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Short communication

Confirmation of a wintering ground of Ross's Gull *Rhodostethia rosea* in the northern Labrador Sea

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Ross's Gull *Rhodostethia rosea* is one of the world's least known seabirds; < 1% of the estimated global population can be accounted for at known breeding sites, and its wintering range has never been determined. Anecdotal reports over the last two centuries have prompted extensive speculation as to possible wintering areas used by this species in the north Pacific/Bering Sea region, but none has ever been confirmed. Using satellite and geolocator telemetry, we show that some Ross's Gulls from a colony in the Canadian Arctic winter in a restricted area of the northern Labrador Sea. Our discovery of a wintering area in the northwest Atlantic indicates that Ross's Gulls breeding in the Nearctic may be part of a disjunct population, or that birds breeding in the Palaearctic may winter off the east coast of North America.

Keywords: Canada, high Arctic, Labrador Sea, migration, *Rhodostethia rosea*, Ross's Gull, telemetry, wintering area.

With growing concerns about the need for more reliable information concerning the distribution and population trends of Arctic birds, tracking studies seeking to establish or clarify the habitat use and migration patterns of such species play an increasingly important role in informing protection and management practices and policies.

Much of our current understanding of the distribution, biology and ecology of Ross's Gull *Rhodostethia rosea* is largely speculative and based on infrequent opportunistic studies or observations. There have been very few nesting records of Ross's Gull since the first colonies were described from northern Siberia over a century ago (Buturlin 1906), and breeding has subsequently only been intermittently reported from widely scattered sites around the circumpolar Arctic (Kondratyev *et al.* 2000, Egevang & Boertmann 2008, Maftei *et al.* 2012); perhaps fewer than 200 nests have ever been found. Given that birds at known or suspected breeding sites account for < 1% of the estimated global population of 45 000–55 000 breeding adults (Degtyaryev 1991, Maftei *et al.* 2014), it remains unclear where the vast majority of the world's Ross's Gulls are breeding.

The wintering range of Ross's Gull has remained even more of a mystery. Despite considerable speculation about possible wintering areas, there have been no reliable observations of any significant numbers of birds during the winter anywhere in the world. The edge of the Arctic pack ice (Murdoch 1899), polynyas around the New Siberian Islands (Ilyichev & Zubakin 1988), the Sea of Okhotsk (Divoky *et al.* 1988, Ilyichev & Zubakin 1988), the Gulf of Anadyr and the northern Bering Sea (Shuntov 1993), and other areas in the northern Pacific basin have all been suggested or identified anecdotally as wintering areas of this species, but no counts or surveys have supported these claims. While it seems likely that Ross's Gulls winter in at least some of these areas, the lack of any confirmed seasonal concentrations is notable. The only time and place where Ross's Gulls are known to congregate is during late September and early October off the northern coast of Alaska, particularly around Point Barrow, where tens of thousands of birds pass along the coast in both directions (Maftei *et al.* 2014). This annual movement was first noted over a century ago (Murdoch 1899), but even recent detailed studies (Divoky *et al.* 1988, Maftei *et al.* 2014) have failed to elucidate the origin or ultimate destination of these birds.

In the Nearctic, Ross's Gulls have only been confirmed to breed in Canada and Greenland, where they are listed as Threatened (COSEWIC 2007a) and Vulnerable (Boertmann 2007), respectively. Both countries consider this species to be data-deficient, and a better understanding of its non-breeding distribution and habitat requirements is a recognized research priority to inform the development of meaningful conservation and protection measures (COSEWIC 2007b).

To clarify the distribution of Ross's Gulls and determine where they winter, we deployed geolocators and satellite transmitters on adult Ross's Gulls from a colony in the Canadian High Arctic, and tracked individuals to a restricted wintering area within the northern Labrador Sea. This is the first time that Ross's Gulls have ever been tracked, and our study provides conclusive evidence that at least a portion of Ross's Gulls breeding in Canada also winter there. Our discovery of a

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wintering area in the northwest Atlantic indicates that Ross's Gulls breeding in the Nearctic may be part of a disjunct population, or that birds breeding in the Palaearctic may winter off the east coast of North America.

METHODS

Study site

Ross's Gulls were captured at two known breeding sites in Queens Channel, Nunavut: Nasaruvaalik Island (75.8°N, 96.3°W) and Emikutailaq Island (75.5°N, 97.1°W), both of which been described in detail by Maftei *et al.* (2012, 2015).

Deployment and recovery of tags

We deployed 10 geolocators (Lotek LAT2900; St. John's, NL, Canada) and two satellite transmitters (platform terminal transmitters (PTTs); Microwave Telemetry PTT-100; Columbia, MD, USA) on breeding adult Ross's Gulls in 2011 and 2012. Geolocators were attached to Darvic tarsal bands with two plastic zip-ties (2.1 g), and PTTs (5.1 g) were attached using a leg-loop harness made of Teflon ribbon (Mallory & Gilbert 2008), averaging 1.2 and 2.9% of adult body weight, respectively (mean = 174.1 g, sd 19.4 g, n = 12). Although three geolocators were recovered on Nasaruvaalik Island, we were only able to download data from one of the tags deployed in 2011. Data from a breeding pair of PTT-tagged birds were downloaded directly via the ARGOS satellite system (CLS America Inc., Lanham, MD, USA). Our final dataset therefore included data from two PTTs (one of which logged for 2 years) and one geolocator (mean track = 296 days, range = 130–534 days; Table 1).

Data processing

The geolocators used in this study estimated location once daily; latitude was estimated from the duration of daylight between sunset and sunrise, and longitude from the exact time of sunrise and sunset (Ekstrom 2004). Sea-surface temperature (SST) was recorded by the geolocator when immersed for more than two consecutive samples (i.e. 120 s) and the minimum daily value was stored. We used SST correlation (LAT VIEWER STUDIO©; Lotek Wireless Inc., St. Johns, NL, Canada) to improve the accuracy of latitude estimates for the geolocator track based on the approach used by Shaffer *et al.* (2005). Locations were then filtered (ARGOSFILTER VERSION 0.62; Freitas *et al.* 2008) to remove positions implying an unrealistic flight speed in program R (R Core Team 2013). We assumed that Ross's Gulls did not exceed a maximum velocity of 13.4 m/s (> 50 km/h sustained over a 48-h period) (Hedenström 1998). To further reduce the mean error in position estimates (Phillips *et al.* 2004), each geolocator track was smoothed twice using a sliding window boxcar smoother (with a window size of 3) whereby each smoothed position was the weighted mean (in a 1 : 2 : 1 ratio) of the previous, current and subsequent position (Fifield *et al.* 2014).

Analysis of movement data

To determine areas of high use throughout the annual cycle, we generated a kernel density estimate from all valid locations (ESRI ARCGIS 10.1, search radius:

Table 1. Migration timing, distance and speed travelled by tagged Ross's Gulls from the Canadian Arctic in 2011–2013.

Tag	Sex	Year	Stage	Distance (km)	Speed (km/day)	Duration (days)	Start	End	Tag failure	Days logged[a]
GEO	♂	2011	Breeding	NA	NA	51	7/8/11	26/9/11		
			Autumn	1746	249	7	27/9/11	4/10/11		
			Winter	11 766	71	165	5/10/11	NA	18/03/12	223
PTT 1	♂	2012	Breeding	NA	NA	31	13/6/12	14/7/12		
			Autumn	3757	36.1	99	15/7/12	NA	26/10/12	130
PTT 2	♀	2012	Breeding	NA	NA	31	13/6/12	14/7/12		
		2012	Autumn	9568	102	94	15/7/12	17/10/12		
		2012	Winter	21 900	103	212	18/10/12	18/5/13		
		2013	Spring	2355	124	19	19/5/13	7/6/13		
		2013	Breeding	NA	NA	12	8/6/13	20/6/13		
		2013	Post-br.[b]	7023	260	27	21/6/13	18/7/13		
		2013	Breeding	NA	NA	21	19/7/13	9/8/13		
		2013	Autumn	8626	139	62	10/8/13	11/10/13		
		2013	Winter	7056	126	56	12/10/13	NA	7/12/13	534

[a]Total number of days logged per bird during tag deployment. [b]Post-breeding refers to movements undertaken outside the breeding area but before autumn migration.

200 km, output cell size: 10 km). Occupancy contours (25%, 50%, 75%) were then created from the kernel (GME; Beyer 2012). We considered the 50% occupancy contour to represent the 'core range' of tracked birds. Two distinct core areas were then identified – one around the known breeding area and the other around the putative wintering area (contour lines set the boundary of each area). As with previous studies (e.g. Ramírez *et al.* 2013, Fifield *et al.* 2014), we then split each track into four periods: breeding (locations within the breeding area contour), autumn (from the first location outside the breeding area contour to the last location outside the wintering area contour) winter (locations within the wintering area contour) and spring (from the first location outside the wintering area contour to the last location outside the breeding area contour the following year).

Distance (km) was calculated as the total distance (great circle) travelled by each tracked bird during the autumn, winter and spring periods. Duration was calculated as the number of days in each period (days) and speed (km/day) as the distance divided by the duration for each period (as per Fijn *et al.* 2013).

RESULTS

Tagged Ross's Gulls from the Canadian High Arctic wintered in a restricted area of the Labrador Sea (Fig. 1). The core wintering area we identified is 292 761 km^2 and lies roughly along the Labrador Shelf, an area characterized by high surface currents and minimal ice cover (Heide-Jørgensen & Laidre 2004).

Our data provide the first indications that Ross's Gulls breeding in Canada range throughout the Arctic (Fig. 2). Distances and timing of movement are summarized in Table 1.

The geolocator-tagged Ross's Gull moved north of the breeding site in late August 2011, spending early September south of Ellesmere Island before moving rapidly east through Lancaster Sound and then south into Davis Strait, eventually arriving in the western Labrador Sea on 5 October 2011, where it spent the winter (Fig. 2, blue). The pair of PTT-tagged Ross's Gulls both left Nasaruvaalik Island immediately following a failed breeding attempt on 15 July 2012, flying east through Lancaster Sound, then north along the eastern coast of Ellesmere Island (Fig. 2, red and green). The female continued to move northwards through Kane Basin and into the Lincoln Sea, reaching a maximum latitude of 85.8°N (< 500 km from the North Pole) on 9 August 2012 (Fig. 2), and the male followed a similar route, reaching 79.6°N on 15 August 2012 (Fig. 2). Both birds returned to Queens Channel in late August and then spent most of September following the same route as the geolocator-tagged bird, moving east through Lancaster Sound into Davis Strait before moving rapidly southeast towards the northwestern Labrador Sea (female) and towards western Davis Strait (male) at the beginning of October 2012 (Fig. 2). The female remained in this area for the winter, and the male's last position before its tag stopped transmitting on 26 October indicated that it was moving southeast on a course towards the same wintering area in the Labrador Sea. The female began spring migration in late May 2013, arriving at the

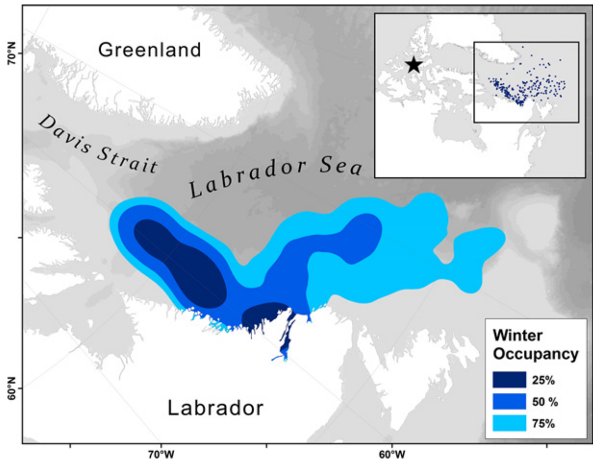

Figure 1. Wintering ranges of three tagged Ross's Gulls in the Labrador Sea from 2011 to 2013 showing 25, 50 and 75% occupancy contours. Inset map shows all winter locations. Black star in inset shows the breeding site of Nasaruvaalik Island. A full colour version is available online.

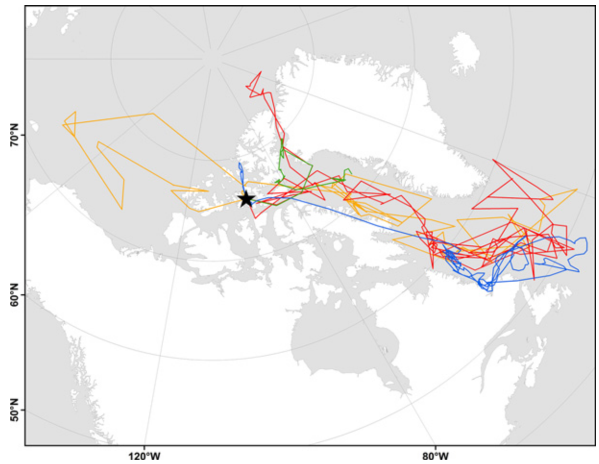

Figure 2. Annual migration tracks of three tagged Ross's Gulls from a breeding site in the Canadian High Arctic (black star). Blue = male geolocator 2011–2012; green = male PTT 2011; red = female PTT 2011–2012; yellow = female PTT 2012–2013. A full colour version is available online.

breeding site on 8 June 2013. This bird deferred breeding (along with all other ground-nesting larids in 2013) and departed the breeding site on 21 June, travelling rapidly westwards through the Canadian Arctic and into the Chukchi Sea (see below) before returning to the breeding area on 19 July. It then returned to the same wintering area along a similar route as in 2012, arriving off the coast of Labrador on 12 October 2013 (Fig. 2, yellow).

The Ross's Gulls we tracked showed a propensity to wander widely, particularly during the post-breeding season (i.e. after failed breeding attempts but before autumn migration; Fig. 2). Most notably, the PTT-tagged female undertook a 7023-km round trip between Nasaruvaalik Island and waters just north of Wrangel Island over 27 days between 21 June and 18 July 2012 (Fig. 2, yellow). Collectively, the PTT-tagged female travelled 40 846 km in 1 year (15 July 2012–18 July 2012; Table 1), a distance greater than the circumference of the earth, and considerably further than that travelled by many trans-equatorial migrants (e.g. Stenhouse *et al.* 2012), which is remarkable considering that this individual stayed almost entirely north of 50°N.

DISCUSSION

Our discovery that Ross's Gulls from the Canadian High Arctic winter in the Labrador Sea was unexpected as there have been no winter (October–May) records from this region (eBird 2012, EC-CWS 2015); however, observer effort is extremely low at this time of year. The consistency in timing and movements shown by the individuals we tracked over 3 years, and anecdotal reports from local ecological knowledge (Mallory *et al.* 2001), suggest that the wintering area in the Labrador Sea is also used by other Ross's Gulls. The possibility that substantial numbers of Ross's Gulls winter in the North Atlantic is supported by the relative frequency with which this species is recorded as a vagrant in both northwestern Europe (Bledsoe & Sibley 1985, BirdGuides 2008) and northeastern North America (eBird 2012).

Although the breeding range of Ross's Gull is technically circumpolar, the majority of known colony sites lie in two geographically disparate and ecologically distinct regions: Low Arctic tundra/taiga in the Palaearctic (Buturlin 1906, Pavlov & Dorogov 1976, Densley 1999, Kondratyev *et al.* 2000) and High Arctic tundra in the Nearctic (Egevang & Boertmann 2008, Maftei *et al.* 2012). Barring a few exceptions of pairs of birds nesting in taiga habitat in Canada (Chartier & Cooke 1980, Béchet *et al.* 2000) and High Arctic habitat in Svalbard (Løvenskiold 1964), most known breeding sites are found in either the High Arctic habitat type in Canada and Greenland or the taiga habitat in northeastern Russia, areas situated in almost exactly opposite hemispheres. Our discovery that Ross's Gulls breeding in Canada also winter there suggests that birds in the Nearctic may constitute a discrete population. An analysis of genetic samples has revealed that Canadian birds are weakly differentiated from those from Russia/Alaska (Royston & Carr 2015), which would support the idea that the Nearctic population is reproductively isolated. It is particularly important to assess whether the Canadian population exhibits less genetic variability because it is a recent founder population, or rather a historically isolated population whose size has been limited by environmental or other ecological constraints (Maftei 2014).

Although our sample size was small and consisted of unsuccessful breeders, our data provide three key pieces of information for conservation and management of the species. First, while our results do not preclude the existence of other as-of-yet undiscovered or unconfirmed wintering areas elsewhere, our confirmation of a wintering area for Ross's Gulls in the Labrador Sea provides critical information to inform management and conservation decisions for this threatened species (COSEWIC 2007a). Secondly, our results provide an essential context for future studies aimed at determining whether Nearctic and Palaearctic populations of this species are disjunct populations or whether the considerable geographical divide between known breeding populations belies a much lower degree of migratory connectivity within the global population than might be assumed. Finally, these findings add to the growing body of evidence suggesting that the Labrador Sea and Davis Strait form a critical wintering area for many species of marine birds (e.g. Little Auk *Alle alle* – Fort *et al.* 2013, auks *Uria* spp. – Gaston *et al.* 2011, McFarlane Tranquilla *et al.* 2014, Black-legged Kittiwake *Rissa tridactyla* – Frederiksen *et al.* 2012, Northern Fulmar *Fulmarus glacialis* – Mallory *et al.* 2008, Ivory Gull *Pagophila eburnea* – Spencer 2014, Spencer *et al.* 2014), and collectively merit consideration for protected area status, particularly as both Threatened (Ross's Gull) and Endangered (Ivory Gull) species rely on this habitat for a significant portion of their annual cycle (Spencer 2014, Spencer *et al.* 2014).

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