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Riding the waves: use of the Pelamis device by seabirds.

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ABSTRACT
Seabirds are important marine predators that may be influenced by developments in marine renewable energy. To explore how seabirds might exploit novel floating structures at sea, an autonomous camera system was used to record attendance of seabirds on a Pelamis wave-energy device. Numbers and identities of seabirds on the machine were explored in relation to a set of metocean variables. Use of the machine was most affected by time of day, but less so by state of the tide. Birds did not use the machine during strong winds or when waves were large. Cameras can provide an effective, low-cost way to collect data about seabirds over weeks or months in inaccessible locations and under inclement metocean conditions.

INTRODUCTION
Rapid developments in the marine renewable energy industry are stimulating need for a range of ecological studies. These are to ensure we meet requirements of European and national legislation and to alleviate any concern over potential and uncertain impacts caused by such developments. As there are yet no deployed arrays of devices, so there are few opportunities for case-studies in the field. Studies have been limited to baseline surveys[1], literature review and expert opinion[2], modelling scenarios[3], development of methods[4] and small-scale experiments at test-sites[this report].

Being important marine predators, there is particular interest in potential effects on seabirds[5,6]. Potential effects on seabirds are often placed in three categories: (i) mortality or injury from collisions,(ii) changes in behaviour and (iii) change in habitat[7,8].

Seabirds are often attracted to and take advantage of structures at sea as platforms for foraging or resting[9,10]. Behaviour of birds is often influenced by local conditions of tide, wind and waves[11]. To investigate how seabirds might use the new floating, coastal structures provided by the Pelamis Wave Power Ltd. P2 machine, an automated digital camera was used to record attendance by birds at the device.

I predicted that:

1) shags, gulls and terns would use the machine to rest or roost.
2) more birds would use the machines during summer months than during winter months.
3) use of the machine would be influenced by the time of day and state of the tide.
4) there would be some conditions of wind or waves, during which the machine would not be used.

METHODOLOGY
The study was done on a P2 wave energy converter that was moored intermittently at the EMEC Billia Croo wave energy test site off the west coast of mainland Orkney, UK (N58.982°; W3.391°). An *in-situ* digital stills camera, mounted facing aft on section 1 of the P2 took photographs of seabirds using sections 2-5 of the device (Fig. 1). Images were collected at five minute intervals, 24 hours a day, during three deployments (Feb.-Mar.; May; June) in 2013. From these photos, numbers and identities of all visible birds sitting on the machine were recorded.

Data on tidal state (ebb/flood), waves (significant wave height and maximal wave height) and wind speed were acquired from local tide predictions and from a directional wave buoy and weather station operated by the European Marine Energy Centre (EMEC). Patterns of use in relation to these variables were explored using radar plots and correlations.

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Figure 1. Autonomous stills camera mounted on the P2 machine.

Figure 2. Arctic terns resting on the P2 machine during May 2013.

RESULTS

Eight species of seabird were recorded.

Common name	Presence
Arctic tern	Frequently from early May
Black guillemot	Regular, but in small numbers
Greater black-backed gull	Occasional single bird
Herring gull	Occasional single bird
Black-legged kittiwake	Regularly during June
Black-headed gull	One seen regularly with kittiwakes during June
Fulmar	Occasional
Wheatear?	1 possible record

Differences in detectability on different sections of the machine were apparent. Most birds were observed on section 2 and numbers of birds on this section were most strongly correlated with total numbers of birds visible ($r = 0.95$, $n = 268$, $p < 0.001$).

No birds were seen in > 3300 photos taken during February or March. During May, large numbers of Arctic terns (up to 65) started to rest on the machine (Fig. 2). During May, terns still used the machine regularly and were joined by black guillemot (near-daily in small numbers) and by moderate numbers of kittiwakes.

Different species used the machine at different times of day. During May, Arctic terns were observed around lunchtime or during the evening. During June, they were seen most frequently between 10:00 and 18:00 (Fig. 3). In contrast, black guillemot used the machine during the early morning 04:00 – 08:00.

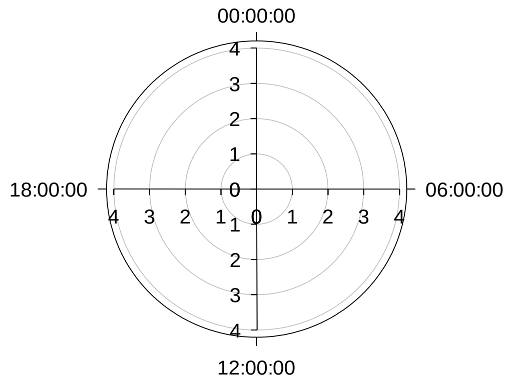

Figure 3. During three weeks in June 2013, Arctic terns used the P2 machine mainly between midday and 18:00. Radial axes indicate mean number of birds.

Arctic terns and black guillemot were not influenced by state of the tide, but kittiwakes sat on the machine only during ebb tide.

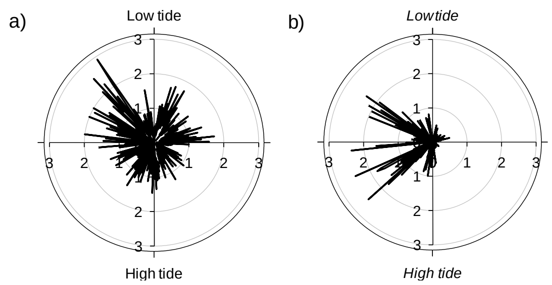

Figure 4. Numbers of a) Arctic terns and b) kittiwake present at different states of tide. Radial axes indicate mean number of birds.

There were weak, but significant negative correlations between numbers of birds and wave height (e.g. for *Hs* in June, $r = -0.12$, $n = 446$, $p < 0.01$; Fig. 5).

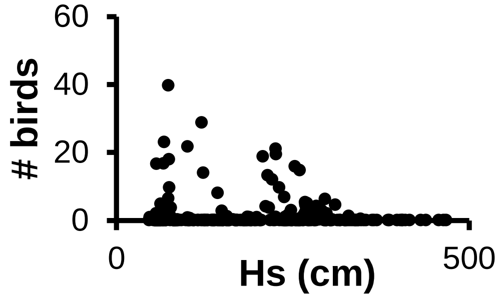

Figure 5. Numbers of birds present on the P2 machine under varying significant wave heights *Hs* (in cm).

Similarly, during May, there was a moderate and significant negative correlation between wind speed and the numbers of birds (almost all Arctic terns) sitting on the machine (r = -0.291, n = 268, $p <<$ 0.001). During June, the pattern was much weaker.

DISCUSSION & OBSERVATIONS

Seabirds made extensive use of the new floating platform provided by the Pelamis wave-energy device, although, it was surprising that shags did not use the machine as a base for foraging and wing-drying. This may have been because the device was in too deep water or too far offshore[12]. Large numbers of Arctic terns began to use the device during early May. Onset of this behaviour coincided closely with their arrival from Antarctica. A few individuals of three species of gull were recorded, but they did not form a major component of the data. In addition, small numbers of black guillemot used the machine and its vicinity, particularly during June. Although this species is a benthic forager, their presence in these depths (55-60 m) and above sandy substrata was not anticipated.

Numbers of birds recorded were markedly greater during spring and early summer than in later winter, supporting the second prediction. It is not possible, however, to make definitive statements about differences among seasons. This is because data were available from limited deployments in a single year. Differences could be attributable to differences other than season (e.g. availability of birds, learned behaviours).

Timing of use of the machine varied among species. Reasons for these differences were not immediately apparent. The lack of association with different states of tide (except for kittiwakes) was unexpected.

The weak, but significant negative correlations between attendance and wave height suggested that there was perhaps some threshold height, above which seabirds would not use the machine. This threshold differed between months, but very few birds were recorded with *Hs* > 3m. Numbers of birds were also inversely related to wind-speed and were not present in winds stronger than 8 ms^{-1}. Both these patterns were as predicted, but the study provided specific detail about conditions that may be beyond the ability or tolerance of these birds.

The study demonstrates that relatively low-cost equipment can be used to collect continuous, medium-term (weeks-months) data about behaviour of seabirds and their interactions with offshore wave-energy devices. Floating wave-energy devices can provide seabirds with new locations to rest and potentially forage. Use of these platforms is influenced by local conditions and may not be a resource that is available at all times. This approach has considerable scope for testing specific hypotheses about use of renewables devices by seabirds. Such hypotheses might include development of learned behaviours or use in relation to presence of migrants. The method could also facilitate post-deployment monitoring and investigation of cumulative effects of multiple devices or arrays, for example through contemporaneous data from multiple devices or locations.

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