Review of current knowledge on *Mesoplodon densirostris* in the North Pacific and North Indian oceans, including identification of knowledge gaps and suggestions for future research

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1 INTRODUCTION

This working paper summarizes current knowledge of the species *Mesoplodon densirostris* in the North Pacific and North Indian Ocean, and includes recommendations for future research.

2 TAXONOMY AND NOMENCLATURE

Scientific name: ***Mesoplodon densirostris* (Blainville, 1817)**
Vernacular names: Blainville's Beaked Whale, Dense-beaked Whale

Delphinus densirostris, Blainville 1817:178. Type locality unknown (Laboratoire d'Anatomie comparée du Muséum national d'Histoire naturelle, Paris - CAC: A. 3552).

Ziphius sechellensis, Gray 1846:28, pl. 6, figs 1,2. Type locality Seychelles Islands.

Dioplodon densirostris, Gervais 1850:16. Type species *Delphinus densirostris*, Blainville 1817.

Mesodiodon densirostre, Duvernoy 1851. Included species *Delphinus densirostris,* Blainville 1817.

M[esoplodon] densirostris, Flower 1878:684. First use of current name combination.

Nodus densirostris, Galbreath 1963:422. Use of *Nodus* Wagler 1830 as a senior synonym of *Mesoplodon* Gervais 1850. Melville (1985) suppressed *Nodus* and conserved *Mesoplodon*.

Order Cetacea, Suborder Odontoceti, Family Ziphiidae. There are 14 (15 including *M. hotolua*) species recognized in the genus Mesoplodon. Gervais (1850) erected the genus *Dioplodon* for *M. densirostris*. *M. densirostris* is monotypic (Mead and Brownell, 2005).

3 DISTRIBUTION, POPULATION STRUCTURE AND MOVEMENTS

Distribution:

M. densirostris has the most extensive distribution of the *Mesoplodon* species. They range from tropical and warm-temperate waters of all oceans, including offshore, deep waters, tropical oceanic archipelagos, and on continental or insular coasts along which warm currents flow. There are no records of either sightings or strandings from polar or other high-latitude regions. *M. densirostris* are seen infrequently at sea, and positive identifications in the field can be difficult unless key diagnostic characters of the head are observed. As a result, knowledge of the distribution of this species has been inferred almost entirely from stranding records, and conclusions drawn from records of stranded animals must be viewed with caution; firm distributional conclusions should only be made when an area possesses a large sample size of strandings that remains temporally consistent. Photo-identification and tagging studies are possible in areas where these whales are known to reliably occur, typically around oceanic island groups such as the Bahamas Islands (Claridge et al. 2009), the Canary Islands (Johnson et al. 2007), and the Hawaiian Island (Schorr et al. 2009).

In the eastern North Pacific, sighting records of this species range from California (Carretta et al. 2012) to the offshore waters of the Pacific EEZ of Costa Rica (May-Collado et al. 2005). Sightings and strandings in the central North Pacific are known from the Hawaiian Islands, including Oahu, Hawaii, Molokai, Kauai, and Laysan islands, as well as the Society Islands, the Line Islands, Midway Atoll. The first stranding of *M. densirostris* reported from Sand Island (Midway) occured in 1961 (Galbreath 1963).

Strandings have been reported from the western North Pacific in the Philippines, Taiwan, the Ryukyu Islands, Kuroshima, Korea (southern peninsula), China, and Honshu, Japan (Kasuya and Nishiwaki 1971, Miyazaki 1986, Kim et al. 2000, Wang and Yang 2006). Records of *M. densirostris* in the northern Indian Ocean are from Nicobar Island (Evans 1987, Corbet and Hill, 1992), Sri Lanka (Ilangakoon 2002), the Republic of Maldives (Anderson 2005, Ballance et al. 2001), and from equatorial waters around the Seychelles (Besharse 1971, Sathasivam 2004). As elsewhere, the lack of data from this region is probably due at least in part to low observer effort.

Population structure:

Despite the wide distribution of the species, local populations of *M. densirostris* appear to be small in areas where long-term studies area possible, such as Hawaii, El Hierro (Canary Islands), and the Bahamas. Recurrent sightings of this species have enabled researchers to use photo-ID data for mark-recapture studies of population abundance; preliminary best estimates are around 144 whales in Hawaii (Baird et al. 2007). Three *Mesoplodon* stocks are defined in the North Pacific for the U.S. Marine Mammal Protection Act (MMPA) stock assessment reports: 1) all *Mesoplodon* species off California, Oregon and Washington, 2) *M. stejnegeri* in Alaskan waters, and 3) *M. densirostris* in Hawaiian waters. Two stocks of *M. densirostris* are recognized in U.S. North Pacific waters: the Hawaiian stock and the California/ Oregon/ Washington stock (defined as Mesoplodont beaked whale stock, which potentially includes six *Mesoplodon* species – *M. densirostris*, *M. perrini*, *M. peruvianus*, *M. stejnegeri*, *M. gingkodens*, and *M. carlhubbsi*). Although not ideal, the management unit is defined to include all *Mesoplodon* stocks occuring in this region until methods of distinguishing these six species are developed. Insufficient sighting records exist off the U.S. west coast to determine any possible spatial or seasonal patterns in the distribution of mesoplodont beaked whales.

Group size and composition:

Shallenberger (1981) reported on pods of three to seven *M. densirostris* sighted off Hawaii, one of the earliest reports suggesting that a small group size may be typical. Tagging studies and resights of individuals spanning over 15 years suggest long-term site-fidelity of a small island-association resident population of *M. densirostris* in waters near the west coast of the island of Hawaii (Baird et al. 2009a, b, McSweeney et al. 2007, Schorr et al. 2009). Adult females were primarily documented long-term, although most groups had only a single adult male present (McSweeney et al. 2007). Shallenberger (1981) reported on pods of three to seven *M. densirostris* sighted off Hawaii, one of the earliest reports suggesting that a small group size may be typical of this species, which is supported by the small group sizes repeatedly observed by McSweeney et al. (2007) near Hawaii and in other areas of the world where long-term studies are possible (i.e., Great Abaco Island in the northern Bahamas, Claridge 2006; El Hierro in the Canary Islands, Aguilar de Soto 2006). All resightings of adult males suggested repeated associations between adult females and adult males, occurring over periods from 1 to 154 days (McSweeney et al. 2007). Repeated associations among adult females were also observed, as much as 9 years apart; however, individual adult females were seen separately in intervening years. Resightings of individuals occurred over multiple months and seasons (McSweeney et al. 2007).

Movements:

Movements of eight satellite-tagged animals, lasting 15-71 days, showed no movements from the west side of the island of Hawaii to the east side of the island despite the availability of similar deep-water habitat; maximum displacement from tagging location for any individual was only 139 km (Schorr et al. 2009). Overall movement patterns and resightings of individuals suggest long-term site fidelity and a strong association of this population with the habitat off the west side of the island of Hawaii, which could have implications for population structure, management, and susceptibility of such small populations to human impacts (McSweeney et al. 2007, Schorr 2009).

Schorr et al. (2009) summarize the movements of 8 Blainville's beaked whales, 3 adult males and 5 adult females, satellite-tagged during November-December 2006 and July 2008. Movement rates were low, and despite cumulative distances greater than 2000 km, all individuals remained relatively close to the original tagging site over periods up to 71 days (Schorr et al. 2009). All tagged whales utilized similar depths (grand mean depth = 1,156 m, range = 880 to 1,455 m, n = 6) and showed a distinct association with the slope of the island of Hawaii; the range of slopes varied between 0 and 41°, with whales spending most of their time both on the shelf and in areas of steep bathymetry (Schorr et al. 2009). There was no movement to the east side of the island. Baird et al. (2009a) reported on an additional single adult male *M. densirostris* that was satellite tagged in the waters off the west side of the island of Hawaii during the spring of 2009. This animal and the two other individuals in the group had not been previously photo-identified, and were initially encountered further offshore (31.3 km) and in deeper water (3,500 m) than the other 8 tagged individuals reported by Schorr et al. (2009). Over the 40 day tagging period, this individual approached closer to shore, then traveled 1,008 km from the initial tagging location in waters averaging 4,702 m deep, a depth more than three times greater than that recorded from the eight previously tagged whales from the island-associated population (Baird et al. 2009a). Currently, only one stock of Blainville's beaked whales is recognized within the U.S. EEZ surrounding the Hawaiian Islands (Carretta et al. 2012). Based on the lack of associations, deep-water habitat use, and movement patterns of the tagged whale reported in Baird et al. (2009a), this may suggest the presence of two stocks in the U.S. EEZ around Hawaii, and open-ocean population and an island-associated population (Schorr et al. 2009). These studies (Baird et al. 2009a, McSweeney et al. 2007, Schorr et al. 2009) demonstrate the importance of individual photo-identification for interpreting movement patterns and populations of beaked whales, and supports the need for genetics studies in defining stock structure, understanding stock-specific resource requirements, and measuring impacts of potential risks to individual stocks.

Behavior – Diving and Acoustics

Diving behavior of four *M. densirostris* whales in Hawaiian waters was studied using suction-cup-attached time-depth recorders (Baird et al. 2007). Mean dive depth was 922 m, with a maximum depth of 1,408 m for durations as long as 48-68 min during routine dives that exceeded 800 m, dive depths similar to those recorded by this species off the Canary Islands (Johnson et al. 2004). Although no noticeable difference between ascent and descent rates was detected for short dives, ascent rates for long, deep dives were significantly slower than descent rates (Baird et al. 2007). These whales also spent extended periods of time (approximately 1-2 hr) near the surface (less than 50 m), and had an increase in the number of respirations before and after long dives, presumably in preparation for and to recover from long dives. Foraging dives from individuals tagged with time-depth recorders occur over the shelf and further south, where a steeper bathymetry exists, suggesting that a specific slope angle does not influence foraging strategies or prey availability for this population (Baird et al. 2007, 2008; Schorr 2009). No significant diel variation in foraging dive depth or rate was observed, although tagged whales did spend more time at depths <100 m between foraging dives at night than during the day (Baird et al. 2008). A similar pattern was also observed for Blainville's beaked whales off the Canary Islands where long foraging dives were performed during both the day and night, separated by an average of 1.5 hrs (Aguilar de Soto 2006).

Most acoustic data on Blainville's beaked whales is known from whales tagged with multi-sensor orientation and acoustic tags (DTAGS) in waters around the Canary Islands and Bahamas (Johnson et al. 2004, 2006, 2007; Madsen et al. 2005; McCarthy et al. 2011). These tags demonstrate that *M. densirostris* echolocate for prey during deep foraging dives, including search, approach, and terminal phases (Johnson et al. 2004, 2006, 2007; Madsen et al. 2005). DTAGs were used to record high-frequency clicks (click duration ca. 250 µs) produced by Blainville's beaked whales in waters near the Canary Islands during deep dives; tagged whales only clicked at depths below 200m and clicked almost continuously while at depth (Johnson et al. 2004). On decent, tagged whales started clicking at an average depth of 400 m (range of 200-570 m) and stopped clicking at an average depth of 720 m on ascent (range of 500-790 m) (Johnson et al. 2004). Two distinct types of click sounds were produced: search clicks and buzz clicks (Johnson et al. 2006). *M. densirostris* produces numerous short, directional, ultrasonic clicks (no significant energy below 20 kHz); clicks have a relatively flat acoustic spectrum and a sharp low-frequency cut-off, with 0.2 to 0.4 s intervals between clicks (Johnson et al. 2004). Regular click patterns of tagged whales often terminate with a rapid increase in click rate, up to nearly 250 clicks per second; Johnson et al. (2004) defined this acceleration as a "buzz". Echoes from prey items suggest that the source level of *M. densirostris* clicks is in the range of 200-220 dB re 1µPa at 1 m. The inter-click interval of search clicks ranged between 0.2 and 0.4 s with trains of regular clicks ending in a short burst, rapid increase in click rate, or "buzz", as much as 250 clicks/ sec (Johnson et al. 2004, 2006, 2007). Buzzes were presumed to signify pursuit of prey since they were associated with a rapid acceleration of the tagged whale and terminated in impact sounds 65% of the time; an average of 23 buzzes was recorded per foraging dive with regular clicking resuming after the end of each buzz (Johnson et al. 2004). Data analyses from DTAGs, which record both outgoing echolocation clicks and echoes returning from mesopelagic prey, demonstrate that the clicking rate at the beginning of buzzes is related to the distance between whale and prey, supporting the presumption that whales focus on a specific prey target during the buzz (Johnson et al. 2007).

Click sounds, described from airborne vocalizations as "whistles" and "chirps", have been previously reported for *M. densirostris* (Caldwell and Caldwell 1971); however, these recordings were made with a limited bandwidth. In addition to the high-frequency clicks >20 kHz (Johnson et al. 2004), mid-frequency sounds have been recorded in close proximity to a group of *M. densirostris* off the Hawaiian Islands, including one frequency-modulated whistle, and three frequency- and amplitude-modulated pulsed sounds, with energy between 6 and 16 kHz (Rankin and Barlow 2007). Acoustic vocalizations similar to those made by *M. densirostris* were detected at Cross Seamount southwest of Hawaii during April through October, with most detections occurring at night, suggesting that seamounts may be a habitat feature affecting the presence of beaked whales (Johnston et al. 2007).

DTAGs attached to *M. densirostris* recorded high frequency clicks during deep dives; tagged whales only clicked at depths below 200m and clicked almost continuously while at depth (Johnson et al. 2004). On decent, tagged whales started clicking at an average depth of 400 m (range 200 - 570 m) and stopped clicking at an average depth of 720 m on ascent (range of 500 – 790 m). *M. densirostris* produces numerous short, directional, ultrasonic clicks (no significant energy below 20 kHz); clicks have a relatively flat acoustic spectrum and a sharp low-frequency cut-off, with 0.2 to 0.4 s intervals between clicks (Johnson et al. 2004). Regular click patterns of tagged whales often terminate with a rapid increase in click rate, up to nearly 250 clicks per second; Johnson et al. (2004) defined this acceleration as a "buzz". Echoes from the bottom and from prey in the water column were recorded on the tag from clicks produced by the tagged whale, with the prey echoes often detectable immediately prior to buzzes and regular clicking resuming after the end of each buzz. Buzzes are often associated with an increase in acceleration of the tagged whale, and 65% of buzzes ended with impact sounds, suggesting buzzes are closely associated with a sudden movement and attempt to capture prey (Johnson et al. 2004). An average of 23 buzzes was recorded per foraging dive of tagged whales (Johnson et al. 2004). Results from a multi-sensor DTAG, which records both outgoing echolocation clicks and echoes returning from mesopelagic prey, demonstrate that the clicking rate at the beginning of buzzes is related to the distance between whale and prey, supporting the presumption that whales focus on a specific prey target during the buzz (Johnson et al. 2008).

4 LIFE HISTORY PARAMETERS

Life history

The maximum reported lengths for males and females are 473 cm and 471 cm, respectively (Mead, 1984), both of which are specimens that stranded along the Indian Ocean coast of South Africa reported in Ross (1984). Minimum age at sexual maturity recorded in a female was 9 years based on the number of GLGs in the teeth in addition to the presence of one corpus albicans in the ovaries, indicating the animal had recently become sexually mature (Mead 1984; Ross 1984). Mead (1984) reported a weight of 27 g for the testis of an immature male and a minimum weight of the ovaries at sexual maturity is 12 g; maximum weight of ovaries is 25 g, with a total mean weight of ovaries of 14 g. The longest recorded fetus length was 190 cm (Mead 1984), and the length of the shortest known calf was 261 cm (Smithsonian Institution, Cetacean Distributional Database accessed 05 June 2012). The length of the periods of gestation and lactation have not been determined.

The relative age of an individual specimen can be approximated from the state of mesorostral ossification, although this character is sexually dimorphic with adult males developing a hyperdense ossification of the rostral bones (Forbes 1893, Moore 1963, Heyning, 1984, Lambert et al. 2011). Although several hypotheses have been proposed (acoustic reflector, Cranford et al. 2008; dynamic ballast to aid in deep-diving, de Buffrenil et al. 2000; reinforcement during intraspecific fights, Heyning 1984; MacLeod 2002) no satifactory explanation has entirely supported the reason for the extreme sexual dimorphism in the hypermineralization of the rostral bones in adult males of this species. No significant intraspecific difference has been observed to date that would suggest different acoustic requirements, echolocation, swimming style, or dive depths of adult males, adult females, and juveniles, and the high mineral content of the hyperdense rostrum would be more susceptible to fracture and unsuited to impact loading (Lambert et al. 2011). Perrin and Myrick (1980) determined that absolute age estimation is most reliable by reading the growth layer groups (GLGs) in the cement; dentine deposition ceases or becomes irregular at a relatively early age, making an absolute age estimate using the dentine GLGs less accurate. It is assumed that GLG deposition occurs annually as it does in many other odontocete species; however, there are presently no data to confirm this assumption in this species. The accelerated development and eruption of the teeth of adult males occurring near the onset of sexual maturity will need to be considered in the interpretation of GLGs in adult males (Heyning, 1984).

M. densirostris commonly exhibit superficial linear scarring matching the tooth pattern of conspecifics (Heyning, 1984; Mead, 1989). These scars are observed most frequently on the dorsal body of adult males, suggesting that these wounds are inflicted during intraspecific combat (Heyning 1989, Mead 1989). Only male *M. densirostris* exhibit a single pair of erupted teeth in the lower jaw, leading many to speculate that this feature has evolved through sexual selection. MacLeod (1998) suggested scars caused by intraspecific interactions may serve as an indicator of male “quality” during aggressive interactions.

Diet:

Squid has been described as the primary prey of beaked whales; however, large quantities of other invertebrates and fish may also be consumed (Ross, 1979; Mead, 1989; Heyning and Mead, 1996, MacLeod et al. 2003). Most information about the diet of *M. densirostris* has been obtained from the stomach contents of stranded specimens, to which investigators should apply the usual caveat that stranded animals may not reliably represent the overall population. The stomach of an adult female Blainville's beaked whale that stranded in South Africa contained 21 fish otoliths, identified as coming from *Cepola sp.* (1), *Scopelogadus sp.* (1), and *Lampanyctus sp.* (19) (Ross, 1979). Another *M. densirostris* from South Africa had two squid beaks in its stomach, identified as coming from *Todarodes sagittatus* and *Octopoteuthis sp.* (Ross, 1979; Aguilar et al., 1982). MacLeod et al. (2003) summarized the stomach contents reported in the literature of 3 specimens of *M. densirostris*, one from South Africa which primarily consisted of hake and other unidentified fish species, *Ptrygosquilla armata*, and *Lepidopus caudatus*, another from Wales consisting of remains from only *Histioteuthis reversa*, and a third specimen from Brazil which contained 100% plastic threads in the stomach. Preliminary analyses of the stomach contents of three *M. densirostris* uncovered no fish remains, and trace quantities of squid beaks (Mead, 1989). Based on the sparse nutritive data available, it appears that the diet of *M. densirostris* may be more extensive than the existing data suggest, although mesopelagic squid and fish seem to comprise the bulk of their diet. MacLeod et al. (2003) found the diet of Mesoplodon spp. to consist primarily of cephalopods from the families Cranchiidae, Histioteuthidae, and Gonatidae, as well as a large proportion of bottom-dwelling and deep-water fish species, and some crustaceans.

Predation and Parasites:

There are no documented observations of predation on *M. densirostris*. Long and Jones (1996) summarize white shark predation and scavenging on cetaceans; no known cases of predation were reported, although scavenging on *Ziphius cavirostris* and *Mesoplodon spp*. carcasses does occur. McSweeney et al. (2007) report on an individual photographed off Hawaii with scarring from a large shark bite. Well-healed tooth rake scars were observed on both sides of the ventral surface of the caudal peduncle of an adult female (USNM 504217) that stranded at Buxton, North Carolina (Mead, 1989). Based on the tooth spacing of at least 2 cm, either *Orcinus orca* or *Pseudorca* *crassidens* are believed to be the source of these marks although there was no evidence of serious injury resulting from infliction.

Conchoderma auritum, stalked barnacles, occur on the teeth of *M. densirostris* (Mead 1989). *Conchoderma spp*. have been reported on *M. densirostris* worldwide, including off South Africa, Hawaii, North Carolina (USA), and Chile (Pringle 1963, Ross 1984, Minasian et al. 1984, Mead 1989, Pastene et al. 1990), which can be mistaken for seaweed when desiccated (*e.g.*, Pringle 1963). Such barnacles attach only to hard surfaces; thus, the protrusive teeth of males are a suitable substrate for this commensal. A photograph taken off Hawaii of an adult male *M. densirostris* with clumps, about 10 cm wide, of cf. *Conchoderma* attached to each tooth can be found in Minasian et al. (1984:116). Additional photos of Conchoderma present on the teeth of beaked whales off Hawaii are available from the Hawaii Cetacean Studies website hosted by Cascadia Research Collective (http://www.cascadiaresearch.org/hawaii/beakedwhales.htm). Pastene et al. (1990) described colonies of *Conchoderma auritum* that encrusted the teeth of either side of the lower jaw of a *M. densirostris* that was killed by fishermen of Pargua Bay, Chile. Other reports of barnacles occurring on *M. densirostris* include a report by G. J. B. Ross of *Xenobalanus* and an unidentified balanoid barnacle, deeply embedded on the flank of the whale stranded in South Africa.

Known parasites of *M. densirostris* include unindentified adult cestodes that infected the proximal intestine of a juvenile male that stranded in New Jersey (Mead 1989:417). Nematodes, *Anisakis spp*., have been found in the stomachs of *M. densirostris* from Spain, South Africa, and New Zealand and acanthocephalan (*Bolbosoma vasculosum*) has been found in the intestines (Iglesias et al. 2008, Mattiucci et al. 2009). *Xenobalanus* and *Phyllobothrium* cysts in the blubber and have also been reported at necropsy in specimens in the Smithsonian Institution NMNH collection.

Oval scars, usually 4 - 8cm in diameter, are frequently observed on the body of *M. densirostris* (Mead 1989:385). These scars are presumed to result from bites made by the small cookie-cutter or cigar shark. Photographs of multiple unsuccessful *Isistius* bites, resulting in faint crescent marks on a specimen of *M. densirostris* from California, are presented in Schonewald (1978:28). Additional photos of *M. densirostris* with recent and well-healed *Isistius* lesions can be seen on the Hawaii Cetacean Studies website hosted by Cascadia Research Collective (http://www.cascadiaresearch.org/hawaii/beakedwhales.htm). The parasitic copepod *Penella* can also cause punctate or oval scars in *M. densirostris*.

5 ABUNDANCE AND TRENDS

5.1 Abundance

Very little is known about abundance of *M. densirostris* in the North Pacific and North Indian oceans. Based on a 21-year photo-identification dataset, a minimum of 59 distinctive or very distinctive (“marked”) individuals are known to occur off the west coast of the island of Hawai’i (McSweeney *et al.* 2007). Baird et al. (2009b) updated this count, reporting an estimate of 125 marked individuals in this population based on pooled 2003/2004 and 2005/2006 data, with a point estimate of 140 individuals based on the proportion of marked individuals (0.89; CV = 0.19). It is highly likely that sampling includes individuals from both an island-associated population and an offshore population (Baird et al. 2009b). Long-term site fidelity and year-round occurrence in this area is supported by resights of individuals spanning a 15 year period (McSweeney et al 2007). Adult females represented most of the long-term resightings that were documented.

Abundance and density estimates of beaked whale species are difficult due to difficulty in identifying species, the affect of sea state on detection rates, and the long duration and depth of dives (Barlow et al. 2006). A ship-based line-transect survey was conducted by NOAA in 2002 in the U.S. EEZ around the Hawaiian Islands resulted in an abundance estimate of 2,872 (CV=1.17; PBR=13) Blainville’s beaked whales; this estimate is based on three sightings made during the 2002 survey, includes a correction factor for unobserved diving animals, and is the best available abundance estimate for the U.S. Hawaiian stock (Barlow 2006; Carretta *et al.* 2012). An abundance estimate of Blainville’s beaked whales in the California, Oregon, and Washington stock is based on a single sighting that occurred during the 2005 and 2008 survey (Carretta *et al.* 2012). This individual was identified as a ‘probable’

Mesoplodon densirostris, resulting in an abundance estimate of 603 (CV=1.16). The combined estimate of abundance (based on 5 sightings) for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nmi is 1,024 (CV=0.77; PBR=5.8) animals, which does not include sightings of 'unidentified beaked whales' due to the possibility of the inclusion of sightings from other genera (Carretta *et al.* 2012). Beaked whale habitat in the eastern tropical Pacific Ocean may encompass a broader definition than previously proposed, ranging from the continental slope to the abyssal plain and in waters ranging from well-mixed to highly stratified (Ferguson et al. 2006).

No estimates of abundance exist for *M. densirostris* for other areas of the North Pacific or Indian oceans.

5.2 Trends

No data are available regarding trend in abundance due primarily to the rarity of sightings and challenges in making species-level identifications of *Mesoplodon spp*.

6 DIRECT REMOVALS

6.1 Directed takes

No known fisheries exist that regularly target *Mesoplodon*. Directed takes of *M. densirostris* are not common, although they are occassionally taken by small-scale harpoon fisheries (e.g. Kasuya and Nishiwaki, 1971). Kasuya and Nishiwaki (1971) and Miyazaki (1986) reported on two specimens in the National Science Museum, Tokyo collection that were captured in 1968 and taken to market in Taiwan. A capture of a single animal off Pamilacan Island, Philippines occurred in 1992 and reported by S. Leatherwood (in litt. 28 May 1992) to J. Mead (Smithsonian Institution, archived correspondances and Cetacean Distributional Database, accessed 04 June 2012) . A juvenile male *M. densirostris* was captured in 1986 off Japan and held at an aquarium for 6 days (Brownell, R.L. pers. comm. 6 Jan 1987; Uchida in litt. 18 Jun 1987; Smithsonian Institution, Cetacean Distributional Database, accessed 04 June 2012).

6.2 Incidental takes

Mesoplodon are incidentally taken by fisheries around the world, particularly drift gillnet fisheries and longline fisheries (Forney 2004, Henshaw et al., 1997; Mead, 1989). It is unclear whether these entanglements occur from the whales randomly encountering nets that they did not know were there, or whether these individuals were attracted to the catch that were in the nets. Due to the difficulty of making reliable species identifications in the field, the varying level of taxonomic training of fisheries observers, and the limited knowledge of beaked whale population dynamics, the impact of fishery mortality on specific beaked whale populations has been difficult to assess (Henshaw et al., 1997). Use of acoustic pingers appears to have eliminated the bycatch of beaked whales in a California drift net fishery since their initial use in 1996 (Barlow and Cameron 2003, Carretta *et al.* 2008); however, occasional serious injuries and mortalities in fisheries still occur and some stranded beaked whales present with signs of potential entanglement (Waring *et al.* 2009, Carretta *et al.* 2012).

Incidental take estimates of U.S. MMPA beaked whale stocks are reported in the U.S. Pacific Marine Mammal Stock Assessment Reports based on the most recent 5-year period (Caretta et al. 2012). Between 2004 and 2008, no Blainville's beaked whale was observed killed or seriously injured in the shallow-set longline fishery (100% observer coverage) or the deep-set longline fishery (DSLL, 20-28% observer coverage) (Forney 2009, McCracken and Forney 2010) and one Blainville's beaked whale was observed taken, but not seriously injured, in international waters in the DSLL fishery (20-28% observer coverage) (McCracken & Forney 2010). Average 5-yr estimates of annual mortality and serious injury for 2004-2008 are 0.7 (CV=0.9) Blainville's beaked whales outside of the U.S. EEZs, and zero within the Hawaiian Islands EEZ (Caretta et al. 2012).

Baker *et al.* (2006) used molecular methods, including mitochondrial DNA control region or cytochrome b sequences and the web-based program DNA-surveillance, to identify the species of whale-meat products purchased from Korean markets between late 2003 to early 2005. The 357 samples analyzed originated from 15 species of cetaceans, including three beaked whale species: *M. densirostris*, *M. stejnegeri*, and *Ziphius cavirostris*. It is assumed these meat products were obtained from incidental fisheries mortalities (“bycatch”) reported by the Korean government to the IWC, the only legal source of these products. In 1963, an adult male Blainville’s beaked whale was incidentally taken by the Japanese tuna fleet operating in waters off the Seychelle Islands (McCann 1963). This species has also been incidentally taken by fisheries off Sri Lanka (Ilangakoon, 2002).

7 OTHER ACTUAL AND POTENTIAL THREATS

Moderate levels of organochlorine residues (DDT and PCBs) have been found in *M. densirostris* (Taruski et al., 1975; Aguilar et al., 1982). Levels of both DDTs and PCBs appear to be lower in beaked whales than in other cetaceans. Alzieu and Duguy (1979) suggested that a teutophic diet could result in lower pollutant levels; however, findings from stomach content analysis suggest a more extensive diet for beaked whales, concluding that other biological factors may account for a relatively low organocontaminant load.

Plastic is occasionally found in the stomach contents of stranded beaked whales. Secchi and Zarzur (1999) reported on a 419 cm female Blainville’s beaked whale stranded in Brazil that had no contents in the stomach other than plastic threads. The stomach of a 361 cm female stranded along the U.S. Atlantic coast (NJ) was empty except for 14 grams of plastic wrapping impacted in the anterior opening of the stomach, and the blubber layer appeared thin; a 420 cm male stranded along the U.S. Atlantic coast (NY) contained one plastic bottlecap in the stomach (Smithsonian Institution, Cetacean Distributional Database, accessed 04 June 2012).

Live mass strandings of beaked whales, including *M. densirostris*, coinciding with military activity have occurred in several locations, including Fuerteventura, Canary Islands and Bahamas (e.g., Cox *et al.* 2006; Fernandez *et al.* 2004, 2005; Simmonds and Lopez-Jurado, 1991; Tyack et al. 2011; U. S. Department of Commerce and U. S. Navy 2001). These strandings are usually associated with the use of mid-frequency sonars and are atypical, involving multiple animals and often a mixed-species mass stranding. Tyack et al. (2011) found that tagged *M. densirostris* whales stopped echolocating during deep foraging dives, broke from foraging dives with long, slow ascents, and moved away when exposed to both multi-day naval exercises involving tactical mid-frequency sonars as well as playbacks of simulated sonar sounds. Whales returned to the study area 2-3 days after the sonar exercises ended, suggesting these sounds led to disruption of foraging and avoidance behavior. McCarthy et al. (2011) noted that vocal activity of foraging groups of *M. densirostris*, as determined by the detection of echolocation clicks, declined during active sonar exercises and increased upon cessation of sonar transmissions. Potential explanations for this decline in vocal activity detection include: 1) the animals continued to vocalize, but move off the range, 2) the animals remained present on the range but ceased vocalizing during military operations, or 3) animal vocalizations were masked by the noise associated with military operations and not detected. Data from this analysis strongly suggest that these animals avoided ships using active sonar by moving off range during operations, returning to the range after sonar activity ceased (McCarthy et al. 2011).

8 STATUS

Very little information exists on the status of populations of *M. densirostris*, with the exceptions of Hawaii, Bahamas, and Canary Islands where repeated sightings of individuals and tagging studies have been conducted (Aguilar de Soto 2006, Baird et al. 2009b, Claridge 2006). This is due in large part to the pelagic and elusive nature of the species, which has made research exceedingly difficult. *M. densirostris* is not listed as endangered internationally by the Convention on International Trade in Endangered Species (CITES Appendix II), nor as “threatened” or “endangered” in the U. S. under the Endangered Species Act, and is not considered “depleted” under the U. S. Marine Mammal Protection Act. *M. densirostris* is classified as “data deficient” (IUCN).

9 RECOMMENDATIONS

- Increased effort into obtaining species-level identifications; do not use Mesoplodon spp. as a management unit
- Species-level management is desirable, and a high priority should be placed on finding means to obtain species-specific abundance information.

- Photo-identification and tagging efforts to monitor movement patterns (seasonal as well as ranges); determination of population sizes/ movements of individuals, identifying whether site-fidelity to specific habitats
- Consider the use of pingers where longline bycatch a concern
- Increased communication and coordination between research community, government agencies, and industry regarding activities in known beaked whale habitat. This should include but not limited to: pre-activity monitoring, monitoring and mitigation efforts during activities, and post-operational monitoring, including observations and presence/ absence data, sightings (aerial and/ or ship-based), acoustic monitoring, increased monitoring for strandings, etc.
- Better information on population structure of oceanic Z. cavirostris as well as those around archipelagos ; this should include genetics, morphometrics, photo-identification, acoustics, and long-term tagging studies, as well as habitat requirements and life history
- Use of passive acoustics concurrent with surface observations
- Differentiate among the potential effects of various anthropogenic sources of noise - determine effects of various source levels, frequencies, and signal types
- Increase observer training for making at-sea identification of beaked whales

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