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ABSTRACT

Three surveys focusing on the satellite tracking of Arabian Sea humpback whales (ASHW) off the coast of Oman were completed between 2014 and 2015. A total of nine tags were deployed revealing the movements of eight males and one female between the months of February and June. Funds were secured in 2016 for a second phase of this project to cover two additional field seasons with the purpose of addressing data gaps from the previous tagging work with the deployment of as many as 8 new tags. Survey objectives for this second phase of telemetry work includes; minimising m sex bias in previous tagging efforts by tagging more females, deployment of tags at an alternative field site (in the Gulf of Masirah) and extending the seasonal coverage of the telemetry data to cover the months between June and October. No humpbacks were tagged during the survey. Existing gaps in our knowledge of ASHW spatial ecology are demonstrated by the absence and low encounter rates with ASHWs during this recent survey. Findings highlight the importance of continued tagging to understand the temporal dynamics of habitat selection. Including the ASHWs, a total of eight different species were observed at the southern survey site including; common dolphins, bottlenose dolphins, Risso's dolphins, false killer whales, killer whales, Brydes whales and humpback dolphins. Brydes, false killer whales, common dolphins, bottlenose dolphins and one humpback whale were observed feeding at this study site. The findings suggest the importance of this area as a diverse and complex cetacean habitat. There was a noticeable increase in anthropogenic threats as the number of fishing vessels increased from five vessels in March 2015 to over 20 vessels in March 2017. Fishers were engaged in overnight deployments of gillnets within 10km of the coast in an area previously identified as ASHW and at least 14 other species' habitat. Recent confirmed bycatch of two common dolphins and a baleen whale in this area combined with on-going industrial developments in the Gulf of Masirah underline the need for a revised strategic approach to resourcing research and mitigation activities in the Sultanate.

INTRODUCTION

Reeves *et al*. (1991) and Mikhalev (1997) were the first to suggest that the humpback whales found in the Northern Indian Ocean form an isolated, non-migratory, population. Further work conducted in Oman confirmed this theory (Minton et al. 2011) and led to the designation of this population as 'Endangered' on the International Union for the Conservation of Nature (IUCN) Red List. This designation was based on a mark-recapture population estimate of 82 individuals (95% CI 60-111; Minton *et al*. 2008). Recent genetic analysis supports the isolated status of these whales and indicates that they diverged from Southern Hemisphere populations ~70,000 yrs BP (Pomilla, Amaral *et al*. 2014). The population is demonstrably vulnerable to anthropogenic threats (Baldwin et al. 1999, Minton *et al.* 2008; Baldwin *et al*. 2010), with evidence that fishing, commercial vessel traffic and oil and gas exploration and production are increasing within habitats associated with higher whale sighting densities (Corkeron *et al.* 2012; Willson *et al*. 2014).

Boat-based surveys conducted between 2000 and 2012 focused on two main study areas off the coast of Oman, the Gulf of Masirah and the Hallaniyats Bay, (Figure 1). Genetic sampling of ASHW's and behavioural cues (e.g. singing or the presence of a calf) observed at these sites indicated a near parity of males and females in the Gulf

of Masirah and a male bias in the Hallaniyats Bay (Minton *et al.* 2011, Willson *et al* 2014). Feeding was observed in both of these areas during February-March surveys in the Hallaniyats Bay and October-November surveys in the Gulf of Masirah. However, limitations to the timing and geographical coverage of previous surveys led the IWC to recommend further investigation of this population, including the implementation of satellite telemetry techniques (IWC, 2011).

Three satellite tag deployment seasons were conducted off the coast of Oman between 2014 and 2015, (Willson *et al.* 2016). These resulted in the tagging of nine humpback whales (eight males and one female), six from southern Oman (Hasik) and three in the Gulf of Masirah, central Oman (Duqm). Tracking results revealed whales traveling within a 1,150km corridor, ranging between northern Yemen and the Gulf of Masirah. Five of six whales tagged in southern Oman moved north into the Gulf of Masirah during the month of March. Analysis revealed tagged whales spent most of their time in the Gulf of Masirah and Hallaniyats Bay (35% and 22% respectively). There are however seasonal gaps in tag data coverage, a bias towards males and a bias in the number of animals sampled at each location. To address these gaps further seasons of tagging were recommended and planned (IWC, 2016)

Here we report on the results on the most recent tagging survey, including details of other cetacean sightings and documentation of pertinent anthropogenic activities documented within the study sites.

METHODS

The second phase of tagging work was intended to entail two surveys in the Gulf of Masirah, lasting two weeks each, immediately before and after the south west monsoon (May-September). It was hoped that the parity of males and females encountered in this area from previous surveys (Minton *et al.* 2011) would provide the opportunity to redress the male bias from previous tagging that was conducted primarily in the Hallaniyats Bay.

Kernel density plots of habitat use generated with data from previous tagging studies were used to identify an area where whale encounters were likely in the Gulf of Masirah (Willson et al. 2016). From 16 March – 02 April 2017, the field team operated from a beach base camp to the west of this area (Sarab). Two 6.5m rigid hull inflatable boat (RHIB) navigated simultaneous parallel line transect at a distance of 2-3km apart. Data collection methods were consistent with previously reported protocols (Minton *et al.* 2010; Corkeron *et al.* 2012; SC/65a/SH06). The team moved to a second survey site in the Hallaniyats Bay after an absence of encounters in the Gulf of Masirah. At this site the surveys were also supported by a clifftop observation station to direct vessels towards sightings via VHF radio. Omni-directional dipping hydrophones (High Tech Inc., HTI96) were also employed in both survey areas to guide research vessels towards singing males. During tagging work each vessel had a clearly defined role; one RHIB (crewed by tagger, biopsy specialist, cameraman and driver) was dedicated to the application of satellite tags and the other acted as a support and safety vessel (including a paramedic). Tagging protocol would have been the same if a suitable tagging opportunity had presented itself (Willson *et al.* 2016).

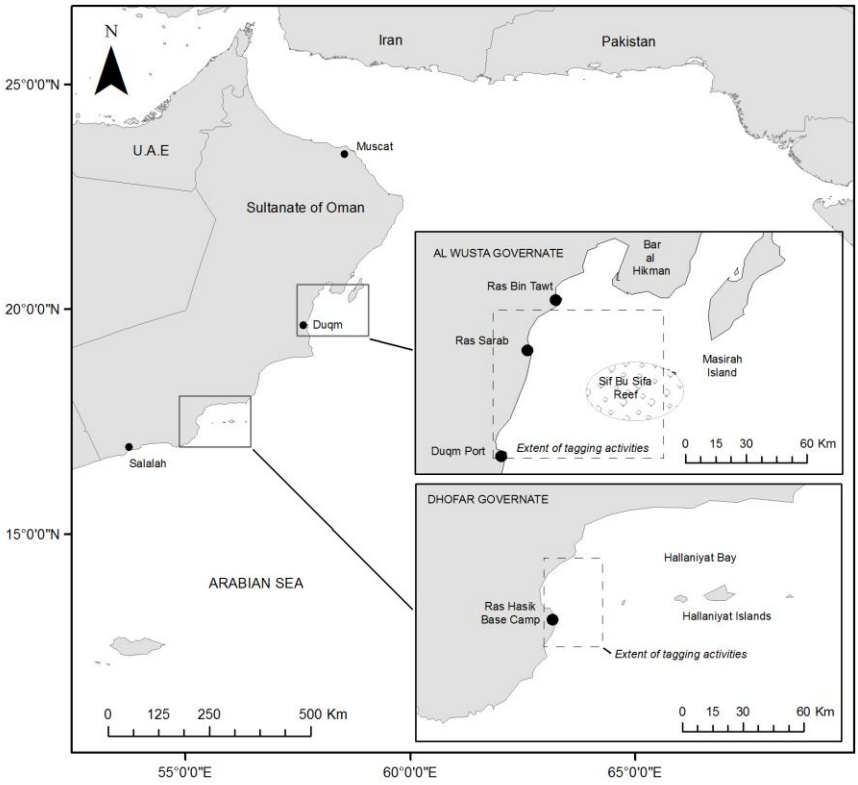

Figure 1 Location of tagging activities from a base camp in Hasik (February 2014 & 2015 & March 2017) a mobile research vessel in the Gulf of Masirah (November 2015 mobilized from Port of Duqm) and small-boat surveys from beach base in Sarab, Gulf of Masirah (March 2017).

RESULTS

Vessel surveys in the Gulf of Masirah between 18th and 23rd of March resulted in a total of over 51 hours at sea with 21:29 (hh:mm) of dedicated search effort resulting in a single 'on ffort' sighting (a Bryde's whale). The absence of humpback whale sightings during this period resulted in the team moving to the southern site where tagging had been conducted in previous years. Over 103 hours at sea and 14:08 of dedicated search effort were completed in the Hallaniyats Bay between the 26th and 30th of March (Table 1). In total eight species were observed in the Hallaniyats Bay. On effort observations included five sightings of Bryde's whales across multiple days (two groups of 3, and three single individuals). Humpback whales were seen on four out of five survey days, resulting in six sightings of the same two individuals. Evasion and surface activity (breaching and pectoral slapping) made these whales unsuitable for tagging. One of these was an animal in the Oman photo-identification catalogue (male) and the other was unknown although both were detected singing. A sloughed skin sample was recovered from the unknown animal. These two animals were also documented interacting on two occasions and were surface active with pectoral fin slapping.

Other species sighted

Common dolphins (*Delphinus capensis tropicalis*) were observed on all days in the Hallaniyat Bay (n=5) in group sizes estimated up to 500 animals and within 1 to 10km of the coastline. Groups were engaged in a variety of behaviours including traveling and feeding. Other sightings included a group of Risso's dolphins (*Grampus griseus*) (best estimate = 7), false killer whales (*Pseudorca crassidens*) (best estimate = 100), and seven killer whales (*Orcinus orca*). Six biopsies were taken from the group of false killer whales. An unidentified number of humpback dolphins (*Sousa plumbea*) was observed from the clifftop station. The killer whale group included one juvenile, and was observed in close proximity (1-2km) to a group of Bryde's whales. Prior to the killer whale sighting Bryde's whales were feeding. As the killer whales approached within 1km, the Bryde's whales behaviour changed, and were observed traveling away from the area at speed. Bottlenose dolphins (*Tursiops sp.*) were observed on the same day as false killer whales traveling away from the group at speed. The false killer whales

were documented feeding, some on the surface with remains of fish in their mouth although the fish species could not be identified. A number of individuals discarded the fish roe.

Table 1 Summary of survey effort and sightings details ('on' and 'off' effort) in the Gulf of Masirah and Hallaniyats Bay, (March 2017).

		Gulf of Masirah	Hallaniyats Bay
Total Vessel Time (hours:min)		51:07	103:21
Total Vessel Effort (hours:min)		21:39	14:08
		Number of Observations	Number of Observations
	Unidentified Whale		1
	Bryde's	1	5
	Humpback whale		6
	Humpback dolphin		1
	Common dolphin		5
	Bottlenose dolphin		1
	Risso's dolphins		1
	Killer whale		1
	False killer whale		1

DISCUSSION

The success of previous satellite tagging field surveys in Oman has beendependent on suitable weather conditions and working in areas known to have the highest encounter rates for ASHWs as determined by vessel survey and satellite telemetry models (Corkeron *et al*. 2011; Willson *et al*. 2016).The selection of the Gulf of Masirah as a primary location for the 2017 tagging survey was based on these studies as well as assessment of acoustic detections from passive acoustic monitoring stations (Cerchio *et al*. 2016), and the known parity of sexes. The absence of acoustic or visual detections of whales in the Gulf of Masirah in March 2017 was thus unexpected and suggests that there may be some inter-annual variability of the use of habitats beyond that described by existing sources of data. Social media sources revealed at least three sightings of humpback whales reported by fishermen roughly 100km east of Masirah Island at the same time that the research team was unable to locate whales inshore in the Gulf of Masirah (Juma al Araimi, pers. comm. 28th March 2017). Two of these groups were documented feeding, indicating that shifts in prey availability may have drawn whales to a different area in 2017.

The months of late September and early October have been identified as important tagging months in the second phase of this telemetry project. However, a paucity of research effort during this period in previous years leads to considerable uncertainty about where whale sightings can be "guaranteed" in these months. Funding is limited and can only support a two-week long tagging field survey. In order to maximise our chances for successful tag deployment, the team is proposing to amend the schedule to work in the Gulf of Masirah later in the year (November and December) when encounter rates have been the highest of any survey season and location. Although this approach will not address seasonal gaps in data it should provide more sightings and improve the potential for tagging females.

A project initiated in 2015 to process acoustic data from autonomous bottom-mounted passive acoustic SM2M monitoring units (www.wildlifeacoustics.com) deployed off the coast of Oman between 2011 and 2013 is still underway. An initial analysis of these data was presented to the IWC Scientific Committee in 2016 (SC/66b/SH/32). The report documented the acoustic presence and absence of whales from arrays deployed in the Gulf of Masirah and Hallaniyats Bay. A second phase of analysis focusing on ambient and human-induced noise is ongoing. The last phase of this work planned for late 2017 will compare Oman humpback whale song with that collected in India and Madagascar, and will examine the potential for connectivity between different sites where song has been recorded.

Vessel survey encounter data and the telemetry data is being used to generate ecological niche models as a means to predicting the distribution of whales elsewhere in the Arabian Sea (SC67a/SH/XX) and photo-identification

and mark-recapture methods are being used to review the abundance and conservation status of the population off Oman (see SC67a/SH/XX).

Recent observations and events indicate that anthropogenic threats in both study sites are on the rise. The number of fishing vessels (dhows) operating in the Hallaniyats bay increased from 5-10 vessels anchored off Hasik harbour in 2015 to over 20 vessels operating from the same anchorage during the last survey. These vessels were observed setting gill nets overnight within 10km of the coast in close proximity to the town of Hasik. Gillnets are responsible for high rates of cetacean entanglement around the world (e.g. Read *et al* 2013) with particular danger to humpback whales (Johnson *et al.* 2005). Two fresh dead common dolphin carcasses found floating at seas during this recent survey showed signs of recent net entanglement. At the time of writing (April, 2017) a dead baleen whale was discovered entangled in a net off the town of Hasik. This is the same area identified as high density humpback whale habitat from the 2014-2015 telemetry data and previous boat and shore-based observations (Willson *et al.* 2015, 2016).

Our surveys continue to demonstrate that a wide diversity of cetaceans use the areas of the Hallaniyats and Hallaniyats bay. Fifteen cetacean species have been recorded within a 25km radius of the town of Hasik (OMCD, 2017). The area surrounding Hasik sits within the boundaries of the Jebel Samhan Nature Reserve (Oman Royal Decree 47/97). This reserve has a seaward extent up to 13km offshore. The importance of the area for the Endangered Arabian Sea humpback whale population, as well as its identification as a cetacean biodiversity hotspot, merit the immediate development and enforcement of management measures to address threats associated with the expansion of fisheries activities in the area. Any ASHW injury or mortality in a population of less than 100 animals will have a substantial impact on the long term viability of the population.

Development of industrial facilities also continues along the western coastline of the Gulf of Masirah. Hydrocarbon exploration and well testing continues with the drilling of a fourth test well by Masirah Oil due east of the port area (Your Oil and Gas, 2017). A cluster of projects associated with a new refinery (Willson *et al*. 2016) has been initiated, with the first including dredging of the port basin and extraction of aggregate offshore to fill the construction area. Both these activities will result in increased vessel presence/traffic in the area to transport material (Dredging Today, 2017). Requests have been made to ensure vessels engaged in these activities observe voluntary speed restrictions (of 10knots) detailed in the Port of Duqm whale mitigation plan (Baldwin et al. 2015). US$ 10.7 billion has recently been secured from a Chinese backed group of companies to fund further development of an industrial complex within the port free-zone in the Duqm area within the next 5 years, (The National, 2016). These developments will accelerate and expand port service industries and commercial shipping traffic in a critical area. Strategic environmental impact assessment of multiple projects is urgently required to understand the combined impact all activities will have on this habitat.

In keeping with threats to cetaceans globally, those that effect species in Omani waters continue to grow, and continue to be documented. Although multiple research methods are being used by the Oman ASHW programme there are still significant knowledge gaps, and the resources required to investigate the many aspects of ecology, distribution, status and management are in very short supply. New resourcing and advocacy strategies are required for priority areas to ensure robust information is shared with the public and private sector. This will enable both the public and the private sector to make informed and balanced decisions on the design and implementation of effective conservation and management measures. Developing partnerships with other institutions engaged in developing mitigation and management strategies elsewhere may offer a means to addressing these requirements.

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