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Collision Risk: a brief review of available information on behaviour of mammals and birds in high tidal energy areas

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1 Executive Summary

The large body of published literature focusing on the movement, habitat preference and behaviour of marine birds and mammals was examined for evidence of overlap of marine mammals and birds with sites with potential for tidal energy generation developments. From the review it is clear that there is a wide range of species that use areas of high tidal energy and there is confirmation of the overlap between ecologically important mammal and bird populations with possible tidal turbine sites.

2 Introduction

Areas of interest to the tidal energy industry inevitably overlap with the geographic ranges of several marine species including mammals, birds, fish, turtles and invertebrates and it is therefore important to assess the potential environmental consequences of the installation and operational processes involved in harnessing this energy. Currently, there is limited knowledge of the movements of marine animals in areas of high tidal energy. The lack of information with which to assess the potential levels of risk means that a precautionary approach has to be applied in the permitting process for any future tidal turbine deployments. The conservation status of many of the vertebrate species deemed to be potentially at risk means that there is a high likelihood that these concerns will constrain the permitting of large scale array deployments. This poses a serious financial risk to the industry and a potential regulatory risk to government. With the focus on high energy sites, the necessity for thorough environmental impact assessments and the existence of key data gaps can have severe effects.

Recent attempts to address these issues through a variety of methodologies have been restricted to making inferences based on limited data sets involving other species and different locations and/or habitat types. Extrapolation to a population level effect is even more problematic with assumptions often being speculative. Nevertheless, a significant effort has been expended on assessing the collision risks that tidal turbines pose to marine animals, specifically diving birds and mammals, in conjunction with increased efforts to monitor distributions in proposed areas for tidal energy development.

With environmental processes having a great effect on the behaviour of marine animals, investigations into predator-prey interactions in physically distinct areas such as tidal channels is important in understanding the potential ramifications of renewable energy installations. There is empirical evidence that high energy sites are key foraging areas for piscivorous predators due to the aggregation of plankton and fish, providing, often seasonal, food sources (Zamon, 2003).

Here a brief review of information from previous studies is presented, focusing on animal movement in high energy sites to inform the assessment of possible collisions with tidal turbines.

3 Mammals

3.1 Grey and harbour seals (*Halichoerus grypus* and *Phoca vitulina*)

Both phocid species found in the UK, the harbour seal and grey seal, commonly occur in almost all coastal regions of the UK. Quantitative studies of seal usage directly relating to tidal areas is sparse; however, telemetry has been employed in a few instances with potentially influential results regarding proposed tidal turbine sites.

As reproductive and resting behaviour is largely conducted on land, seal movement in the marine environment appears almost exclusively driven by foraging activity or transit between haul-out sites (Thompson *et al.*, 1991, 1996; McConnell *et al*., 1999). Studies of foraging activity on small spatial scales have noted both grey and harbour seal usage of tidal areas as foraging locations, however, quantitative studies are limited and exploitation of high energy areas as feeding grounds is largely anecdotal. Brown & Mate (1983) observed harbour seals taking advantage of increased chum salmon concentrations, holding position at river mouths during flooding tides in Oregon, USA. Thompson (2012) observed what appeared to be a different foraging tactic with juvenile grey seals moving “forwards and backwards with the tide repeatedly diving to the bottom” suggesting foraging activity in the fast moving tidal currents off Anglesey and Ramsey Sound, Wales. In a similar study on the west coast of Scotland, Thompson (2013) observed nine tagged adult harbour seals demonstrating similar foraging techniques in tidal rapids. It was noted that seals were only present in this area during the summer months but that during this time they all concentrated their efforts in a small area of high tidal energy, with only two of the individuals showing extensive movements outside the narrow tidal channels. This suggests that seals have the ability to exploit tidal areas for foraging and that tidal rapids may provide access to important seasonal food resources.

While foraging activity may go some way to explaining the apparent patterns in seal distribution during different phases of the tidal cycle, haul-out behaviour and breeding strategies must also be considered when inferring the reasons for these observations. The availability of intertidal haul-out sites decreases during flooding tides and there is a noticeable geographic variation in the haul-out behaviour of seals as a result of the differing tidal regimes (Thompson *et al*., 1997). Consequently studies have noted higher seal abundances in narrow channels during flooding tides (e.g. Zamon, 2001) and attributed this to being driven by foraging behaviour. While this may be true, the cause and effect relationship between tidal regimes and foraging activity cannot yet be absolutely established as the desire to rest and haul-out may be equally strong and the use of flood tides to forage may be driven primarily by limited haul-out space. Furthermore VanParijs *et al.,* (1999) noted reproductive strategies of harbour seals were spatially and temporally affected by tide cycles with male vocalisations being significantly greater in tidally dominated areas, during flooding tides suggesting the complexity of tidal usage by phocids may be increased by seasonal variability.

3.2 Harbour porpoise (*Phocoena phocoena*)

Harbour porpoises are widely distributed in UK waters and sightings are common in many coastal regions. The highest concentrations of porpoises in UK waters have been seen in tidally dominated areas such as the Inner Hebrides (Northridge *et al*., 1995; Embling *et al*., 2010). However, there are conflicting observations suggesting that the use of high tidal energy sites may vary between different geographical locations. Several studies of harbour porpoise spatial usage in tidal areas of the UK have reported higher abundance (observation rates) during periods of strong tidal flow (e.g. Pierpoint, 2008; Marubini *et al*., 2009). Behavioural observations indicated foraging primarily during fast, ebb tides where individuals would adopt the strategy of using the flow to hold position and ambush prey swimming with the tide. Conversely, Embling *et al*. (2010) used habitat models to predict annual relative densities in the southern Inner Hebrides and found that maximum tidal current was the best predictor of distribution with greater numbers predicted in areas of low current. The differences may be a result of the tidal differences in the study areas or due to subtle differences in the analytical methods. For example, Embling *et al.*, (2010) considered separate spatial and temporal measures of tide rather than a blanket temporal measure which is more commonly used. Arguably this method has more explanatory power as the state of tide can vary dramatically over a relatively small area and modelling flow rates over the entire study area concurrently can give a broader perspective on the movements and spatial usage of a dynamic marine predator. Recent investigations in the Sound of Islay and Kyle Rhea, Scotland have concluded that it is not the tidal narrows themselves but turbulent eddies, formed as a result of tidal outflow from the channels, that harbour porpoises utilise more frequently (Wilson *et al.*, 2013, 2014). Regardless of the reasons behind the differences it seems clear from all investigations into harbour porpoise usage of high energy areas, that tidal currents play a significant role in their distribution.

3.3 Other

While several other marine mammal species are sighted in UK waters few have been seen in tidal areas and fewer still have been observed to exploit tidally dominated areas for foraging or reproductive purposes. Possibly the best studied population of marine mammals in the UK, the Moray Firth bottlenose dolphin (*Tursiops truncatus*), has been sighted swimming directly against tidal currents indicating a trade-off must be occurring where prey-capture is compensating for the increased energy needed for transport (Bailey & Thompson, 2010). This use of tidal currents, and the indication that species tend to display intra-specific variability and specialisation in prey-capture techniques and prey-selection (Baird & Dill, 1995; Beck *et al*., 2007; Tinker *et al*., 2007; Torres & Read, 2009) suggest that it is likely that these populations will utilise high energy areas throughout their range. However, more dedicated quantitative research would need to be conducted combining a range of observation methods to confirm general foraging habits and utilisation of tidal areas by delphinids.

4 Birds

Similarly to marine mammals, several bird species utilise tidal streams for foraging although there do not appear to be any species that specialise exclusively on high energy tidal streams. There is great inter-species variability in foraging tactics such as shallow diving from the surface, plunge-diving and deep diving. However, for the purposes of this report and in the scope of the overall project, only the deeper diving species are considered as they are more likely to encounter tidal turbine devices (Furness *et al*., 2012; Waggitt & Scott, 2014). This is not, however, a presumption that shallow diving birds are not an important consideration in high energy areas. The fact that deeper diving birds have been observed foraging in tidal streams may make it more likely that shallow diving birds will forage at such locations because deep diving bird species often drive fish into shallower depths where they are more available to plunge divers (Hoffman *et al*., 1981; Grover & Olla, 1983).

4.1 Auks (Family: Alcidae)

The Auk family is varied both in size and prey selection, however, a common feature is their ability to swim and dive to great depths (common guillemot, *Uria aalge* being recorded diving up to 180 metres deep; Piatt & Nettleship, 1985). As a deep diver it can be assumed that foraging behaviour is limited by tide cycles, and multiple studies have noted differences in dive behaviour and abundance during changes in tidal current direction and speed.

Holm & Burger (2002) observed significant differences in densities, between slack and flood/ebb tides, of ancient murrelets (*Synthliboramphus antiques*) and pigeon guillemots (*Cepphus Columba*) in the strong tidal currents of Vancounver Island, Canada. Exploitation of fast flowing tidal currents for foraging by pigeon guillemots was also noted in this area: a behaviour which has since been reported in the UK for black guillemots (*Cepphus grylle*), razorbills (*Alca torda*) and common guillemots (Furness *et al.*, 2012; Waggitt & Scott 2014). Zamon (2003) observed that not only does the rhinoceros auklet (*Cerorhinca monocerata*) utilise tidal flows of the San Juan archipelago, USA to forage but is significantly more present during flooding tides than ebbing tides. This was also true for the common guillemot.

4.2 Cormorants and Shags (Family: Phalacrocoracidae)

While several studies have noted foraging in tidal currents by phalacrocoracids in Canada and the USA (Zamon, 2003; Ladd *et al*., 2005; Elliott *et al*., 2008) few dedicated studies have tracked their behaviour in tidal systems of the UK. Wade *et al*. (2013) observed foraging activity within the tidal system of inner Pentland Firth, UK by the European shag (*Phalacrocorax aristotelis*). They noted that diving shags often surfaced upstream from the point of submergence indicating swimming against the current. They interpreted this as foraging activity; the increased costs of swimming against a fast flowing current would require the individual to offset this by consuming more prey.

Similar to the behaviour of alcids, Zamon (2003) also noted *Phalacrocorax* species exploiting flooding tides of the San Juan archipelago with reduced activity during ebbing tides.

4.3 Other

The final, deep diving family of diving birds, the Divers (family: Gavidae) which are considered a vulnerable group of birds when considering depths of tidal turbine devices (Furness *et al*., 2012; Waggitt & Scott, 2014) are not often observed in tidally dominated areas. Great northern divers (*Gavia immer*) have been cited as a risk and they are the only species of gavid which have been observed diving in tidal areas. There are very limited published data regarding the foraging habits of any of the three UK divers (*G. immer)*, red-throated divers (*Gavia stellate*) and black-throated divers (*Gavia arctica*) (Waggitt & Scott 2014). Available information on gavid foraging is therefore of limited use in assessing abundance, behaviour and tidal state preferences in high energy areas.

Gulls and gannets (family: Laridae and Sulidae respectively) have been observed using high energy sites to varying degrees and it is likely they profit from increased prey concentrations caused by both tidal currents and prey aggregation by deep divers. With regard to UK sites, Elliot *et al*., (2008) found significant abundances of black legged kittiwakes (*Rissa tridactyla*) and northern gannets (*Morus bassanus*) in the Gulf of Corryvrecken (a tidally dominated, high energy site on the west coast of Scotland), however, this was attributed primarily to prey abundance rather than association with deeper diving birds.

5 Conclusions

It is clear that a wide range of species use areas of high tidal energy. While information on species which are difficult to observe at fine-scales is limited, enough evidence is available to confirm the overlap between ecologically important populations and potential sites for tidal turbines, and therefore there is a significant collision risk posed to these species.

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