

Author's Accepted Manuscript

Harbour porpoise distribution can vary at small spatiotemporal scales in energetic habitats

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www.elsevier.com/locate/dsr2

PII: S0967-0645(16)30184-9
DOI: <http://dx.doi.org/10.1016/j.dsr2.2016.07.002>
Reference: DSR14099

To appear in: *Deep-Sea Research Part II*

Received date: 6 December 2015
Revised date: 23 June 2016
Accepted date: 1 July 2016

Cite this article as: Steven Benjamins, Nienke van Geel, Gordon Hastie, Jim Elliott and Ben Wilson, Harbour porpoise distribution can vary at small spatiotemporal scales in energetic habitats, *Deep-Sea Research Part II* <http://dx.doi.org/10.1016/j.dsr2.2016.07.002>

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DSR2-D-15-00143

1 Title: Harbour porpoise distribution can vary at small spatiotemporal scales in energetic habitats

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17
18 **Abstract**

19 Marine habitat heterogeneity underpins species distribution and can be generated through
20 interactions between physical and biological drivers at multiple spatiotemporal scales. Passive
21 acoustic monitoring (PAM) is used worldwide to study potential impacts of marine industrial
22 activities on cetaceans, but understanding of animals' site use at small spatiotemporal scales (<1 km,
23 <1 day) remains limited. Small-scale variability in vocalising harbour porpoise (*Phocoena phocoena*)
24 distribution within two Scottish marine renewable energy development (MRED) sites was
25 investigated by deploying dense arrays of C-POD passive acoustic detectors at a wave energy test
26 site (the European Marine Energy Centre [Billia Croo, Orkney]) and by a minor tidal-stream site
27 (Scarba [Inner Hebrides]). Respective arrays consisted of 7 & 11 moorings containing two C-PODs
28 each and were deployed for up to 55 days. Minimum inter-moorings distances varied between ~300-
29 600 m. All C-POD data were analysed at a temporal resolution of whole minutes, with each minute
30 classified as 1 or 0 on the basis of presence/absence of porpoise click trains (Porpoise-Positive
31 Minutes/PPMs). Porpoise detection rates were analysed using Generalised Additive Models (GAMs)
32 with Generalised Estimation Equations (GEEs).

33
34 Although there were many porpoise detections (wave test site: N = 3,432; tidal-stream site: N =
35 17,366), daily detection rates varied significantly within both arrays. Within the wave site array (<1
36 km diameter), average daily detection rates varied from 4.3-14.8 PPMs/day. Within the tidal-stream
37 array (<2 km diameter), average daily detection rates varied from 10.3-49.7 PPMs/day. GAM-GEE
38 model results for individual moorings within both arrays indicated linkages between porpoise
39 presence and small-scale heterogeneity among different environmental covariates (e.g. tidal phase,
40 time of day). Porpoise detection rates varied considerably but with coherent patterns between
41 moorings only several hundred metres apart and within hours. These patterns presumably have
42 ecological relevance.

43
44 These results indicate that, in energetically active and heterogeneous areas, porpoises can display
45 significant spatiotemporal variability in site use at scales of hundreds of metres and hours. Such
46 variability will not be identified when using solitary moored PAM detectors (a common practice for
47 site-based cetacean monitoring), but may be highly relevant for site-based impact assessments of
48 MRED and other coastal developments. PAM arrays encompassing several detectors spread across a
49 site therefore appear to be a more appropriate tool to study site-specific cetacean use of
50 spatiotemporally heterogeneous habitat and assess the potential impacts of coastal and nearshore
51 developments at small scales.

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