Hitchhiking goose barnacles and their potential implications on the functioning of animal-borne instruments

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Goose barnacles (*Lepas australis*) were found attached to satellite-tracking and time-depth recording (TDR) instruments carried by two lactating Subantarctic fur seals (*Arctocephalus tropicalis*) from Marion Island. We report on the movements of these seals, both of which crossed the Subantarctic Front. Barnacles surrounding the temperature probe of one TDR device did not appear to directly influence temperature recordings, although disturbances to recording accuracies by other high-precision devices carrying goose barnacles are considered likely.

Key words: goose barnacle, animal-borne instruments, *Lepas australis*, Subantarctic fur seal.

Stalked barnacles attach to various substrata, including kelp, floating plastics, pumice and wood (Barnes *et al.* 2004; Thiel & Gutow 2005). The goose barnacle (*Lepas australis* Darwin, 1851) is also known to attach to free-swimming animals, such as seals and penguins, including Subantarctic fur seals (*Arctocephalus tropicalis*) (Setsaas & Bester 2006) (see Reisinger & Bester 2010 for a summary of other reports). Recently, Reisinger *et al.* (2010) reported on the attachment of goose barnacles to tracking devices deployed on southern elephant seals (*Mirounga leonina*) at Marion Island in the Southern Indian Ocean. They discussed the potential role that elephant seals may play in the transport of goose barnacles across the Polar Frontal Zone (defined as the area between the Subantarctic Front (SAF) in the north and the Antarctic Polar Front (APF) in the south (Belkin & Gordon 1996)), and the possible spread of these barnacles in the Southern Ocean. Other barnacle species also attach to plastic leg rings placed on lesser black-backed gulls (*Larus fuscus*) in Europe (Tøttrup *et al.* 2010). This was postulated to potentially result in the unexpected introduction of barnacles to new habitats or genetic exchange between barnacle populations otherwise separated climatically or geographically. Here we report on the attachment of goose barnacles to instruments carried by Subantarctic fur seals at Marion Island and their potential influence on the accuracy of data recorded by such instruments.

During April 2009, satellite-tracking devices (Sirtrack, Kiwisat 101, 110 × 42 × 10 mm), as well as time-depth recorders (TDRs) (Wildlife Computers, Mk9, 90 × 17 × 17 mm) were deployed on five tagged (with uniquely numbered, colour-coded Dal 008 Jumbotags®, Dalton Supplies Ltd., Henley-on-Thames, United Kingdom), lactating Subantarctic fur seals from a single site (Van den Boogaard river – VdB) on Marion Island (46°54′S, 37°45′E) as part of an investigation into their foraging ecology (de Bruyn *et al.* 2009). Tracking devices and TDRs were attached to the fur on the dorsal midline of the seals, immediately posterior to the scapulae, using a quick-setting epoxy resin (Araldite®, Ciba Geigy). Upon their return to the island between 21 May and 8 June of the same year, seals were recaptured and TDRs removed and replaced. Prior to plotting the tracks, location estimates obtained through system Argos (CLS 2006) were filtered, based on maximum swim speeds and turning angles (Freitas *et al.* 2008). Accordingly, location points requiring a swim speed of more than 3 m/s were discarded. Locations creating spikes in the tracks with angles smaller than 15° and 25° and extensions between successive points in excess of 2500 and 5000 m, respectively, were also removed.

Four seals returned to the island after an initial foraging trip, and only two seals (FB 513 and GW 522) returned again after a second foraging trip (Table 1). One seal did not return after the initial deployment and location uplinks ceased within 21 days of deployment. Two seals did not return after leaving on their second foraging trip – location uplinks having ceased while they were at sea. FB 513 and GW 522 returned to the island in September of the same year, with goose barnacles attached to the carried devices. Track data confirmed that both seals had undertaken two foraging trips each between April and September 2009 (Figs 1 & 2). During their first trips, neither seal crossed the SAF, the approximate locations of which were estimated from Belkin & Gordon

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Table 1. Summary of deployment and recapture dates of lactating *Arctocephalus tropicalis* females at one study location (VdB) on Marion Island in 2009. Dates when goose barnacles were present on devices are printed in bold.

Animal	Deployment date	1st recapture	Barnacles present	2nd recapture	Barnacles present
GW522	24 Apr 09	21 May 09	No	**10 Sep 09**	**Yes**
GW495	24 Apr 09	06 Jun 09	No	Not recaptured	
GW524	24 Apr 09	Not recaptured	Not recaptured		
FB515	28 Apr 09	08 Jun 09	No	Not recaptured	
FB513	28 Apr 09	27 May 09	No	**27 Sep 09**	**Yes**

(1996). Their subsequent foraging trips were longer and both crossed the SAF multiple times during these trips.

Barnacles were attached primarily to the exposed fringe of epoxy adhesive next to the edges of the devices on both seals and no barnacles were observed on the fur of the seals themselves. Notably, many barnacles also attached themselves under the protective hood of the fast-reacting temperature probe of the TDR (in direct contact with the temperature probe) deployed on GW 522 (Fig. 3). The location of attachment was likely due to the possible turbulence zone created by the protective hood (this study), either enabling easier settlement, or providing an increase in available food sources for the barnacles (Reisinger *et al.* 2010). It was not established whether the goose barnacles were still alive upon retrieval of the instruments, but they were dead and desiccated by the time the TDR calibration test was done (see below).

Temperature values downloaded from the device

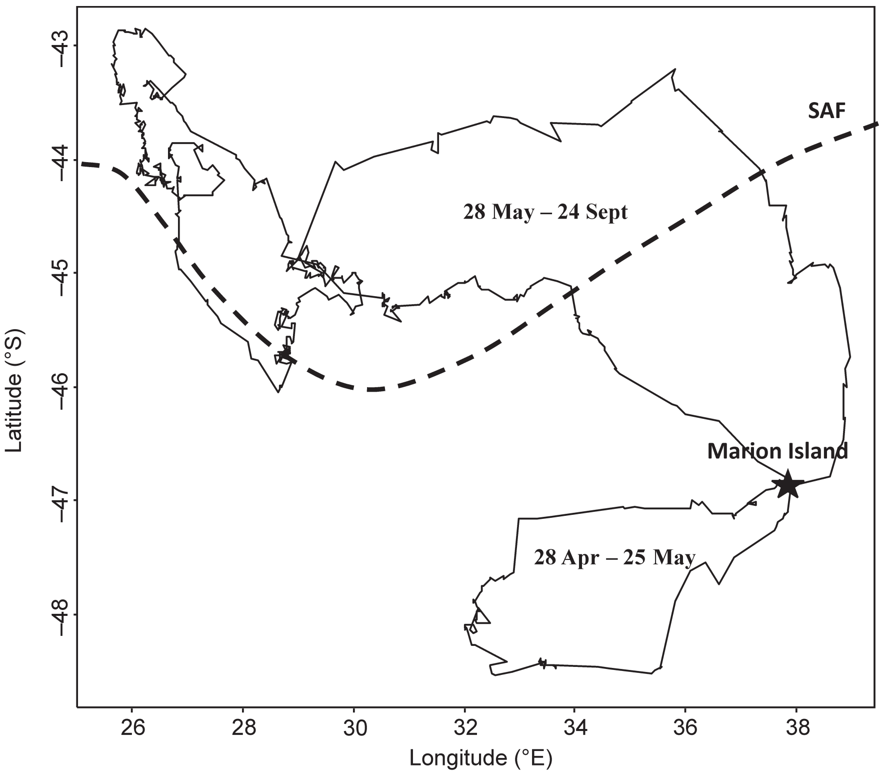

Fig. 1. Map indicating track of FB 513. The initial foraging trip (28 Apr – 25 May) was largely in a southwest direction away from Marion Island, while the second trip (28 May – 14 Sept) extended further north past the Subantarctic Front (SAF). The approximate position of the SAF is indicated (after Belkin & Gordon 1996), as well as the position of Marion Island.

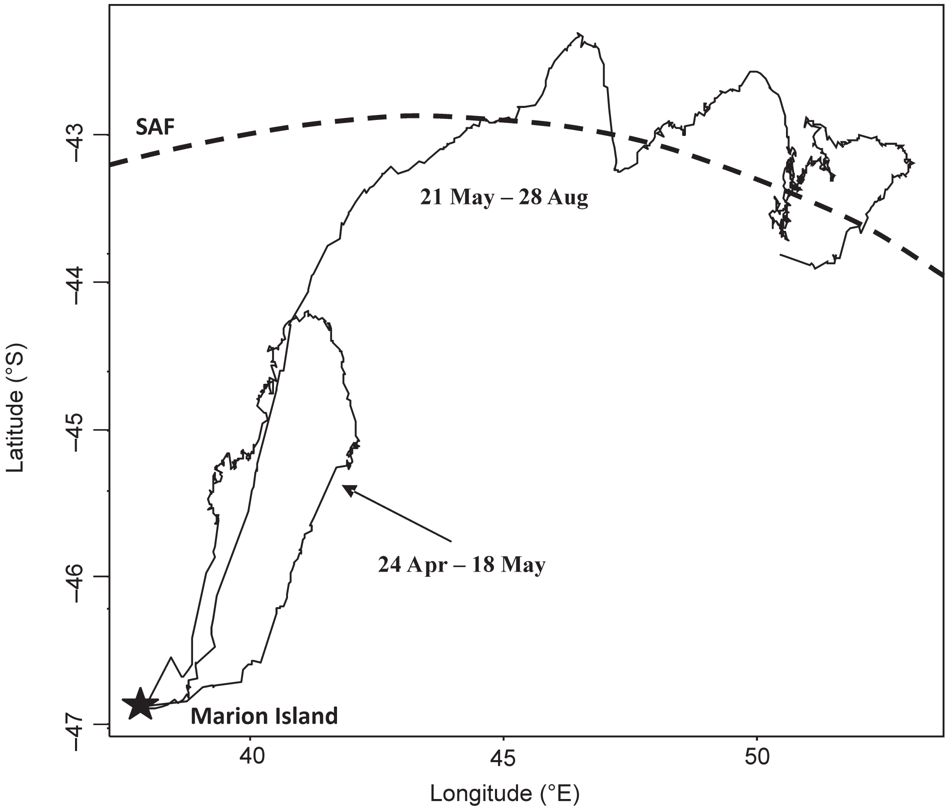

Fig. 2. Map indicating track of GW 522. The initial foraging trip (24 Apr – 18 May) was in a northeast direction in relatively close proximity to Marion Island, while the second trip (21 May – 28 Aug) extended further north past the Subantarctic Front (SAF). The approximate position of the SAF is indicated (after Belkin & Gordon 1996), as well as the position of Marion Island.

after retrieval from GW 522 revealed that the temperature probe malfunctioned during the foraging trip. We therefore did a calibration test to quantify the potential influence of the barnacles on temperature readings obtained from the TDR. The reset TDR, with the dead barnacles attached (named 'BP' (Barnacles Present) henceforth), and two, new TDRs (named 'Control 1' and 'Control 2') were subjected to cycles of warming and cooling inside a water bath (GRANT GR150 (R2) – Grant Instruments (Cambridge) Ltd.) over a period of approximately two hours. TDRs were programmed to record temperature at 10 s intervals. The water bath was set to: (1) cool to –2°C over a period of 32 min 30 s and remain at –2°C for 5 min, (2) heat to 15°C over a period of 7 min 30 s and remain at 15°C for 5 min, (3) cool to –2°C over a period of 30 min and remain at –2°C for 5 min, (4) heat to 15°C over a period of 7 min 30 s and remain at 15°C for 5 min. The rates of heating and cooling were limited by the capacity of the water bath used. The range of temperatures selected was representative of potential temperatures encountered throughout the foraging range of Subantarctic fur seals from Marion Island (Bester 1989; de Bruyn *et al.* 2009). However, it was considered unlikely that this range of temperatures is experienced by the fur seals during any individual dives, since they are relatively shallow-diving animals (Robinson *et al.* 2002; Luque *et al.* 2007).

Of the three instruments, Control 1 appeared to perform best, recording both maximum and minimum temperatures within the closest range of the target temperatures (water bath) (Fig. 4, Table 2). Neither Control 2 nor the BP TDR recorded the minimum temperatures of the water bath (Control 2: –0.8°C; BP: –0.85°C). Control 2 also did not record the maximum temperatures, recording a maximum temperature of 13.3°C. The BP TDR recorded similar maximum temperatures as Control 1.

Advances in sensor capabilities and reductions

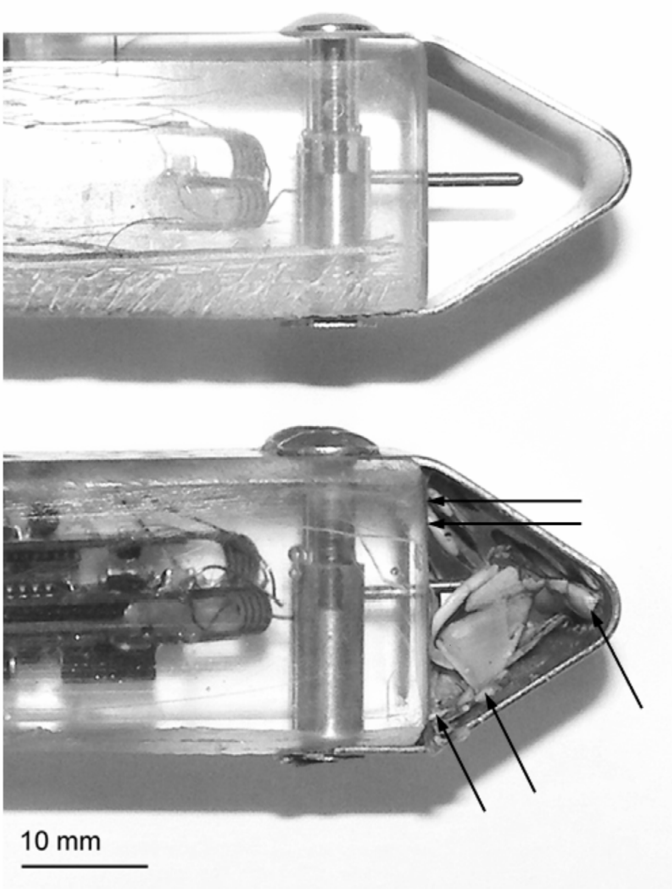

Fig. 3. Photograph showing the clustering of goose barnacles (*Lepas australis*) around the temperature probe of a used time-depth recorder (TDR, Wildlife Computers, Mk9) (**bottom**), compared to a new TDR (**top**). Arrows indicate the approximate settling positions of individual barnacles.

in instrument sizes have recently made it possible to incorporate sophisticated sensors, capable of recording high-quality oceanographic data, into animal-borne instrumentation (Fedak 2004; Charrassin *et al.* 2008; Nicholls *et al.* 2008). The accuracy of such sensors, particularly conductivity sensors and high-accuracy temperature probes, are easily disturbed by the presence of fouling agents or through proximity to the animal (Hooker & Boyd 2003; Boehme *et al.* 2009). It is therefore feasible that the presence of goose barnacles is likely to influence the accuracy of recordings. Our results suggest that dead goose barnacles around the temperature probe of the time-depth recorder in this study did not significantly influence temperature recordings by the device through direct interference. Nevertheless, we were unable to discount the potential role that live goose barnacles played in the failure of the device to record representative temperatures while at sea. It is also further likely that the physical presence of barnacles around temperature probes (and other sensors on various animal-borne instruments) would impede water flow and thereby perhaps negatively influence recordings.

The PFZ presents an important barrier restricting the movement and dispersal of a number of taxa (Barnes *et al.* 2006). We were unable to determine where the goose barnacles originated or how long they had been attached to the devices. It is likely, however, that attachment occurred north of the SAF, or in the vicinity thereof, because neither seals carried barnacles after initial foraging trips that did not cross the SAF. As suggested by

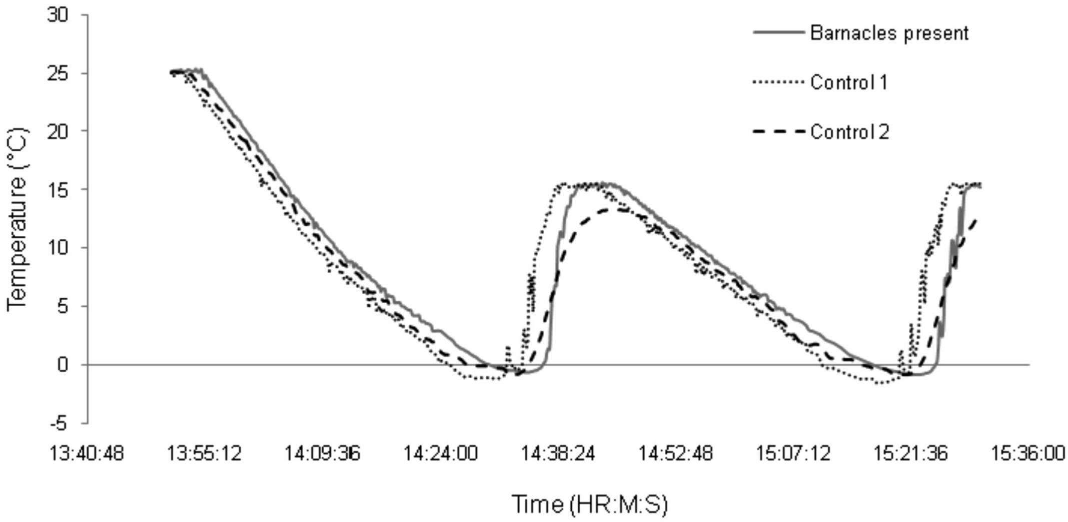

Fig. 4. Temperatures recorded by the three time-depth recorders (Wildlife Computers, Mk9) subjected to the water bath treatment. The visible temporal offset of the 'Barnacles present' and Control 2 temperature recordings, compared to Control 1 are likely the result of slight differences between devices in time settings.

Table 2. Summary water bath trial results, indicating nearest recorded temperature (N.R. temp.) values, as well as minimum/maximum temperature (Min/Max temp.) values of individual TDRs in relation to the target temperatures (Target temp.) as programmed for the water bath. All temperature values are in °C.

		Barnacles present		Control 1		Control 2	
Trial stage	Target temp.	N.R. temp.	Min/Max temp.	N.R. temp.	Min/Max temp.	N.R. temp.	Min/Max temp.
1	–2	–0.65	–0.65	–1.2	–1.2	–0.8	–0.8
2	15	15.05	15.6	15.05	15.6	13.3	13.3
3	–2	–0.85	–0.85	–1.6	–1.6	–0.8	–0.8
4	15	14.9/15.1	15.45	14.9	15.65	12.55	12.55

Barnes *et al.* (2004), future studies should employ DNA profiling to accurately determine the origins of these and other barnacles found attached to animals and/or animal-borne instruments (Setsaas & Bester 2006; Reisinger & Bester 2010; Reisinger *et al.* 2010). Since local food availability and water temperature (which would determine growth rates) were unknown we did not attempt to age (from capitulum size) individual barnacles, which need about 50 days from settling to breeding size at sea temperature of 11–16°C (MacIntyre 1966). The wide-ranging movements of the lactating fur seals (de Bruyn *et al.* 2009), two of which repeatedly crossed the SAF during their second foraging trip (this study) indicate the likely effectiveness of fur seals as transport and potential vectors for *Lepas australis.*

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