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Definition of ‘range’ in the context of marine renewable energy development and marine mammal conservation

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1 Executive Summary

There are a number of potential issues affecting the populations of cetaceans living in or using UK waters. Without knowing the distribution and abundance of these animals the ability to assess how any of these issues could be affecting UK cetaceans are limited.

The area of sea, or range, specifically used by each cetacean species is an important factor when looking at issues such as Marine Renewable developments. If a development site falls within the natural range of a cetacean species, that species may be likely to be present and therefore collection of baseline data is of vital importance. However, the definition of a natural range, and whether a particular species is likely to be present at a particular site, is not straightforward as cetaceans may only be present at a site seasonally or sporadically because of their wide ranging movements.

There are a wide variety of techniques developed to explore the issue of animal range but not all of these may be suitable for cetaceans, and for some there are not adequate data. Further research will be necessary to ascertain whether there is enough existing cetacean sightings data to explore the utility of some of the measures that have been devised, and therefore to find a model that best serves the need to define the ‘natural range’ of these animals both within the context of the Habitats Directive and any other legislative obligations.

2 Introduction

Current Government Guidance on the Protection of Marine European Protected Species from injury and disturbance in Scottish inshore waters, requires developers to collect baseline data on European Protected Species that are 'likely to be present' at a proposed development site. An obvious and convenient interpretation of the phrase 'likely to be present' is to consider whether a proposed development site is within the 'natural range' of a species. The 'natural range' is specifically identified as a conservation feature in European legislation.

The 'Natural Range' of a European Protected Species is an important descriptor which has significant implications under EU and domestic legislation. The main objective of the Habitats Directive is to maintain or restore European Protected Species to 'favourable conservation status'; Commission Guidelines suggest that this objective can be met when, inter alia 'the natural range is neither being reduced nor is likely to be reduced in the near future'. Furthermore, Article 12(1) of the Habitats Directive requires member States to establish a system of strict protection for European protected Species "in their natural range" prohibiting among other things, any deliberate disturbance of these animals. Along with the Marine Strategy Framework Directive (2008/56/EC) (MSFD) requirements to establish and implement coordinated monitoring programmes for the ongoing assessment of the environmental status of marine waters, it is clearly important to define range.

It can be assumed that when development sites are outside the natural range of a particular European protected Species there is no need to collect baseline data on that species nor conduct any risk assessment, while conversely, if a site is within the natural range of a species, that species should be considered likely to be present.

How then are natural ranges to be defined, and how can it be determined whether a particular species is likely to be present at a particular proposed development site? For rare and cryptic species like beaked whales, or for species that are only present at a site seasonally, or sporadically because of their wide ranging movements, extensive monitoring may be required to confirm presence, while confirmation of absence may be practically impossible.

Clearly it would be helpful to be able to define a species range in such a way that developers could determine whether a given species is 'likely to be present'.

3 Current Status

Currently developers are pointed to the JNCC Atlas of Cetacean Distribution in north-west European waters (Reid *et al.*, 2003) to determine which species are likely to be present. The data that were used to construct this Atlas, however, are coarse grained. Furthermore, for many species the reported sightings that have been used to construct the Atlas are disjointed with large areas between recorded sightings. It is difficult to know when and whether single or limited numbers of sightings represent vagrant animals perhaps exploring beyond their natural range and when such sightings represent cryptic or rare animals sighted infrequently but within their natural range. Furthermore, should the areas between such isolated sightings and areas of higher numbers of sightings be considered contiguous areas of distribution with a single extensive range, or two disjoint areas of occupation?

Specific examples can easily be seen in the JNCC atlas. White-sided dolphins have been recorded sporadically in the north-western North Sea, but none was recorded in the Moray Firth region (Reid *et al.,* 2003). It is difficult to know whether this is due to insufficient search effort so that the natural range of this species should include all of the northern North Sea including the Moray Firth, or whether the Moray Firth is outwith the natural range. To address this concern, some preliminary thoughts have been put together here on possible ways to consider natural range, based on considerations for other animals.

4 Discussion

A great deal of time and effort has been devoted to trying to describe and define the ranges of animals and it would be impossible to provide a complete overview within the present context. What follows is, therefore, a brief summary of the methods that might be explored and a suggestion for some explorations of some simple methods to try to provide a rationale for delimiting cetacean species ranges.

With respect to the delineation of a species' range, Fortin *et al.*, (2005) concluded their review of possible methods with the statement that "there is no such thing as the best method to delineate border and characterise range". Indeed while there is an abundance of methods described in the ecological literature that might be deployed there does not appear to have been a great deal of thought directed towards the delineation of cetacean species' ranges. This group of animals has some interesting features that make such considerations more difficult than most.

Two important features of cetaceans are that they are able to move over very large distances with respect to their normally perceived 'ranges', and that as they inhabit a fluid environment they exhibit changes in distribution that may be driven by hydrodynamic variables or food resources at scales that would be very unusual for many terrestrial organisms that are more typically restricted by geophysical features. Thus common dolphins have been sighted in the Barents Sea thousands of km from their 'normal' range, and a grey whale was recently sighted in the Mediterranean having wandered there from the North Pacific (Scheinin *et al.,* 2011). Such vagrancies are not uncommon among birds, but among cetaceans, which are less likely to be seen than vagrant birds, it is often less easy to be sure whether they may represent range extensions or perhaps seasonal habitat fluctuations. Large scale shifts in porpoise densities that were highlighted between the two SCANS surveys (Hammond *et al.*, 2013) illustrate how cetacean habitat can also be 'fluid' and not linked to specific geographical features in the way that most terrestrial species are constrained by habitat type.

These two characteristics of cetacean distribution limit the ability to make use of some of the more widely used methods to describe animal distributions.

Describing the range of an animal species can be done in several ways (Fortin *et al.*, 2005). Typically species ranges are delimited based on either presence-absence data or estimates of abundance by location (typically gridded cells).

It is worth noting in passing that presence-only data are also used in some cases to describe species distributions, and methods for doing so have been championed by several authors. Hastie & Fithian, (2013) have criticised such approaches, concluding that "although many interesting aspects of the species distribution can be learned from such data, one cannot learn the overall species occurrence probability, or prevalence, without making unjustified simplifying assumptions". While some authors continue to use presence only data to delimit ranges, these are most usually done in the context of Species Distribution Models, where presence can be explicitly linked to some eco-geographic variables; cetaceans, unlike plants, make poor candidates for such models for the two reasons stated above: their distribution is fluid with respect to most easily quantified eco-geographic variables, and because unusual or 'extra-limital' sightings (without prejudging what those limits might be) are not infrequent. Inferred absence is therefore very hard to justify.

More usually then, species ranges are described through presence-absence data or estimates of animal density, most crudely in terms of sightings rates. Maps based on such data are easily produced (e.g. Reid *et al.*, 2003), and the simplest way to define range is therefore to use such maps to convey spatial information that implies a range, or to circumscribe (by using a pen) any areas where sightings have been made to describe the range. More formally there are two approaches to defining range based on such data, which are derived in the main from the literature addressing home ranges of individual animals. Species range descriptions are, crudely speaking, a generalisation of descriptions of home ranges and are subject to many of the same concerns.

Firstly, (home) ranges may be described by several Convex Hull approaches. In the classical minimum convex hull approach, a polygon representing the range is constructed which is the smallest possible polygon in which no internal angle exceeds 180 degrees and which contains all occupied sites (Burgman & Fox, 2003). Minimum convex hull descriptors of species ranges are an internationally accepted and standard way to estimate a species’ range, especially where presence only data are to be used. The approach was recommended by IUCN to measure habitat area, but suffers from an obvious bias, which is that they can and do encompass areas that are unsuitable habitat. This is particularly problematic for wide ranging species and those where presence data are sparse, or where the range is irregularly shaped. In such cases, the minimum convex hull may grossly overestimate the range.

A less biased approach is described by Burgman and Fox (2003) who used an α-hull (a generalisation of the minimum convex hull) to describe range. In brief the approach requires each and every presence location to be joined by lines, with the constraint that no lines intersect between points. A network of connections (tessellation) is thereby constructed. The length of each segment is then measured and the mean calculated. All lines that are longer than some specified multiplier of the mean segment length are then deleted. The smaller the value of the multiplier the finer will be the resolution of the hull. The approach will delete long segments joining widely spaced areas of occupancy, thereby eliminating areas that are unlikely to represent ‘good habitat’. Burgman and Fox (2003) showed that this method is much more reliable than the minimum convex hull approach.

A second category of approaches includes kernel density estimation methods (Worton, 1989), where a kernel or probability density function is applied to each location (e.g. sighting), producing a surface of probability density functions which, when summed together provide an overall density estimator. A smoothing parameter is used to define the individual or kernel density function. Thus if a small value is used for the smoothing parameter, the location values are seen in high resolution, whereas at higher smoothing parameter values finer scale details are merged into a more general picture of the range – or more properly the utilisation distribution.

A concern with the kernel density estimation methods is that generally speaking they do not provide good definition of range boundaries. In part this is because range boundaries are not well defined in reality: “Species boundaries are rarely lines, but should instead be represented as gradients, boundary zones in abundance” (Fortin *et al.,* 2005). But for the purposes of this report – that is ruling certain species in or out of proposed development areas - hard boundaries are preferable and for this reason alone kernel density estimation methods may not be the optimal approach.

Getz & Wilmers, (2004) and Getz *et al.,* (2007) have also developed a hybrid approach - termed a local convex hull non-parametric kernel method (LoCoH), which will generate Utilisation Distributions – or ranges – that do not overshoot the data as kernel methods always do, as they use the data points directly, and will converge on true boundaries to the observations as the density of data increases. This provides a means of delineating ranges in a more useful if less realistic way.

More sophisticated modelling approaches use observational data on animal distributions coupled with eco-geographic variables in order to be able to predict distributions and ranges. This approach may include kriging – interpolating between observations, or predictive habitat models. The latter have been widely used in the context of cetaceans and a review of the methods most widely used up to the end of the last century is given by Guisan & Zimmerman, (2000).

There are two concerns with such modelling approaches in the present context: firstly – as already stated, cetacean distributions are usually driven by prey availability, not by static geographic features, and as such may change. More relevant in the present context is the fact that there are no predictive habitat distribution models for cetaceans at the scale that would be needed to predict which species will be present at which sites.

A more pragmatic approach may therefore be required here. The data underlying the Cetacean Atlas (and further effort-related distribution data that have been collected since and collated under the JNCC funded JCP project) could be re-mapped at the same or even at a greater spatial resolution than was done for the cetacean atlas in 2003. This would provide a grid of cells of sightings rates for each of the species listed. One might then explore the use of some of the methods listed above to determine the best way to define range.

Some preliminary data preparation would be required. Some cells will have zero or very low sightings rates despite significant amounts of effort. Other cells would also likely have limited or no sampling effort with unpredictable associated sightings rates. In order to assess the presence/absence of species in a given cell it would then be necessary to determine how much effort is ‘necessary’ to detect any animals that are present in a given area. To do so, one might resample existing data and look at the probability of sightings in relation to survey effort for all the cells, (it would probably be necessary to exclude cells deemed extra-limital during this process though this may introduce some circularity). This would enable one to say how many hours or survey effort are needed to detect the presence of animals above a given mean sightings rate threshold. Eliminating any cells where insufficient sampling has been done to make detection likely will then limit the extent of the data to cells where presence and absence can be determined. This would enable exploration of range boundaries using convex hull and kernel methods. Seasonal ranges might also be explored. Determining the optimal feasible spatial scale would need to be explored on a species by species basis, and will depend on the true density of the animals and the associated sightings rates at different spatial scales.

4.1 Conclusion

It is sufficient at this stage to note that there is a wide variety of techniques that have been developed to explore the issue of animal range. Not all of these may be suitable for cetaceans, and for some there will not be adequate data. But there are certainly enough cetacean sightings data available to explore the utility of some of the measure that have been devised, and perhaps to find a method that best services the need to define the ‘natural range’ of these animals in the context of the collection of baseline data on European Protected Species ‘likely to be present’ at proposed development sites.

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