision, barrier and displacement?
  - This was agreed - focus should be on displacement assessment but that in longer term it should be given consideration.
- Should the focus be on requirement for consent or to consider what would be needed from post-consent monitoring (PCM). It is crucial to measure empirical evidence from PCM in order to better inform assessments.
  - The former was greed, with the proviso that conversations/knowledge gaps will be informed by the former;
  - It will be useful to come up with a framework that identifies uncertainty which can help inform PCM/research questions.

B. Long-term:

There was limited discussion - some key points were captured on the flip chart:

- A long-term approach likely to be the same as a shorter-term approach but incorporating more empirical evidence enabling perhaps more informed decisions/assumptions at each stage.
- There is a need to get a better understanding of population consequences of displacement – the link between displacement and mortality or reduced productivity.

Comments by second carousel group

- Concerns were expressed by developers about multiple matrices.
- Initial thoughts were that incorporating the LSD model would be sensible but they had questions they needed to ask the authors to get a greater understanding of what the formula was actually doing:
  - Is it possible for the habitat quality to place you in smaller area of the matrix?
  - Is it appropriate to compare the relative density of the OWF to ESAS data?
- **The group discussed a need for an expert review of the evidence base to better inform our understanding of displacement rates.**
- Population modelling:
  - There are issues with the quality of data feeding into statistical models. In the short-term it was felt that Population Viability Analysis (PVA) was feasible to use as the final/follow-on step to the DAF (i.e. modelling the population consequences of displacement). But that this would, at least initially, be reliant on somewhat subjective predictions of likely demographic rate changes resulting from particular levels of displacement. However, it was felt that in the longer-term Individual Agent-based Models (IAMs) might be a way of more realistically characterising the demographic rate changes attributable to displacement, which would then in turn feed into more reliable PVA outputs.
  - Longer-term - It would be great if there could be a standardised fit for purpose model i.e. like the SOSS gannet model (http://www.bto.org/science/wetland-and-marine/soss/projects), but expanded to cover other species.

- Use a PVA when you can but when you are not able to do so, use something else – PBR.

Comments by third carousel group

- The group moved onto discussion of population modelling – there is a need for a range of options that are risk-based with degree of evidence.
- A decision needs to be made on whether the output of DAF gives you a number that you put into population model (i.e. along with collision figures) or if the output of DAF gives you an output of a population model. Initial thoughts were that population modelling would sit outside of DAF but would need to consider density dependence (DD). Individual Based Models (IBM) can incorporate DD but as we do not have an evidence base for seabirds as yet, can we do it? Is it sufficient to use the wader evidence in the short-term?
    - In some English casework both DD and density independent population modelling was undertaken and presented side-by-side. There was recognition that there is an uncertainty factor with incorporating DD.
    - There is a need to come up with a list of key input parameters that are required for IBM (Need to clearly identify what we need to have confidence in IBM outputs.
- It was noted that the LSD approach was what the applicant/NE did for London Array for the red-throated diver assessment. Clarification of the equation is needed.

Review/overview by original group of other groups' comments

Short-term to longer-term: It is seen as a continuum or gradual process as you build your evidence base (i.e. terminology is not so relevant (short/long term)). In other words, the approach is unlikely to change but just be refined in what can be done, in terms of incorporating emerging evidence.

The group returned to a discussion on LSD, and trying to get better clarity. The idea is that the formula incorporates a scaling factor to identify how important the relative habitat of the site is relative to the quantity of alternative available habitat. One idea would be that you build original matrices then build additional matrices where you multiply the original matrix numbers by the site importance factor. It would give an understanding of the relative importance of the site and puts first matrix in context. Another tier of complexity that could be added would be how important is the population of birds i.e. SPA etc. For undertaking CIA (Cumulative Impact Assessment) do not look at the project level numbers but instead look at the cumulative numbers that sit inside the total area.

This group worked out the LSD formula written on the board. This formula was merely a first suggestion, resulting from thinking out loud. But whatever you put into the model, what came out was a dimensionless figure equalling the number of birds supposed to occur in the OWF footprint area (i.e. the number you put into the bottom right corner of the displacement matrix). The formula was not yet thought through thoroughly. The idea was to incorporate 'habitat quality' in the displacement matrix, but any displacement matrix exercise starts with the number of birds present in the OWF footprint, which in itself is a measure of the habitat quality of the area. How important the affected numbers are (which will be high in 'high quality' habitat) in a population context, will then be determined in the commonly agreed Step 3 ('Population Consequences').

Mortality: A mortality factor should not be applied to the number of displaced birds but instead it should be linked to the relative density of the area that the displaced birds relocate to. A question was raised over the possibility of running a re-distribution model. One suggestion was to cut-out the area of OWF(s) and redistribute it across preferred areas; but it was noted that there are problems in not knowing the density in areas outside wind farms. Another suggestion

was to run simulation models. The effect on the population will depend on the proportion of the population being affected.

Discussed amending matrix table to have 3 rows:

- Numbers in the population.
- Relative importance of site.
- Population increase in site.

The numbers will help to make a judgement call. The issues are with not knowing how density dependence plays a part. There was a suggestion that you could make an assumption that if density in surrounding area doubles that mortality (background mortality for the species in that area) will double.

The general agreement within Group 3 was to take mortality out of the matrix and assume that the rate of increase in mortality is related to the rate of increase in density.

7.5 Final recommendations/suggestions from plenary discussion

The group as a whole was asked to identify what they thought were the common themes from each of the three attempts (within the carousel work) at creating a DAF.

This final session made reference to the flip chart summary sheets, produced from each of the three group discussions, in the preceding carousel session.

Common suggestions for inclusion (and issues to consider) in a short-term DAF:
There was agreement that there are roughly three stages in any displacement assessment:

1. Screening;
2. Matrix Approach;
3. Population consequences.

Everyone accepted the continued use of some form of the Matrix Approach in the short-term and everyone agreed that expert elicitation was needed to inform and decide the parameters to be used in any future DAF (both short and long-term). There was consensus that the outputs from individual project assessments should be comparable and consistent in order for any cumulative impact assessments to be reliant. It was also noted that the transparency of project assessments was very important. Clear records should be kept of methods used, decisions made and outcomes of each assessment.

It was suggested that it would be helpful to introduce aspects of 'habitat quality' (or 'habitat importance') into the Matrix Approach (Stage 2). However, there was less consensus that this was achievable in the short-term and that it might be better considered as a medium-term aim for inclusion within any future DAF (potentially exploring something similar to the approach used in the Dogger Bank projects). It was suggested that the LSD approach was worth further investigation and that this type of approach had been used for London Array.

There was some discussion about whether or not population modelling (Stage 3) should form part of any DAF. The population consequences of displacement do have to be addressed in any assessment, but is this better considered as part of the overall impact assessment process considering that the same is true of collision risk?

There was agreement that there needed to be a further iteration, following the Matrix Approach, to determine the final 'short list' of species for which population modelling would be needed (i.e. the species to take forward to Stage 3 of assessment).

Common suggestions for inclusion (and issues to consider) in a longer-term DAF:
There was consensus that key evidence gaps needed to be addressed in the longer-term.

It was noted that assessment methods will improve over time, that individual/agent based modelling will continue to develop and are likely to be used more commonly.

There was also some discussion around CIA – that a strategic overview is needed, but that it might be difficult to collate the figures for operational and consented wind farm schemes, especially for Rounds 1 & 2 where displacement was not often assessed. Developers noted a strong concern that they might be asked to collate this baseline for their individual project assessments, and noted that this work was a regulatory responsibility.

There was some discussion about the list of current data gaps and queries, and a suggestion that a broader empirical approach be used, including using data from wider (not necessarily wind farm related) studies.

8. Key Conclusions from the Workshop

There was a need for:

- Short and long-term options, in terms of DAF guidance;
- Consideration of species and seasonal aspects;
- Consideration of CIA and transboundary displacement impacts in the development of methods for assessing population consequences of displacement.
- A more structured review of the evidence (UK and European).

For an effective DAF, the following need to be prioritised:

- Common analytical approaches;
- More empirical evidence;
- Clearer guidance.

Overall, the participants felt that:

- The Matrix Approach had merit, but did have significant issues and required methodological refinement.
- The 'Displacement as Habitat Loss Approach' could potentially be used as part of a DAF, but it was more likely to form a long-term rather than short-term solution, as there were too many uncertainties and data gaps.

To assess combined impacts (i.e. collision and displacement), two steps required:

- **Step 1:** Make an assumption of which species will be subject to both collision and displacement.
- **Step 2:** Consider which population/data source is being used (i.e. birds-in-flight/birds-on-water/or both).
- In displacement assessment.
- Key evidence gaps need to be addressed, but while existing evidence gaps/queries remain, a broader empirical approach may be necessary, e.g. using data from wider (not necessarily wind farm related) studies.

In a future **short-term DAF**, there should be broadly three key stages:

- Screening (using expert elicitation to inform/chose parameters).
- Matrix Approach.
- Population consequences.

Additional points for a future **Short-term DAF**:

- Displacement/abundance data from individual projects should be comparable and consistent, with clear records of methods used, decisions made and outcomes from each assessment.
- It would be helpful to add aspects of 'habitat quality' (or 'habitat importance') to the Matrix Approach. However, this may be challenging in the short-term, although some projects have attempted to develop methods.
- There needed to be a further iteration, following the Matrix Approach, to determine the final 'short list' of species for which population modelling was necessary.

Additional points for a future **Longer-term DAF**:

- As assessment methods improve over time, individual/agent-based models are likely to develop and be more routinely used in displacement assessment.
- Key evidence gaps need to be addressed, but while existing evidence gaps/queries remain, a broader empirical approach may be necessary, e.g. using data from wider (not necessarily wind farm related) studies.

- It was suggested that the LSD approach (see Page 45) was worth further investigation.

9. Next Steps

The SNCBs are keen to build on the expert input and suggestions made during the Displacement Workshop in May 2015, in order to develop useful guidance on a future DAF. The SNCBs Marine Industries Seabird Group (MIG-BIRD) met in June 2015 to discuss and agree next steps to improve existing SNCB guidance on assessing impacts to seabirds from displacement by OWFs.

The SNCBs fully considered key suggestions stemming from the recent workshop, particularly the desire for short-term and longer-term solutions to the formulation of a DAF, as well as the need to formulate an appropriate method for eliciting expert input into developing such guidance.

The SNCBs agreed to rapidly develop a follow-up joint interim advice note, which will seek to clarify points of confusion/diversion that have arisen since the Matrix Approach was originally put forward in the NE/JNCC Interim Advice Note (2012).

The intention is for this short-term advice largely to provide clarity on best practice use of the existing Matrix Approach, rather than attempt to incorporate workshop suggestions put forward under the medium or longer-term DAF approaches. The timescale for publication of this short-term SNCB advice is anticipated to be September 2015.

Additionally, MIG-BIRD has highlighted the need for wider discussion (initially through MROG) to develop research ideas/funding proposals to develop and expand on key workshop suggestions made under the longer-term DAF approach.

MIG-BIRD will continue to have a standing agenda item on parallel streams of work related to development of the various DAF approaches. Ultimately, the hope would be to merge short-term and longer-term DAF approaches into a single best practice approach, when the evidence base and method developments allow.

A number of the Concept Note ‘think-pieces’, developed in advance of the Displacement Workshop, have since been finalised and are now publicly available online (see below).

Concept Note 1:
Busch, M., Buisson, R., Barrett, Z., Davies, S., Rehfisch, M. (2015) Developing a Habitat Loss Method for Assessing Displacement Impacts from Offshore Wind Farms.
http://jncc.defra.gov.uk/page-6987

Concept Note 5:
Humphreys, E., Cook, A., Burton, N. (2015) Collision, displacement and barrier effect concept note. BTO Research Report No. 669, undertaken on behalf of Natural England.
http://www.bto.org/sites/default/files/u196/downloads/rr669.pdf

10. Appendices

APPENDIX I: Workshop agenda

Wednesday 6th

09.00 REGISTRATION

09.30 **Start**

Jess Campbell, Consents Advisor, The Crown Estate will open the meeting.

Orea Anderson, Marine Renewables Ornithologist, JNCC and give a bit of context and background, including an explanation of why a framework is needed, how it might be used, and why your input is needed.

Rob Angell, the independent facilitator for the workshop will then run through the Agenda & Objectives for the two days and how the workshop will run.

Industry perspective on displacement impact assessment for OWFs (CN6)

There will be a short presentation by Marcus Cross, Scottish Power Renewables, on the Offshore wind farm industry perspective on the assessment of seabird displacement.

You will have a chance to ask questions of clarification on the presentation
And to discuss how this might fit with the Framework.

BREAK

Evidence / Information to inform the Framework

There will be four short presentations to give you some key input to inform this discussion:

- Evidence for displacement: an aide-memoire - Orea Anderson, JNCC
- Latest displacement results from Dutch studies - Mardik Leopold, IMARES
- Seabird displacement at an offshore wind farm in the Belgian part of the North Sea – Nicolas Vanermen, INBO
- Changes in distribution and abundance of Red-throated Diver (RTD) in Greater Wash - Andy Webb, HiDef

You will have a chance to ask questions of clarification (on the presentations).

Then you will be asked to consider in more detail what elements might be most suitable to take forward as common themes in a Displacement Assessment Framework (DAF). This will be done in a combination of group work and plenary discussion.

12.45 LUNCH

1.45 **Furness & Wade Sensitivity Scores (CN2) + the Displacement Matrix Approach (CN7)**

There will be three short presentations to give you some key input to inform this discussion:

- Use of Furness & Wade (2012) Sensitivity Scores as a proxy for displacement levels – Vicki Saint, JNCC
- Key revisions to assessments of displacement presented in the Furness & Wade (2012) offshore wind vulnerability indices – Helen Wade, MacArthur Green
- Summary of the Displacement Matrix Approach – Glen Tyler, SNH

You will have a chance to ask questions of clarification (on the presentations).

About half of you will be asked to consider the merits of the Displacement Matrix Approach and if it should be part of any new Framework. You will also be asked to discuss if the updated Sensitivity Scores should be used to inform the matrix. The other half of the workshop will consider if there is sufficient evidence to support the use of particular displacement and mortality rates and what the evidence is for a varying spatial extent of displacement for different species (i.e. buffers).

There will then be time to share and discuss the work as a whole group.

BREAK

CEH Displacement Model + Integrating collision, barrier & displacement effects (CN5)

There will be two short presentations to give you some key input to inform this discussion:

- Potential for wider application of the CEH Displacement Model approach used in the Firth and Tay – Francis Daunt, CEH
- Integrating collision, displacement and barrier effects – Liz Humphreys, BTO

You will have a chance to ask questions of clarification (on the presentations).

Then, you will be asked to consider how the CEH approach could be applied more widely and how might it fit in any future Framework. In addition, you will be asked to think about how interacting impacts could be dealt with in a future Framework.

Review emerging thoughts / suggestions

As a way of bringing the work of the day together, there will be some time to take stock of what has been suggested as components / issues for the framework. In particular, it could be appropriate to think about anything that now looks incompatible and if anything now looks missing.

Reflection / Feedback

Before we finish for the day you will have a quick opportunity to say how productive you have found the day and if there is anything we should do differently tomorrow.

5.30 FINISH

Thursday 7th

9.00	**REGISTRATION**

9.15 **Start**

There will be a quick run through of the agenda and an opportunity to share any reflections on the work you may have had overnight

Developing a Habitat Loss Method for assessing displacement (CN 1)

There will be a short presentations to give you some key input to inform this discussion:

- Developing a Habitat Loss Method for assessing displacement – Roger Buisson, APEM

You will have a chance to ask questions of clarification (on the presentations)

You will have time to consider if the habitat loss approach should form part of the Frameworks and if so, how.

BREAK

Other considerations for a future DAF

There will be three short presentations to give you some key input to inform this discussion:

- Determining fine scale pre- and post-construction bird distribution and abundance changes in and around two Danish offshore wind farms – Monique MacKenzie, CREEM
- Agent-based models to assess the cumulative impact of displacement from offshore wind farms on bird populations – Ib Krag Peterson, DMU
- Wader displacement/habitat loss assessment and parallels for seabirds – Richard Stillman, Bournemouth University

You will have a chance to ask questions of clarification (on the presentations)

You will then be asked to spend time considering what else should/could form part of the Framework

12.50	**LUNCH**

1.50 **Bringing it Together**

The rest of the meeting time will be focused on bringing all your considerations so far together. Some of the questions you will be asked to think about could include:

- Is complex or simple modelling the solution to displacement impact assessment?
- Should we be treating displacement as a habitat-loss versus year-on-year effect?
- Is there a sliding scale of approaches for less versus more sensitive species? (E.g. for less sensitive species, or even all species, is there a need for a DAF to cover the non-breeding season?).
- Taking simple and complex modelling approaches, how do we integrate breeding and non-breeding season displacement effects and impacts within any future framework?
- How do we integrate/isolate interacting impacts in any future DAF?

3.00	**BREAK**

Bringing it Together (Cont'd)

Continuing the session from after lunch, you will either continue on the work you have started and/or be asked to see if you can develop an outline Displacement Assessment Framework (or at least list its key components).

4.30	**FINISH**

APPENDIX II: List of attendees

First name	Surname	Organisation
Benedict	Gove	RSPB
Glen	Tyler	SNH
Tim	Frayling	NE
Liz	Humphreys	BTO
Helen	Wade	MacArthur Green
Chris	Eastam	SNH
Ib Krag	Petersen	DMU
Jared	Wilson	MSS
Vicki	Saint	JNCC
Richard	Caldow	NE
Aonghais	Cook	BTO
Stefan	Garthe	FTZ
Andy	Webb	HiDef
Lisa	Chilton	JNCC
Orea	Anderson	JNCC
Alex	Robbins	SNH
Marcus	Cross	SPR
Ross	McGregor	Natural Power
Francis	Daunt	CEH
Mardik	Leopold	IMARES
Richard	Stillman	Bournemouth University
Melanie	Kershaw	NE
Sophie	Banham	Forewind
Martin	Perrow	Econ
Erica	Knott	SNH
Nicolas	Vanermen	INBO
Bob	Furness	MacArthur Green
Jess	Campbell	The Crown Estate
Patrick	Lindley	NRW
Madeline	Hodge	Smart Wind
Mark	Trinder	MacArthur Green
Catriona	Gall	SNH
Chris	Thaxter	BTO
Roger	Buisson	APEM
Monique	Mackenzie	CREEM
Rob	Angell	RKP (Facilitator)

APPENDIX III: List of presenters

First name	Surname	Organisation
Glen	Tyler	SNH
Liz	Humphreys	BTO
Helen	Wade	MacArthur Green
Ib Krag	Petersen	DMU
Vicki	Saint	JNCC
Andy	Webb	HiDef
Orea	Anderson	JNCC
Marcus	Cross	SPR
Francis	Daunt	CEH
Mardik	Leopold	IMARES
Richard	Stillman	Bournemouth Uni
Nicolas	Vanermen	INBO
Roger	Buisson	APEM
Monique	Mackenzie	CREEM

APPENDIX IV: Glossary of terms

BACI	Before After Control Impact
BAGI	Before After Gradient Impact
CEH	Centre for Ecology & Hydrology
CIA	Cumulative Impact Assessments
CRM	Collision Risk Model
DAF	Displacement Assessment Framework
DMA	Displacement Matrix Approach
EIA	Environmental Impact Assessment
HRA	Habitats Regulations Assessment/Appraisal
IAM	Individual Agent Models
JNCC	Joint Nature Conservation Committee
MROG	Marine Renewables Ornithology Group
MSS	Marine Scotland Science
NE	Natural England
NIEA	Northern Ireland Environment Agency
NRW	Natural Resources Wales
OWF	Offshore Wind Farm(s)
PBR	Potential Biological Removal
PCM	Post-Consent Monitoring
PCoD	Population Consequences of Disturbance
PVA	Population Viability Analysis
RSPB	Royal Society for the Protection of Birds
SEA	Strategic Environmental Assessment
SNCBs	Statutory Nature Conservation Bodies
SNH	Scottish Natural Heritage
SPA	Special Protected Area
TCE	The Crown Estate

APPENDIX V: Abstracts

Section 2: Industry Perspective

Offshore Wind Farm Industry Perspective on the Assessment of Seabird Displacement
Authors: Scottish Power Renewables, FOREWIND and SMartWind.

The workshop on seabird displacement from offshore wind farms is a timely opportunity to agree best practice on assessment methods for future projects. The offshore wind farm developers highlight that due the UK's ambitious programme a limited number of projects are still to be consented and therefore any guidance needs to be developed as soon as possible to maximise the potential benefit, and that guidance is underpinned by a robust evidence base wherever possible. However, in the absence of data, guidance based on expert elicitation should be developed in the interim.

The offshore wind farm developers highlight the potential for this workshop to recognise the difficulties in monitoring displacement at offshore wind farms but this is an opportunity to highlight key knowledge gaps that may inform in principle monitoring discussions.

Section 3: Displacement – the evidence

A: Evidence for Displacement – an Aide-Mémoire
Author**:** JNCC

Consistent empirical evidence for displacement from offshore wind farms remains relatively limited. This is likely due to both the inherent complexities of species distribution data that has strong temporal and spatial variation and that wind farm projects are not identical to one another both in scale, density and their physical location (i.e. near versus offshore or underlying habitat/geology). However, while there may be differences both within and between species from different sites, some patterns are emerging, data is summarised where results are available from two or more sites[4]:

Largely DISPLACED: divers, scoters, northern fulmar[5], northern gannet, little gull[2], common guillemot and razorbill.
Consistently ATTRACTED: great cormorant.
ATTRACTED or NEUTRAL: common, herring and greater black-backed gulls.
CONFLICTING EVIDENCE: black-legged kittiwake and lesser black-backed gull[6].

Very few studies present results quantifying the rate and scale of displacement. Those that do, indicate these rates are likely to be species and site specific. Evidence on habituation may be emerging but it is sparse and not necessarily clear-cut. Equally to-date studies have not indicated to what extent seasonality may influence a species likelihood of, and vulnerability to, displacement.

While we struggle to obtain evidence on the rate and scale of displacement from a site, understanding the wider implications of what that effect may have on an individual/population is even more challenging. To-date impacts of displacement on mortality and/productivity has largely been informed through theoretical modelling.

[4] See Table 1 in Concept Note 2 for literature that is used to produce this summary.
[5] Based on one significant and one non-significant result.
[6] Leopold et al. (2013) note that if fishing vessels are excluded from OWF's, then detection of a displacement effect may instead be more representative of changes in 'prey availability'.

Finally, the majority of evidence referred to within this summary is from grey literature. We believe it will be of benefit to consider the relative strengths and weaknesses of the available studies to better inform our confidence in any results presented.

B: *Recent Dutch Offshore Wind Farm studies on displacement and turbine density*
Authors: Mardik Leopold (Wageningen-IMARES, The Netherlands)

Extensive work in and around the first two offshore wind farms in Dutch waters (Leopold *et al* 2013) has indicated that common guillemots were displaced by these wind farms, but not completely (displacement factor <1). Moreover, displacement appeared to be stronger in the wind farm that had the higher turbine density of the two. This prompted us to look for other data of guillemot densities in and around offshore wind farms in other countries and these were supplied by colleagues working in the UK, Belgium, Germany and Denmark. A first analysis on the combined datasets indicates that, indeed, displacement in guillemots is stronger at higher turbine densities. More work on this subject is being planned, and hopefully new data, from more wind farms can be included in the analysis.

Cumulative effects of wind farms across the southern North Sea (ca 100 existing and planned projects) were considered by adding up collision mortalities and presumed displacement mortalities (set at 0.1xnumbers of displaced birds per wind farm). The resulting values, cumulative for all 100 wind farms were compared to PBR values for each species, estimated by demographic modelling. The ten most vulnerable seabirds were found to be Lesser and Great Black-backed Gull, Kittiwake, Herring Gull, Gannet, Guillemot, Great Skua, Red- and Black-throated Diver, and Razorbill, with considerable variation in impacted numbers between individual wind farms, and between the various countries around the southern North Sea.

Leopold M.F., van Bemmelen R.S.A. & Zuur A.F. 2013. Responses of local birds to the offshore wind farms PAWP and OWEZ off the Dutch mainland coast. IMARES Report C151/12. http://edepot.wur.nl/279573

C: *Seabird displacement evidence at an offshore wind farm in the Belgian part of the North Sea*
Authors: Nicolas Vanermen, Wouter Courtens, Marc Van de walle, Hilbran Verstraete & Eric Stienen. Research Institute for Nature and Forest (Belgium).

The Belgian Research Institute for Nature and Forest (INBO) is in charge of monitoring seabird displacement occurring after offshore wind farm (OWF) developments at the Belgian part of the North Sea. To this purpose, seabird abundance and distribution was studied through monthly ship-based seabird surveys following a before–after control–impact monitoring design.

Results after 3 years of post-impact monitoring at the Bligh Bank OWF demonstrate that northern gannet (*Morus bassanus*), common guillemot (*Uria aalge*) and razorbill (*Alca torda*) avoided the wind farm area, and decreased in abundance with 85, 71 and 64%, respectively. Lesser black-backed gull (*Larus fuscus*) and herring gull (*Larus argentatus*) appeared to be attracted to the wind farm, as their numbers increased by a factor 5.3 and 9.5. Other gull species too were found to frequent the turbine-built area, most notably common gull (*Larus canus*), black-legged kittiwake (*Rissa tridactyla*) and great black-backed gull (*Larus marinus*). The ecological incentives behind the observed attraction effects are still poorly understood, but on top of the increase in roosting possibilities it is plausible that OWF's offer enhanced feeding opportunities. Importantly, attraction of seabirds to OWF's implies an increased collision risk. Based on the post-construction densities observed in wind farm footprint area at the Blighbank, the Band (2012) collision risk model estimates 1.9 collision victims per turbine per year, which would add up to more than 1,000 collision mortalities per year, mostly gulls, once all planned Belgian OWF's will be operational (564 turbines at most).

Also, based on reference ('before') data collected at the Thorntonbank, we investigated how our impact assessment method performs in term of power, being the chance of statistically detecting a change in numbers. Because of high over-dispersion and/or zero inflation in the 'seabirds at sea' count data, the power to detect a 50% decrease in numbers was generally low, but did reach 90% within less than 10 years of post-impact monitoring for northern gannet and common guillemot. Importantly, any monitoring programme is designed within certain logistical and budgetary constraints, inevitably reflected in an upper power limit. In this respect, both researcher and policymaker should be aware of the fact that not being able to statistically detect a change in seabird numbers should not be mistaken for 'no change'.

D: *Changes in distribution and abundance of Red-throated Diver (RTD) in Greater Wash*
Author: Andy Webb, HiDef Aerial Surveying Limited

Strategic visual aerial and digital video aerial transect surveys were carried out over a wide geographical area around the Lincs, Lynn and Inner Dowsing wind farms between 2001 and March 2014 for Centrica Renewable Energy Limited's first year of post-construction monitoring for the Lincs Offshore Wind Farm. Spatially explicit density surface modelling was used create grids of predicted abundance for the key pre-, during-, and post-construction phases of development at the three wind farms. The density surface models used month, bathymetry and 'Complex Regional Spatial Smoothers' ("CReSS") as terms, and Generalized Estimating Equations ("GEEs") to account for autocorrelation in the data. Boat-based survey data were also collected, but not used in the analysis because known biases in such data would be focussed around a small area of the impacted site in any analysis carried out. Models were generated for fulmar, gannet, all divers (as a proxy for red-throated diver Gavia stellata), little gull Hydrocoloeus minutus, common gull Larus canus, lesser black-backed gull L. fuscus, small gull species (Laridae), common or Arctic tern Sterna hirundo & St. paradisae, all terns (Sternidae), and all auks (Alcidae).

The outputs from the models examined changes in abundance for these species and species groups over the development phases for the wind farm projects, examining the impacted site; the impacted site + a 4km buffer; just the 2–4km buffer; and all parts of the Greater Wash beyond the 4km buffer. For most species and species groups, there was no difference in the temporal pattern in abundance change between the impact site and the Greater Wash area beyond the 4km buffer. However, for 'all divers', there was a significant ten-fold increase in abundance between the baseline period and the first year period after construction of Lincs in the wider Greater Wash beyond 4kms, whereas at the impact site, this ten-fold increase in abundance did not take place. Visual inspection of the difference in abundance at the scale of individual grid cells for 'all divers' across the Greater Wash demonstrated significant increases in abundance in virtually all regions other than at the impacted site and extending up to 2–4km outwards. This demonstrates a clear displacement effect for 'all divers' (over 99% of which would have been red-throated divers according to historical data and the most recent surveys). If the area surveyed around the site had been any less than 10km, then it would have not have been possible to detect this change in spatial distribution.

A small part of the abundance increase may be attributable to a switch in aerial survey methods between phases, but comparison between visual and digital aerial survey methods in Germany suggest that differences for red-throated divers are small and unlikely to contribute more than a 50% increase in abundance. The drivers behind the large influx of divers to the un-impacted parts of the Greater Wash are unknown, but appear to be considerably more important at the local population scale than the impact of displacement from the wind farms.

Clarifications, questions and comments

For Bligh Bank we will try and investigate tidal patterns and other environmental co-variates. However, the recorded impacts do appear to be linked to the wind farm as the control site showed no change. For Lincs and Inner Dowsing the picture is much less clear - there appears to have been a large-scale movement of red-throated diver to the south east of the Wash. The spatial scale over which this has occurred seems to indicate it's probably not due to the wind farm.

It's important to realise that there is not an instantaneous switch from baseline conditions to operational impacts. A wind farm "grows" over time as it is being built (and different parts may be commissioned at different times) – it could be informative to track changes in bird distribution during the construction phase.

The Red-Throated Diver (RTD) data for London array indicates that displacement impacts on this species were linked to shipping and helicopter movements during construction. While digital aerial survey data has been collected across the site, it has not been analysed for any other species.

A question was raised regarding consideration of other drivers, such as prey resources. To actually carry out studies could be extremely difficult - red throated divers had 25 prey species alone. This diversity of environmental variables could be extremely difficult and costly to build into surveys.

It should be possible to compare displacement impacts against Potential Biological Removal (PBR) thresholds – this can be done at a strategic level to take an overview of cumulative impacts.

This discussion also highlighted issues around calculation of collision risk and displacement and whether these impacts were cumulative or not. This would be returned to later in the workshop.

Section 4: Using the Furness & Wade Sensitivity scores as a proxy/The Displacement Matrix Approach

A: Use of Furness & Wade (2012), Sensitivity Scores as a proxy for displacement levels.

Author: JNCC

It is widely recognised that displacement is one of the four key impacts that seabirds and marine waterbirds are vulnerable to from offshore wind farms. However, empirical evidence as to the scale and implications of displacement is limited thereby making assessments of this impact particularly challenging. To date a variety of different approaches have been applied to undertake a displacement assessment and the development of a consistent approach would be of benefit SNCBs, Regulators and Developers. One of the more recent approaches, and the focus of this Concept Note, has been to utilise the Furness and Wade (2012)[7] sensitivity scores as a proxy for displacement.

We consider here the evolution of the sensitivity score publications and give examples of how these have been used as proxies in casework. We then consider how the proxies compare to emerging evidence from wind farm post-consent monitoring reports and how informative the proxies are.

A preliminary attempt was made to locate and consider alternative metrics but was unsuccessful.

We should be mindful that while developing any approaches that rely on the sensitivity publications, Helen Wade, as part of her PhD thesis, has undertaken a review of the sensitivity scores which includes a re-visit of the evidence base and a re-working of the formula(s).

While the focus of this note is on offshore wind farms, there will be merit in considering the suitability of the outputs/recommendations for the assessment of wave and tidal development impacts.

B: Key revisions to assessments of displacement presented in the Furness and Wade (2012) offshore wind vulnerability indices

Authors: Wade, H.M.[a,b], Masden, E.A.[b], Jackson, A.C.[c] and Furness, R.W.[a,d]

[a] MacArthur Green, 95 South Woodside Road, Glasgow, UK;
[b] Environmental Research Institute, North Highland College – UHI, University of the Highlands and Islands, Thurso, UK;
[c] Cornwall College Newquay, Wildflower Lane, Trenance Gardens, Newquay, Cornwall, UK;
[d] College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow, UK.

In the absence of information regarding the specific effects of displacement caused by offshore wind farms (OWF) on seabirds, we can draw on existing knowledge of seabird ecology and behaviour to predict which species might be most vulnerable. Furness *et al* (2013) developed an index to rank Scottish seabird species' vulnerability to displacement caused by OWF. Since this publication, more information has become available and it was deemed appropriate to update and revise this index to ensure it remains a useful guidance tool. In Furness *et al.* (2013) species were scored on their combined vulnerability to displacement caused by structures, vessels and helicopters. A key update to the vulnerability index was to separately score vulnerability to displacement caused by i) structures, and ii) vessels and/or helicopters. This was based on information that some species respond differently to turbine structures than

[7] Furness, R. and Wade, H. Vulnerability of Scottish Seabirds to Offshore Wind Turbines. 2012. Report to Scottish Government. http://www.scotland.gov.uk/Resource/0040/00401641.pdf.

to vessels and helicopters (e.g. gannet). The two vulnerability factors were updated with newly available information and species scores were adjusted where strong evidence suggested it was appropriate to do so. The calculation used by Furness *et al.* (2013) to generate overall species rankings of vulnerability to displacement was modified to incorporate the new displacement factors; with a greater weighting on the effect of fixed turbine structures than transient vessel and helicopter traffic. Following recalculation of rankings using the modified calculation, species vulnerability to displacement remained broadly the same, although the rankings for some species did alter (e.g. gannet, cormorant, razorbill). Confidence indices for both displacement factors were also developed to indicate the quality and quantity of data underlying species scores and rankings. Confidence indices highlight where caution in interpreting vulnerability rankings may be required, identify areas where more research and monitoring could prove beneficial, and could inform the process of screening species out of more detailed displacement assessment.

C: Concept Note 7 Abstract: The Displacement Matrix Approach

Author: Glen Tyler, SNH

Empirical estimates seabird displacement levels from offshore wind farms (OWFs) and other developments are only fairly recently being made. The estimates vary with the type of development and species involved, but also many other factors.

Modelling of seabird energetics (Searle *et al* 2014) shows that displacement can have a significant impact on both survival and productivity. This needs to be considered when assessing offshore development impacts on seabird populations.

Until now Statutory Nature Conservation Bodies (SNCBs) have been either agreeing single values of displacement and displacement impacts with developers and regulators or, more recently have adopted a 'matrix approach' where, within a full range of displacement values from 0% to 100% and a similarly broad range of impacts, a focussed area of final values is presented and discussed.

These values are based on sensitivity indices produced from reviews of available information, and refined as more relevant information appears. The process of using these indices to produce a final range of displacement impact values through the Matrix Approach is presented in this concept note. This gives a clearer more consistent method to agree final figures used in the assessments.

Section 5: CEH Displacement Model + Integrating collision, barrier and displacement effects

A: Potential for wider application of the CEH Displacement Model approach used in the Forth and Tay

Authors: Daunt, F.[1*], Searle, K.[1], Mobbs, D.[1], Butler, A.[2], Bogdanova, M.[1], Freeman, S[3]. & Wanless, S.[1]

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The purpose of this presentation was to describe the potential for wider application of the CEH Displacement model. Marine Scotland commissioned CEH to develop a model to estimate the population consequences of displacement from proposed offshore wind energy developments for five seabird species breeding at four SPAs in proximity to proposed Forth/Tay offshore wind farm developments (Searle et al. 2014). We considered impacts of displacement and barrier effects of single wind farms and cumulative effects of multiple wind farms on population size operating via two main processes: reduced survival of offspring during the breeding season, and reduced body mass of adults leading to lower survival in the following winter. The principal requirement was to develop time and energy models of foraging of breeding seabirds during the chick-rearing period to estimate consequences for demographic rates. The model simulated foraging decisions of individual seabirds under the assumption that they were acting in accordance with optimal foraging theory. Subsequent breeding behaviour of birds (principally rates of temporary un-attendance and permanent abandonment of nests) was then simulated incorporating realistic assumptions and empirical data. Adult survival was estimated from adult body mass/survival relationships in the literature. Breeding success was estimated from chick body mass (relevant to starvation probability) and adult attendance behaviour (relevant to probability of chick mortality from exposure or predation). The impacts of the proposed single wind farms and multiple wind farms (cumulative effects) were assessed by comparing simulated values of adult and chick survival in models that included the wind farms against the baseline simulations with no wind farms. A sensitivity analysis informed which input variables the model outputs were most sensitive to.

The model is flexible and modular in structure and therefore has the potential to be used more widely. Refinements can readily be incorporated in future versions, incorporating greater functionality (e.g. more complex foraging trip structure; effects on immature survival as well as adult survival and breeding success) or new information as it becomes available (e.g. foraging site fidelity; habituation). Application of the model to other study areas is also readily achievable. The decision on whether to do so will depend on what data exist, or could be collected, to parameterise the subset of variables that have the most influence on model outputs. Some variables are generally considered to be generic, and therefore estimates from other locations from the same or related species could be used. Other variables require local data of sufficient quality. Of particular importance is the time spent in the footprint by the population of birds relative to other areas in the potential foraging range. The decision on whether to proceed should be undertaken on a case-by-case basis with careful consideration of these factors.

Reference:

Searle, K., Mobbs, D., Butler, A., Bogdanova, M., Freeman, S., Wanless, S. & Daunt, F. (2014) Population consequences of displacement from proposed offshore wind energy developments for seabirds breeding at Scottish SPAs (CR/2012/03). Report to Scottish Government (http://www.gov.scot/Topics/marine/marineenergy/Research/SB7

B: Integrating Collision, Barrier and Displacement Effects

Authors: Elizabeth M. Humphreys, Aonghais S.C.P. Cook and Niall H.K. Burton.

Summary of work commissioned by Natural England and carried out by the British Trust for Ornithology. April 2015.

1. Offshore wind farms (OWFs) may potentially affect birds in a number of ways, most notably through: i) collisions with turbines; ii) displacement of birds due to effective loss of habitat; and iii) barrier effects where the wind farm creates an obstacle to regular movements to and from breeding colonies or migration. In part due to the different ways in which these effects might impact populations, these effects have usually been considered separately in Environmental Impact Assessments (EIAs), although there is a need to consider whether the multiple impacts from these different effects may be significant.

2. This summary concept note outlines the issues associated with and options for integrating the impacts associated with collision, displacement and barrier effects associated with OWFs in a statistically and ecologically appropriate way. The extent to which barrier effects have been differentiated from displacement effects is questionable, however, as both are manifested as a reduction in the number of birds in flight within the wind farm.

3. An initial overview is provided of key reviews which have assessed the sensitivities or vulnerabilities of species to the likely effects of OWFs in order to derive a list of key species where two or more effects could operate together and therefore where multiple impacts need to be considered in combination. Displacement, barrier and collision effects have often not been considered in combination because the species considered at greatest risk from collision have generally been considered to be of low risk from displacement and vice versa. Nevertheless, some recent EIAs have considered whether these effects could be significant in combination for northern gannet and black-legged kittiwake. For many gull species, the evidence with respect to displacement/attraction, as derived from post-construction monitoring reports, is also equivocal with some studies suggesting evidence for attraction, others evidence for displacement, and others no significant response. However, should a potential change in numbers be predicted, given their high sensitivity to collision, there may be need to consider effects in combination for northern gannet, all gulls, as well as skuas and terns.

4. A further review briefly summarises how collision, displacement and barrier effects have been assessed and treated by different OWF project applications for these species in the UK. Four main approaches appear to have been taken:

   i. Mortalities calculated separately for both collision and displacement – effects not combined;

   ii. Mortalities calculated separately for both collision and displacement – effects combined by simple addition of predicted losses;

   iii. Mortalities calculated separately for both collision and displacement – effects combined and displacement considered as the population lost in the long-term due to the effective loss of habitat;

   iv. Mortality calculated for collision and reduced productivity assumed to be the result of displacement – effects combined.

5. Before the effects of wind farms on bird populations can be combined, it is important to consider the processes by which displacement/barrier effects and collision may impact populations, i.e. which components of the population may be affected and how. With

respect to displacement/barrier effects, impacts might occur through: increased chick mortality (observed as a decrease in productivity), increased juvenile mortality, increased immature mortality (i.e. of pre-breeding birds), increased adult mortality (of breeders and/or non-breeders) and breeding adults becoming non-breeders. With respect to collision, impacts might occur through: increased chick mortality (indirect but could arise through the loss of a parent), increased juvenile mortality, increased immature mortality and increased adult mortality.

6. Potential alternative methodologies for combining the impacts associated with collision, displacement and barrier effects into a single integrated metric of impact are based on two broad approaches. Given the practical difficulties in distinguishing between displacement and barrier effects in the field, we focus our discussion on displacement/barriers effects collectively and how they may be combined with collision.

   i. The first approach, hereafter referred to as **Additive Mortality**, is a simple addition, for each relevant age class, of the estimated annual (or seasonal) mortality arising from displacement/barrier effects and the predicted annual (or seasonal) mortality arising from collisions, as derived from Collision Risk Models (CRMs), to give a total mortality rate.

   ii. The second approach is hereafter referred to as **Displacement/Barrier Effect Corrected Additive Mortality.** Here a revised annual (or seasonal) collision rate is calculated, for each relevant age class, based on the number of birds available to collide with turbines following displacement or barrier effects. This value is then combined with an estimate of the annual (or seasonal) mortality arising from displacement/barrier effects for each relevant age class, to give a total mortality rate.

   If the effect of displacement is simply considered by estimating the proportion of displaced birds that might be expected to be lost in the long-term, i.e. as Displacement as Habitat Loss (Busch et al. 2015), then a Displacement/Barrier Effect Corrected Additive Mortality approach would effectively be taken, but, having accounted for the assumed population loss, the only ongoing impacts on demographic rates would be through collision.

7. The key aim of our work here is to consider the process of combining effects of wind farms rather than focus on potential modelling frameworks which could be used thereafter to investigate the population level consequences (i.e. changes in population size) resulting from the development over its operational lifetime. Hence, it is not part of our brief to review the range of population models available and comment on their suitability. Nor can we provide guidance as to whether sufficient empirical data exist to test the predictions of these population models.

   Note, however, for any population modelling framework used, consideration would have to be given to as to whether density dependent processes were operating, such that the impacts of displacement on demographic rates reduce over time as population size decreases.

Careful consideration should be given as to whether the assumptions regarding the processes by which displacement/barrier effects, in particular, may impact populations can be justified given the limitations of the data available and evidence base.

Clarifications, questions and comments

Q: Is the calculation of the time spent in the wind farm footprint dependent on the number of birds that have been tracked and do we have a sufficient number of birds tracked to make the calculation? Is it possible to use other sources of data?
A: In the CEH modelling, we did explore using the “at sea” survey data for the Forth & Tay wind farms in respect of puffin (as this species is notoriously difficult to tag). However, the key

limitation was the lack of available information on foraging range (little understood and potentially enormous). The wind farm proposals (i.e. the area surveyed) only occupied a very small percentage of the possible total. Before undertaking any modelling, the availability and quality of data does need to be sense-checked.

The process used in the CEH modelling was helpful, but how to deal with non-breeding individuals in the breeding season? Also could individual animal behaviour/physiology be taken into account by using seabird demographics in the model?
There are established equations regarding adult body mass and survival rates, but that care needs to be taken in using these due to geographical differences (such as kittiwakes in Shetland being bigger than those in the Forth).

Conceptually it would be possible to apply the CEH model in the non-breeding season (note that the Forth & Tay assessment had been undertaken for breeding season only). However, so much less is known about bird movements and behaviour in the non-breeding season, particularly about adult over-winter survival rates. There are significant limitations on understanding the effects of displacement, and there are very few studies or data available on energetic impacts or impacts on birds' individual fitness. In this regard there's only two papers that have been published; Bob Furness's one on kittiwake and a puffin paper from Norway.

For the Forth & Tay model we did not look at chick recruitment into the population, however, it would be possible to do this, the modelling has that capability.

Taking a view on whether or not it will be possible to adapt the CEH model for use in data poor areas* will depend on whether or not you think that adult life history decisions are generic. (*Note that most areas other than the Isle of May are considered data poor.)

Can the short & long term effects be combined in the work on integrating collision, displacement and barrier effects? This would be dependent, as CRM calculates a predicted mortality per year, whereas displacement would calculate population consequences – further work in the area would be required

Section 6: Developing a Habitat Loss Method for Assessing Displacement Impacts from Offshore Wind Farms

Authors: Busch, M., Buisson, R., Barrett, Z., Davies, S., Rehfisch, M. APEM, 2015.

The impacts of offshore wind farms (OWFs) on seabirds are typically divided into three forms: collision mortality, barrier impacts and displacement impacts. The report "Developing a Habitat Loss Method for Assessing Displacement Impacts from Offshore Wind Farms" investigates the validity of assumptions underlying a recently suggested approach, defined as the ′Displacement as Habitat Loss′ approach. This approach interprets displacement impacts as a time restricted, quasi-permanent habitat loss rather than a year-on-year effect across the entire operational lifetime of an OWF. It proposes that after displacement impacts have been exerted on a population, a new, stable population equilibrium is reached at some level below the initial starting population. By examining the assumptions underlying this approach and outlining ways of translating it into a staged assessment framework, this report provides an analysis of the pros and cons of the ′Displacement as Habitat Loss′ approach.

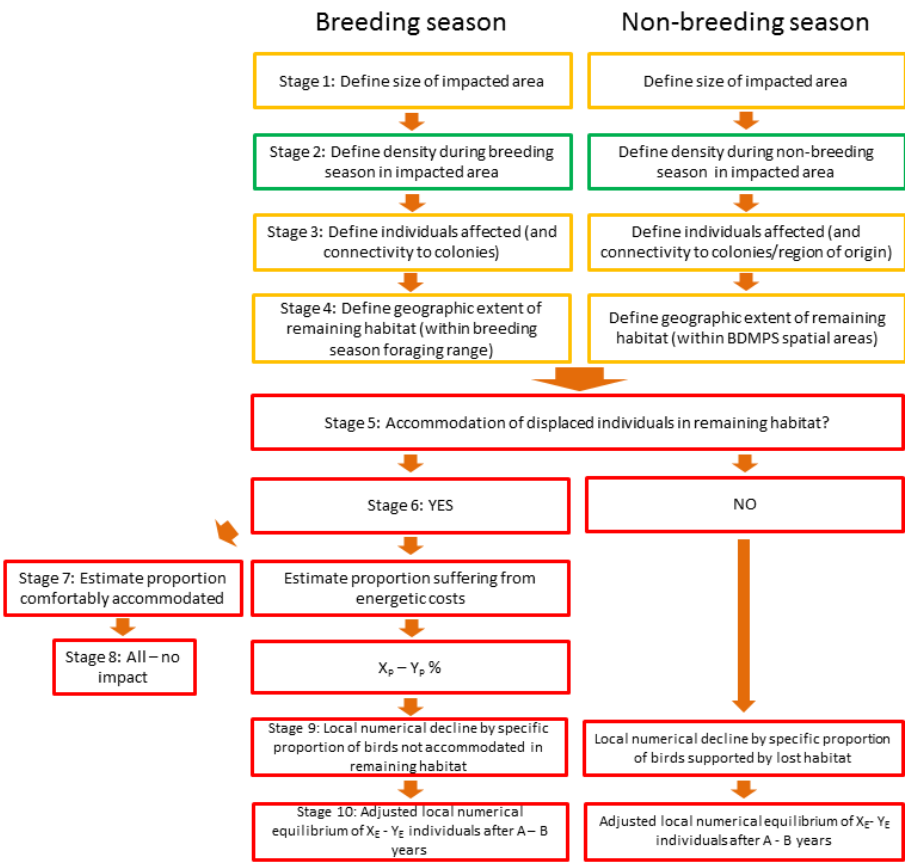
An assessment framework has been developed that is presented, discussed and applied in case studies for two species. Additionally, alternative ways of developing a staged framework to the ′Displacement as Habitat Loss′ approach are considered. It has been found that, independent of the focus of any assessment framework, challenges relating to the understanding and assessment of ecological processes governing the strength of any potential

displacement effect, will affect the delivery of any potential assessment framework. Estimating (by season) the size of the original habitat, the habitat remaining after displacement impacts have occurred, and the likely number of birds that may need to relocate to alternative (remaining) habitat, appears possible but is challenging in its own right. Available evidence on percentage displacement suggests strong site-specific variations. For assessments the use of generic displacement categories for species (such as high, medium or low sensitivity) may be best, unless variations can be explained by, for example, habitat quality, which could represent a factor governing the strength of any site-specific displacement effect.

Considerable evidence gaps as well as difficulties with quantitatively assessing those ecological processes, which are subject to considerable natural variability, impede the assessment of the biological consequences of displacement. Quantification of the likely fitness implications of displacement requires a detailed understanding of the degree to which local populations are below, at, or above carrying capacity. This appears to be a precondition of any attempt to estimate what proportion of displaced birds are forced to relocate to alternative habitat and the proportion of those that might be accommodated within remaining habitat without considerable energetic costs. Moreover, if population equilibrium exists in seabird populations, it may not be possible to reliably characterise the point at which this equilibrium has been reached, due to the strong fluctuations that are inherent in marine ecosystems. Population equilibrium is unlikely to be constant and thus separating displacement effects from natural population fluctuations, as well as other pressures on the population being assessed, may be impossible.

A clear benefit of a staged assessment framework is that it provides transparency on where assumptions are made in the process and at which stage they are introduced. This is an advantage over the existing ‘Displacement Matrix’ approach as it helps breakdown the particular areas of uncertainty needing further research. The ’Displacement as Habitat Loss’ framework, particularly in later stages, requires empirical evidence on seabird species that are absent from the literature. Each stage has particular uncertainties associated with it, meaning that cumulatively an unacceptable level of uncertainty can be the result. The ‘Displacement as Habitat Loss’ approach provides a thorough theoretical framework to assess displacement impacts from OWFs. However, the absence of empirical evidence to support/refute various the assumptions required throughout mean that in practice the framework is currently unlikely to be applied in a ‘real-world’ scenario, until some of the uncertainties have been further explored

Stage	Underlying assumptions
1.	Sufficient knowledge on appropriate, species-specific buffers to define geographic extent of impacted area
2.	Survey methodology and assessment methods suitable to report densities at a precision allowing assigning changes to OWF operation
3.	Sufficient knowledge on % displacement
4.	Ability to define the extent of specific seasonal habitat available to a local population
5.	Sufficient knowledge about carrying capacity of respective population
6.	
7.	Ability to define proportion of birds that could still be supported by remaining habitat/available resources considering habitat quality & density dependence
8.	Immediate impact
9.	Ability to define if affected pop. suffers from mortality or reduced reproduction; Pop. will adjust to new equilibrium; length of such adjustment process; no immigration into affected population causing ongoing effect;
10.	Ability to reliably predict time scales over which new equilibrium is achieved; consider potential habituation impacts



Clarifications, questions and comments

This approach does not include any consideration of habituation, it assumes that displacement can equate to a single, permanent loss of habitat within the wind farm footprint which seabirds will no longer be able to access/utilise. It should be possible to address seabird habituation by making some adjustments to the modelling: you could assume the effect is temporary rather than permanent and allow for population recovery. We were not able to investigate this, however, as it was beyond the scope of the brief.

This approach does not limit the assessment to a one off calculation - the new population can be calculated at various times e.g. to over a period 1-3 years, or 3-10 years. It will require another stage in the assessment – a temporary displacement step.

This work did not go on to consider how it should be used in the HRA process, this was seen to be part of the EIA/HRA process.

Even with the species studies as part of this research contract, for both Red Throated Diver and Lesser Black Backed Gull, it is not possible to carry though all the steps required due to information required not being available.

Section 7: Other considerations for a future Displacement Assessment Framework

A: Spatially adaptive modelling: mapping distribution and behaviour

Author: Dr. Monique L. Mackenzie[1]

My interest in the marine renewables sector is based around modelling the abundance and distribution of birds and marine mammals, in and around development sites. In particular, my work is focused towards spatial surfaces which are able to accommodate (sometimes abrupt) local changes in often large areas, even when these areas have complex topography (e.g. islands and coastlines).

As a result, my colleagues and I have developed the Complex Region Spatial Smoother (CReSS[2]) with automatic model selection (via the Spatially adaptive Local Smoothing Algorithm (SALSA[3]). These methods have been employed on both small and large (e.g. 1 million km2) spatial scales, and have been tested up against industry standards with good success[4].

These methods produce `heat maps' of abundance, distribution (and most recently behaviour) for the area(s) of interest in addition to spatially-explicit measures of uncertainty about these surface predictions. These surfaces are often of interest before any interventions (e.g. windfarm installation), during intervention (e.g. construction), and post intervention (e.g. post-construction monitoring).

The uncertainty about these surfaces is crucial since this is the only way to disentangle genuine impacts from natural change. For this reason we consider uncertainty carefully, and accommodate un-modelled patterns (i.e. spatio-temporal residual autocorrelation) should these exist.

I see an opportunity to combine the spatially explicit behavioural information we already collect with spatially explicit distribution/abundance information to help us understand how interventions affect animal populations.

Robust methods to do this are available and we may gain valuable insights about population consequences as a result.

[1]Monique is a statistician based at the Centre for Research into Ecological and Environmental Modelling (CREEM), at the University of St. Andrews, Scotland.
For more: http://moniquemackenzie.wix.com/drmoniquemackenzie

[2]Complex Region Spatial Smoother (CReSS), Journal of Computational and Graphical Statistics Volume 23, Issue 2, 2014

[3] a spatially adaptive local smoothing algorithm, Journal of Statistical Computation and Simulation, Volume 81, Issue 2, 2011

[4]Mackenzie, M.L, Scott-Hayward, L.A.S., Oedekoven, C.S., Skov, H., Humphreys, E., and Rexstad E. (2013). Statistical Modelling of Seabird and Cetacean data: Guidance Document. University of St. Andrews contract for Marine Scotland; SB9 (CR/2012/05).
http://creem2.st-andrews.ac.uk/download/mrsea-guidance

B: Development of an agent-based model to compare the impacts from different OWF development scenarios on Divers

Author: Ib Krag Petersen, Chris Topping, Aarhus University, Dept. of Bioscience (Denmark)

The local effects of the presence of offshore wind farms on the distribution of Red-throated Divers have been assessed in several studies. These results indicate that Red-throated Divers are less abundant within and around an offshore wind farm post-construction compared to pre-construction.

Such displacement does not cause direct mortality, and the local effect is therefore not easily assessed in terms of the impact on the population level. Hence an agent-based model was developed in an attempt to assess the impact of these displacements on the general population.

Model development was carried out using a Pattern-Oriented Modelling procedure, which involved developing the model in an iterative cycle comparing model performance against real world data patterns via an inverse modelling procedure. The result is that the extent to which the model predicts impacts of windfarms correctly is directly related to the quality of real world test data available.

Having established the model, we compared the potential impact of 3 wind farm development scenarios encompassing the full range of possible wind farm developments in the region covering the entire Baltic and eastern North Sea, from the Netherlands in the south to mid-Norway in the north.

The assessments were based on two basic assumptions. Firstly, that windfarm development removed habitat pro-rata by area and did not have a wider reaching implication for diver resources. Based on this assumption, evaluation of the simulations led to predictions of minimal impacts of the proposed windfarm developments. Primarily this was due to the avoidance behaviour of the divers, whereby they would fly around or over windfarms, rather than perceiving windfarms as barriers to movement. The second assumption is that the data used to develop the model was representative of the diver population behaviour. Hence, the results presented here must be interpreted in the light of these assumptions and the available data.

http://www.ens.dk/sites/ens.dk/files/undergrund-forsyning/vedvarende-energi/vindkraft-vindmoeller/havvindmoeller/miljoepaavirkninger-3/Roedstrubet%20lom,%20agent_based%20model.pdf

C: Wader displacement/habitat loss assessment and parallels for seabirds

Author: Richard Stillman, Bournemouth University

Many types of environmental change can potentially adversely affect waders and wildfowl, including sea level rise, disturbance from humans, tidal barrages, habitat loss and climate change. Similar types of change will influence seabirds.

An approach to predicting the effects of environmental change on waders and wildfowl has been to develop detailed knowledge of how individual animals alter their behaviour (e.g. diet or location choice) to adapt to change. Using this understanding it has been possible to develop individual-based models, based on optimal foraging behaviour and physiology, to predict population consequences (e.g. survival) of change from the behavioural responses of individuals. Such models have been used to predict the effect of environmental change on waders and wildfowl in several sites in Europe and worldwide.

Measuring the required parameter values is more straightforward in waders and wildfowl, than in most seabirds. For example, the feeding behaviour of waders and wildfowl can be observed, as they typically feed in open intertidal habitats, and the distribution and abundance of their prey can be measured using intertidal surveys. In contrast, measuring the feeding behaviour of seabirds, and measuring the abundance of their prey can be complex, or is currently unachievable.

It has been possible to use this approach to predict the effect of wind farm developments one seabird, the common scoter. One step was to measure the distribution and biomass of the scoter's bivalve food supply using marine benthic surveys. A second step was to gain knowledge of the energetics of diving to understand the energy costs and benefits for scoter's feeding on different biomasses of prey at different water depths. The model's predictions (e.g. for survival and distribution) were compared to observations to test the accuracy with which it represented the real system. The model was then used to predict the effect of alternative wind farm developments on the survival rate of the birds.

The scoter system is relatively simple compared to many other seabird systems, which could comprise more mobile prey that are difficult to survey, or more complex foraging behaviour of the birds. One approach to estimating the abundance of prey could be to use environmental proxies for habitat quality (e.g. sediment type, water depth, current flow), and more advanced technologies may make measuring the detailed behaviour of seabirds more achievable.

Lessons from waders and wildfowl suggest that assessing the impact of wind farms on sea birds should ideally consider the ability of the birds to compensate for displacement. Important components of this are the adaptive behaviour of birds, the density of birds relative to the amount of food (or habitat) available, the ease with which birds meet requirements prior to wind farm development, and the location, quantity, quality and availability of prey.