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Species identity and local use of cetaceans in the Gilbert Islands, Republic of Kiribati

C. Scott Baker^{1,2}, Al Hutt³, Kirsten Thompson², Merel L. Dalebout⁴, Judith Robins⁵ and Greg Stone⁶

- 1) Marine Mammal Institute, Oregon State University, Newport, Oregon 97365 USA
- 2) School of Biological Sciences, University of Auckland, Auckland, New Zealand
- 3) Department of Conservation, Akaroa, New Zealand
- 4) School of Biological, Earth, and Environmental Sciences, University of New South Wales, Sydney, NSW 2052, Australia
- 5) Department of Anthropology, University of Auckland, Auckland, New Zealand
- 6) Conservation International, 2011 Crystal Drive, Suite 500, Arlington, Virginia, 22202, USA

Email: scott.baker@oregonstate.edu

Abstract

We investigated the species identity and local use of cetaceans on the Gilbert Islands of the Republic of Kiribati. The first evidence of an unknown species of beaked whale came from strips of dried meat served during a local festival on one of the islands in July 2003. Using DNA ‘barcoding’, we identified the meat as originating from a beaked whale but found that the sequences were not a close match to any known species. To learn more about cetacean diversity and local use in Kiribati, we worked with government agencies to survey several of the outer Gilbert Islands in June-July 2009. A total of 24 fragments of bone or teeth were collected and exported to New Zealand for identification. DNA was successfully amplified from 12 fragments and identified as originating from four species: *Mesoplodon* sp. representing a new species or subspecies of beaked whale (Dalebout *et al.* 2012), the dense-beaked whale *M. densirostris*, Cuvier’s beaked whale *Ziphius cavirostris*, and the pygmy sperm whale *Kogia breviceps*. This is the first confirmed documentation of these species in Kiribati. All specimens appeared to have been used for human consumption.

Introduction

The beaked whales (Family: Ziphiidae) are among the least known of all vertebrate groups. Found in deep oceanic waters, typically far from shore, several species were initially described only from partial skeletal remains found beachcast on remote islands and shorelines. Previously thought to include 20 extant species, a recent survey of the molecular systematics of this family resulted in the discovery of a new species, *Mesoplodon perrini*, identified by phylogenetic analysis of mitochondrial (mt) DNA sequences (Dalebout *et al.* 2002), using methods similar to those now known as DNA ‘barcoding’.

Development of a comprehensive molecular taxonomy of the family Ziphiidae by DNA ‘barcoding’ (as summarized in Dalebout *et al.* 2004) resulted in two other molecular discoveries. First, previously misidentified specimens from South Africa were linked to the holotype of Longman’s beaked whale *Indopacetus pacificus* from tropical north Queensland, Australia, providing the first evidence of the physical appearance of this species (Dalebout *et al.* 2003). Second, a single tooth and partial skull held in New Zealand institutions were linked to the holotype of Bahamonde’s beaked whale *M. bahamondi* Reyes, van Waerebeek, Cárdenas and Yáñez, 1995 held in the National Museum of Chile, confirming the genetic distinctiveness of the species and uncovering a prior description of this species as *M. traversii*, dating back to the recovery of the tooth on the Chatham Islands of New Zealand in the 1870s (van Helden *et al.* 2002). Together, these discoveries and taxonomic revisions demonstrate the power of integrating traditional museum curation and morphological analyses with DNA ‘barcoding’ for describing rare and cryptic species (Baker *et al.* 2003; Dalebout *et al.* 2004). They also confirm the need for continued exploration of the oceans to document rare species of cetaceans, some of which might be subject to direct or indirect mortality from human activity, including the growing threat of human consumption (Robards and Reeves 2011).

In 2003, strips of dried whale meat served at a local feast on Tabiteuea Island (1° 12' 14" S and 174° 44' 51" E), in the outer Gilbert group of the Republic of Kiribati, provided evidence to be yet another new species (or subspecies) of beaked whale. Mitochondrial (mt)DNA from the whale meat was sequenced and compared to a comprehensive database of reference sequences of all known cetaceans, as implemented in the web-based program www.DNA-surveillance (Ross *et al.* 2003). Phylogenetic analyses of mtDNA sequences showed, with certainty that the meat came from a member of the beaked whale genus, *Mesoplodon*. Although grouping conclusively within the *Mesoplodon*, the sequences grouped most closely with *Mesoplodon ginkgodens* but showed a degree of genetic divergence consistent with species-level classifications in this group (Dalebout *et al.* 2007). Subsequent investigation (Dalebout *et al.* 2012), have associated the Kiribati samples with the type specimen for *M. hotaula* (Sri Lanka), described as a new species in 1963 but subsequently synonymised with *M. ginkgodens*.

Discussions with the local island community at the time suggested that this unknown species could be threatened by unregulated exploitation around the Gilbert Islands. The meat served in July 2003 was taken from seven whales taken in an apparent 'drive-kill' in October 2002. The villagers said that they regularly (several times a year) chased and killed "long whales" when they come into the shallow waters of the nearby lagoon. The large group size and the regular occurrence near small islands are unusual for beaked whales and suggest an interesting ecology for this unknown species.

Here we report on efforts to further describe the 'unknown species' represented by the dried meat samples obtained in 2003, and to document cetacean diversity and local use in the Gilbert Islands (Figure 1). Traditional shamanistic practices relating to the local consumption of cetaceans in the Gilbert Islands were reported by Grimble (1952) but the persistence of these practices is unknown. More recently, Robards and Reeves (2011) reported that melon-head whales (*Peponocephala electra*) and other unidentified delphinids were used for local consumption in certain islands in the Republic of Kiribati. Otherwise, little is known about the current diversity and human consumption of cetaceans in these remote islands.

Methods

Collection of bones from the Gilbert Islands

One or more coauthors (A Hutt and G Stone) visited the capital city of Bairiki, on the Island of Tarawa, in April 2006 and again in June 2008 to arrange permits from the Kiribati Ministry of Environment, Lands and Agricultural Development (MELAD) and logistic for visits to the outer islands. From 18 June to 14 July 2009, one of us (A Hutt), accompanied by an interpreter and a local Biodiversity Officer, visited three of the outer islands of the Gilbert group: Onotoa Island, Tabiteuea North, and Butaritari Island (Figure 1). On each island, village elders were shown a copy of *Whales and Dolphins of New Zealand and Australia, an Identification Guide* [Baker, Alan N. Wellington, NZ: Victoria University Press, 1999] and asked about local use of whales and dolphins and the location of any meat or skeletal remains.

DNA extraction and species identification

Bones and teeth collected in the Gilbert Islands were exported to New Zealand (with appropriate permits) and stored at the School of Biological Sciences, University of Auckland. The bones were isolated from potential contamination with DNA from other samples of whales and dolphins. The primary laboratory analysis was conducted in a laboratory isolated from cetacean DNA in the School of Biological Sciences, University of Auckland. Each bone was drilled in several areas with a 1.5mm drill bit as described in Pichler *et al.* (2001) and approximately 50 mg of material was collected on sterile foil. DNA was extracted from the powdered bone using a Qiagen Blood and Tissue Extraction Kit, following the manufacturer's protocols. Amplification and sequencing of the mtDNA control region (D-loop) and cytochrome *b* gene generally followed those described in detail by Dalebout *et al.* (2004). Following initial identification, a subset of bones was transferred to an ancient DNA facility in the Department of Anthropology, University of Auckland for independent replication of DNA extraction and amplification. The methods for DNA extraction used for these independent bone extractions were modified from that of Matisoo-Smith *et al.*, (1997).

The species were identified by submitting control region and cytochrome *b* sequences to the web-based program *DNA-surveillance* (Ross *et al.* 2003), as well as by BLAST searches of GenBank and by comparison to the unpublished sequences from other specimens of *Mesoplodon* sp. (Dalebout *et al.* 2007). Although the subsequent investigation by (Dalebout *et al.* 2012) associate these specimens with *M. hotaula*, we refer to them here as *Mesoplodon* sp., given the uncertain taxonomic ranking.

Results

Local use and skeletal remains

Tarawa Island. Attempts to collect information on cetaceans from around Tarawa (the location of the capital of Kiribati) proved unrewarding – there was little local or institutional knowledge. There were some cetacean artifacts from the local museum, showing ‘dolphin teeth’, sperm whale ambergris, and a whale vertebra. Of some interest was the whaling try pot in use as a water cistern, presumably an artifact of 19th century whaling contact. See also Figure 2A. No cetacean artifacts or skeletal material were collected from Tarawa Island.

Tabiteuea North Island. Tabiteuea Island has an extensive coastline and discussions with the locals suggested that strandings were common. Unfortunately, the teeth and bones are considered to have no value by the Islanders and are often used as fuel for fires. There was no evidence of remains from the seven whales killed in 2003. No samples were collected from Tabiteuea North Island.

Butaritari Island. Villagers reported incidental strandings of what were described as minke and sperm whales, based on reference to the identification guide. The teeth and ribs of sperm whale were displayed by the Islanders (Figure 2C). Islanders also reported the stranding of an unusual whale of approximately 4m in length, a pointed jaw and a full set of teeth in its lower jaw. Although the stranding had occurred in 2008, the jaw and teeth were still available and were contributed to the collection, along with a sperm whale tooth.

Onotoa Island. The Islanders reported that a whale stranded sometime in the previous two months at the northern tip of island. The whale was flensed and the meat was dried for eating. The bones were left on site as they are not considered of practical use by the Islanders. The whale was described by an elder who participated in the flensing, as about 4-5m in length, dark in color, lacking baleen or teeth and with a head like a swordfish. When shown a copy of *Whales and Dolphins of New Zealand and Australia, an Identification Guide* [Baker, Alan N. Wellington, NZ: Victoria University Press, 1999] the elder identified the whale as looking like a cross between the Andrew’s beaked whale [*M. bowdoini*] and the Indo-Pacific beaked whale [=tropical bottlenose whale, *I. pacificus*]. A number of vertebrae were collected from the site of the stranding and beachcombing revealed older material, including one skull and one partial skull and a number of vertebrae. Some strips of dried meat and 21 skeletal samples were collected from Onotoa Island: 11 vertebrae, 9 bone fragments, and one definite skull fragment.

Species identification of bones

In total, the June-July 2009 expedition to the outer islands was able to collect 24 samples, including one partial skull and a lower jaw with teeth and some dried skin attached, and one sperm whale tooth (Table 1). The strips of dried meat prepared for human consumption were also collected on Onotoa, but were destroyed by rats during storage in Tarawa and are not included in Table 1. The majority of samples (n = 21) were vertebrae and likely skull fragments collected from Onotoa Island (Figure 3B). Of the 21 bone samples, 11 yielded genetic material of sufficient quality for successful PCR-amplification of mtDNA fragments from the control region and/or cytochrome *b* and subsequent species identification (Table 1). Of these, 6 were independently replicated and confirmed by the collaborating laboratory. Seven of the vertebrae, all collected from Onotoa Island, were identified as the putative new species *Mesoplodon* sp. Three of the bone fragments (including a very dense fragment, thought to be part of a skull) were identified as a dense-beaked whale, *M. densirostris*, and a single vertebra was identified as a Cuvier’s beaked whale, *Z. cavirostris*. The lower jaw from Butaritari was confirmed to be from a pygmy sperm whale, *K. breviceps* (both teeth and dried skin from the jaw were used as a source of DNA). We were unsuccessful in extracting DNA from the large

tooth from Buritartari, but based on size and shape it is clear that it represents a sperm whale, *Physeter macrocephalus*.

Discussion

Local use

On each of the three outer islands of the Gilbert group, discussions with the elders (through translators with MELAD) confirmed the ongoing local use of cetaceans (including as food for human consumption), through either directed hunting or incidental takes and strandings. Descriptions offered by Islanders suggested that these strandings or takes regularly included beaked whales. Unfortunately, there appeared to be no cultural use of either the bones or teeth of cetaceans and so few artifacts are available for confirming the full extent of species involved in the subsistence use. In some villages, the bones are burned for fuel and, if teeth are recovered, these are sometime sold to fishermen from passing foreign vessels. We encountered no obvious evidence of the shamanistic practice of 'porpoise calling' documented by Sir Author Grimble during his experiences in the Gilbert Islands prior to World War II (Grimble 1952).

Species diversity

Our surveys provide new validated records of cetacean species around the remote islands of the Republic of Kiribati and confirm the continued local use of these species for human consumption. Other than the report of the putative species *Mesoplodon* sp. (Dalebout *et al.* 2012), only the sperm whale (Miller 2007), and the melon-headed whale (Robards and Reeves 2011) have been report to occur in this area. None of the species that we identified were listed in a recent summary of cetacean species used for human consumption in Kiribati (Robards and Reeves 2011). Our finding of further material from *Mesoplodon* sp. on the island of Onotoa suggests that, like Palmyra Atoll, the Gilbert Islands are likely to be a hotspot for this rare species of beaked whale, and raises concerns about its frequent stranding or potential exploitation for local consumption.

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Table 1: Cetacean material collected from the outer islands of the Gilbert group, in the Republic of Kiribati, with species identification based on mitochondrial (mt) DNA control region (D-loop, DLP) and cytochrome *b* (CYB) sequences. For samples where DNA extraction and subsequent PCR-amplification of mtDNA fragments was not successful, species identification is listed as “failed”. Sequence lengths in base pairs (bp) are shown for successful DNA identification. An asterisks* indicates samples for which DNA extraction and amplification were replicated by an independent laboratory (see text). Samples were collected by Al Hutt during surveys of the Gilbert Islands between 18 June to 14 July 2009, with the assistance of the Kiribati Ministry of Environment, Lands and Agricultural Development (MELAD) and Fisheries Division.

Sample code	Sample Description	Species identification from mtDNA	Island	DLP	CYB
KI001	Fragment	failed	Onotoa		
KI002*	Fragment	<i>Mesoplodon densirostris</i>	Onotoa	310 bp	219 bp
KI003	Fragment	failed	Onotoa		
KI004	Vertebra	<i>Mesoplodon</i> sp.	Onotoa		255 bp
KI005	Vertebra	failed	Onotoa		
KI006	Fragment	failed	Onotoa		
KI007	Fragment	failed	Onotoa		
KI008	Vertebra	<i>Mesoplodon</i> sp.	Onotoa	293 bp	
KI009*	Vertebra	<i>Ziphius cavirostris</i>	Onotoa		236 bp
KI010	Vertebra	failed	Onotoa		
KI011*	Vertebra	<i>Mesoplodon</i> sp.	Onotoa	293 bp	141 bp
KI012*	Vertebra	<i>Mesoplodon</i> sp.	Onotoa	293 bp	178 bp
KI013	Vertebra	<i>Mesoplodon</i> sp.	Onotoa	239bp	
KI014	Fragment - rib?	failed	Onotoa		
KI015	Vertebra	<i>Mesoplodon</i> sp.	Onotoa	239 bp	
KI016	Vertebra	failed	Onotoa		
KI017	Vertebra	<i>Mesoplodon</i> sp.	Onotoa		171 bp
KI018*	Fragment - skull?	<i>Mesoplodon densirostris</i>	Onotoa	309 bp	109 bp
KI019*	Skull fragment	<i>Mesoplodon densirostris</i>	Onotoa	204 bp	136 bp
KI020	Fragment - skull?	failed	Onotoa		
KI021	Fragment - scapula?	failed	Onotoa		
KI022	Tooth – sperm whale	failed	Butaritari		
KI023	jaw - teeth	<i>Kogia breviceps</i>	Butaritari		
KI024	jaw - dried skin	<i>Kogia breviceps</i>	Butaritari	487 bp	

Figure 1: The location of the Gilbert Islands, Republic of Kiribati, relative to other features of the central Pacific. Shown are the capital city of Bairiki, on the Island of Tarawa, and the three outer islands (Onotoa, Tabitauea North, and Butaritari) surveyed in this study.

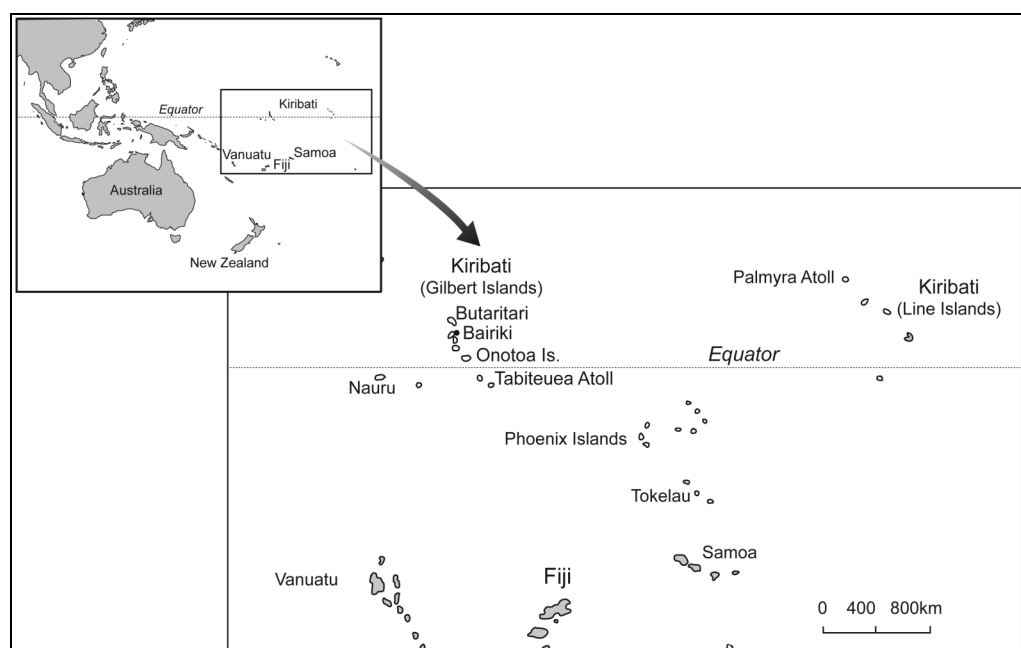


Figure 2: Whaling artifacts and cetacean bones collected during surveys of the Gilbert Islands from 18 June to 14 July 2009 (courtesy of Al Hutt). A) A whaling ‘try-pot’, a remnant of 19th century whaling contact. B) A vertebra (KI004, identified as *Mesoplodon* sp.) and rib bone (KI014, no DNA identification) collected on Onotoa Island. C) Jaw, rib and teeth of a sperm whale on display in Butaritari Island.

