Extensive offshore movements of harbour porpoises (*Phocoena phocoena*)

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ABSTRACT

This paper presents the first data from satellite tracking of harbour porpoises (*Phocoena phocoena*) from West Greenland. Two female harbour porpoises (1 adult and 1 subadult) were driven into drift nets and equipped with satellite transmitters in July 2012, off West Greenland. The tags provided positions for +431 days (still transmitting) and 417 days, and data on daily depths of dives (± 0.5 m). After leaving the west coast of Greenland, one porpoise made extensive movements north to the Disko Bay, south to East Greenland and south east into the central North Atlantic where it wintered. It moved back to West Greenland the following summer. The other porpoise crossed the southern Davis Strait to Canada twice where it wintered in offshore waters before returning to the tagging site in West Greenland one year later. The porpoises travelled >17,500 km and 10,000 km, spent on average 83 % (72% for the subadult and 94% for the adult) of their time in offshore areas (depths >200 m) and had maximum dives down to 382 m and 410 m. This is the first documentation of the annual movement cycle of an odontocete in the North Atlantic. The two harbour porpoises in this study displayed site fidelity to the summer feeding ground and despite different movement patterns both demonstrated that they are capable of inhabiting oceanic parts of the North Atlantic for a major part of the year. This is in contrast to common knowledge about the species and suggests that the occurrence of the species in offshore areas has been overlooked likely because of their inconspicuous appearance and frequent sightings in coastal waters.

Introduction

Studies of the dispersal and migrations of marine top predators is critical for addressing pertinent questions about stock delineations, abundance of stocks, individual response to climate change and ultimately to inform management decisions (*e.g.* Grémillet and Boulinier 2009, Newson *et al.* 2009, Ponchon *et al.* 2012, Heide-Jørgensen *et al.* 2013). Satellite-linked radio transmitters are essential for obtaining information on movement and behaviour on an individual level and have been applied to several species of cetaceans over the past 40 years (*e.g.* Mate *et al.* 2007; Heide-Jørgensen *et al.* 2002; Heide-Jørgensen *et al.* 1995; Mate 1989; Watkins *et al.* 1984; Evans *et al.* 1971, Sveegaard *et al.* 2011).

Harbour porpoises (*Phocoena phocoena*) are among the smallest odontocetes and are believed mainly to be distributed in coastal areas on the continental shelf (Read 1999). For this reason most surveys of abundance have been focused on coastal areas (*e.g.*; Pike *et al.* 2008, Hammond *et al.* 2002, 2013) and there is no data published on their distribution in the deeper offshore waters. Tagging of harbour porpoises have only been done in a few locations worldwide and active capturing in nets has not yet been used for tagging porpoises (Teilmann *et al.* 2012; Johnston *et al.* 2005; Otani *et al.* 1998; Westgate and Read 1997). In this study, two female harbour porpoises were actively captured in surface drift nets off Maniitsoq in West Greenland and instrumented with satellite-linked-dive-recorders (SPLASH, Wildlife Computers) which provided information on movement and diving behaviour (Table 1).

Results and discussion

Two harbour porpoises were tracked for 431 and 417 days, respectively, and provided a total of 2784 and 3012 positions (Table 1). The two porpoises travelled over an extensive area, however, porpoise 7618 performed by far the most extensive movements of 17,558 km and went as far as 54°07'N and 22°32'W while 7617 travelled 10,035 km and spend the majority of its time in the southern part of Davis Strait (Fig. 1). Both porpoises spend only 28 % and 6 % of the 14 months they were tracked on the continental shelf of West Greenland (at depths < 200 m); the rest of the period was spent in offshore areas (> 200 m). Although Westgate *et al.* (1997) and Read *et al.* (1996) suggest winter movement into deeper waters in the Bay of Fundy, Canada, however, this has never been documented.

The average daily travel rates for the two harbour porpoises were 24 km (range 0.6 – 103 km, SD=21.9) and 42 km (range 1.9 – 118.7 km, SD=25.2), respectively, which are in the same range of harbour porpoises from Bay of Fundy (range 13.9 – 58.5 km, SD=13.9), Canada (Read & Westgate 1997) but slightly higher than found for the North Sea (20.4 kmd^{-1}) and the Baltic Sea (15.4 km d^{-1}) (Sveegaard et al. 2011). A highly significantly seasonal variation in the daily movement was seen in porpoise 7618 (, P<0.001) which moved a shorter average distance of 32.0 km d^{-1} per day in the winter months (December – June) than in the remaining months (47.5 km d^{-1}, July – November) (Fig. 2). There was no seasonal variation in porpoise 7617 (*t-test*, P=0.73) which is probably linked to its much smaller home range.

The two harbour porpoises both returned to the tagging site the following summer indicating site fidelity to the tagging area as also suggested by Wang *et al.* (1996). The return, not just to West Greenland but to the very same place where they were tagged the previous year, also suggest that this area is an important feeding and possibly breeding ground during the summer months as they are known to feed intensively in this area (Heide-Jørgensen *et al.* 2011).

Both porpoises made record deep dives to a maximum of 382 m and 410 m which is almost twice the depth previously reported (Westgate *et al.* 1995 (max=226 m), Teilmann *et al.* 2007, (max=132 m)) and therefore by far the deepest dives ever recorded for harbour porpoises. This significant increase in max dive depth may be due to previous studies being conducted in shallower areas or that the harbour porpoises from Greenland explore other pelagic food resources when not being able to reach the bottom of the seafloor in most of their range. The daily maximum dive depths of the two porpoises were available for 94 and 80 days, with an average of 236 m and 264 m, respectively (Fig. 3).

The average number of dives h^{-1} deeper than 4 m was 7.5 and 6.6 which is somewhat lower than found in other harbour porpoise studies (Linnenschmidt *et al.* 2013; Teilmann 2007; Otani *et al.* 1998). The low number of dives h^{-1} for harbour porpoises in West Greenland reflects that they spend the majority of their time in offshore areas (> 200 m) where they make few but deep dives (Table 2).

This study demonstrates that harbour porpoises area capable of inhabiting oceanic parts of the North Atlantic and that their coastal appearance only represent short periods of their annual cycle. Perhaps it is due time that harbour change the vernacular name to ‘oceanic porpoise’. The tracking also demonstrated that despite wide ranging dispersal capability harbour porpoises also show strong site fidelity to specific summer feeding grounds.

Acknowledgments

We thank the hunters Svend and Knud Heilmann for helping with the tagging of the porpoises. The project was supported by the Greenland Research Council and the Greenland Institute of Natural Resources. The harbour porpoises were caught and tagged with permission from the Government of Greenland.

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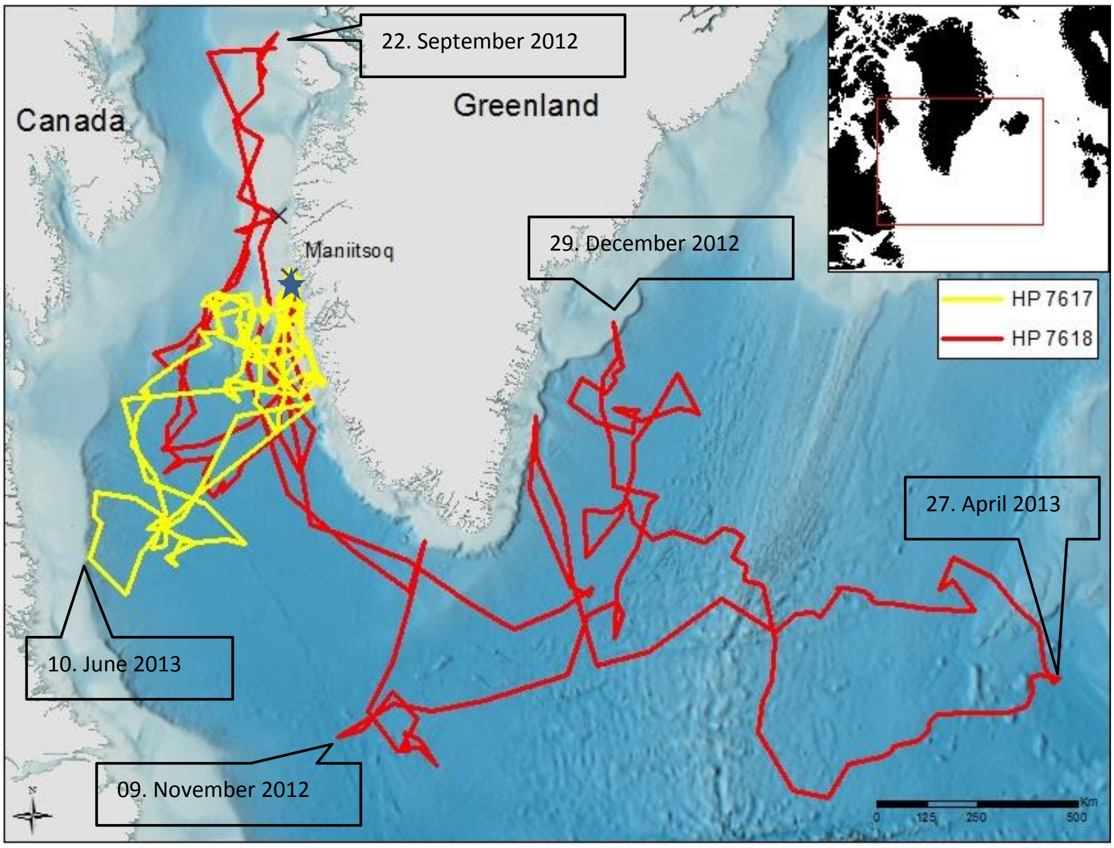

Figure 1. Movements of two harbour porpoises tracked by satellite. The star indicates where the porpoises were tagged on 25 July 2012 and the X's show the end of the track on 30 September 2013 after 431 and 417 days with positions.

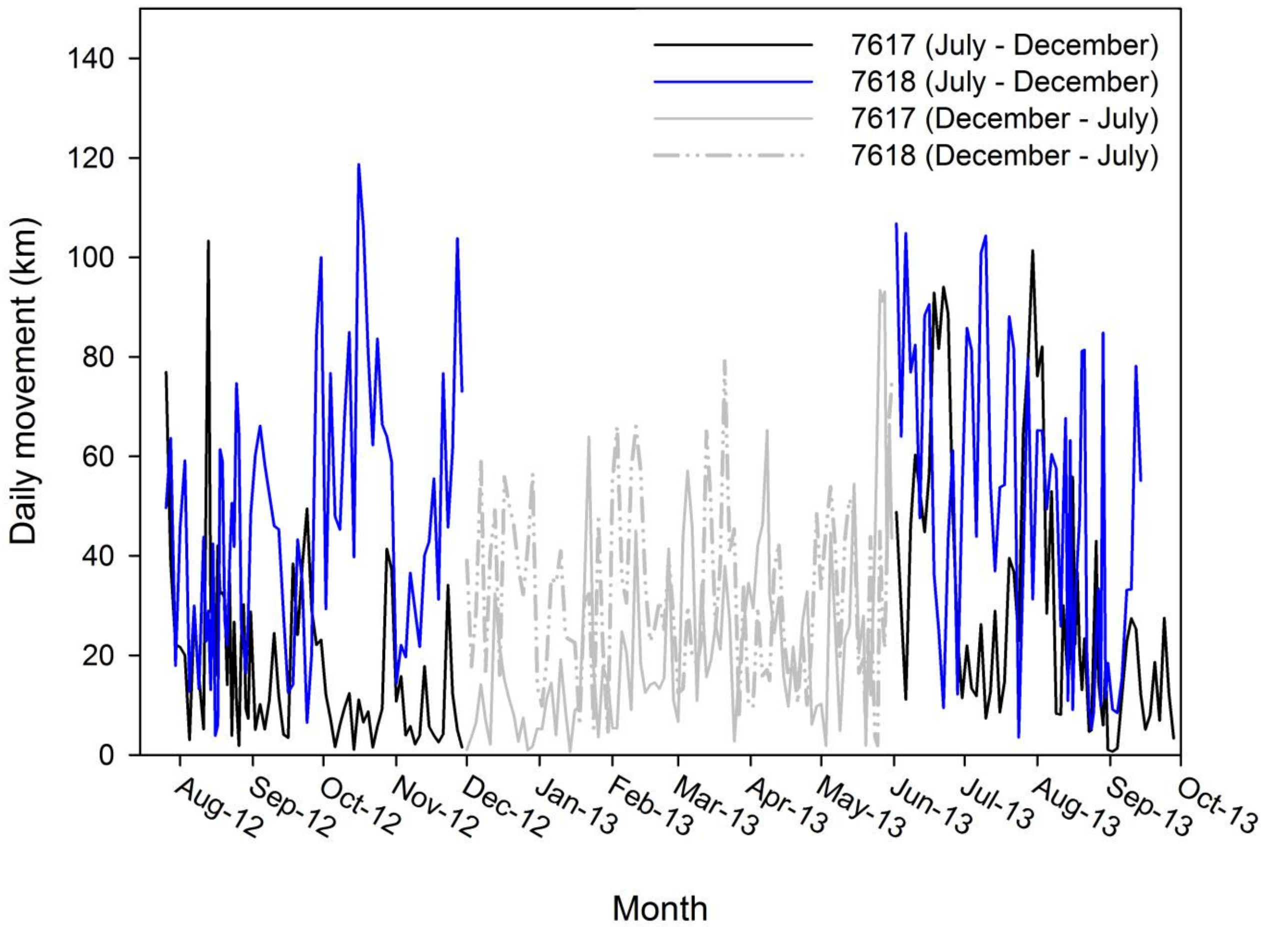

Figure 2. Daily movements (km) of the two harbour porpoises from West Greenland during 14 months. A highly significantly seasonal variation in the daily movement was seen in porpoise 7618 (*t-test*, P<0.001) that moved a shorter distance per day during winter (December through May) than in the remaining months (June through November, total travel distance 17,500 km). There was no significant seasonal variation in porpoise 7617 (*t-test*, P=0.73) that also travelled the shortest distance (10,000 km).

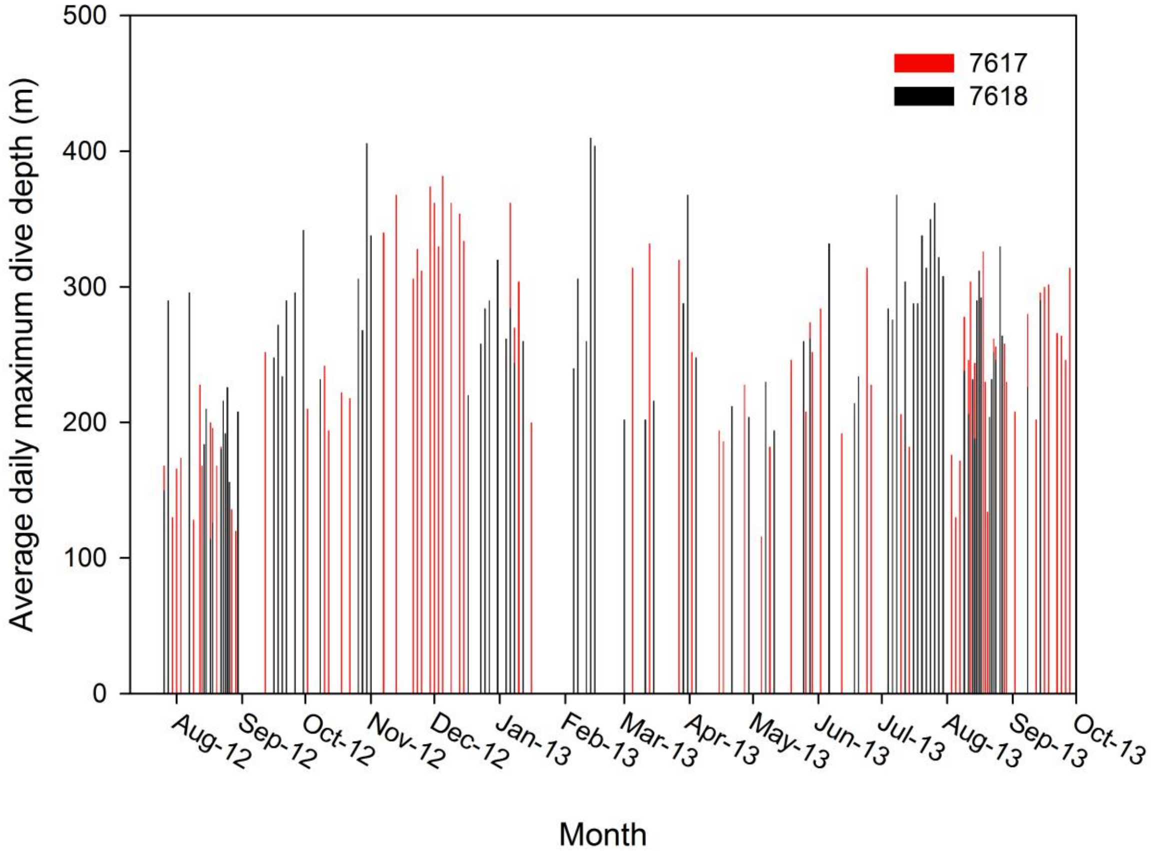

Figure 3. The average daily maximum dive depths (m) of two harbour porpoises from West Greenland. The maximum dive depth was not included in all transmissions, thus not every day is represented.

Table 1. Data on two female harbour porpoises instrumented with satellite-linked radio transmitters in West Greenland on 25. July 2012. SD provided in parenthesis.

ID	Standard length (cm)	Transmission days	No. of positions	Total distance travelled (km)	Average daily travel rate (km)		Average maximum dive depth (m)	Maximum dive depth (m)	Average number of dives (d^{-1})
					Offshore (> 200 m)	Inshore (< 200 m)			
7617	128	+431*	2784	10,035	19.8 (±17.7)	24 (±27.3)	236.3 (±67.3)	382	7.4 (±4.1)
7618	159	417	3012	17,558	40.6 (±25.0)	48.7 (±26.7)	263.7 (±61.3)	410	6.8 (±8.3)

* Harbour porpoise 7617 is still transmitting 1. November 2013.

Supplementary materials

Materials and Methods

Live captures of harbour porpoises were conducted off the coast of Maniitsoq in July 2012. During a two week period daily searches for harbour porpoises were conducted from the town of Maniitsoq. Two 19-feet dinghies with 150 hp engines and four persons participated in the field operations. One boat had the capturing nets (the net-boat) while the other was used for chasing the porpoises (the chasing-boat). Searches for harbour porpoises were conducted from both boats and only in sea state 0 and preferably with overcast conditions that kept a grey appearance of the sea surface.

When a porpoise or a group of porpoises were located one or more surface salmon gill nets (monofilament with approximate dimension of 5 m deep and 50 m long with stretched mesh size of 20 cm) was quickly launched from the net-boat. The net was deployed with a flag buoy at one end and was pulled out from the net-boat while it was drifting away from the flag buoy. The current was used to stretch out the net and the engine in the net-boat was not started until the net was completely deployed, where after the net-boat assisted the chasing-boat with pushing the porpoise towards the net.

While the net was launched the chasing-boat tried to follow the porpoise(s). The boat driver and one observer kept a vigilant lookout for the porpoise(s) as it was critical not to miss a surfacing event. When a porpoise surfaced the chasing-boat went toward the animal but kept it on the starboard side and thereby pushing it to the right. If a surfacing was missed (*i.e.* the duration since last surfacing exceeded 10 min) the chasing boat started to do a large circle about 1 nmi from the last detected surfacing. This ensured that the porpoise had not left the area inside the circle and it made it possible to relocate the animal and continue the chase. While chasing the porpoise towards the net it was important not to push it too much, *i.e.* passing in front of it or getting too close to the animal. Eventually the porpoise would be in front of the net and if close enough it would get entangled but it could also dive below where after the chase was re-initialized on the other side of the net.

Entanglement of the porpoise was easily observed when the float line of the net was pulled down. As soon as the porpoise was entangled the boats went to the net and a boat hook was used to close the bottom of the net before the porpoise was grabbed by the tail and hauled on board the boat for tagging. It took less than 2 min from the porpoise was entangled until it was on board the boat and both engines was stoped to prevent further stress of the animals.

Two female harbour porpoises (body length: 129 and 160 cm, respectively) were captured on 25. July 2013. Both porpoises swam in the net with head first and thus got minimum entangled and could simply be pulled backwards out of the net and placed in the boat on a foam pad and dowsed with sea water regularly. The standard length (to the nearest cm) was measured and the sex determined visually. The porpoises were instrumented with satellite-linked radio transmitters (SPLASH tags, Wildlife Computers,Redmond, Seattle) and modified for use on harbour porpoises by Mikkel Villum Jensen (www.mikkelvillum.com) and Jonas Teilmann. The tag was attached to the dorsal fin using three 5 mm-diameter delrin nylon pins, that were pushed through holes drilled in the fin with a sterilized cork borer mounted on a cordless electric drill. The pins were secured to a backing plate with stainless steel nuts and flattened at the end of the pins to prevent the nuts to come off. Both backing plate and tag facing the fin of the porpoise were lined with open-cell foam to reduce the possibility of abrasion. The handling time was between 5 and 6 min respectively and after release they both swam calmly.

Information on position, number of dives (below 2m) and maximum dive depth (m) during 24 hrs were relayed through the Argos Data Collection and Location System and decoded using Argos Message Decoder (DAP Ver. 3.0, build 114, Wildlife Computers). Data on dive depths were collected in 6 hr intervals using GMT time (01:00-07:00, 07:00-13:00, 13:00-19:00 and 19:00-01:00).