International Journal of Marine Energy 17 (2017) 56–63

Contents lists available at ScienceDirect

International Journal of Marine Energy

journal homepage: www.elsevier.com/locate/ijome

Visualising the aspect-dependent radar cross section of seabirds over a tidal energy test site using a commercial marine radar system

D.L. McCann *, P.S. Bell

National Oceanography Centre, Brownlow Street, Liverpool L3 5DA, UK

ARTICLE INFO

Article history:
Received 6 May 2015
Revised 7 September 2016
Accepted 11 January 2017
Available online 12 January 2017

Keywords:
Marine radar
Radar cross section
Environmental assessment
Marine ecology

ABSTRACT

The long-term monitoring of seabirds around proposed marine renewable energy (MRE) sites is vital to assess the large-scale and long-term environmental impacts of MRE installations. Marine radar could be a valuable tool to augment traditional seabird surveys but the problem of aspect dependency of the generic radar cross section (RCS) of live birds in flight must be understood before radar data is correctly interpreted. A marine radar multiple target tracking algorithm ('GANNET') was applied to data from an un-calibrated, horizontally polarised, 10 kW X-band marine radar sited at the European Marine Energy Centre (EMEC) tidal renewable energy test site, Scotland U.K. From 24 days of data over 1.84 million target readings were recorded. For each target reading the radar aspect angle (bearing of radar beam incident on target), range and non-dimensional echo magnitude were derived allowing a view to be generated of the variation of echo magnitude with aspect angle for all tracked targets. The resulting polar diagram shows a significant change in echo magnitude with range between side-on and head/tail-on aspects indicating a large contribution of the RCS from the wings of birds in flight. The species-unspecific detectability of seabirds, especially at long range, is found to be strongly dependent on aspect angle. This has direct implications for the use of marine radar equipment for avian monitoring at proposed and active marine energy sites and must be taken into account if data from these radars are to be used to augment traditional bird abundance and area use surveys conducted by human observers.

1. Introduction

With increasing exploitation of coastal seas for marine renewable energy (MRE) there is a requirement to monitor changes in the marine ecosystem directly or indirectly affected by the MRE industry [1]. As such, there is an increased need for ecological monitoring systems that can work over large areas and long time periods, potentially continuously, in order to better characterise changes in the marine ecosystem; especially if the MRE sector is to move away from overly-conservative assumptions for Environmental Impact Assessments (EIAs), a vital part of the consenting and approval process for MRE projects. Current monitoring strategies involving shore- or vessel-based human observers are applied to attempt to produce maps of spatial overlap [2] but are limited (currently) to daytime operation and the duration of observer presence. Additional

* Corresponding author.
E-mail address: dmca@noc.ac.uk (D.L. McCann).

http://dx.doi.org/10.1016/j.ijome.2017.01.002
2214-1669/

problems with observer-based, visual surveys over wide areas suited to marine energy development (seabirds present on the sea surface) were found by Ref. [3], with viable analyses requiring sacrifices in the form and quality of data used.

Radar (an acronym of radio detection and ranging), in its many forms, has been a valuable tool for avian research since the identification of the radar echoes dubbed 'angels' by British pilots in WWII as those generated by birds in flight [4,5], being found operating both on local and national scales [6] and especially around aerodromes [7]. Radar has also been used extensively to monitor seabirds around offshore wind turbine installations to varying degrees of success [8]. Although a powerful tool for avian research, radar data has certain limitations and caveats that must be thoroughly understood before interpretation of the data [9].

The National Oceanography Centre (NOC) has been operating a marine X-band radar station as part of the Flow and Benthic Ecology 4D (FLOWBEC 4D) project [10] overlooking the waters of the European Marine Energy Centre (EMEC) on the Island of Eday, North Scotland U.K. The tidal race offshore of Eday ('the Fall of Warness', FOW) is home to numerous tidal stream turbine research and demonstration projects and as such is a prime candidate for the testing of long-term monitoring strategies which should be deployed alongside the numerous tidal stream MRE developments planned for the future in European waters. Part of the NOC operational radar oceanography suite comprises a research-grade multiple small target tracking program 'GANNET', capable of detecting and tracking small targets on or above the sea surface. As the NOC radar is non-coherent and un-calibrated GANNET has been extensively tested and tuned to maximise the number of target detections while simultaneously minimising false alarms due to other high-magnitude scatterers such as sea spikes and precipitation. The result is a set of algorithms that is consistently capable of identifying and tracking the radar echoes from birds in flight while minimising the effect of backscatter due to sea clutter (Fig. 1). Although not presently validated through visual observations the echoes due to seabirds are identifiable due to their apparent motion in successive radar images [11]; being high-velocity, high magnitude (compared with the low sea state clutter) and displaying the kinematic behaviour of seabirds in flight over coastal waters. This *a priori* information is the basis of the following analysis; the majority of automatic bird tracking algorithms require human input at some point in the process and here it exists as the end result of model tuning.

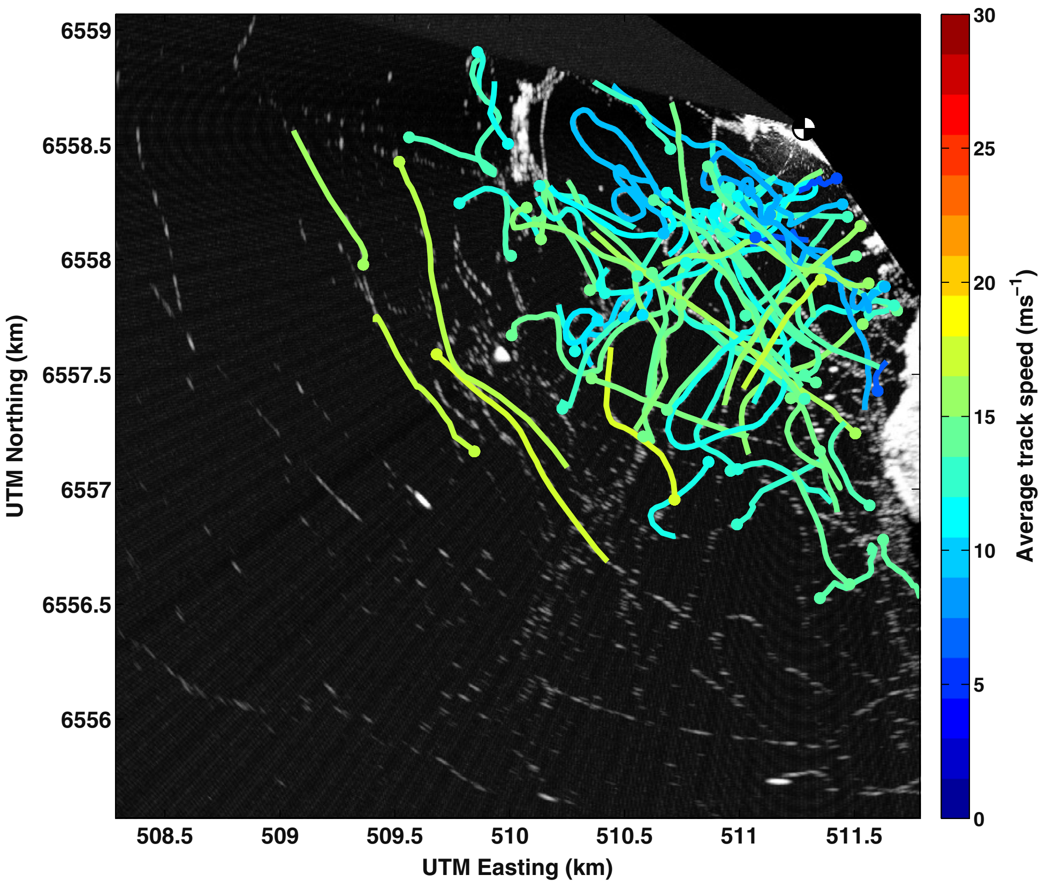

Fig. 1. Example output from GANNET from 256 frames of radar data (5.5 min) showing bird tracks coloured by average track speed (ms^{-1})