Deep-Sea Research II 98 (2013) 438–444

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

Tracking a northern fulmar from a Scottish nesting site to the Charlie-Gibbs Fracture Zone: Evidence of linkage between coastal breeding seabirds and Mid-Atlantic Ridge feeding sites ☆

Ewan W.J. Edwards [a,*], Lucy R. Quinn [a], Ewan D. Wakefield [b], Peter I. Miller [c], Paul M. Thompson [a]

[a] University of Aberdeen, Institute of Biological and Environmental Sciences, Lighthouse Field Station, Cromarty, Ross-shire IV11 8YL, UK
[b] Faculty of Biological Sciences, University of Leeds, Leeds LS2 9JY, UK
[c] Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth PL1 3DH, UK

ARTICLE INFO

Available online 12 April 2013

Keywords:
Tracking
Marine birds
Mid-ocean ridges
Oceanic fronts
Foraging behaviour
First-passage time
Northern fulmar

ABSTRACT

The seas above mid-ocean ridges are biodiversity hotspots in an otherwise largely oligotrophic environment, but the nature and extent of linkage between these offshore regimes and coastal ecosystems remains uncertain. Using a combination of GPS and geolocation tracking data, we show that a male fulmar, breeding on the Scottish coast, foraged over areas of persistent thermal fronts along the Charlie-Gibbs Fracture Zone (CGFZ) of the Mid-Atlantic Ridge during the incubation period. The bird travelled over 6200 km in 14.9 days. First-passage time analysis identified seven areas of restricted search, four on the shelf and three in the vicinity of the Mid-Atlantic Ridge. Previous studies of incubation foraging trip durations at this site suggest that a trip of this duration is unusual, and further work is required to assess the extent to which different individuals use these offshore resources. Nevertheless, these data highlight the potential importance of high sea areas beyond the limits of national jurisdiction when considering the management and conservation of seabirds breeding in NW Europe, and raises the potential for even greater linkage between the CGFZ and seabirds breeding colonies in other regions.

1. Introduction

In recent years, the sea above the Charlie-Gibbs Fracture Zone (CGFZ) has become recognised as a region of rich biodiversity (Letessier et al., 2011, 2012), providing an important foraging area for a broad suite of marine predators, including fishes (Fossen et al., 2008), seabirds (Bogdanova et al., 2011; Egevang et al., 2010; Frederiksen et al., 2012) and mammals (Doksæter et al., 2008; Skov et al., 2008). As a result, the region has been designated as a large High Seas Marine Protected Area by the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Commission) and the North-East Atlantic Fisheries Commission (NEAFC) (OSPAR, 2010). However, the nature and extent of linkage between these offshore areas and coastal ecosystems remains uncertain. Some of the animals (e.g. cetaceans, fishes) feeding in these areas remain in the pelagic environment throughout their life. But seabirds must return to land to breed, and an understanding of the relationship between these high seas regions and seabird breeding sites is essential to support efforts to conserve their populations. For example, European legislation calls for specific action to protect birds and their habitats (European Commission, 2009) with a particular focus on reduction of incidental bycatch of seabirds in fishing gears within European Union waters (FAO, 2008) However outwith territorial waters the legislation is more difficult to enforce.

Previous surveys of seabirds at sea (e.g. Boertmann, 2011) have been unable to determine the breeding origin, fidelity or frequency of use of individuals observed in high seas areas such as the CGFZ. Furthermore, seabirds do not recruit until they are several years old, and may skip breeding in some years. Consequently, even when seabirds have been observed in the CGFZ during the breeding season, these individuals may represent birds from the non-breeding component of the population that spend extended periods foraging at sea.

Tracking technologies have recently revealed that seabirds from Icelandic, Scottish and Canadian breeding colonies may spend some of their time over the Mid-Atlantic Ridge (MAR) area (Bogdanova et al., 2011; Egevang et al., 2010; Mallory et al., 2008a). Most published studies provide examples of seabirds foraging in this region during the winter, when individuals do not need to return regularly to coastal breeding colonies. To date, the only example of actively breeding adult birds that foraged over the CGFZ has been a study of Cory's shearwaters (*Calonectris diomedea*), which breed approx. 1200 km away on the Azores archipelago (Magalhães et al., 2008).

* Corresponding author.
E-mail address: e.edwards@abdn.ac.uk (E.W.J. Edwards).

0967-0645/$ - see front matter © 2013 The Authors. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.dsr2.2013.04.011

In this paper, we present tracking data from an adult male northern fulmar (*Fulmarus glacialis*) breeding on a Scottish island, which demonstrate that seabirds breeding at colonies on the European continental shelf can actively forage in the MAR area during the breeding season. This finding emphasises the trophic importance of high seas beyond the limits of national jurisdiction when considering the management and conservation of seabirds, and highlights the potential for even greater linkage between the CGFZ and seabird breeding colonies in other regions.

2. Study species

Northern fulmars, a circumpolar boreal species, are the most widespread and abundant seabird in the North Atlantic, breeding on coastal cliffs and grassy slopes from Arctic islands to the coast of Brittany, France (Mitchell et al., 2004). As generalist predators and scavengers, they consume a variety of fish, squid, crustaceans and offal (Phillips et al., 1999). Typical of other Procellariids, they are long-lived (Grosbois and Thompson, 2005), with a breeding period that extends, at Scottish colonies, from laying a single egg in mid-May, to fledging in late August (Dunnet, 1991). Foraging trips during the breeding season are considered to be constrained in range and duration because both partners share incubation (Mallory et al., 2008b), and then continue to take turns brooding and feeding the chick until fledging (Hamer and Thompson, 1997; Phillips and Hamer, 2000). Foraging trips during the breeding season have been reported to have a maximum duration of 18 days (Mallory et al., 2008b), and assumed to be limited to a maximum range of 580 km (Thaxter et al., 2012) based upon published information on foraging trip durations during chick rearing (Furness and Todd, 1984).

3. Methods

The study was conducted at a fulmar breeding colony on Eynhallow, an uninhabited island in Orkney, off the north coast of Scotland (59°8′N, 3°7′W). This colony has been the subject of detailed demographic studies since 1950 (Dunnet, 1991). On-going tracking studies at Eynhallow seek to define the range of foraging by adults during the breeding season, and broad-scale winter distribution patterns. This paper presents data from tracking records that shows how far and for how long one fulmar forages.

3.1. Datalogger deployment and recovery

To attach and recover dataloggers, fulmars were caught under licence on the nest using a net or noose. In May 2012, 22 birds were fitted with a GPS logger (attached to mantle feathers using strips of Tesa® waterproof tape; MobileAction® iGot-U GT-120, weight 18 g after modification) and geolocator (using a cable tie around a Darvic leg ring; BAS Mk15, 3.6 g). Together the devices weigh ~3% of the birds' body mass. The GPS was set to record position every hour for the duration of the battery life or foraging trip, whichever came first. Geolocators (GLS) logged light levels (Phillips et al., 2004), and whether the device was wet or dry (see Mackley et al., 2011), every 3 s, and stored summary data (maximum light level and number of wet samples) every 10 min. Although these devices were used on deployments over single foraging trips in May 2012, they had previously been fitted to over 100 birds between 2008 and 2011, allowing daily data collection until recovery in subsequent breeding seasons.

The data presented in this paper were collected from an adult male (sexed using morphometric measurements, Dunnet and Anderson, 1961), fulmar (♯1568), which had bred at the same nest site, with the same partner, since 2001. This bird was captured on the nest at 12:06 BST on May 23, 2012, while its female partner was on a foraging trip. Following capture, we removed a GLS logger that had previously been fitted to this male in July 2010, and a new GLS logger and GPS tag were then applied before he was resettled onto the nest. Both the new GLS logger and GPS tag were then recovered at 10.00 BST on June 10, 2012, after the male bird had completed one foraging trip and returned to relieve the incubating female. Following recovery, the male bird was resettled on the nest.

3.2. Analyses

GPS data were downloaded using the manufacturer's software, and tracks plotted using ESRI Arc GIS 10. Great circle distances between each at-sea location and the nest site were calculated. Flight speeds between successive GPS locations were also calculated using great circle distances. We identified core foraging or resting areas using first-passage time (FPT) analysis (Fauchald and Tveraa, 2003; Pinaud and Weimerskirch, 2007), using the 'adehabitatLT' package (Calenge, 2006) in R 2.12.2 (R Development Core Team, 2008).

Data on light levels and activity were downloaded from the GLS logger, extracted and filtered using the BASTrak software suite (Fox, 2010). Sunsets and sunrises were manually identified using the programme TransEdit; the solar angle of elevation was set as −3.5°. All data from the equinoxes were excluded to avoid periods when latitude estimation was not possible, and noon and midnight positions were then visualised in ArcGIS. Activity data, available as the number of wet samples within each 10-min period through the deployment, were then used to classify the activity within each 10-min sample as completely dry, completely wet or mixed. Subsequently, sequences of these records were analysed to define the duration of extended bouts of each of these activity category.

Remote sensing data from microwave (AMSR-E, TMI, WindSAT) and infrared sea surface temperature (SST; AVHRR, MODIS) sensors were used to locate persistent oceanic fronts. Merging these data, seven-day composite front maps (Miller, 2009) were derived. More detailed descriptions of these methods are presented in Miller et al. (2013).

4. Results

4.1. General foraging trip pattern and areas of restricted search

GPS loggers were recovered from 12 out of 22 tagged birds. In May and June 2012, GPS tracks indicated that 10 male and 2 female birds made foraging trips ranging from 4 to 15 days during incubation. Most trips were within 100 km of the breeding colony, one male travelled to the eastern North Sea (approx. 800 km). Of particular interest was male fulmar, ♯1568, who flew 2500 km west to the MAR as described in detail below. The foraging characteristics of the remaining 11 birds will be reported elsewhere.

Following tagging on May 23, bird ♯1568 remained on the egg until the return of his partner. At around 10:30 BST on May 26, 2012, he left the nest site and spent the next 48 h to the northwest of Orkney, before embarking on a sustained flight (11 h) to the middle of the Shetland-Faeroes Channel (Fig. 1A). After spending approximately 18 h around the Wyville Thompson Ridge, he headed WSW into the mid-Atlantic Ocean, remained around the CGFZ region for 2–3 days and then headed due east. After 19 h his route deviated to the ESE towards Ireland, reaching Galway Bay where he spent 8 h before turning north along the Irish coast.