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UNCERTAINTY IN THE ASSESSMENT OF CUMULATIVE IMPACTS: THE CASE OF MARINE RENEWABLE ENERGY IN THE UK

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ABSTRACT

Cumulative impacts and their assessments are receiving more attention in the UK as marine renewable energy applications are increasing with an unprecedented industrialisation of the marine environment. The uncertainty surrounding cumulative impacts however remains high and is becoming a cause of delay in the consenting process. Using the example of birds and wind farms, this study examines the types and sources of uncertainty in cumulative impact assessments and provides recommendations as to how these may be reduced. To reduce uncertainty in the cumulative impact assessment process, adequately assess cumulative impacts and streamline the consenting process for marine renewable energy applications, all sources of uncertainty must be addressed.

INTRODUCTION

As governments pledge to invest in reducing carbon emissions, they are focussing on renewable-energy solutions, to reduce reliance on fossil fuels. The UK government has set a target of delivering 15% of energy demand from renewable sources by 2020 and the Scottish Government has set an even more stringent target of 100% [1]. Both will rely on marine renewables for their delivery and have prompted an increase in proposals for large offshore wind turbine arrays in UK waters [2], raising concerns about cumulative impacts i.e. the net result of environmental impacts from multiple projects or activities [3]. However, environmental impacts of the devices often remain unknown or uncertain.

Uncertainty in the knowledge of ecological systems can introduce risk into the process of making regulatory policy decisions [4]. For renewable energy development, planning decisions have to be made based on the potential environmental impacts of the developments, but there is uncertainty around those impacts. Consequently, there is the possibility that a development may have an impact greater (or lesser) than predicted. This is increasingly becoming a problem when cumulative impacts of multiple projects have to be considered. Within environmental statements, there is very little recognition of the inherent uncertainty within the impact assessment process (including cumulative impact assessment; CIA) despite the fact that "…the knowledge base available for decision-making on environmental risks…is characterized by imperfect understanding of the complex systems involved" [5].

The aim of this paper is to highlight where uncertainty may be present (and previously overlooked) within cumulative impact assessments as "The first step to quantifying risk is to identify the sources of uncertainty" [6]. Following on from ideas presented by Ascough et al. [7], sources and types of uncertainty are discussed and recommendations are provided on methods and practices to describe, address, and potentially reduce uncertainty in CIAs.

TYPES OF UNCERTAINTY

In order to manage uncertainty, it must first be identified and categorised. It is useful to consider a hierarchical framework when determining where uncertainty enters the CIA process (Figure 1).

Level 1: Random and systematic uncertainty

Uncertainty can be partitioned into that which is random and that which is systematic. Random uncertainty is the natural variability related to the stochasticity of ecological systems. Systematic uncertainty is therefore the non-random portion of uncertainty and a function of human understanding and measurement of a situation or environment; e.g. our perception of how a bird may be affected by a wind turbine and the subsequent measurement and collection of data. Increasing amounts of data can often reduce systematic uncertainty but this is not the case for random uncertainty [7]. Therefore efforts should focus on the systematic uncertainties if uncertainty is to be reduced within CIA.

Level 2: Linguistic, decision-making and knowledge uncertainty

Linguistic uncertainty arises because language is vague and/or the precise meaning of words changes over time or between disciplines [7]. In CIA this causes a problem because the guidelines are often vague and open to interpretation. For example, cumulative impacts have previously been defined as "Impacts that result from incremental changes caused by other past, present or reasonably

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foreseeable actions together with the project" [8] however there is much ambiguity in this description.

Decision-making uncertainty relates to how knowledge and predictions are interpreted, communicated and used in the management and policy arena. It includes uncertainty in the priorities of decision-makers and also includes uncertainty surrounding values of different societal groups. Decision-making uncertainty can be closely linked to linguistic uncertainty. It is increasingly becoming a problem for wind farm applications where uncertainty in CIA leads to a delay in the application process, due to an inappropriate and inconsistent presentation and interpretation of data and results.

Knowledge uncertainty refers to the limitation of our knowledge and understanding of a system. Commonly, knowledge uncertainty may be caused by a lack of data, particularly because ecological data can be expensive to collect [4]. Consequently, this type of uncertainty can be reduced by further data collection or scientific experiments. The consideration of knowledge uncertainty is of particular importance for cumulative impacts because multiple projects will be involved, each with associated knowledge uncertainty thus knowledge uncertainty will likely increase with increasing numbers of projects in a CIA.

Level 3

Here we further inspect knowledge uncertainty, following the example of birds and wind farms presented in Figure 1. When considering birds and wind farms, it is thought that birds are affected by four main processes: habitat loss, collision mortality, barrier effects, and disturbance [9–11]. It is possible however, that our scientific understanding of the interactions of birds and wind farms is uncertain and incomplete and the four main processes described above may not encapsulate all of the processes by which wind farms may affect birds. At present it may be the best understanding but knowledge is constantly changing and theories are challenged.

Level 4

Within each process in Level 3 there may be uncertainty not only in the theoretical understanding of the problem but also data collection and analysis. For example, birds are known to collide fatally with wind turbines but the issue is one of frequency of interaction, conservation status, resilience of populations (in relation to impact levels and thresholds) and how collisions may be minimised, all of which require understanding of the mechanisms leading to a collision.

RECOMMENDATIONS FOR PRESENTING AND REDUCING UNCERTAINTY IN CIA

Once sources of uncertainty within cumulative impact assessments have been identified, it should be determined whether it is possible to reduce or remove any of these sources, in order to reduce the risk of the marine renewable energy development and streamline the consenting process.

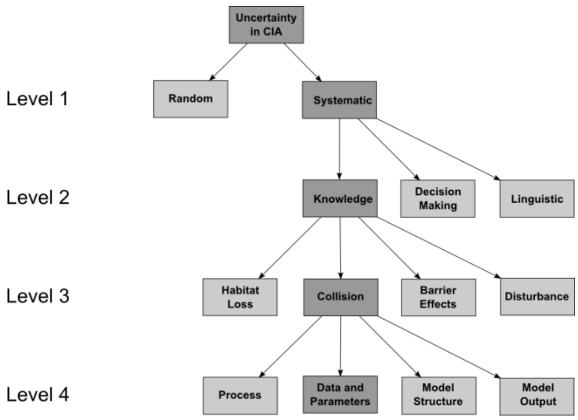

Figure 1 Hierarchical description of uncertainty within wind farm cumulative impact assessments. Dark grey boxes depict uncertainty in data and model parameters, on which collision risk estimation depends.

Linguistic uncertainty: Developing a widely-accepted common language will reduce linguistic uncertainty. Establishing standard guidelines and unambiguous definitions will help to achieve this. Masden et al. [9] provided a framework and King et al. [12] produced a standard protocol to reduce uncertainty in the expectations of CIA practitioners. Careful and consistent use of terms in CIA documents across the renewable energy sector will therefore help to reduce some of this uncertainty.

Decision-making uncertainty: Keeping results and findings clear and simple where possible is vital. There is a balance to be achieved however between i) presenting a simplified account of a more complex situation which may be persuasive though pay insufficient attention to the reliability of the results and ii) emphasising the uncertainties in the results which may make them less accessible and less usable for policy-makers [6]. Environmental statements are too frequently verbose, time consuming to read and inaccessible. Decision-making uncertainty would be greatly reduced if guidelines were set out not only for the contents of environmental statements but also for the presentation of such documents.

Knowledge Uncertainty: this does not have to be a barrier to using scientific knowledge [13]. Often we simply need to know enough and know how to best use the available information to inform a decision. That said, the amount of uncertainty should always be described quantitatively where possible or qualitatively where not, to provide a measure of confidence in the data which underpin decisions.

Uncertainty in data should always be explicitly recognised in some form. Qualitative descriptors can be used to present the likelihood that a change may occur as predicted and the Intergovernmental Panel on Climate Change (IPCC) provide a useful classification system [14]. It is also beneficial to express confidence in the scientific understanding as recently demonstrated by Thompson et al. [15] to summarise confidence in data.

There are well-established statistical methods for calculating and expressing uncertainty, such as confidence limits which may be estimated directly or by techniques such as bootstrapping [6,13]. Other methods are available for reporting variation in results e.g. standard deviation or error, range, etc. These metrics present a measure of confidence in the data which is unambiguous.

It is also sensible to assess the potential effect of any uncertainty. This is possible using sensitivity analyses and can show potential variation in key results should uncertain information or data in the study be incorrect. Sensitivity analyses were used to assess the effects of data uncertainty in a population viability analysis of the north Norfolk Sandwich tern population related to wind farm developments [16].

CONCLUSIONS

With increasing numbers of renewable energy developments, cumulative impact assessment is becoming ever more important to determine the potential combined impacts of multiple projects. In recent years there have been improvements in the quality of cumulative impact assessments but there remains more to be achieved. There is much uncertainty surrounding the environmental impacts of the renewable energy sector and it has been highlighted that this uncertainty is not only associated with knowledge and data but also more strategically within language and decision-making processes. The task of assessing the cumulative impacts of multiple developments will likely be a challenge for many years to come, but by addressing and highlighting uncertainties in the assessment process, the challenges ahead may become more tractable and it may then be possible to cope with those uncertainties that are irreducible [17].

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