The world's rarest whale

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The vast expanses of the South Pacific Ocean have, until recently, concealed the identity of the world's rarest whale, the spade-toothed beaked whale (*Mesoplodon traversii*). Based on the scarcity of records and the total absence of previous sightings, this species is the least known species of whale and one of the world's rarest living mammals. Two individuals of this species, previously known from only two skull fragments and a mandible, were recently discovered beach-cast in New Zealand. Although initially misidentified, we have used DNA analysis to reveal their true identity. We provide the first morphological description and images of this enigmatic species. This study highlights the importance of DNA typing and reference collections for the identification of rare species.

The South Pacific Ocean represents approximately 85 million km^2, covering around 14% of the Earth's surface [1]. This massive and poorly surveyed habitat has some of the deepest ocean trenches. Within this area are many rare deep-water species, including the enigmatic beaked whales (Family Ziphiidae). Very little is known of the life history of these cetaceans and whilst there are 21 recognized species, many are described from only a small number of records [2]. Beaked whales are thought to be exceptionally deep divers, foraging for squid and small fish and spending little time at the surface [3]. Due to similarities in their external morphology, species are very difficult to distinguish and, given their elusive habits, are rarely seen at sea.

New Zealand has an extensive coastline and is a known hotspot for whales stranding. It has one of the highest rates and greatest diversities of stranded cetacean species in the world [4], including 13 species of beaked whale, one of which is the spade-toothed whale [5]. The only previously known specimens of this whale were a single mandible with teeth from an adult male (the holotype), collected from the Chatham Islands, New Zealand in 1872 (Figure 1A), and two skulls without mandibles, one from White Island, collected in the 1950s (Figure 1A, S1) and one from Robinson Crusoe Island, Chile, collected in 1986 (Figure 1A).

In December 2010, a female (5.3 m) and a male (3.5 m) beaked whale stranded and subsequently

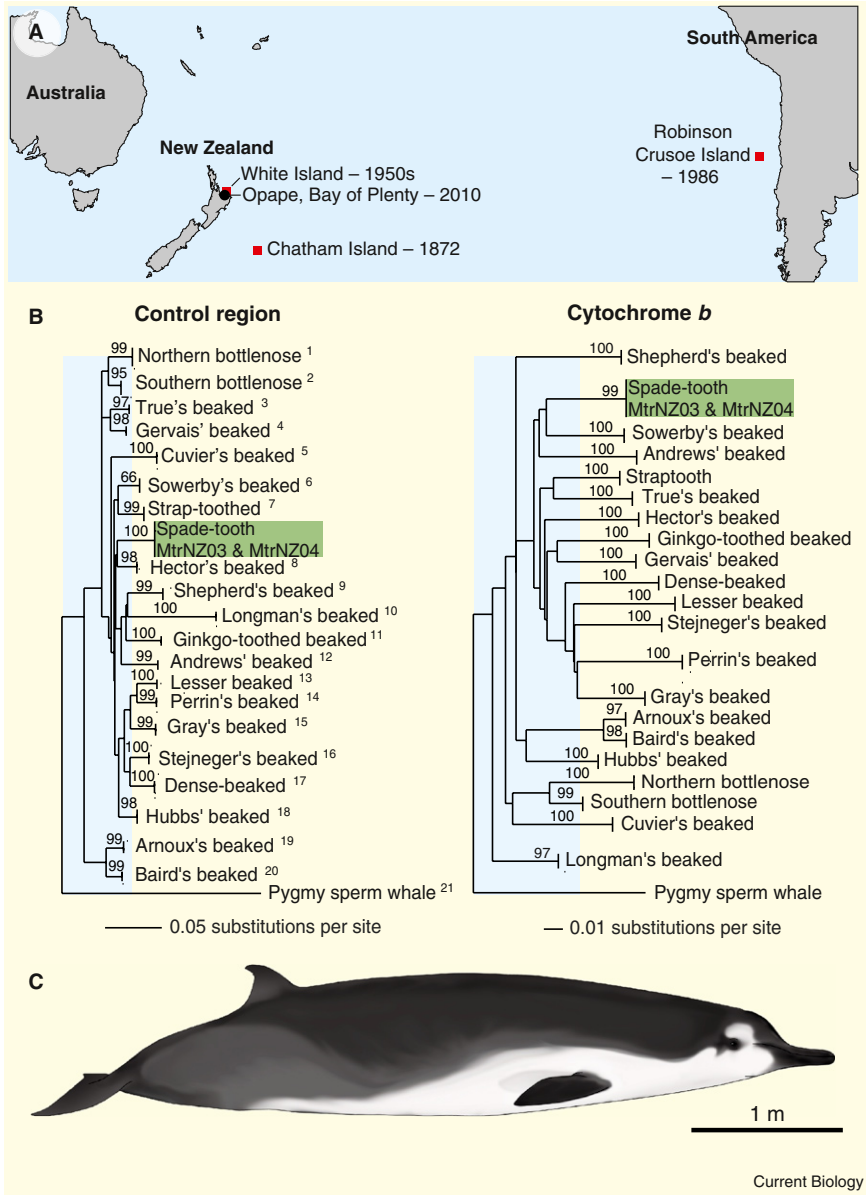

Figure 1. Location, species identification and morphology of the spade-toothed beaked whale (*Mesoplodon traversii*).
(A) Location of partial skulls found on the Chatham and White Islands, New Zealand, on Robinson Crusoe Island, Chile (red squares) and the two recently stranded specimens discovered on Opape Beach, New Zealand (black circle). (B) Neighbour-joining tree of control region and cytochrome *b* sequences from ziphiid species and the two Opape specimens (MtrNZ03 and MtrNZ04) group in a monophyletic clade (green box). Higher-level relationships within the blue shading are not well resolved. Bootstrap values are shown as percentages for a total of 1000 bootstrap replicates. The vertical bars denote several specimens included in the analysis. Scientific names are as follows: 1: *Hyperoodon ampullatus*; 2: *H. planifrons*; 3: *M. mirus*; 4: *M. europaeus*; 5: *Ziphius cavirostris*; 6: *M. bidens*; 7: *M. layardii*; 8: *M. hectori*; 9: *Tasmacetus shepherdi*; 10: *Indopacetus pacificus*; 11: *M. ginkgodens*; 12: *M. bowdoini*; 13: *M. peruvianus*; 14: *M. perrini*; 15: *M. grayi*; 16: *M. stejnegeri*; 17: *M. densirostris*; 18: *M. carlhubbsi*; 19: *Berardius arnuxii*; 20: *B. bairdii*; 21: *Kogia breviceps*. (C) Illustration depicting a generalized external morphology derived from photographs of the adult female spade-toothed beaked whale (see supplemental information for photographs).

died on Opape Beach, New Zealand (38°5′S, 177°17′E). Staff from the New Zealand Department of Conservation photographed the animals after death and collected morphometric measurements and tissue samples.

From their initial description the whales were identified as Gray's beaked whales (*M. grayi*), the most commonly stranding ziphiid around New Zealand. However, to confirm their identity, we amplified and sequenced two mitochondrial DNA regions (control region and cytochrome *b*) (GenBank JX901028, JX901029). The sex of the specimens was confirmed by amplification of a short region of the male-specific SRY gene with a ZFX/Y gene control found in both males and females.

Surprisingly, a comparison with sequences from the holotype and the other two reference specimens revealed that both whales were not Gray's beaked whales, but rather the previously unseen spade-toothed whale [5]. Control region sequences for both beach-cast specimens matched the holotype sequences (99% pairwise identity, GenBank AF439992), and a neighbour-joining tree provided robust support (100% bootstrap) for a species-specific clade (Figure 1B). This result was verified with a 400-bp region of cytochrome *b*, which showed 100% pairwise identity to the holotype sequence (GenBank AY579555) with 99% bootstrap support (Figure 1B).

It is particularly difficult to distinguish between different species of beaked whales using external morphological characters alone, especially in New Zealand where diversity is high [6]. Traditional descriptions of beaked whale species focus on the position and characteristic shape of the erupted teeth of mature males. However, this is not a useful diagnostic character for females and juveniles as the teeth are not erupted. Species diagnosis using color patterns is also problematic due to their rapid deterioration *post mortem*. Consequently, over the last two decades an increased emphasis has been placed on genetic information to complement morphometric data and photographic records. The results of these collections continue to reveal surprises about this rare and cryptic family of cetaceans.

Photographs show that the adult female spade-toothed whale has a similar mouth-line, dorsal fin and pectoral flipper shape to the Gray's beaked whale. However, it can be distinguished by the following features. The melon is more prominent and more similar to the straptoothed beaked whale (*M. layardii*), and the coloration of the rostrum is dark gray or black, rather than white as in adult Gray's beaked whales. Also notable is a dark eye-patch, the white belly and dark flippers (Figure 1C; Supplemental information). However, the long rostrum of this animal with its dark coloration does not distinguish this species from juvenile Gray's beaked whales (Supplemental information). The second animal has a color pattern characteristic of most juvenile mesoplodont beaked whales, making species identification in the field more difficult.

Based on its scarcity, only two intact animals having been seen in the last 140 years, the spade-toothed whale is the world's rarest whale. Once the stranded animals were genetically identified, the skeletal remains were exhumed and taken to the Museum of New Zealand Te Papa Tongarewa for further morphological analysis. The discovery of these specimens highlights the importance of DNA identification in conjunction with the collection of specimens and photographs from beach-cast animals. New Zealand is unique in that it has developed a co-ordinated national response to cetacean strandings. The public notifies the Department of Conservation, and after rescue attempts, stranding information is recorded by the Department of Conservation and the Museum of New Zealand Te Papa Tongarewa, and tissue samples are retained in the New Zealand Cetacean Tissue Archive [7]. This long-term strategy operates in collaboration with indigenous peoples and university scientists and has resulted in the accumulation of 20 years of specimens and records on rare species.

Rapid advances in DNA technology are having a profound effect on our understanding of the natural world and have added value to museum and other reference collections. This has been particularly important in the field of conservation biology, where losses in biodiversity are increasingly evident [8]. We can now confirm that the spade-toothed whale is extant (Supplemental information), and for the first time we have a description of the world's rarest and perhaps most enigmatic marine mammal.

Supplemental Information

Supplemental Information including experimental procedures and two figures can be found with this article online at http://dx.doi.org/10.1016/j.cub.2012.08.055.

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