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Which seabird species use high-velocity current flow environments? Investigating the potential effects of tidal-stream renewable energy developments

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At present, there is a paucity of information regarding the effects that marine renewable energy developments may have on seabirds. There is also insufficient information regarding which species of seabird may be most vulnerable to these effects. In the case of tidal-stream developments this is particularly true, as most developments and work to monitor associated environmental impacts are at an early stage. Owing to the rapid development of the marine renewable energy industry currently underway in Scotland, there is, however, an urgent need to assess which seabirds may be most vulnerable to tidal-stream energy installations.

Proposed sites for tidal-stream energy generation are characterized by visible small-scale oceanographic features that are caused by high-velocity current flows, resulting from the macrotidal range, interacting with coastal topography and bathymetry. The amplification of current velocity occurs when water is funnelled through a narrow strait, between islands or around headlands. The resulting visible features include eddies, turbulent shearlines and upwellings. There is evidence that the current flow and hydrodynamic processes that generate these features aggregate plankton and fish, which provides a predictable and profitable resource for foraging seabirds (Zamon 2003)

There is a potential conflict between renewable energy developments and conservation legislation (Scottish Habitats Regulations) that protects the numerous internationally important populations of seabird species found in Special Protection Areas (SPAs) in Scotland. This legislation requires that renewable energy developments do not negatively affect protected species and that protected populations remain in a favourable conservation status. Owing to the relative infancy of the industry, the ecological effects of generating energy from the marine environment are largely unknown. However, research suggests that seabirds could potentially be affected by the deployment of tidal-stream renewable energy devices through collision with underwater structures. In addition, if energy extraction from tidal currents modifies current flows and hydrodynamic processes, this could subsequently alter foraging opportunities for seabirds (Langton *et al.* 2011). At present, we have a poor understanding of how seabirds use high-velocity current flow environments (Furness *et al.* 2012) and whether seabirds associate with small-scale oceanographic features. This makes predicting the potential effects of tidal-stream renewable energy generation on seabird species problematic.

Our research addresses this knowledge deficit by identifying which seabird species use high-velocity current flow environments and whether seabirds associate with small-scale oceanographic features by conducting observations of a proposed tidal-stream development site. The study site is located in the Inner Sound of the Pentland Firth, on the north coast of the Scottish mainland. The site experiences a range of current flows with maximal velocities of approximately 4.5 m s^{-1}

(Easton *et al.* 2011). These extreme current flows interact with bathymetry and coastal topography to create visible small-scale oceanographic features, including eddies and turbulent shearlines. The study site is located in the vicinity of several SPAs designated specifically to protect breeding populations of seabirds.

Vantage point observations (VPOs) of the study site were undertaken from the mainland. The study site was a 90° arc of 2-km radius, extending from a fixed vantage point location on land and was defined by a grid (Fig. 1). Seasonal observations took place in four blocks during a 12-month period to incorporate ecologically important periods in the seabird life cycle. To account for differences in current velocity, the observations targeted a range of tidal phases (ebb, flood and slack) throughout the spring to neap cycle. VPOs consisted of scans across the study site to record the distribution and behaviour of birds interacting with the water, counts of birds flying past a fixed bearing for a fixed time period and focal observations of individual birds to record behaviour and location of the bird within the defined grid. Observations were conducted only under weather conditions equivalent to sea state 4 or below on the Beaufort scale. The surveys were designed to identify which seabird species use the study site, particularly for foraging, and whether species associate with small-scale oceanographic features.

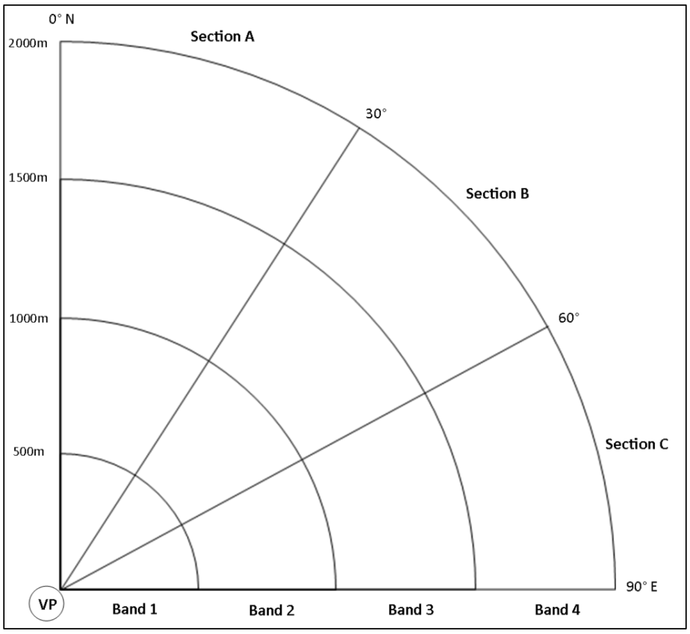

Figure 1 Grid defining the study site. VP indicates the fixed vantage point location.

During scans (summer 2012), 12 species of seabird were observed on the water within the study site (Table 1). All interactions recorded during scans were defined as foraging or non-foraging behaviour, according to criteria outlined in Holm and Burger (2002). Following these criteria, five of the 12 species observed were foraging within the study area (Table 1). Of these five species, four were diving seabirds: Atlantic Puffin *Fratercula arctica*, Black Guillemot *Cepphus grylle*, European Shag *Phalacrocorax aristotelis* and unidentified auk species. Diving seabirds (e.g. auks) are predicted to be most at risk of collision with tidal-stream devices (Furness *et al.* 2012) owing to their potential spatial overlap, and of the four diving species identified here, all have previously been identified as moderately to highly vulnerable to tidal-stream renewable energy developments and collision risk (Furness *et al.* 2012, McCluskie *et al.* 2012).

Table 1 Seabird species observed interacting with the water during scans of the study site in summer 2012. Species observed foraging are identified.

Species		Observed foraging?
Greylag Goose	*Anser anser*	No
Northern Fulmar	*Fulmarus glacialis*	No
Northern Gannet	*Morus bassanus*	No
European Shag	*Phalacrocorax aristotelis*	**YES**
Arctic Skua	*Stercorarius parasiticus*	No
Great Skua	*Stercorarius skua*	No
Unidentified skua species		No
Atlantic Puffin	*Fratercula arctica*	**YES**
Black Guillemot	*Cepphus grylle*	**YES**
Razorbill	*Alca torda*	No
Common Guillemot	*Uria aalge*	No
Unidentified auk species		**YES**
Black-legged Kittiwake	*Rissa tridactyla*	**YES**
Great Black-backed Gull	*Larus marinus*	No

To improve our understanding of seabird collision risk, we investigated the dive direction of seabirds in relation to the current flow. Birds that dive from sitting on the water were significantly more likely to dive into the current flow than against it (Sign test: $Z = 15.1$, $P = 0.01$). This corroborates evidence from other studies (e.g. Harding *et al.* 2009), which assert that seabirds do not move passively with the flow of water as some have suggested (Fraenkel 2006). In addition, we observed that diving birds often surface upstream or close to where their initial dive descent began. This was not always the case, however, with some birds being carried downstream during a dive, particularly if diving in areas of fast flow (Fig. 2). This diving behaviour could have implications for collision risk, as diving birds could approach tidal-stream energy devices facing away from them, which will have implications for their ability to detect and avoid energy-generating devices.

Currently, however, there is insufficient information regarding whether diving species forage in the high-velocity currents where tidal-stream energy-generating devices will be located. Heath and Gilchrist (2010) suggested that some species (e.g. eiders) may avoid diving to forage in these physically demanding environments due to energetic constraints. Future work should correlate observations of foraging seabirds with currents of different velocities to identify which seabird species dive to forage in high-velocity currents and so could be vulnerable to potential collisions.

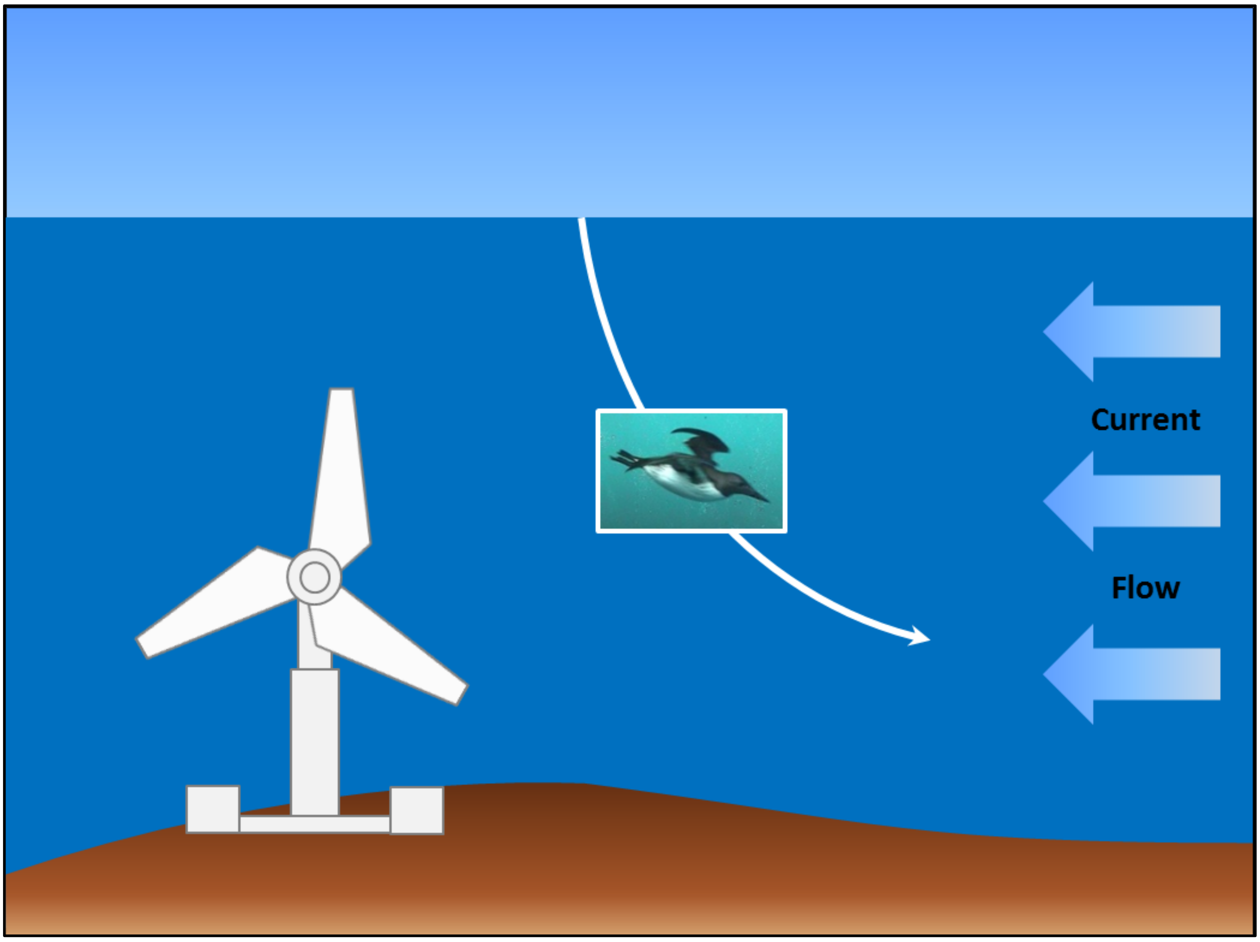

Figure 2 This illustrates the possible approach to a tidal-stream energy-generating device by a seabird diving into the current flow, and where a high-velocity tidal current carries the bird downstream. This indicates the potential difficulty for the bird to detect and avoid the obstacle presented by the device.

There is evidence that some seabirds time their foraging to coincide with particular tides, with a suggestion for increased foraging success (Slater 1976). Different tidal states and the subsequent hydrodynamic processes have the potential to generate different small-scale oceanographic features, which could influence the availability of profitable foraging resources for seabirds. To investigate this, all observations during summer 2012 for Atlantic Puffin and Black Guillemot were allocated to their relevant grid cell within the study area (Fig. 1) and were visually assessed according to tide phase (ebb, flood and slack). Visual assessment suggested differences in seabird distribution across the study site according to tidal phase. Our work will further explore these potential differences in distribution and investigate whether differences are driven by seabird associations with visible small-scale oceanographic features. By identifying whether seabirds associate with small-scale oceanographic features, we will be better able to predict the effects on seabird species should tidal-stream energy-generating installations alter hydrodynamic processes.

This research will inform compulsory Environmental Impact Assessments (EIAs), conservation monitoring and research, and ensure that limited resources are focused on species identified as most likely to be vulnerable to marine renewable energy developments.

REFERENCES

Easton, M.C., Harendza, A., Woolf, D.K. & Jackson, A.C. 2011. Characterisation of a tidal energy site: hydrodynamics and seabed structure. *Proc. 9th European Wave and Tidal Energy Conference.* Southampton, UK.

Fraenkel, P.L. 2006. Tidal current energy technologies. *Ibis* 148: 145–151.

Furness, R.W., Wade, H.M., Robbins, A.M.C. & Masden, E.A. 2012. Assessing the sensitivity of seabird populations to adverse effects from tidal stream turbines and wave energy devices. *ICES Journal of Marine Science* 69: 1466–1479.

Harding, A.M.A., Egevang, C., Walkusz, W., Merkel, F., Blanc, S. & Gremillet, D. 2009. Estimating prey capture rates of a planktivorous seabird, the little auk (*Alle alle*), using diet, diving behaviour, and energy consumption. *Polar Biology* 32: 785–796.

Heath, J.P. & Gilchrist, H.G. 2010. When foraging becomes unprofitable: energetics of diving in tidal currents by common eiders wintering in the Arctic. *Marine Ecology Progress Series* 403: 279–290.

Holm, K.J. & Burger, A.E. 2002. Foraging behavior and resource partitioning by diving birds during winter in areas of strong tidal currents. *Waterbirds* 25: 312–325.

Langton, R., Davies, I.M. & Scott, B.E. 2011. Seabird conservation and tidal stream and wave power generation: information needs for predicting and managing potential impacts. *Marine Policy* 35: 623–630.

McCluskie, A.E., Langston, R.H.W. & Wilkinson, N.I. 2012. Birds and wave & tidal stream energy: an ecological review. *RSPB Research Report No. 42*. RSPB, Sandy.

Slater, P.J.B. 1976. Tidal rhythm in a seabird. *Nature* 264: 636–638.

Zamon, J.E. 2003. Mixed species aggregations feeding upon herring and sandlance schools in a nearshore archipelago depend on flooding tidal currents. *Marine Ecology Progress Series* 261: 243–255.