EIMR2014-573

A review of marine bird diving behaviour: assessing underwater collision risk with tidal turbines

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ABSTRACT

Tidal turbines have the potential to impact diving birds, primarily through collision with turbine blades. There is a legal requirement to assess these impacts. Collision risk modelling has been used widely to quantify collision risk to birds flying through wind farms. Intuitively, the same approach can be taken when assessing risk of underwater turbines to diving birds. Such models require data on a bird's foraging and diving behaviour to calculate their likely exposure to a tidal turbine array while foraging underwater. Accordingly, we have reviewed studies from peer-reviewed literature that present estimates for diving parameters for diving marine birds that occur in UK waters. These values can be used within underwater collision risk models. This work will provide a key resource to the consenting process as it can be used in the assessment of environmental impacts of marine renewable developments.

INTRODUCTION

The Scottish Government has committed to achieving a target of meeting 100% of Scottish electricity demand through renewable sources by 2020. With up to 25% of Europe's tidal power in the seas around Scotland, there is a strong desire to harness this energy through tidal turbines. These underwater devices have the potential to impact diving birds through collision with turbine blades, disturbance and habitat loss.

EU and UK legislation requires that these impacts are assessed through an Environmental Impact Assessment (EIA) and Habitats Regulations Appraisal (HRA). Collision risk modelling has been used widely to quantify collision risk to volant birds with terrestrial and offshore wind farms. The same approach can be taken when assessing risk of underwater turbines to diving birds but this approach is still in its infancy. These models will require data on a bird's foraging and diving behaviour to calculate their likely exposure to a tidal turbine array while foraging underwater.

The aim of this review is to provide values for parameters related to bird's foraging and diving behaviour for use within underwater collision risk modelling.

METHODOLOGY

We have reviewed studies from peer-reviewed literature that present estimates for 18 diving parameters for 22 species of marine birds that occur in UK waters (comprising divers, grebes, shearwaters, gannet, cormorants, seaducks and auks). We included all species that have been recorded diving to within or beyond the depth range occupied by tidal turbines (3-80m)[1].

Parameters included dive depth, duration and frequency, descent and ascent speeds and foraging trip duration and frequency. We calculate the maximum, mean maximum and global mean for each parameter.

Using the approach adopted by Thaxter *et al.* (2012) [2] we prioritised studies where direct methods, such as the use of time-depth recorders, have been used to calculate parameters, and provide a measure of confidence for the data reviewed (refer to table 1).

Table 1. Definitions of confidence measures

Confidence Measure	Definition
High	>5 direct studies
Moderate	2-5 direct studies
Low	Indirect measures or only 1 direct study
Uncertain	Survey-based estimates
Poor	Few survey estimates or speculative data

OBSERVATIONS

Initial findings from our literature review highlight significant variation in both the number and confidence of studies for the range of species and parameters reviewed. We present examples of a data rich species (European shag; refer to table 2)

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and moderate to poor species (black guillemot and red-throated diver; refer to tables 3 and 4).

Table 2. European shag: data rich

	Global Mean	Locations (Studies)	Confidence
Dive Depth (mean)	23.2m	3 (13)	High
Dive Duration	41.7s	5 (16)	High
Pause Duration	33.8s	3 (10)	High
Dives/Bout	20.9	1 (5)	Moderate
Ascent Speed	1.5 ms^{-1}	1 (4)	High
Descent Speed	1.8 ms^{-1}	1 (4)	High
Dives/Trip	26.6	1 (8)	Moderate
Forage Trip Duration	91.2 min	1 (5)	Moderate
Forage Trip Frequency	2.8/day	1 (7)	Moderate

Table 3. Black guillemot: data moderate/poor

	Global Mean	Locations (Studies)	Confidence
Dive Depth (mean max)	26.5m	2 (2)	Low
Dive Duration	77.1s	3 (6)	Moderate
Pause Duration	31.2s	1 (1)	Poor
Dives/Bout	8.75	2 (3)	Low
Ascent Speed		*No data*	
Descent Speed		*No data*	
Dives/Trip		*No data*	
Forage Trip Duration		*No data*	
Forage Trip Frequency		*No data*	

CONCLUSIONS

Our current knowledge of foraging and diving behaviour is highly variable across species and also parameters. Some of the more vulnerable species [3], such as divers and black guillemot, are difficult to study and confidence in these data is lower. However, improvements in technology, such as remote downloading, may increase the potential for future studies of these species. Well-studied species, such as shag, gannet and common guillemot are likely to be the most valuable for studying effects of renewables. They are tractable for obtaining logger data on foraging behaviour and other associated data e.g. breeding performance.

There is a need to measure the more poorly understood parameters, such as horizontal speeds at depth, which are likely to be particularly relevant for tidal turbine collision risk.

It is unknown how species will interact with these underwater devices e.g. if they are likely to exhibit avoidance behaviour. Quantifying this in the models will be challenging and highlights the importance for robust post-construction monitoring to inform future assessments.

Table 4. Red-throated diver: data poor

	Global Mean	Locations (Studies)	Confidence
Dive Depth (mean)	5.3m	3 (3)	Poor
Dive Duration	26.1s	2 (2)	Poor
Pause Duration	12.2s	1 (2)	Poor
Dives/Bout		*No data*	
Ascent Speed		*No data*	
Descent Speed		*No data*	
Dives/Trip		*No data*	
Forage Trip Duration	39.8 min	2 (2)	Poor
Forage Trip Frequency	10/day	1 (1)	Poor

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