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Fine scale biologging of an inshore marine animal

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ABSTRACT

We compared the results of two biologging techniques used to study the foraging behaviour of a colony of small inshore predators, little penguins (*Eudyptula minor*). The first technique involved the use of satellite transmitters and diving loggers deployed on separate individuals, which has been the conventional method of tracking the movements and behaviour of this species for >10 years. The second technique combined a diving logger and a global positioning system (GPS) logger deployed on the same individual, which is similar to the biologging methods presently being developed and used for many other species. We then considered the value of each technique as a conservation tool operating at the small scale (foraging area <5000 ha and duration <1 day).

We found that the separately deployed satellite transmitters significantly underestimated the penguins' foraging area size. However, the size of the foraging area and other foraging parameters, such as total distance travelled, were influenced by the degree of GPS location sub-sampling. Furthermore, only the combined diving and GPS loggers could confidently describe the diving behaviour of the penguins in relation to the sea floor and identify that they were using small areas of conservation interest (shipping channel) inside their foraging area. Hence, the method employed to assess habitat use at fine scales can influence conservation measures that rely upon the data collected. We suggest that researchers fast-track their adoption of high resolution multi-loggers for increased data confidence when tracking animals at a fine scale, but also consider the potential effect of sampling rate on the calculation of parameters of interest.

1. Introduction

Biologging science (use of animal-attached devices, Rutz and Hays, 2009) is commonly employed to identify animal foraging behaviour and areas of conservation significance in a wide range of species (Cooke, 2008). In the marine environment, biologging is often conducted on vertebrates that travel over extensive spatial and temporal scales such as turtles, seals, whales and seabirds (e.g. Guinet et al., 1997; Hays et al., 2006; Kirkwood et al., 2006; Robinson et al., 2007; Lagerquist et al., 2008). However, many breeding colonies and populations of marine vertebrates that are restricted to shallow environments are necessarily coastal, and often coincide with anthropogenic pressures such as run-off pollution, development, fishing, boating and dredging (for example Borboroglu and Yorio, 2007; Hines et al., 2008; Skov and Thomsen, 2008). Conservation of animals that live within such inshore areas requires accurate information about their movements and home range in order to designate appropriate protective measures, such as marine protected areas. Studies of animal movements within coastal areas have been conducted using both Argos (Boersma et al., 2002; Thompson et al., 2003; Zbinden et al., 2007; Seney and Landry, 2008) and global positioning system (GPS) technologies (Heithaus et al., 2002; Schofield et al., 2007; Nanami and Yamada, 2008), yet few studies have compared the efficacy of these techniques to calculate animal movements at small spatial and temporal scales in the marine environment (Yasuda and Arai, 2005; Hazel, 2009).

The Argos satellite network is used to remotely identify the location of many marine vertebrates, but the raw data from this system often gives inaccurate positions (Vincent et al., 2002; Costa et al., 2010). Over large spatial and temporal scales these locations may still prove useful in identifying general movement patterns (Tougaard et al., 2008), but at the small scale position accuracy is very important (Hays et al., 2001) and a high degree of data filtering is required, removing a large number of the locations. To better understand the behaviour of a diving animal it is important to identify its vertical distribution, commonly determined through the use of diving recorders. However, diving data alone do not provide direct information on location at sea. Use of a combination of location and depth to determine the movement of diving animals is becoming more common, particularly with the recent advancements in GPS technology (e.g. Gremillet et al., 2004; Mattern et al., 2007; Schofield et al., 2007), which is able to provide a greater number of locations and accuracy than the Argos network. In some systems the Argos

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network is now being used as a means to remotely transmit data that has been collected by GPS and/or depth loggers back to the user (e.g. Fossette et al., 2008; Sims et al., 2009; Schofield et al., 2010), removing the necessity to retrieve the logging devices.

A good example of a spatially restricted forager is the little penguin (*Eudyptula minor*), distributed through southern Australia and New Zealand. Little penguins are a colonial species that have one of the smallest foraging ranges among seabirds during breeding (Dann and Norman, 2006). The movement of little penguins at sea has been examined through the use of radio-transmitters, satellite transmitters (also known at platform terminal transmitters, PTT) and diving loggers (time-depth recorders, TDR) in a number of studies (e.g. Collins et al., 1999; Ropert-Coudert et al., 2003; Chiaradia et al., 2007; Hoskins et al., 2008; Fallow et al., 2009) that have examined vertical and horizontal activity ranges and diurnal patterns. However, none of these studies have combined location with diving behaviour in the same individual at the same time, due to size limitations of devices that can be used on this small species (approx. 1 kg adult body mass). This means that interpretation of penguin behaviour at sea has been limited to assumptions made from location and dive data collected separately, which has caveats as a management tool. For instance, in our initial study using satellite transmitter and diving logger data collected separately in 2006, we considered it highly likely that the penguin foraging area overlapped with a shipping channel subject to a major dredging project, but we were unable to confirm this with a high level of certainty (Preston et al., 2008).

In this study, we used a miniaturized GPS device that was small enough to be deployed together with a diving logger on little penguins. By combining the GPS with a diving logger on the same individual, we eliminated the problems of interpretation associated from separately collected location and diving data. We analysed how this high resolution multi-logger approach compared with separately deployed satellite transmitters and dive loggers. Our aim was to determine if data on animal distribution and behaviour differed significantly between the two biologging techniques when collected over small spatial (<5000 ha) and temporal (<1 day) scales. In doing so, we also sub-sampled the GPS data at a number of time intervals to examine whether different data collection rates effected calculation of foraging parameters. This study is particularly relevant as the current trend in biologging research continues toward developing higher resolution multi-logging devices. The results of this study could be particularly useful to researchers and managers working with inshore species that require biologging information on which to base conservation decisions.

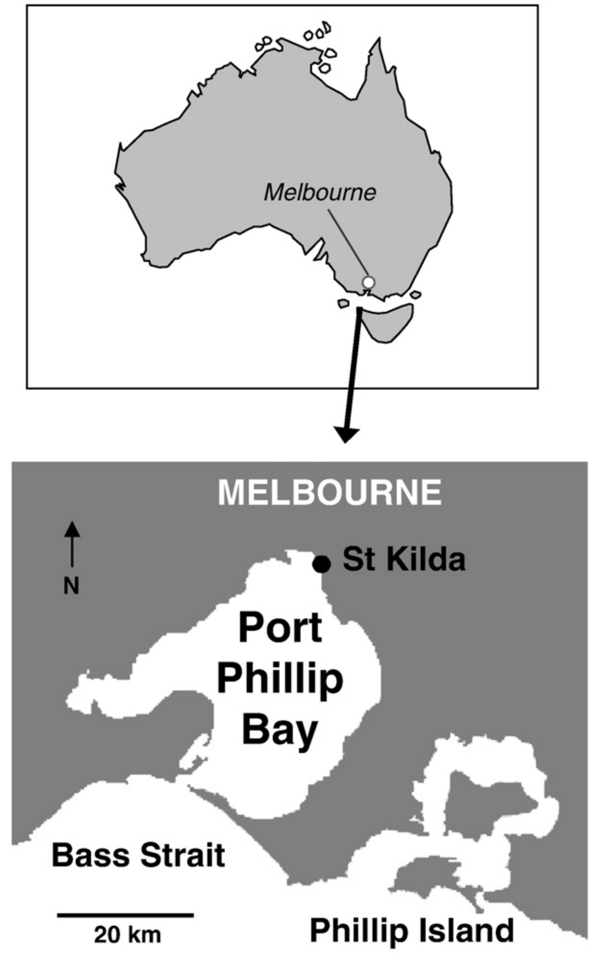

Fig. 1. Location of St Kilda penguin colony in Port Phillip bay where penguins forage.

2. Methods

2.1. Study site and field procedures

The St Kilda colony of little penguins numbers approximately 800 individuals and is located on the St Kilda breakwater, Melbourne, Australia, within close proximity to commercial shipping channels (37° 51′ S, 144° 57′ E, Fig. 1). The study site and field work is described in detail in Preston et al. (2008). Externally attached diving and location recording devices were deployed on breeding penguins during the 2007 and 2008 breeding seasons (approximately October–December). Deepening of the shipping channels occurred in the non-breeding season between the two sampling periods. Thus, there was no turbidity as a result of dredging activity during the time of our sampling, which may affect penguin foraging because they are visual predators (Cannell and Cullen, 1998).

To permit comparison between the two methods, this study considered only single foraging trips made by penguins at the chick-guard stage (first 2-weeks after hatching) when the trip duration is one day (considered typical at this stage of breeding, Chiaradia and Nisbet, 2006). We used data from 13 penguins fitted with a PTT and five penguins fitted with a TDR in 2007, and 17 penguins fitted with both a GPS and TDR in 2008.

The PTTs used were Sirtrack KiwiSat 202 (New Zealand, 60× 31×20 mm, cross-sectional area 514 mm^2, mass in air 43 g, 18 cm antenna spring mounted at 60°) operating on the Argos satellite network and the time-depth recorders were Cefas G5 (United Kingdom, 36×11 mm, cross-sectional area 95 mm^2, mass in air 5.8 g, set to record pressure and temperature at 1 s intervals).

The same TDR units were used in 2008, together with the mini-GPSlog by Earth & Ocean Technologies (Germany, 46.5×31×16 mm, cross-sectional area 496 mm^2, mass in air 29 g, acquisition time 1 to 3 s). The TDR was attached horizontally to the lower end of the GPS with waterproof tape (Tesa® 4651) to improve streamlining (GPS plus TDR mass in air, including tape, 37.7 g). Both GPS and TDR clocks were synchronised on the same computer to local time (eastern Australian daylight-savings) and were set to start approximately 1–2 h before sunrise when penguins left the colony. The GPS only recorded locations when the penguin was at the surface, but it was in continuous search mode (recording interval of 1 s) as the battery was able to last the length of the full deployment (1 day) and trials with longer search intervals were unsuccessful (A. Chiaradia and T. Preston, unpublished data).

All devices were attached using waterproof tape (Wilson et al., 1997) and a strip of adhesive compound (Mastic, Denso) to feathers along the mid-line of the lower back. Attachment and removal of all devices took <5 min and penguins were weighed to the nearest 10 g before and after deployments. Devices were retrieved for data